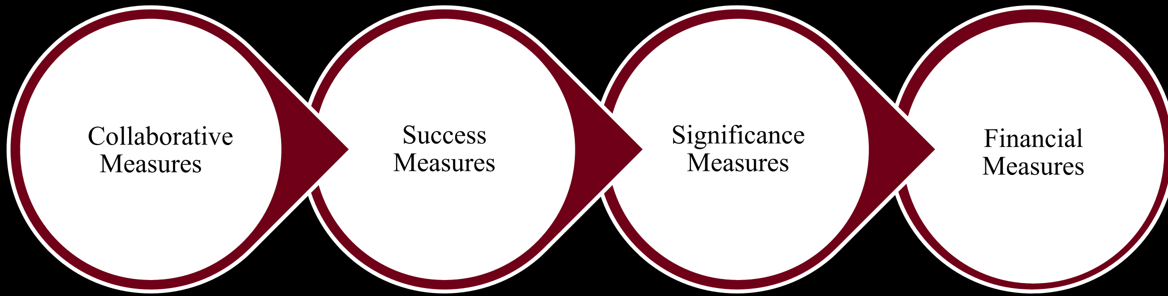

Round 3: Application Form

Local Government Innovation Fund

Step One: Fill out this Application Form in its entirety.

Step Two: Fill out the online submission form and submit your application materials. All supplemental application materials should be combined into one file for submission.

LGIF: Applicant Profile

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")
Project Name	Natural Gas Conversion/Shared Fueling Station Study
Type of Request	Grant
Funding Request	$100,000
JobsOhio Region	Northwest
Number of Collaborative Partners	7

Office of Redevelopment
Website: http://development.ohio.gov/Urban/LGIF.htm
Email: LGIF@development.ohio.gov
Phone: 614 | 995 2292

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	**Round 3**	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Lead Applicant

Mailing Address:	Address Line 1	928 W Market St, Suite A				
	Address Line 2					
	City	Tiffin	State	OH	Zip Code	44883
City, Township or Village		Tiffin		Population (2010)		17,963
County		Seneca		Population (2010)		56,745
Did the lead applicant provide a resolution of support?		✔ Yes (Attached) ☐ No (In Process)				

Project Contact

Complete the section below with information for the individual to be contacted on matters involving this application.

Project Contact		John Davoli		Title		Director
Mailing Address:	Address Line 1	928 W Market St, Suite A				
	Address Line 2					
	City	Tiffin	State	OH	Zip Code	44883
Email Address		jdavoli@ncoesc.org		Phone Number		(419) 447-2927

Section 1 Contacts

Fiscal Officer

Complete the section below with information for the entity and individual serving as the fiscal agent for the project.

Fiscal Officer		Rhonda Feasel		Title		Treasurer
Mailing Address:	Address Line 1	928 W Market St, Suite A				
	Address Line 2					
	City	Tiffin	State	OH	Zip Code	44883
Email Address		rfeasel@ncoesc.org		Phone Number		(419) 447-2927
Is your organization registered in OAKS as a vendor?		✔ Yes ☐ No				

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of	Grant

Single Applicant

Is your organization applying as a single entity?	☐ Yes ☑ No
Participating Entity: (1 point) for single applicants	0

Collaborative Partners

Does the proposal involve other entities acting as collaborative partners?	☑ Yes ☐ No

Applicants applying with a collaborative partner are required to show proof of the partnership with a partnership agreement signed by each partner and resolutions of support from the governing entities. If the collaborative partner does not have a governing entity, a letter of support from the partnering organization is sufficient. Include these documents in the supporting documents section of the application.

In the section below, applicants are required to identify population information and the nature of the partnership.

Each collaborative partner should also be clearly and separately identified on pages 4-5.

Number of Collaborative Partners who signed the partnership agreement, and provided resolutions of support.	7
Participating Entity: (5 points) allocated to projects with collaborative partners.	5

Population

The applicant is required to provide information from the 2010 U.S. Census information, available at: http://factfinder2.census.gov/

Does the applicant (or collaborative partner) represent a city, township or village with a population of less than 20,000 residents?	☑ Yes ☐ No	
	List Entity	
	City of Tiffin	
	Municipality/Township	Population
	Tiffin	17,963
Does the applicant (or collaborative partner) represent a county with a population of less than 235,000 residents?	☑ Yes ☐ No	
	List Entity	
	Seneca County	
	County	Population
	Seneca	56,745
Population: (3-5 points) determined by the smallest population listed in the application. Applications from (or collaborating with) small communities are preferred.	5	

Section 2 Collaborative Partners

Nature of Partnership (2000 character limit)

As agreed upon in the partnership agreement, please identify the nature of the partnership, and explain how the main applicant and the partners will work together on the proposed project.

The Parties agree to participate in a feasibility study to use Local Government Innovation Fund (LGIF) dollars to analyze and chart the feasibility and potential of converting local government and school district fleets to a Natural Gas Vehicle (NGV) fleet. The study will also map out a "Shared Service" distribution network, reducing storage, transportation, and purchasing costs. It is agreed that the NCOESC shall bear the costs associated with the LGIF grant application, take responsibility for administering the grant award, and will coordinate data collection during the study.

List of Partners

The applicant applying with collaborative partners (defined in §1.03 of the LGIF Policies) must include the following information for each applicant:

- **Name of collaborative partners**
- **Contact Information**
- **Population data (derived from the 2010 U.S. Census)**

If the project involves more than 12 collaborative partners, additional forms are available on the LGIF website.

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Collaborative Partners Number 1	City of Tiffin						
Address Line 1	51 E Market St			Popuation			
Address Line 2				Municipality /Township	Tiffin	Population	17,963
City	Tiffin	State	OH	Zip Code	44883	County	Seneca
						Population	56,745
Email Address	mayor@tiffinohio.gov			Phone Number	(419) 448-5401		
Resolution of Support	✔ Yes ☐ No			Signed Agreement	✔ Yes ☐ No		

Collaborative Partners Number 2	Seneca County						
Address Line 1	111 Madison St			Population			
Address Line 2				Municipality /Township		Population	
City	Tiffin	State	OH	Zip Code	44883	County	Seneca
						Population	56,745
Email Address	swilson@seneca-county.com			Phone Number	(419) 447-4550		
Resolution of Support	✔ Yes ☐ No			Signed Agreement	✔ Yes ☐ No		

Collaborative Partners Number 3	Tiffin City Schools						
Address Line 1	244 S Monroe St			Population			
Address Line 2				Municipality /Township	Tiffin	Population	17,963
City	Tiffin	State	OH	Zip Code	44883	County	Seneca
						Population	56,745
Email Address	don_coletta@tiffin.k12.oh.us			Phone Number	(419) 447-2515		
Resolution of Support	✔ Yes ☐ No			Signed Agreement	✔ Yes ☐ No		

Collaborative Partners Number 4	Seneca East Local School						
Address Line 1	13343 E US 224			Population			
Address Line 2				Municipality /Township		Population	
City	Attica	State	OH	Zip Code	44807	County	Seneca
						Population	56,745
Email Address	mikewank@senecaeast.net			Phone Number	(419) 426-7041		
Resolution of Support	✔ Yes ☐ No			Signed Agreement	✔ Yes ☐ No		

Section 2 Collaborative Partners

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Collaborative Partners Number 5	Seneca County Agency Transportation ("SCAT")							
Address Line 1	3140 S St Rt 100, Suite F				Population			
Address Line 2	PO Box 922				Municipality /Township		Population	
City	Tiffin	State	OH	Zip Code 44883	County	Seneca	Population	56,745
Email Address	scat@bright.net				Phone Number	(419) 447-7344		
Resolution of Support	☑ Yes ☐ No				Signed Agreement	☑ Yes ☐ No		

Collaborative Partners Number 6	North Central Academy ("NCA")							
Address Line 1	928 W Market St, Suite B				Population			
Address Line 2					Municipality /Township	Tiffin	Population	17,963
City	Tiffin	State	OH	Zip Code 44883	County	Seneca	Population	56,745
Email Address	bluhring@ncoesc.org				Phone Number	(419) 448-5786		
Resolution of Support	☑ Yes ☐ No				Signed Agreement	☑ Yes ☐ No		

Collaborative Partners Number 7								
Address Line 1					Population			
Address Line 2					Municipality /Township		Population	
City		State		Zip Code	County		Population	
Email Address					Phone Number			
Resolution of Support	☐ Yes ☐ No				Signed Agreement	☑ Yes ☐ No		

Collaborative Partners Number 8								
Address Line 1					Population			
Address Line 2					Municipality /Township		Population	
City		State		Zip Code	County		Population	
Email Address					Phone Number			
Resolution of Support	☐ Yes ☐ No				Signed Agreement	☐ Yes ☐ No		

Section 2 Collaborative Partners

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	**Round 3**	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Collaborative Partners Number 9							
Address Line 1				Population			
Address Line 2				Municipality /Township		Population	
City		State		Zip Code		County		Population	
Email Address				Phone Number			
Resolution of Support	☐ Yes ☐ No			Signed Agreement	☐ Yes ☐ No		

Collaborative Partners Number 10							
Address Line 1				Population			
Address Line 2				Municipality /Township		Population	
City		State		Zip Code		County		Population	
Email Address				Phone Number			
Resolution of Support	☐ Yes ☐ No			Signed Agreement	☐ Yes ☐ No		

Collaborative Partners Number 11							
Address Line 1				Population			
Address Line 2				Municipality /Township		Population	
City		State		Zip Code		County		Population	
Email Address				Phone Number			
Resolution of Support	☐ Yes ☐ No			Signed Agreement	☐ Yes ☐ No		

Collaborative Partners Number 12							
Address Line 1				Population			
Address Line 2				Municipality /Township		Population	
City		State		Zip Code		County		Population	
Email Address				Phone Number			
Resolution of Support	☐ Yes ☐ No			Signed Agreement	☐ Yes ☐ No		

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Identification of the Type of Award	Feasibility Study
Targeted Approach	Efficiency

Project Description (4000 character limit)

Please provide a general description of the project. The information provided will be used for council briefings, program, and marketing materials.

The North Central Educational Service Center (NCOESC), and its team of collaborative partners, proposes to use Local Government Innovation Fund (LGIF) dollars to analyze and chart the feasibility and potential of converting local government and school district fleets to a Natural Gas Vehicle (NGV) fleet. The study will also map out a "Shared Service" distribution network, reducing storage, transportation, and purchasing costs. Natural gas powered vehicles are paving the way to significant savings over standard gasoline and diesel vehicles and allows more efficiency in terms of fuel standards and overall cost. The environmental impact will be baselined to determine current emissions of toxins compared to Natural Gas (NG) emissions.
The study will indicate NG conversion opportunities that each entity, and together in a partnership, has available separately and as a whole. The objective is to implement a renewable energy source to fuel government vehicles at a considerably cheaper fuel cost.
The average price of gasoline in 2010 and 2011 was $2.78 and $3.53 respectively and are projected to continue to rise. Because of advancement in drilling technologies, the reduction of cost for NG conversion technology, the US Department of Energy predicts NG to remain lower than gasoline and diesel. (DOE/EIA-0383 (2012) | June 2012)
As one of Ohio's K-12 educational service centers, the NCOESC has proven experience in providing shared services that enhance operational efficiencies and cost reduction for member districts. The NCOESC is a scalable organization that is well positioned to encourage shared services among local governments and local school districts.

NCOESC services have proven scalable to various sized government agencies, and its organizational expertise is transferrable. Other projects in Ohio and throughout the nation have shown NG systems can be shared across jurisdictional boundaries and scaled to meet the needs, functions and reporting requirements of several types of government entities including educational, city, county, and township.

The feasibility assessment will determine the best approaches to make eventual solutions scalable. After the initial phase of implementation, extensions of the NG infrastructure could be made available to other villages, townships, schools, community colleges, counties and other political subdivisions.

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Past Success	✔ Yes ☐ No
Past Success (5 points)	5

Provide a summary of past efforts to implement a project to improve efficiency, implement shared services, coproduction, or a merger. (1000 character limit)

In the recent past, the North Central Ohio ESC has successfully implemented projects that promote efficiencies and shared services among the school districts it serves. Among these projects are: shared IT networking, web-site posting, shared IT services, web-based learning management system, Individual Education Plan (IEP) records management system, administrative collaboration and network program, cooperative purchasing-technology office commodities, and bus driver services.

Scalable/Replicable Proposal	☐ Scalable ☐ Replicable ✔ Both
Scalable/Replicable (10 points)	10

Provide a summary of how the applicant's proposal can be replicated by other local governments or scaled for the inclusion of other local governments. (1000 character limit)

The project requirements will focus on NG platform solutions that are scalable and pose the greatest prospect for efficiencies to assist all partners, especially villages, small cities, and townships. Although five political subdivisions will serve as the collaborative partners for this initiative, the feasibility study is expected to result in mapping and business planning that will permit the expansion of this shared services approach to other entities in the region.

The initial partners are also charter members of the North Central Ohio Regional Council of Governments (NCORcog) that will ultimately serve a multi-county area. While not the lead applicant for this grant, NCORcog will ultimately serve as a valuable mechanism for recruiting additional regional partners for this solution.

Section 3 Project Information

Probability of Success	✔ Yes ☐ No
Probability of Success (5 points)	5

Provide a summary of the likelihood of the grant study recommendations being implemented. Applicants requesting a loan should provide a summary of the probability of savings from the loan request. (1000 character limit)

As a classic shared service provider, NCOESC is the logical entity to take the lead on this project. The organization has developed a successful track record in providing vital services to political subdivisions. NCOESC organizational expertise will be essential in identifying the capacities of the partner entities, and how NG conversion will be beneficial to our partners.

To increase the chances of success, NCOESC will contract Public Performance Partners (P3), an experienced 501(c) 3 non-profit consulting entity, to conduct the feasibility study and serve as project manager. P3 is a non-profit organization that brings together subject matter experts to help counties, cities, townships, school districts or institutions of higher learning plan and execute cost-saving strategies and continue to provide valuable public service. P3 also will engage an experienced, Ohio-based energy service company (ESCO) as a subject matter expert in NG technology and systems expertise.

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Performance Audit Implementation/Cost Benchmarking	☐ Yes ☑ No
Performance Audit/Benchmarking (5 points)	0

If the project is the result of recommendations from a performance audit provided by the Auditor of State under Chapter 117 of the Ohio Revised Code or a cost benchmarking study, please attach a copy with the supporting documents. In the section below, provide a summary of the performance audit or cost benchmarking study. (1000 character limit)

N/A

Economic Impact	☑ Yes ☐ No
Economic Impact (5 points)	5

Provide a summary of how the proposal will promote a business environment (through a private business relationship) and/or provide for community attraction. (1000 character limit)

As private businesses become increasingly cost aware, the parties know there must be more sophistication in government provided services in order for a geographic area to remain enticing to small businesses and larger companies. By introducing a new and alternative energy source the county and region become more attractive to the business community. Public entities, which are more efficient and approachable, are more likely to develop public-private partnerships, and offer additional services, programs and funding for the community. Rural and small-town areas such as Seneca County must compete with larger urban areas. A local region where entities are working collaboratively, and where NG infrastructure is efficient and up-to-date, will increase its attractiveness to business.
Community attraction will occur if local governments are spending money wisely, and allowing government services to become more accessible to businesses as well as all residents of the municipalities.

Section 3 Project Information

Response to Economic Demand	☑ Yes ☐ No
Response to Economic Demand (5 points)	5

Provide a summary of how the project responds to substantial changes in economic demand for local or regional government services. The narrative should include a description of the current service level. (1000 character limit)

The way local governments work is changing. A more dynamic fuel market is causing even local jurisdictions such as educational institutions (schools/colleges) and county, city, village and township governments to be more adaptable. Taxpayers, including residents and businesses, also are becoming more aware of the benefits of NG and are seeking more accessible and efficient government services based on a cheaper fuel source.

Innovative strategies will be key to responding to the diminishing revenue environment in Ohio. The Tiffin/Seneca County/north-central Ohio area faces some of the tightest budget constraints in decades. In addition to declines in local tax revenue due to the recent recession, HB 153 reduces funding through the State and Local Government Fund to local governments by 50% in fiscal year 2013, and in 2013 the sunset of estate tax revenue creates motivation to seek greater efficiencies to protect vital public services.

Budget Information

General Instructions

•Both the Project Budget and Program Budgets are required to be filled out in this form.

•Consolidate budget information to fit in the form. Additional budget detail may be provided in the budget narrative or in an attachment in Section 5: Supplemental Information.

Project Budget:

- The Project Budget justification must be explained in the Project Budget Narrative section of the application. This section is also used to explain the reasoning behind any items on the budget that are not self explanatory, and provide additonal detail about project expenses.
- The Project Budget should be for the period that covers the entire project. The look-back period for in-kind contributions is two (2) years. These contributions are considered a part of the total project costs.
- For the Project Budget, indicate which entity and revenue source will be used to fund each expense. This information will be used to help determine eligible project expenses.
- Please provide documentation of all in-kind match contributions in the supporting documents section. For future in-kind match contributions, supporting documentation will be provided at a later date.

Program Budget:

- Six (6) years of Program Budgets should be provided. The standard submission should include three years previous budgets (actual), and three years of projections including implementation of the proposed project. A second set of three years of projections (one set including implementation of this program, and one set where no shared services occurred) may be provided in lieu of three years previous if this does not apply to the proposed project.
- Please use the Program Budget Narrative section to explain any unusual activities or expenses, and to defend the budget projections. If the budget requires the combining of costs on the budget template, please explain this in the narrative.

Return on Investment:

- A Return on Investment calculation is required, and should reference cost savings, cost avoidance and/or increased revenues indicated in the budget projection sections of the application. Use the space designated for narrative to justify this calculation, using references when appropriate.

For Loan Applications only:

- Using the space provided, outline a loan repayment structure.
- Attach three years prior financial documents related to the financial health of the lead applicant (balance sheet, income statement, and a statement of cash flows).

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Project Budget

Sources of Funds

LGIF Request:		$100,000
Cash Match (List Sources Below):		
Source:		
Source:		
Source:		
Source:		
In-Kind Match (List Sources Below):		
Source:	Hugh Quill/Public Performance Partners	$7,140
Source:	NCOESC	$7,115
Source:	Other Collaborative Partners	18538
Total Match:		$32,793
Total Sources:		$132,793

Uses of Funds

	Amount	Revenue Source
Consultant Fees:	$60,000	Grant
Legal Fees:	$10,000	Grant
Other: Project Management	$12,000	Grant
Other: Grant Administration	$18,000	Grant
Other: Public Performance Partners	$7,140	In-kind
Other: NCOESC Staff Time	$7,115	In-kind
Other: Other Collaborative Partners	$18,538	In-kind
Other:		
Other:		
Other:		
Total Uses:	$132,793	
Local Match Percentage:	24.69%	

* Please note that this match percentage will be included in your grant/loan agreement and cannot be changed after awards are made.

Local Match Percentage = (Match Amount/Project Cost) * 100 (10% match required)

☑ 10-39.99% (1 point) ☐ 40-69.99% (3 points) ☐ 70% or greater (5 points)

Project Budget Narrative: Use this space to justify expenses (1200 character max).

The consultant will perform three analyses in preparing the feasibility study. First they will analyze the cost benefit of constructing a natural gas fueling station. The second analysis will consider the cost benefit of converting the partners' fleet. The final analysis will consider the leverage of shared natural gas purchasing power. NCOESC will provide grant administration services; assist with data collection, interviews and coordination. A Project Manager will be hired to oversee the entire project to make sure all objectives are met and performed effectively.

Section 4 Financial Information

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Program Budget

Actual ✔ Projected ☐

Expenses	FY 2010 Amount	FY 2011 Amount	FY 2012 Amount
Salary and Benefits			
Contract Services	$321,304	$329,976	$386,183
Occupancy (rent, utilities, maintenance)			
Training and Professional Development			
Insurance			
Travel			
Capital and Equipment Expenses			
Supplies, Printing, Copying, and Postage	$881,872	$1,027,650	$1,344,829
Evaluation			
Marketing			
Conferences, meetings, etc.			
Administration			
***Other -**___			
***Other -**___			
***Other -**___			
TOTAL EXPENSES	$1,203,176	$1,357,626	$1,731,012

	Revenues	Revenues	Revenues
Contributions, Gifts, Grants, and Earned Revenue			
Local Government: Seneca County	$112,047	$109,524	$128,061
Local Government: City of Tiffin	$212,887	$226,324	$271,333
Local Government: Seneca County Gas Tax	$412,507	$505,762	$669,169
State Government			
Federal Government			
**Other -* North Central Academy		$4,460	$15,920
**Other -* Tiffin City Schools	$164,593	$194,492	$202,587
**Other -* Seneca East Schools	$148,172	$126,716	$207,098
Membership Income			
Program Service Fees	$152,970	$190,348	$236,844
Investment Income			
TOTAL REVENUES	$1,203,176	$1,357,626	$1,731,012

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Program Budget

Actual ☐ Projected ☐	FY 2013	FY 2014	FY 2015
Expenses	**Amount**	**Amount**	**Amount**
Salary and Benefits			
Contract Services	$321,391	$348,110	$352,435
Occupancy (rent, utilities, maintenance)			
Training and Professional Development			
Insurance			
Travel			
Capital and Equipment Expenses			
Supplies, Printing, Copying, and Postage	$542,759	$623,272	$643,469
Evaluation			
Marketing			
Conferences, meetings, etc.			
Administration			
***Other -**___________________________			
***Other -**___________________________			
***Other -**___________________________			
TOTAL EXPENSES	$864,150	$971,382	$995,904
	Revenues	**Revenues**	**Revenues**
Contributions, Gifts, Grants, and Earned Revenue			
Local Government: Seneca County	$96,652	$110,211	$106,090
Local Government: City of Tiffin	$172,353	$190,423	$188,710
Local Government: Seneca County Gas Tax	$301,024	$351,044	$368,150
State Government			
Federal Government			
**Other -* North Central Academy	$13,134	$14,447	$15,892
**Other -* Tiffin City Schools	$100,731	$105,191	$106,533
**Other -* Seneca East Schools	$58,546	$59,737	$58,615
Membership Income			
Program Service Fees	$121,710	$140,329	$151,914
Investment Income			
TOTAL REVENUES	$864,150	$971,382	$995,904

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	**Round 3**	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Program Budget

Use this space to justify the program budget and/or explain any unusual revenues or expenses (6000 characters max).

As the cost per gallon of gas/diesel has increased annually this logically translates to higher costs for entities that are dependent on transportation as part of their function. Expenses for school buses, police and sheriff cars are a large burden on budgets of school districts, cities and counties. By reducing fuel and maintenance costs significantly to these vehicles, by making them more efficient, the entities will be able to show their constituents that they are trying to be fiscally responsible with their tax money. The feasibility study will measure up front conversion costs against expected vehicle longevity to determine eligible fleet candidates for this program.

Section 4: Financial Information Scoring

- ☑ (5 points) Applicant provided complete and accurate budget information and narrative justification for a total of six fiscal years.
- ☐ (3 points) Applicant provided complete and accurate budget information and for at least three fiscal years.
- ☐ (1 point) Applicant provided complete and accurate budget information for less than three fiscal years.

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Return On Investment

Return on Investment is a performance measure used to evaluate the efficiency of an investment. To derive the expected return on investment, divide the net gains of the project by the net costs. For these calculations, please use the implementation gains and costs, NOT the project costs (the cost of the feasibility, planning, or management study)--unless the results of this study will lead to direct savings without additional implementation costs. The gains from this project should be derived from the prior and future program budgets provided, and should be justified in the return on investment narrative.

Return on Investment Formulas:

Consider the following questions when determining the appropriate ROI formula for the project. Check the box of the formula used to determine the ROI for the project. These numbers should refer to savings/revenues illustrated in projected budgets.

Do you expect cost savings from efficiency from the project?

☑ Use this formula: $\frac{\text{Total \$ Saved}}{\text{Total Program Costs}} * 100 = \text{ROI}$

Do you expect cost avoidance from the implementation of the project/program?

☐ Use this formula: $\frac{\text{Total Cost Avoided}}{\text{Total Program Costs}} * 100 = \text{ROI}$

Do you expect increased revenues as a result of the project/program?

☐ Use this formula: $\frac{\text{Total New Revenue}}{\text{Total Program Costs}} * 100 = \text{ROI}$

Expected Return on Investment = $\frac{\$3,409,223}{\$6,240,658} * 100 =$ 54.63%

Section 4

Financial Information

Return on Investment Justification Narrative: In the space below, briefly describe the nature of the expected return on investment, using references when appropriate. (1300 character limit)

We anticipated for our partners to save at least 40-60% on their fuel purchases based on current market trends. With uncertainty in the Middle East, demand around the world, and a host of market factors including the hedging of commodity prices gasoline and diesel prices have been forecasted by most economist to continually rise. NG is predicted by most analyst to maintain its low cost for a long duration.

The partners feel that with the accessibility of multiple high pressure gas lines and logically placed fueling stations, they could realize a significant and continually increased savings based off of real time fuel prices. Many government organizations have realized the benefits of fuel switching. Government entities throughout the United States have implemented NG vehicles for their fleets and are seeing significant savings.

Expected Return on Investment is:

☐ Less than 25% (10 points) ☑ 25%-74.99% (20 points) ☐ Greater than 75% (30 points)

Questions about how to calculate ROI? Please contact the Office of Redevelopment at 614-995-2292 or lgif@development.ohio.gov

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Loan Repayment Structure

Please outline the preferred loan repayment structure. At a minimum, please include the following: the entities responsible for repayment of the loan, all parties responsible for providing match amounts, and an alternative funding source (in lieu of collateral). Applicants will have two years to complete the project upon execution of the loan agreement, and the repayment period will begin upon the final disbursement of the loan funds. A description of expected savings over the term of the loan may be used as a repayment source.

N/A

Applicant demonstrates a viable repayment source to support loan award. Secondary source can be in the form of a debt reserve, bank participation, a guarantee from a local entity, or other collateral (i.e. emergency, rainy day, or contingency fund, etc).

☐ Applicant clearly demonstrates a secondary repayment source (5 points)

☐ Applicant does not have a secondary repayment source (0 points)

Section 4 Financial Information

Lead Applicant	North Central Ohio Educational Service Center ("NCOESC")	Round 3	
Project Name	Natural Gas Conversion/Shared Fueling Station Study	Type of Request	Grant

Scoring Overview

Collaborative Measures	Description	Max Points		Applicant Self Score
Section 1: Collaborative Measures				
Population	Applicant's population (or the population of the area(s) served) falls within one of the listed categories as determined by the U.S. Census Bureau. Population scoring will be determined by the **smallest** population listed in the application. Applications from (or collaborating with) small communities are preferred.	5		5
Participating Entities	Applicant has executed partnership agreements outlining all collaborative partners and participation agreements and has resolutions of support. (Note: Sole applicants only need to provide a resolution of support from its governing entity.	5		5
Section 2: Success Measures				
Past Success	Applicant has successfully implemented, or is following project guidance from a shared services model, for an efficiency, shared service, coproduction or merger project in the past.	5		5
Scalable/Replicable Proposal	Applicant's proposal can be replicated by other local governments or scaled for the inclusion of other local governments.	10		10
Probability of Success	Applicant provides a documented need for the project and clearly outlines the likelihood of the need being met.	5		5
Section 3: Significance Measures				
Performance Audit Implementation/Cost Benchmarking	The project implements a single recommendation from a performance audit provided by the Auditor of State under Chapter 117 of the Ohio Revised Code or is informed by cost benchmarking.	5		0
Economic Impact	Applicant demonstrates the project will a promote business environment (i.e., demonstrates a business relationship resulting from the project) and will provide for community attraction (i.e., cost avoidance with respect to taxes)	5		5
Response to Economic Demand	The project responds to current substantial changes in economic demand for local or regional government services.	5		5
Section 4: Financial Measures				
Financial Information	Applicant includes financial information (i.e., service related operating budgets) for the most recent three years and the three year period following the project. The financial information must be directly related to the scope of the project and will be used as the cost basis for determining any savings resulting from the project.	5		5
Local Match	Percentage of local matching funds being contributed to the project. This may include in-kind contributions.	5		1
Expected Return	Applicant demonstrates as a percentage of savings (i.e., actual savings, increased revenue, or cost avoidance) an expected return. The return must be derived from the applicant's cost basis.	30		20
Repayment Structure (Loan Only)	Applicant demonstrates a viable repayment source to support loan award. Secondary source can be in the form of a debt reserve, bank participation, a guarantee from a local entity, or other collateral (i.e., emergency fund, rainy day fund, contingency fund, etc.).	5		0
			Total Points	66

North Central Ohio
Educational Service Center

Tiffin Campus
928 W. Market Street - Suite A
Tiffin, Ohio 44883
419-447-2927
419-447-2825 Fax

Mansfield Campus
State Support Team Region 7
1495 West Longview Ave. - Suite 200
Mansfield, Ohio 44906
419-747-4808

Marion Campus
333 East Center Street
Marion, Ohio 43302
740-387-6625
740-383-4804 Fax

ATTACHMENTS

FOR

NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

A. 1-10 RESOLUTIONS

B. 1-4 LETTER OF INTENT

C. 1-3 MEMORANDUM OF UNDERSTANDING

D. 1-8 CENSUS DATA

E. 1-13 PROJECT AND PROGRAM BUDGETS

Attachment A-1

RESOLUTION NO. NCO-12-48

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE NORTH CENTRAL OHIO EDUCATIONAL SERVICE CENTER TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

WHEREAS, the Board of Governors of the North Central Ohio Educational Service Center ("NCOESC") has expressed an interest in collaboratively partnering with other Ohio municipalities, townships, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center being the main applicant;

WHEREAS, the NCOESC believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the Board of Governors of the North Central Ohio Educational Service Center of Tiffin, Ohio, that:

Section 1. It is in the best interests of the Board of Governors of the North Central Ohio Educational Service Center for it, to authorize and approve the NCOESC to join the application for the LGIF Grant.

Section 2. The Board of Governors of the North Central Ohio Educational Service Center hereby authorizes and approves the Council to join the application for the LGIF Grant and hereby promises to provide the resources necessary for the Board of Governors of the North Central Ohio Educational Service Center to join the LGIF Grant.

Section 3. The Board of Governors of the North Central Ohio Educational Service Center hereby authorizes and approves the superintendent of the NCOESC to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. The Board of Governors of the North Central Ohio Educational Service Center hereby authorizes and approves the superintendent of the NCOESC to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This Board of Governors finds and determines that all formal actions of the NCOESC Board of Governors and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this Board of Governors or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Passed: August 21, 2012

Superintendent

Treasurer

Approved

Attachment A-2

RESOLUTION NO. 12-38

INTRODUCED BY: Jos Robert **DATE:** 8/6/12

RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE CITY OF TIFFIN, OHIO TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY, AND DECLARING AN EMERGENCY.

WHEREAS, the City Council of Tiffin, Ohio has expressed an interest in *collaboratively partnering with other Ohio municipalities, townships, school districts* and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") for a natural gas conversion/shared feeling station study through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant and conducting a Natural Gas Conversion/Shared Fueling Station Study; and

WHEREAS, the City Council of the City of Tiffin, Ohio believes that it is in its best interest to join the application for the LGIF Grant.

THE COUNCIL OF THE CITY OF TIFFIN, OHIO THEREFORE RESOLVES:

Section 1: It is in the best interests of the City Council to authorize and approve the City of Tiffin to join the application for the LGIF Grant described above.

Section 2: The City Council hereby authorizes and approves the Council to join the application for the LGIF Grant and hereby promises to provide the resources necessary for City Council to join the LGIF Grant.

Section 3: The City Council hereby authorizes and approves the Mayor of the City of Tiffin to join the LGIF Grant as a collaborative partner and an applicant by executing a Letter of Intent.

Section 4: This City Council hereby authorizes and approves of the City to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into a Memorandum of Understanding between the partners.

Section 5: This City Council finds and determines that all formal actions of this City Council and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this City Council or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Section 6: Council declares this to be an emergency because the public peace, health, welfare and safety require this Resolution take effect at the earliest time allowed by Sec. 4.07(A), Tiffin Charter, and reason being: Grant funds, received at no cost to the City, may give the City money, to save tax dollars using a natural gas conversion/shared fueling station study.

Authenticated:

Paul L. Elchert Jr. and Ann E. Forrest

President of Council | Clerk of Council

Aug 20 2012 | Aug. 20, 2012

Date | Date

Approved by:

Mayor | August 20, 2012

Date

Effective date: 8/20/2012

12-38.res

STATE OF OHIO
City of Tiffin)
Seneca County) ss
I, Ann E. Forrest, Clerk of Tiffin City Council
Certify that the following is a true & accurate copy
of Resolution 12-38 adopted by Council on the 20th day
August, 2012. IN WITNESS WHEREOF, I have
Subscribed my name & affixed my seal this 20th day of
August, 2012. Ann E. Forrest

Ann E. Forrest, Clerk of Tiffin City Council

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE SENECA EAST LOCAL SCHOOL DISTRICT TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

WHEREAS, the Seneca East Board of Education of Attica, Ohio (the "Board") has expressed an interest in collaboratively partnering with other Ohio municipalities, townships, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant;

WHEREAS, the Board believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the Seneca East Board of Education of Attica, Ohio, that:

Section 1. It is in the best interests of the Seneca East Local School District for it to authorize and approve the district to join the application for the LGIF Grant.

Section 2. The Board hereby authorizes and approves the Council to join the application for the LGIF Grant and hereby agrees that NCOESC will provide the resources necessary for the Board to join the LGIF Grant.

Section 3. The Board hereby authorizes and approves a certified officer of the school district to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. The Board hereby authorizes and approves a certified officer of the school district to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This Council finds and determines that all formal actions of this Council and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this Council or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Passed: August 27, 2012

[Board President]

[Treasurer]

RESOLUTION NO. 13-03

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE SENECA COUNTY AGENCY TRANSPORTATION ("SCAT") TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

WHEREAS, the Board of SCAT of Seneca County, Ohio has expressed an interest in collaboratively partnering with other Ohio municipalities, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant;

WHEREAS, SCAT believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the Board of SCAT of Seneca, Ohio, that:

Section 1. It is in the best interests of SCAT for it, to authorize and approve SCAT to join the application for the LGIF Grant.

Section 2. SCAT hereby authorizes and approves SCAT to join the application for the LGIF Grant and hereby agrees that NCOESC will provide the resources necessary for SCAT to join the LGIF Grant.

Section 3. SCAT hereby authorizes and approves a certified officer of SCAT to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. SCAT hereby authorizes and approves a certified officer of SCAT to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This Council finds and determines that all formal actions of this Council and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this Council or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Passed: August 21, 2012

Linda S. Good, Exec. Dir
[Executive Director]

Dennis H Manning Board Pres
[Board Chair]

RESOLUTION NO. Vol 88 516 & 517

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE SENECA COUNTY COMMISSIONERS TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

WHEREAS, the Seneca County Board of Commissioners, of Seneca County, Ohio has expressed an interest in collaboratively partnering with other Ohio municipalities, townships, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant;

WHEREAS, the this Board believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the Seneca County Board of Commissioners of Seneca County, Ohio, that:

Section 1. It is in the best interests of the Seneca County Board of Commissioners for it, to authorize and approve to join the application for the LGIF Grant.

Section 2. The Seneca County Board of Commissioners hereby authorizes and approves the Council to join the application for the LGIF Grant and hereby promises to provide the resources necessary for Seneca County Board of Commissioners to join the LGIF Grant.

Section 3. The Seneca County Board of Commissioners hereby authorizes and approves a certified officer of the Board of Commissioners to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. The Seneca County Board of Commissioners hereby authorizes and approves a certified officer of the Board of Commissioners to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This Seneca County Board of Commissioners finds and determines that all formal actions of this [Seneca County Board of Commissioners and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this Seneca County Board of Commissioners or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Attachment A-7

Passed: August 14, 2012

I, the undersigned, Clerk of the Board of County Commissioners, Seneca County, Ohio, do hereby certify that the foregoing is true and correct copy from the official record of said Board of County Commissioners as recorded in Journal No. 88 Page 514 & 515

Nicole Smith

Recording Clerk, Board of County Commissioners
Seneca County, Ohio

Benjamin E. Nutter

Jeffrey D. Wagner

David G. Sauber yes

RESOLUTION NO. 12-160

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE TIFFIN CITY SCHOOLS TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY

WHEREAS, the Board of Education for Tiffin City Schools of Tiffin, Ohio has expressed an interest in collaboratively partnering with other Ohio municipalities, townships, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant;

WHEREAS, the Tiffin City Schools believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the Board of Education for Tiffin City Schools of Tiffin, Ohio, that:

Section 1. It is in the best interests of the Board of Education for Tiffin City Schools for it to authorize and approve the Tiffin City Schools to join the application for the LGIF Grant.

Section 2. The Board of Education for Tiffin City Schools hereby authorizes and approves the Council to join the application for the LGIF Grant and hereby agrees that NCOESC will provide the resources necessary for the Board of Education for Tiffin City Schools to join the LGIF Grant.

Section 3. The Board of Education for Tiffin City Schools hereby authorizes and approves a certified officer of the Tiffin City Schools to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. The Board of Education for Tiffin City Schools hereby authorizes and approves a certified officer of the Tiffin City Schools to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This Council finds and determines that all formal actions of this Council and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this Council or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

Passed: August 28, 2012

Donald E. Coletta, Superintendent

Sharon S. Perry, Treasurer

RESOLUTION NO. NCA-12-27

A RESOLUTION OF SUPPORT APPROVING AND AUTHORIZING THE NORTH CENTRAL ACADEMY-FREMONT, TO PARTICIPATE IN AN APPLICATION FOR A LOCAL GOVERNMENT INNOVATION FUND GRANT THROUGH THE STATE OF OHIO FOR A NATURAL GAS CONVERSION/SHARED FUELING STATION STUDY.

WHEREAS, the North Central Academy- Fremont ("**NCA**") Board of Education has expressed an interest in collaboratively partnering with other Ohio municipalities, townships, school districts and counties in order to participate as an applicant for a Local Government Innovation Fund Grant (the "LGIF Grant") through the State of Ohio, with the North Central Ohio Educational Service Center ("NCOESC") being the main applicant;

WHEREAS, the NCA believes that it is in its best interest to join the application for the LGIF Grant.

NOW, THEREFORE, BE IT RESOLVED by the NCA Board of Education for the NCA of Tiffin, Ohio, that:

Section 1. It is in the best interests of the NCA Board of Education for NCA for it, to authorize and approve the NCA to join the application for the LGIF Grant.

Section 2. The NCA Board of Education hereby authorizes and approves the board to join the application for the LGIF Grant and hereby promises to provide the resources necessary for NCA Board of Education to join the LGIF Grant.

Section 3. The NCA Board of Education hereby authorizes and approves a certified officer (superintendent) of the NCA to join the LGIF Grant as a collaborative partner and an applicant by executing that certain Letter of Intent substantially in the form as attached to this Resolution.

Section 4. The NCA Board of Education hereby authorizes and approves a certified officer (superintendent) of the NCA to join the LGIF Grant as a collaborative partner and an applicant by executing and entering into that certain Memorandum of Understanding between the partners substantially in the form as attached to this Resolution.

Section 5. This NCA Board of Education finds and determines that all formal actions of this NCA Board of Education and any of its committees concerning and relating to the adoption of this resolution, and that all deliberations of this NCA Board of Education or any of its committees that resulted in those formal actions, occurred in meetings open to the public in compliance with the laws of the State.

PASSED ON: August 7th, 2012

Treasurer

President of the board of education

North Central Ohio
Educational Service Center

Tiffin Campus
928 W. Market Street - Suite A
Tiffin, Ohio 44883
419-447-2927
419-447-2825 Fax

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State Support Team Region 7
1495 West Longview Ave. – Suite 200
Mansfield, Ohio 44906
419-747-4808

Marion Campus
333 East Center Street
Marion, Ohio 43302
740-387-6625
740-383-4804 Fax

LETTER OF INTENT

August 9, 2012

North Central Ohio Educational Service Center
928 West Market Street, Suite A
Tiffin, Ohio 44883

City of Tiffin
51 E. Market St.
Tiffin, Ohio 44883

Seneca County
111 Madison St.
Tiffin, Ohio 44883

Seneca County Agency Transportation
3140 South SR 100, Suite F- P.O. Box 922
Tiffin, Ohio 44883

Tiffin City Schools
244 S. Monroe St.
Tiffin, Ohio 44883

Seneca East Local Schools
13343 E. US 224
Attica, Ohio 44807

North Central Academy- Fremont
928 West Market Street, Suite B
Tiffin, Ohio 44883

Subject: Local Government Innovation Fund – Grant Application for a
Natural Gas Conversion/Shared Fueling Station Study

Dear Fellow Applicants:

This letter of intent (this "***Letter***") sets forth the terms and conditions of the proposed partnership and application relationship by and among North Central Ohio Educational Service Center, an Ohio educational service center ("***NCOESC***"), the City of Tiffin ("**CITY OF TIFFIN**"), a municipal corporation; County of Seneca ("**SENECA COUNTY**"), an Ohio county; North Central Academy- Fremont ("**NCA**"), a community board of education; Tiffin City Schools ("**TIFFIN CITY SCHOOLS**"), a city board of education; Seneca East Local Schools ("**SENECA EAST LOCAL**"), a local board of education; and Seneca County Agency Transportation ("**SCAT**"), a non-profit corporation. In this Letter, the term "Party" is used to refer to each party individually and the term "Parties" is used to refer to them collectively.

This Letter confirms that it is the Parties' intention to enter into an application to receive grant money from the Local Government Innovation Fund (the "***LGIF Funding***") and, if applicable, other related agreements with respect to the relationship outlined in this Letter as soon as possible, but in no event later than thirty (30) days after the date hereof. For the purposes of the LGIF Funding, NCOESC will serve as the main applicant on the LGIF Funding application and this Letter will serve as an agreement of partnership between the Parties.

1. Overall Nature of the Partnership. The Parties agree to participate in a feasibility study to use Local Government Innovation Fund (LGIF) dollars to analyze and chart the feasibility and potential of converting local government and school district fleets to a Natural Gas Vehicle (NGV) fleet. The study will also map out a "Shared Service" distribution network, reducing storage, transportation, and purchasing costs. It is agreed that the NCOESC shall bear the costs associated with the LGIF grant application, take responsibility for administering the grant award, and will coordinate data collection during the study.

2. Collaborative Effort between the Parties. The NCOESC, as lead applicant, shall coordinate and facilitate data collection, drafting of grant application and submission to the Ohio Department of Development. The City of Tiffin, Seneca County, Tiffin City Schools, Seneca East Local, NCA and SCAT agree to commit staff resources necessary to data collection. They agree to consider modifications to operational protocols related to the functions and plans for this shared facility.

3. Expenses. The main applicant, NCOESC, shall pay respective fees and expenses, including, but not limited to, all such application fees, legal fees and expenses, incurred in connection with the LGIF Funding.

4. Non-Compete Restrictions. Each Party agrees that it is only a party to the application for LGIF Funding as set forth in this Letter. Each Party may not be a party to any other application for LGIF Funding.

5. Public Announcements. No Party shall make any press release or other public statement concerning the matters covered by this Letter unless each Party has agreed upon the form and the contents of the release or statement prior to dissemination.

6. Confidentiality. The Parties acknowledge that they shall not share any proprietary or trade secret information of any other Party, unless required by law or a court order.

7. Binding Provisions. Upon the execution of this Letter, if the LGIF Funding application is denied, then this Letter and all of its provisions shall be non-binding upon the Parties. It is understood between the Parties that the provisions of this

Letter are not intended to create or constitute any legally binding obligation of any Party should the LGIF Funding application be denied, and no Party shall have any liability to any other Party with respect to such provisions except for Section 6. Upon execution of this Letter, if the LGIF Funding application is accepted, then Sections 1-6 of this Letter (collectively, the "***Binding Provisions***") shall constitute a legally binding and enforceable partnership agreement between the Parties. The Binding Provisions may be terminated by the mutual written consent of all of the Parties; provided, however, that the termination of the Binding Provisions shall not affect the liability of a Party for breach of any of the Binding Provisions prior to termination. Upon termination of the Binding Provisions, the Parties shall have no further obligations under the Binding Provisions, except for Section 6, which shall survive the termination of this Letter.

8. Miscellaneous. This Letter may be executed in one or more counterparts, each of which will be deemed to be an original copy of this Letter, and all of which, when taken together, shall be deemed to constitute one and the same. The exchange of copies of this Letter and of signature pages by facsimile transmission (or in PDF copies transmitted via e-mail) shall constitute effective execution and delivery of this Letter as to the Parties and may be used in lieu of the original Letter for all purposes. Signatures of the Parties transmitted by facsimile or in PDF copies transmitted via e-mail shall be deemed to be their original signatures for any purpose whatsoever. The Binding Provisions shall be interpreted and enforced in accordance with the laws of the State of Ohio, United States of America, without regard to conflict of laws principles. The Parties irrevocably submit to the exclusive jurisdiction of the state courts of Seneca County, Ohio, United States of America, to resolve any dispute arising out of or relating to the Binding Provisions and irrevocably waive, to the fullest extent permitted by applicable law, any objection that they may now or hereafter have to the laying of venue in such court or any defense of inconvenient forum. The Binding Provisions contain the entire agreement of the Parties and are the only agreements between the Parties with respect to the subject matter thereof and the Binding Provisions supersede all prior agreements and understandings between the Parties. This Letter shall not be amended or modified except by a writing signed by all of the Parties.

[The remainder of this page has been intentionally left blank.]

If the foregoing correctly sets forth our mutual understanding, please so indicate by signing in the spaces provided below and returning one fully executed copy to the undersigned.

Very truly yours,

NORTH CENTRAL OHIO EDUCATIONAL SERVICE CENTER

By: [signature]
Name: Dr. James Lahoski
Its: Superintendent
Date: 8/22/12

Agreed and Acknowledged:

CITY OF TIFFIN
By: [signature]
Name: Aaron Montz
Its: Mayor
Date: 8/20/2012

SENECA EAST LOCAL
By: [signature]
Name: Michael Wank
Its: Superintendent
Date: 8/27/12

SENECA COUNTY
By: [signature]
Name: Benjamin E. Nutter
Its: President of Commissioners
Date: 8-14-12

TIFFIN CITY SCHOOLS
By: [signature]
Name: Donald Coletta
Its: Superintendent
Date: 8/29/12

SCAT
By: [signature]
Name: Linda Good
Its: Executive Director
Date: 8-21-2012

NORTH CENTRAL ACADEMY
By: [signature]
Name: Brenda Luhring
Its: Superintendent
Date: 8-13-12

Attachment C-1

North Central Ohio Educational Service Center

Tiffin Campus
928 W. Market Street - Suite A
Tiffin, Ohio 44883
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Mansfield Campus
State Support Team Region 7
1495 West Longview Ave. – Suite 200
Mansfield, Ohio 44906
419-747-4808

Marion Campus
333 East Center Street
Marion, Ohio 43302
740-387-6625
740-383-4804 Fax

MEMORANDUM OF UNDERSTANDING

August 10, 2012

Subject: Local Government Innovation Fund – Grant Application for a
Natural Gas Conversion/Shared Fueling Station Study

MEMORANDUM OF UNDERSTANDING

This Memorandum of Understanding is entered as of the 10th day of August, 2012, by and among North Central Ohio Educational Service Center ("**NCOESC**"), an Ohio educational service center; the City of Tiffin ("**CITY OF TIFFIN**"), a municipal corporation; County of Seneca ("**SENECA COUNTY**"), an Ohio county; Tiffin City Schools ("**TIFFIN CITY SCHOOLS**"), a city board of education; Seneca East Local ("**SENECA EAST LOCAL**"), a local board of education; North Central Academy-Fremont ("**NCA**") a community board of education; and Seneca County Agency Transportation ("**SCAT**"), a non-profit corporation. In this Memorandum of Understanding, the term "Party" is used to refer to each party individually and the term "Parties" is used to refer to them collectively.

WHEREAS, in August 2012, each Party adopted, approved and authorized a Resolution showing support to become an applicant to an application for a grant through the Local Government Innovation Project (the "*LGIF Funding*"), with the NCOESC being the main applicant;

WHEREAS, the Parties have had the opportunity to discuss their roles as applicants for the LGIF Funding; and

WHEREAS, the parties have determined that they desire to enter into this Memorandum of Understanding.

NOW, THEREFORE, in consideration of the promises and covenants set forth below, the Parties agree as follows:

1. The Parties agree to participate in a feasibility study to use Local Government Innovation Fund (LGIF) dollars to analyze and chart the feasibility and potential of converting local government and school district fleets to a Natural Gas Vehicle (NGV) fleet. The study will also map out a "Shared Service" distribution network, reducing storage, transportation, and purchasing costs. It is agreed that the NCOESC shall bear the costs associated with the LGIF grant application, take responsibility for administering the grant award, and will coordinate data collection during the study.

2. The NCOESC, as lead applicant, shall coordinate and facilitate data collection, drafting of grant application and submission to the Ohio Department of Development. The City of Tiffin, Seneca County, Tiffin City Schools, Seneca East Local, NCA and SCAT agree to commit staff resources necessary to data collection. They agree to consider modifications to operational protocols related to the functions and plans for this shared facility.

3. That this Memorandum of Understanding contains the entire understanding of the Parties, with respect to the subjects contained herein, and there are no representations, promises, warranties, covenants, agreements or undertakings other than those expressly set forth or provided for in this Memorandum of Understanding; it being understood that this Memorandum of Understanding supersedes all prior agreements and understandings between the Parties, except for those set forth in that certain Letter of Intent, dated August 9th, 2012, which was required for the LGIF Funding.

4. That should any provision or provisions of this Memorandum of Understanding be determined to be unlawful or unenforceable by any arbitrator, any court or any agency having competent jurisdiction, said provision or provisions shall be null and void, the remaining provisions hereof remaining in full force and effect.

5. That the Parties hereby warrant and represent to each other that they understand and agree to each and every term hereof and that they enter into this Memorandum of Understanding of their own free will, without duress or coercion.

6. That the Parties have had a full opportunity to discuss the matters contained in this Memorandum of Understanding, but they do not intend to create any precedent on whether the parties were obligated to discuss these matters or to discuss these matters any more than they already had, and they do not intend to create any new mandatory subjects of bargaining.

7. That it is agreed that this Memorandum of Understanding is made on a non-precedential basis and shall not be utilized by any party hereto in connection with any matter or proceeding among the parties, except with respect to the matter of enforcing and/or interpreting its express terms.

[Signature Page to Follow]

IN WITNESS WHEREOF, the Parties have executed copies of this Memorandum of Understanding, each of which constitutes an original, but each of which, when taken together, will constitute the same document.

AGREED:

CITY OF TIFFIN

By: ______________________
Name: Aaron Montz
Its: Mayor
Date: 8/20/2012

SENECA EAST LOCAL

By: ______________________
Name: Michael Wank
Its: Superintendent
Date: 8/27/12

SENECA COUNTY

By: ______________________
Name: Benjamin E. Nutter
Its: President of Commissioners
Date: 8-14-12

TIFFIN CITY SCHOOLS

By: ______________________
Name: Donald Coletta
Its: Superintendent
Date: 8/29/12

SCAT

By: ______________________
Name: Linda Good
Its: Executive Director
Date: 8-21-2012

NCOESC

By: ______________________
Name: Dr. James Lahoski
Its: Superintendent
Date: 8/22/12

NORTH CENTRAL ACADEMY

By: ______________________
Name: Brenda Luhring
Its: Superintendent
Date: 8-13-12

U.S. Census Bureau

Attachment D-1

AMERICAN FactFinder

DP-1 | Profile of General Population and Housing Characteristics: 2010

2010 Demographic Profile Data

NOTE: For more information on confidentiality protection, nonsampling error, and definitions, see http://www.census.gov/prod/cen2010/doc/dpsf.pdf.

Geography: Tiffin city, Seneca County, Ohio

Subject	Number	Percent
SEX AND AGE		
Total population	17,963	100.0
Under 5 years	1,065	5.9
5 to 9 years	1,089	6.1
10 to 14 years	998	5.6
15 to 19 years	1,727	9.6
20 to 24 years	1,954	10.9
25 to 29 years	1,048	5.8
30 to 34 years	1,056	5.9
35 to 39 years	915	5.1
40 to 44 years	839	4.7
45 to 49 years	1,112	6.2
50 to 54 years	1,189	6.6
55 to 59 years	1,155	6.4
60 to 64 years	970	5.4
65 to 69 years	685	3.8
70 to 74 years	524	2.9
75 to 79 years	558	3.1
80 to 84 years	524	2.9
85 years and over	555	3.1
Median age (years)	35.2	(X)
16 years and over	14,623	81.4
18 years and over	14,239	79.3
21 years and over	12,491	69.5
62 years and over	3,363	18.7
65 years and over	2,846	15.8
Male population	8,790	48.9
Under 5 years	570	3.2
5 to 9 years	563	3.1
10 to 14 years	519	2.9
15 to 19 years	883	4.9
20 to 24 years	1,056	5.9
25 to 29 years	540	3.0
30 to 34 years	530	3.0
35 to 39 years	452	2.5
40 to 44 years	436	2.4
45 to 49 years	548	3.1
50 to 54 years	585	3.3
55 to 59 years	578	3.2
60 to 64 years	447	2.5
65 to 69 years	311	1.7
70 to 74 years	212	1.2
75 to 79 years	214	1.2
80 to 84 years	193	1.1
85 years and over	153	0.9

Subject	Number	Percent
Median age (years)	32.2	(X)
16 years and over	7,046	39.2
18 years and over	6,854	38.2
21 years and over	5,947	33.1
62 years and over	1,323	7.4
65 years and over	1,083	6.0
Female population	9,173	51.1
Under 5 years	495	2.8
5 to 9 years	526	2.9
10 to 14 years	479	2.7
15 to 19 years	844	4.7
20 to 24 years	898	5.0
25 to 29 years	508	2.8
30 to 34 years	526	2.9
35 to 39 years	463	2.6
40 to 44 years	403	2.2
45 to 49 years	564	3.1
50 to 54 years	604	3.4
55 to 59 years	577	3.2
60 to 64 years	523	2.9
65 to 69 years	374	2.1
70 to 74 years	312	1.7
75 to 79 years	344	1.9
80 to 84 years	331	1.8
85 years and over	402	2.2
Median age (years)	38.4	(X)
16 years and over	7,577	42.2
18 years and over	7,385	41.1
21 years and over	6,544	36.4
62 years and over	2,040	11.4
65 years and over	1,763	9.8
RACE		
Total population	17,963	100.0
One Race	17,682	98.4
White	16,871	93.9
Black or African American	467	2.6
American Indian and Alaska Native	31	0.2
Asian	175	1.0
Asian Indian	20	0.1
Chinese	98	0.5
Filipino	22	0.1
Japanese	24	0.1
Korean	5	0.0
Vietnamese	2	0.0
Other Asian [1]	4	0.0
Native Hawaiian and Other Pacific Islander	7	0.0
Native Hawaiian	2	0.0
Guamanian or Chamorro	2	0.0
Samoan	2	0.0
Other Pacific Islander [2]	1	0.0
Some Other Race	131	0.7
Two or More Races	281	1.6
White; American Indian and Alaska Native [3]	44	0.2
White; Asian [3]	17	0.1
White; Black or African American [3]	135	0.8
White; Some Other Race [3]	52	0.3
Race alone or in combination with one or more other races: [4]		
White	17,138	95.4
Black or African American	624	3.5
American Indian and Alaska Native	87	0.5

Attachment D-3

Subject	Number	Percent
Asian	206	1.1
Native Hawaiian and Other Pacific Islander	17	0.1
Some Other Race	188	1.0
HISPANIC OR LATINO		
Total population	17,963	100.0
Hispanic or Latino (of any race)	551	3.1
Mexican	460	2.6
Puerto Rican	31	0.2
Cuban	2	0.0
Other Hispanic or Latino [5]	58	0.3
Not Hispanic or Latino	17,412	96.9
HISPANIC OR LATINO AND RACE		
Total population	17,963	100.0
Hispanic or Latino	551	3.1
White alone	349	1.9
Black or African American alone	14	0.1
American Indian and Alaska Native alone	10	0.1
Asian alone	0	0.0
Native Hawaiian and Other Pacific Islander alone	2	0.0
Some Other Race alone	110	0.6
Two or More Races	66	0.4
Not Hispanic or Latino	17,412	96.9
White alone	16,522	92.0
Black or African American alone	453	2.5
American Indian and Alaska Native alone	21	0.1
Asian alone	175	1.0
Native Hawaiian and Other Pacific Islander alone	5	0.0
Some Other Race alone	21	0.1
Two or More Races	215	1.2
RELATIONSHIP		
Total population	17,963	100.0
In households	16,243	90.4
Householder	7,086	39.4
Spouse [6]	2,903	16.2
Child	4,361	24.3
Own child under 18 years	3,353	18.7
Other relatives	591	3.3
Under 18 years	247	1.4
65 years and over	70	0.4
Nonrelatives	1,302	7.2
Under 18 years	117	0.7
65 years and over	46	0.3
Unmarried partner	546	3.0
In group quarters	1,720	9.6
Institutionalized population	136	0.8
Male	33	0.2
Female	103	0.6
Noninstitutionalized population	1,584	8.8
Male	878	4.9
Female	706	3.9
HOUSEHOLDS BY TYPE		
Total households	7,086	100.0
Family households (families) [7]	4,115	58.1
With own children under 18 years	1,781	25.1
Husband-wife family	2,903	41.0
With own children under 18 years	1,024	14.5
Male householder, no wife present	346	4.9
With own children under 18 years	212	3.0
Female householder, no husband present	866	12.2
With own children under 18 years	545	7.7

Subject	Number	Percent
Nonfamily households [7]	2,971	41.9
Householder living alone	2,429	34.3
Male	1,009	14.2
65 years and over	250	3.5
Female	1,420	20.0
65 years and over	844	11.9
Households with individuals under 18 years	1,941	27.4
Households with individuals 65 years and over	2,085	29.4
Average household size	2.29	(X)
Average family size [7]	2.91	(X)
HOUSING OCCUPANCY		
Total housing units	8,007	100.0
Occupied housing units	7,086	88.5
Vacant housing units	921	11.5
For rent	433	5.4
Rented, not occupied	28	0.3
For sale only	178	2.2
Sold, not occupied	21	0.3
For seasonal, recreational, or occasional use	38	0.5
All other vacants	223	2.8
Homeowner vacancy rate (percent) [8]	3.8	(X)
Rental vacancy rate (percent) [9]	13.9	(X)
HOUSING TENURE		
Occupied housing units	7,086	100.0
Owner-occupied housing units	4,440	62.7
Population in owner-occupied housing units	10,460	(X)
Average household size of owner-occupied units	2.36	(X)
Renter-occupied housing units	2,646	37.3
Population in renter-occupied housing units	5,783	(X)
Average household size of renter-occupied units	2.19	(X)

X Not applicable.

[1] Other Asian alone, or two or more Asian categories.

[2] Other Pacific Islander alone, or two or more Native Hawaiian and Other Pacific Islander categories.

[3] One of the four most commonly reported multiple-race combinations nationwide in Census 2000.

[4] In combination with one or more of the other races listed. The six numbers may add to more than the total population, and the six percentages may add to more than 100 percent because individuals may report more than one race.

[5] This category is composed of people whose origins are from the Dominican Republic, Spain, and Spanish-speaking Central or South American countries. It also includes general origin responses such as "Latino" or "Hispanic."

[6] "Spouse" represents spouse of the householder. It does not reflect all spouses in a household. Responses of "same-sex spouse" were edited during processing to "unmarried partner."

[7] "Family households" consist of a householder and one or more other people related to the householder by birth, marriage, or adoption. They do not include same-sex married couples even if the marriage was performed in a state issuing marriage certificates for same-sex couples. Same-sex couple households are included in the family households category if there is at least one additional person related to the householder by birth or adoption. Same-sex couple households with no relatives of the householder present are tabulated in nonfamily households. "Nonfamily households" consist of people living alone and households which do not have any members related to the householder.

[8] The homeowner vacancy rate is the proportion of the homeowner inventory that is vacant "for sale." It is computed by dividing the total number of vacant units "for sale only" by the sum of owner-occupied units, vacant units that are "for sale only," and vacant units that have been sold but not yet occupied; and then multiplying by 100.

[9] The rental vacancy rate is the proportion of the rental inventory that is vacant "for rent." It is computed by dividing the total number of vacant units "for rent" by the sum of the renter-occupied units, vacant units that are "for rent," and vacant units that have been rented but not yet occupied; and then multiplying by 100.

Source: U.S. Census Bureau, 2010 Census.

U.S. Census Bureau

Attachment D-5

AMERICAN FactFinder

DP-1

Profile of General Population and Housing Characteristics: 2010

2010 Demographic Profile Data

NOTE: For more information on confidentiality protection, nonsampling error, and definitions, see http://www.census.gov/prod/cen2010/doc/dpsf.pdf.

Geography: Seneca County, Ohio

Subject	Number	Percent
SEX AND AGE		
Total population	56,745	100.0
Under 5 years	3,553	6.3
5 to 9 years	3,767	6.6
10 to 14 years	3,739	6.6
15 to 19 years	4,432	7.8
20 to 24 years	3,986	7.0
25 to 29 years	3,114	5.5
30 to 34 years	3,305	5.8
35 to 39 years	3,225	5.7
40 to 44 years	3,320	5.9
45 to 49 years	4,021	7.1
50 to 54 years	4,454	7.8
55 to 59 years	4,083	7.2
60 to 64 years	3,321	5.9
65 to 69 years	2,340	4.1
70 to 74 years	1,802	3.2
75 to 79 years	1,590	2.8
80 to 84 years	1,359	2.4
85 years and over	1,334	2.4
Median age (years)	38.8	(X)
16 years and over	44,918	79.2
18 years and over	43,377	76.4
21 years and over	40,267	71.0
62 years and over	10,258	18.1
65 years and over	8,425	14.8
Male population	28,337	49.9
Under 5 years	1,852	3.3
5 to 9 years	1,950	3.4
10 to 14 years	1,943	3.4
15 to 19 years	2,288	4.0
20 to 24 years	2,109	3.7
25 to 29 years	1,601	2.8
30 to 34 years	1,719	3.0
35 to 39 years	1,641	2.9
40 to 44 years	1,704	3.0
45 to 49 years	2,032	3.6
50 to 54 years	2,235	3.9
55 to 59 years	2,062	3.6
60 to 64 years	1,650	2.9
65 to 69 years	1,118	2.0
70 to 74 years	830	1.5
75 to 79 years	663	1.2
80 to 84 years	528	0.9
85 years and over	412	0.7

Attachment D-6

Subject	Number	Percent
Median age (years)	37.1	(X)
16 years and over	22,206	39.1
18 years and over	21,416	37.7
21 years and over	19,788	34.9
62 years and over	4,437	7.8
65 years and over	3,551	6.3
Female population	28,408	50.1
Under 5 years	1,701	3.0
5 to 9 years	1,817	3.2
10 to 14 years	1,796	3.2
15 to 19 years	2,144	3.8
20 to 24 years	1,877	3.3
25 to 29 years	1,513	2.7
30 to 34 years	1,586	2.8
35 to 39 years	1,584	2.8
40 to 44 years	1,616	2.8
45 to 49 years	1,989	3.5
50 to 54 years	2,219	3.9
55 to 59 years	2,021	3.6
60 to 64 years	1,671	2.9
65 to 69 years	1,222	2.2
70 to 74 years	972	1.7
75 to 79 years	927	1.6
80 to 84 years	831	1.5
85 years and over	922	1.6
Median age (years)	40.6	(X)
16 years and over	22,712	40.0
18 years and over	21,961	38.7
21 years and over	20,479	36.1
62 years and over	5,821	10.3
65 years and over	4,874	8.6
RACE		
Total population	56,745	100.0
One Race	55,678	98.1
White	53,183	93.7
Black or African American	1,305	2.3
American Indian and Alaska Native	109	0.2
Asian	324	0.6
Asian Indian	52	0.1
Chinese	142	0.3
Filipino	43	0.1
Japanese	40	0.1
Korean	15	0.0
Vietnamese	10	0.0
Other Asian [1]	22	0.0
Native Hawaiian and Other Pacific Islander	10	0.0
Native Hawaiian	4	0.0
Guamanian or Chamorro	2	0.0
Samoan	3	0.0
Other Pacific Islander [2]	1	0.0
Some Other Race	747	1.3
Two or More Races	1,067	1.9
White; American Indian and Alaska Native [3]	180	0.3
White; Asian [3]	64	0.1
White; Black or African American [3]	549	1.0
White; Some Other Race [3]	155	0.3
Race alone or in combination with one or more other races: [4]		
White	54,187	95.5
Black or African American	1,945	3.4
American Indian and Alaska Native	345	0.6

Attachment D-7

Subject	Number	Percent
Asian	410	0.7
Native Hawaiian and Other Pacific Islander	28	0.0
Some Other Race	951	1.7
HISPANIC OR LATINO		
Total population	56,745	100.0
Hispanic or Latino (of any race)	2,524	4.4
Mexican	2,182	3.8
Puerto Rican	82	0.1
Cuban	7	0.0
Other Hispanic or Latino [5]	253	0.4
Not Hispanic or Latino	54,221	95.6
HISPANIC OR LATINO AND RACE		
Total population	56,745	100.0
Hispanic or Latino	2,524	4.4
White alone	1,444	2.5
Black or African American alone	78	0.1
American Indian and Alaska Native alone	25	0.0
Asian alone	3	0.0
Native Hawaiian and Other Pacific Islander alone	4	0.0
Some Other Race alone	696	1.2
Two or More Races	274	0.5
Not Hispanic or Latino	54,221	95.6
White alone	51,739	91.2
Black or African American alone	1,227	2.2
American Indian and Alaska Native alone	84	0.1
Asian alone	321	0.6
Native Hawaiian and Other Pacific Islander alone	6	0.0
Some Other Race alone	51	0.1
Two or More Races	793	1.4
RELATIONSHIP		
Total population	56,745	100.0
In households	54,211	95.5
Householder	21,774	38.4
Spouse [6]	11,235	19.8
Child	15,865	28.0
Own child under 18 years	11,867	20.9
Other relatives	2,156	3.8
Under 18 years	1,077	1.9
65 years and over	245	0.4
Nonrelatives	3,181	5.6
Under 18 years	377	0.7
65 years and over	121	0.2
Unmarried partner	1,667	2.9
In group quarters	2,534	4.5
Institutionalized population	870	1.5
Male	426	0.8
Female	444	0.8
Noninstitutionalized population	1,664	2.9
Male	916	1.6
Female	748	1.3
HOUSEHOLDS BY TYPE		
Total households	21,774	100.0
Family households (families) [7]	14,870	68.3
With own children under 18 years	6,141	28.2
Husband-wife family	11,235	51.6
With own children under 18 years	3,939	18.1
Male householder, no wife present	1,165	5.4
With own children under 18 years	664	3.0
Female householder, no husband present	2,470	11.3
With own children under 18 years	1,538	7.1

Subject	Number	Percent
Nonfamily households [7]	6,904	31.7
Householder living alone	5,720	26.3
Male	2,697	12.4
65 years and over	652	3.0
Female	3,023	13.9
65 years and over	1,793	8.2
Households with individuals under 18 years	6,837	31.4
Households with individuals 65 years and over	5,823	26.7
Average household size	2.49	(X)
Average family size [7]	2.97	(X)
HOUSING OCCUPANCY		
Total housing units	24,122	100.0
Occupied housing units	21,774	90.3
Vacant housing units	2,348	9.7
For rent	810	3.4
Rented, not occupied	82	0.3
For sale only	429	1.8
Sold, not occupied	89	0.4
For seasonal, recreational, or occasional use	121	0.5
All other vacants	817	3.4
Homeowner vacancy rate (percent) [8]	2.6	(X)
Rental vacancy rate (percent) [9]	12.3	(X)
HOUSING TENURE		
Occupied housing units	21,774	100.0
Owner-occupied housing units	16,054	73.7
Population in owner-occupied housing units	40,176	(X)
Average household size of owner-occupied units	2.50	(X)
Renter-occupied housing units	5,720	26.3
Population in renter-occupied housing units	14,035	(X)
Average household size of renter-occupied units	2.45	(X)

X Not applicable.

[1] Other Asian alone, or two or more Asian categories.

[2] Other Pacific Islander alone, or two or more Native Hawaiian and Other Pacific Islander categories.

[3] One of the four most commonly reported multiple-race combinations nationwide in Census 2000.

[4] In combination with one or more of the other races listed. The six numbers may add to more than the total population, and the six percentages may add to more than 100 percent because individuals may report more than one race.

[5] This category is composed of people whose origins are from the Dominican Republic, Spain, and Spanish-speaking Central or South American countries. It also includes general origin responses such as "Latino" or "Hispanic."

[6] "Spouse" represents spouse of the householder. It does not reflect all spouses in a household. Responses of "same-sex spouse" were edited during processing to "unmarried partner."

[7] "Family households" consist of a householder and one or more other people related to the householder by birth, marriage, or adoption. They do not include same-sex married couples even if the marriage was performed in a state issuing marriage certificates for same-sex couples. Same-sex couple households are included in the family households category if there is at least one additional person related to the householder by birth or adoption. Same-sex couple households with no relatives of the householder present are tabulated in nonfamily households. "Nonfamily households" consist of people living alone and households which do not have any members related to the householder.

[8] The homeowner vacancy rate is the proportion of the homeowner inventory that is vacant "for sale." It is computed by dividing the total number of vacant units "for sale only" by the sum of owner-occupied units, vacant units that are "for sale only," and vacant units that have been sold but not yet occupied; and then multiplying by 100.

[9] The rental vacancy rate is the proportion of the rental inventory that is vacant "for rent." It is computed by dividing the total number of vacant units "for rent" by the sum of the renter-occupied units, vacant units that are "for rent," and vacant units that have been rented but not yet occupied; and then multiplying by 100.

Source: U.S. Census Bureau, 2010 Census.

Attachment E-1

The Brewer-Garrett Company

6800 Eastland Road
Middleburg Heights, Ohio 44130
440/243-3535
Fax: 440/243-9993
OH LIC-28482

August 1, 2012

Proposal for a LGIF Grant for Natural Gas Feasibility Study

- **Cost benefit analysis on constructing NG fueling station**
- **Cost benefit analysis on converting partners fleet**
- **Leverage shared NG purchasing power**
- **Cost benefit analysis on constructing NG fueling station**
    1. Mapping gas lines in contrast to collaborative partners. ($2,500)
    2. Strategic placement of fueling stations ($6,220)
    3. Fueling need of partner ($2,300)
    4. Strategic need of Fast Fuel vs. Slow Fuel stations ($3,000)
    5. Quantity of fueling units ($2,200)
    6. Capacity for expansion of fueling station ($2,300)
- **Cost benefit analysis on converting partners fleet**
    1. Reviewing the make, model, age, fuel consumption, fuel component of partner fleets ($10,300)
    2. Forecasting 3 year vehicle purchasing for partner fleets ($3,000)
    3. Analysis on miles and consumed fuel last 2 years ($18,980)
    4. Analysis on maintenance cost vs. reduction ($3,700)
- **Leverage shared NG purchasing power**
    1. Review partnership contracts with gas suppliers and distributers ($3,000)
    2. Begin negotiating price based off of NG consumption increase ($2,500)

Brewer-Garrett ($60,000)

Grant administration, data collection, interviews, coordination ($18,000)

Project Management, P3 ($12,000)

Legal, Thomas C. Holmes, Pepple & Waggoner, Ltd ($10,000)

Total……$100,000

Attachment E-2

NAME:	John Davoli							
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 136							
OCCUPATION:	NCORcog							
TITLE	Director							
Natural Gas								
DATE	**DESCRIPTION OF IN-KIND SERVICES PROVIDED**	**TIME**	**PAY RATE**	**AMOUNT**	**MEDICARE**	**BWC**	**RETIREMENT**	**TOTAL IN-KIND**
4/16/12	Natural Gas information meeting	3.00	37.19	111.57	1.62	0.71	15.62	129.51
4/24/12	Research/phone calls	4.00	37.19	148.76	2.16	0.94	20.83	172.69
4/27/12	Internet research	3.00	37.19	111.57	1.62	0.71	15.62	129.51
5/8/12	Research/phone calls	2.00	37.19	74.38	1.08	0.47	10.41	86.34
5/11/12	Internet research	3.00	37.19	111.57	1.62	0.71	15.62	129.51
5/17/12	Research/phone calls	2.50	37.19	92.98	1.35	0.59	13.02	107.93
5/22/12	Information gathering/calls	4.00	37.19	148.76	2.16	0.94	20.83	172.69
5/29/12	Meet with Consultant	4.00	37.19	148.76	2.16	0.94	20.83	172.69
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		25.50		948.35	13.75	6.00	132.77	1,100.87

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE John Davoli DATE 8-31-12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoey 8/31/12

MARGARET A [illegible], Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

Attachment E-3

NAME:	John Davoli							
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 136							
OCCUPATION:	NCORcog							
TITLE	Director							
Natural Gas								
DATE	**DESCRIPTION OF IN-KIND SERVICES PROVIDED**	**TIME**	**PAY RATE**	**AMOUNT**	**MEDICARE**	**BWC**	**RETIREMENT**	**TOTAL IN-KIND**
6/5/12	Research/Internet/Phone Calls	4.00	37.19	148.76	2.16	0.94	20.83	172.69
6/7/12	Resolution work	3.00	37.19	111.57	1.62	0.71	15.62	129.51
6/13/12	Project management meeting	4.00	37.19	148.76	2.16	0.94	20.83	172.69
6/15/12	Meeting with consultant	3.50	37.19	130.17	1.89	0.82	18.22	151.10
6/18/12	Columbus visit with consultant	3.50	37.19	130.17	1.89	0.82	18.22	151.10
6/20/12	Planning/Phone calls	3.00	37.19	111.57	1.62	0.71	15.62	129.51
7/9/12	Research/Phone calls/Email	2.50	37.19	92.98	1.35	0.59	13.02	107.93
7/13/12	Emails/Internet Research	3.00	37.19	111.57	1.62	0.71	15.62	129.51
7/17/12	SCAT Board Meeting	2.50	37.19	92.98	1.35	0.59	13.02	107.93
7/20/12	Internet/Emails	2.00	37.19	74.38	1.08	0.47	10.41	86.34
7/26/12	Phone Calls/Resolution work	4.50	37.19	167.36	2.43	1.06	23.43	194.27
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		35.50		1,320.25	19.14	8.36	184.83	1,532.58

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS	0.25	15 MINUTES
	0.50	30 MINUTES
	0.75	45 MINUTES

SIGNATURE John Davoli DATE 8-31-12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

NAME:	John Davoli
ADDRESS:	928 West Market St. Tiffin, Ohio 44883
PHONE NUMBER:	419-447-2927 ext. 136
OCCUPATION:	NCORcog
TITLE	Director
Natural Gas	

DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
8/1/12	Internet research/phone calls	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/3/12	Emails/phone calls/internet	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/6/12	LGIF Group meeting	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/8/12	Work on Narratives	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/9/12	Work on Narratives	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/14/12	SCAT Board Meeting/Seneca Co. Commissioners	8.00	37.19	297.52	4.31	1.88	41.65	345.37
8/17/12	Internet research/phone calls	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/20/12	LGIF Group meeting	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/20/12	Tiffin City Council	3.00	37.19	111.57	1.62	0.71	15.62	129.51
8/21/12	SCAT Board Meeting/NCOESC Board Meeting/paperwork	8.00	37.19	297.52	4.31	1.88	41.65	345.37
8/22/12	Work on Narratives	3.00	37.19	111.57	1.62	0.71	15.62	129.51
8/24/12	Paperwork/Phone Calls/Emails	3.50	37.19	130.17	1.89	0.82	18.22	151.10
8/25/12	Work on Narratives	2.00	37.19	74.38	1.08	0.47	10.41	86.34
8/27/12	Application work	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/27/12	Seneca East Board meeting	3.00	37.19	111.57	1.62	0.71	15.62	129.51
8/28/12	Phone calls/inter office work	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/28/12	Tiffin City Schools Board meeting	3.00	37.19	111.57	1.62	0.71	15.62	129.51
8/29/12	Scan and format application	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/30/12	Final group meeting	4.00	37.19	148.76	2.16	0.94	20.83	172.69
8/31/12	Final proof and send to ODOD	3.00	37.19	111.57	1.62	0.71	15.62	129.51
		80.50		2,993.80	43.41	18.95	419.13	3,475.29

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS	0.25	15 MINUTES
	0.50	30 MINUTES
	0.75	45 MINUTES

SIGNATURE John Davoli DATE 8-31-12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

Attachment E-5

NAME:	Lynette Cameron		**LGIF Natural Gas**					
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 116							
OCCUPATION:	NCOESC							
TITLE	Assistant Treasurer							

DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
8/6/12	Meeting with John & Kim	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/6/12	Phone calls & emails	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/13/12	Phone calls & emails	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/14/12	Meeting with P3, John & Kim	1.50	25.75	38.63	0.56	0.24	5.41	44.84
8/15/12	Phone calls & emails	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/20/12	Meeting with P3,B G, John & Kim	3.00	25.75	77.25	1.12	0.49	10.82	89.67
8/22/12	Meeting with John, budgets	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/23/12	Program Budget spreadsheet	2.50	25.75	64.38	0.93	0.41	9.01	74.73
8/24/12	Program Budget spreadsheet	1.00	25.75	25.75	0.37	0.16	3.61	29.89
8/27/12	Program Budget spreadsheet	2.75	25.75	70.81	1.03	0.45	9.91	82.20
8/28/12	Program Budget spreadsheet	4.50	25.75	115.88	1.68	0.73	16.22	134.51
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
		20.25		521.44	7.56	3.30	73.00	605.30

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE Lynette Cameron DATE 8/31/12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

Attachment E-6

NAME:	Lynette Cameron		LGIF Natural Gas					
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 116							
OCCUPATION:	NCOESC							
TITLE	Assistant Treasurer							

DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
7/19/12	COG Meeting	1.00	25.75	25.75	0.37	0.16	3.61	29.89
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
		1.00		25.75	0.37	0.16	3.61	29.89

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE Lynette Cameron DATE 8/31/12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

NAME:	Lynette Cameron		**LGIF Natural Gas**					
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 116							
OCCUPATION:	NCOESC							
TITLE	Assistant Treasurer							
DATE	**DESCRIPTION OF IN-KIND SERVICES PROVIDED**	**TIME**	**PAY RATE**	**AMOUNT**	**MEDICARE**	**BWC**	**RETIREMENT**	**TOTAL IN-KIND**
6/21/12	COG Meeting	1.00	25.75	25.75	0.37	0.16	3.61	29.89
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
			25.75	0.00	0.00	0.00	0.00	0.00
		1.00		25.75	0.37	0.16	3.61	29.89

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE Lynette Cameron DATE 8/31/12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12
MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

Attachment E-8

NAME:	Kim Fisher		**Natural Gas**					
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 174							
OCCUPATION:	NCORcog							
TITLE	Secretary							
DATE	**DESCRIPTION OF IN-KIND SERVICES PROVIDED**	**TIME**	**PAY RATE**	**AMOUNT**	**MEDICARE**	**BWC**	**RETIREMENT**	**TOTAL IN-KIND**
6/27/12	Internet research	1.00	17.30	17.30	0.25	0.11	2.42	20.08
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		1.00		17.30	0.25	0.11	2.42	20.08

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE Kimberly Fisher DATE 8/31/12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

Attachment E-9

NAME:	Kim Fisher		Natural Gas					
ADDRESS:	928 West Market St. Tiffin, Ohio 44883							
PHONE NUMBER:	419-447-2927 ext. 174							
OCCUPATION:	NCORcog							
TITLE	Secretary							
DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
8/6/12	Meeting - Grant	2.00	17.30	34.60	0.50	0.22	4.84	40.16
8/14/12	Meeting - Grant	3.00	17.30	51.90	0.75	0.33	7.27	60.25
8/20/12	Meeting - Grant	3.00	17.30	51.90	0.75	0.33	7.27	60.25
8/23/12	Typing Grant	2.00	17.30	34.60	0.50	0.22	4.84	40.16
8/27/12	Input Info - Grant	1.00	17.30	17.30	0.25	0.11	2.42	20.08
8/28/12	Input Info - Grant	2.00	17.30	34.60	0.50	0.22	4.84	40.16
8/29/12	Prepare PDFs - Grant	2.00	17.30	34.60	0.50	0.22	4.84	40.16
8/30/12	Submit Grant email	1.00	17.30	17.30	0.25	0.11	2.42	20.08
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		16.00		276.80	4.01	1.75	38.75	321.32

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE Kimberly Fisher DATE 8/31/12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Margaret A Hoerig 8/31/12

MARGARET A HOERIG, Notary Public
In and for the State of Ohio
My Commission Expires Oct. 23, 2016

ESTIMATED FUTURE DATA COLLECTION HOURS

Project Budget Narrative:

1. We will seek information from our partners for the following information:
   a. Make of vehicle
   b. Model of vehicle
   c. Age of vehicle
   d. Fuel spend per vehicle
   e. Miles driven per vehicle
   f. Maintenance per vehicle

Hours per partner: ~~72~~ 36 x 6 partners = 216 hrs x Estimated Average salary rate $75 = $16,200.00

2. We will conduct interviews with partners:
   a. Treasurer/CFO to determine 5 year forecast of fleet purchases
   b. Treasurer/CFO to determine future operational changes
   c. Treasurer/CFO regarding financing mechanisms for conversions
   d. Transportation Director regarding maintenance aptitude
   e. Transportation Director regarding fleet housing capacity

Hours per partner: 5 x 6 partners = 30 hrs x Estimated Average salary rate $75 = $2,250.00

NAME:	Gwynn Reinhart							
ADDRESS:	53 E. Market St.							
PHONE NUMBER:	419-448-5403, Ext. 1400							
OCCUPATION:	City of Tiffin							
TITLE	Director of Finance							
	LGIF Natural Gas							
DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
8/14/12	Preparation of Spreadsheet-	2.00	30.31	60.62	0.88	0.18	8.49	70.16
	Fuel & Vehicle Costs			0.00	0.00	0.00	0.00	0.00
8/13-8/14/12	E-mail & Phone Calls	0.50	30.31	15.16	0.22	0.05	2.12	17.54
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		2.50		75.77	1.10	0.23	10.61	87.71

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS	0.25	15 MINUTES
	0.50	30 MINUTES
	0.75	45 MINUTES

SIGNATURE [signature] DATE 8-23-12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

Natural Gas Conversion/Shared Fueling Station Study

Attachment E-12

Program Budget

ACTUAL	FY 2009/2010	FY 2010/2011	FY 2011/2012
Supplies - Gasoline, Diesel, Maintenance Supplies			
Seneca County- SCOC	14,586	14,668	15,280
- Job & Family Services	85	94	130
- EMS	8,980	14,441	18,208
- Engineer (Maintenance, SCOC, JFS, Sheriff)	401,212	499,104	656,967
City of Tiffin - Municipal Court	0	0	0
- Engineer/ Street Maintenance	27,872	25,528	22,672
- Police/Fire	61,886	75,836	96,954
- Parks	6,704	7,930	10,312
- Sewer Plant/Maintenance	17,091	25,502	43,162
SCAT	97,636	119,772	164,146
North Central Academy	0	0	0
Tiffin City Schools	99,373	125,140	138,000
Seneca East Local Schools	146,447	119,635	178,998
Total Supplies	*$881,872*	*$1,027,650*	*$1,344,829*
Contract Services - Repairs and Maintenance			
Seneca County - Maintenance	2,483	2,856	3,980
- SCOC	94,978	92,000	108,801
- Job & Family Services	4,267	4,480	3,429
- EMS	10,467	11,153	11,212
- Engineer	11,295	6,658	12,202
City of Tiffin - Municipal Court	0	156	1,011
- Engineer/ Street Maintenance	10,078	22,138	17,285
- Police/Fire	67,697	48,537	53,027
- Parks	6,931	7,454	6,271
- Sewer Plant/Maintenance	14,628	13,243	20,639
SCAT	31,535	40,408	39,719
North Central Academy	0	4,460	15,920
Tiffin City Schools	65,220	69,352	64,587
Seneca East Local Schools	1,725	7,081	28,100
Total Contract Services	*$321,304*	*$329,976*	*$386,183*
Total Expenses	**$1,203,176**	**$1,357,626**	**$1,731,012**
Revenues			
General Fund - Seneca County	112,047	109,524	128,061
- City of Tiffin	212,887	226,324	271,333
- North Central Academy	0	4,460	15,920
- Tiffin City Schools	164,593	194,492	202,587
- Seneca East Local Schools	148,172	126,716	207,098
Subtotal General Fund	*637,699*	*661,516*	*824,999*
Gas Tax - Seneca County	412,507	505,762	669,169
Charges for Services - Seneca County	19,447	25,594	29,420
- Job & Family Services	4,352	4,574	3,559
- SCAT	129,171	160,180	203,865
Subtotal Charges for Services	*152,970*	*190,348*	*236,844*
Total Revenues	**$1,203,176**	**$1,357,626**	**$1,731,012**

Natural Gas Conversion/Shared Fueling Station Study

Attachment E-13

Program Budget

PROJECTED	FY 2012/2013	FY 2013/2014	FY 2014/2015
Supplies - Gasoline, Diesel, Maintenance Supplies			
Seneca County- SCOC	14,733	15,826	14,447
- Job & Family Services	711	753	812
- EMS	6,535	7,545	7,489
- Engineer (Maintenance, SCOC, JFS, Sheriff)	291,415	340,954	357,555
City of Tiffin - Municipal Court	0	0	0
- Engineer/ Street Maintenance	13,269	13,285	12,483
- Police/Fire	37,067	44,930	45,529
- Parks	3,791	4,555	4,280
- Sewer Plant/Maintenance	19,788	21,715	20,480
SCAT	68,241	83,504	92,730
North Central Academy	0	0	0
Tiffin City Schools	50,159	52,394	51,414
Seneca East Local Schools	37,050	37,811	36,250
Total Supplies	*$542,759*	*$623,272*	*$643,469*
Unadjusted Projected Costs	1,431,704	1,641,918	1,804,456
Cost Savings	(888,945)	(1,018,646)	(1,160,987)
Contract Services - Repairs and Maintenance			
Seneca County - Maintenance	3,582	4,298	5,159
- SCOC	78,337	90,087	86,484
- Job & Family Services	3,476	3,649	3,831
- EMS	8,998	9,628	10,302
- Engineer	9,609	10,090	10,595
City of Tiffin - Municipal Court	338	338	338
- Engineer/ Street Maintenance	21,600	21,600	21,600
- Police/Fire	47,625	55,125	55,125
- Parks	5,625	5,625	5,625
- Sewer Plant/Maintenance	23,250	23,250	23,250
SCAT	33,750	35,250	36,750
North Central Academy	13,134	14,447	15,893
Tiffin City Schools	50,572	52,797	55,120
Seneca East Local Schools	21,497	21,926	22,365
Total Contract Services	*$321,391*	*$348,110*	*$352,435*
Unadjusted Projected Costs	$428,521	$464,146	$469,913
Cost Savings	($107,130)	($116,037)	($117,478)
Total Expenses	**$864,150**	**$971,382**	**$995,904**
Unadjusted Projected Expenses	**$1,860,225**	**$2,106,064**	**$2,274,369**
Cost Savings	(996,075)	(1,134,682)	(1,278,465)
General Fund - Seneca County	96,652	110,211	106,090
- City of Tiffin	172,353	190,423	188,710
- North Central Academy	13,134	14,447	15,893
- Tiffin City Schools	100,731	105,191	106,534
- Seneca East Local Schools	58,547	59,737	58,615
Subtotal General Fund	*441,416*	*480,009*	*475,840*
Gas Tax - Seneca County	301,024	351,044	368,150
Charges for Services - Seneca County	15,533	17,173	17,791
- Job & Family Services	4,187	4,402	4,643
- SCAT	101,991	118,754	129,480
Subtotal Charges for Services	*121,710*	*140,329*	*151,914*
Total Revenues	**$864,150**	**$971,382**	**$995,904**

Total
6,240,658
(3,409,223)
0.54629222 ***ROI***

North Central Ohio Educational Service Center

Tiffin Campus
928 W. Market Street - Suite A
Tiffin, Ohio 44883
419-447-2927
419-447-2825 Fax

Mansfield Campus
State Support Team Region 7
1495 West Longview Ave. – Suite 200
Mansfield, Ohio 44906
419-747-4808

Marion Campus
333 East Center Street
Marion, Ohio 43302
740-387-6625
740-383-4804 Fax

To: ODSA
Re: LGIF "Cure Letter" ROUND 3 Application-
"Natural Gas Conversion/ Shared Fueling Station Study"

Issues for Response

471. Breakdown detail outlining the specific match contribution of each collaborative partner (**Attachment F 1 and 2).**

472. In addition to our narrative for "Program Budget" on page 15 –
The program budget is the cost of fuel that the partners consume yearly. The projected budget reflects the amount saved by the reduced cost of natural gas which is currently averaged at $1.30 GGE (gallon gas equivalent) from the cost of diesel and regular gas which is currently averaged at $3.88 and $3.43, respectively (**Attachment I**). Shown in The Hamilton Projects June 2012 study "Leveling the Playing Field for Natural Gas in Transportation" (**Attachment G**), the price of diesel and gasoline is increasingly volatile while natural gas is domestically abundant and steady.

473. In addition to our narrative for "Return on Investment" on page 16 –
The return on investment has been determined from research conducted by the U.S. Department of Energy's National Renewable Energy Laboratory study, "Business Case for Compressed Natural Gas in Municipal Fleets Technical Report NREL/TP-7A2-47919 June 2010" (**Attachment H**), and the National Energy Policy Institute's study, "What Set of Conditions Would Make the Business Case to Convert Heavy Trucks to Natural Gas May 2012" (**Attachment J**). These studies show the percentage reduction in costs yet they do not show the infrastructure implementation necessary. They also do not provide specific information on the partners fleets for conversion, which is what our feasibility study will discover.

ESTIMATED FUTURE DATA COLLECTION HOURS

Attachment F-1

Project Budget Narrative:

1. We will seek information from our partners for the following information:
   a. Make of vehicle
   b. Model of vehicle
   c. Age of vehicle
   d. Fuel spend per vehicle
   e. Miles driven per vehicle
   f. Maintenance per vehicle

Hours per partner: ~~72~~ 36 x 6 partners = 216 hrs x Estimated Average salary rate $75 = $16,200.00

2. We will conduct interviews with partners:
   a. Treasurer/CFO to determine 5 year forecast of fleet purchases
   b. Treasurer/CFO to determine future operational changes
   c. Treasurer/CFO regarding financing mechanisms for conversions
   d. Transportation Director regarding maintenance aptitude
   e. Transportation Director regarding fleet housing capacity

Hours per partner: 5 x 6 partners = 30 hrs x Estimated Average salary rate $75 = $2,250.00

Attachment F-2

NAME:	Gwynn Reinhart							
ADDRESS:	53 E. Market St.							
PHONE NUMBER:	419-448-5403, Ext. 1400							
OCCUPATION:	City of Tiffin							
TITLE	Director of Finance							
	LGIF Natural Gas							
DATE	DESCRIPTION OF IN-KIND SERVICES PROVIDED	TIME	PAY RATE	AMOUNT	MEDICARE	BWC	RETIREMENT	TOTAL IN-KIND
8/14/12	Preparation of Spreadsheet-	2.00	30.31	60.62	0.88	0.18	8.49	70.16
	Fuel & Vehicle Costs			0.00	0.00	0.00	0.00	0.00
8/13-8/14/12	E-mail & Phone Calls	0.50	30.31	15.16	0.22	0.05	2.12	17.54
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
				0.00	0.00	0.00	0.00	0.00
		2.50		75.77	1.10	0.23	10.61	87.71

*TIME - RECORD HOURS AND MINUTES - 15 MINUTE INCREMENTS

0.25	15 MINUTES
0.50	30 MINUTES
0.75	45 MINUTES

SIGNATURE ______ DATE 8-23-12

SIGNATURE CERTIFIES AMOUNTS SUBMITTED ARE TRUE AND ACCURATE.

THE HAMILTON PROJECT

DISCUSSION PAPER 2012-03 JUNE 2012

ncoesc Attachment G Pgs 1-28

Leveling the Playing Field for Natural Gas in Transportation

Christopher R. Knittel

MISSION STATEMENT

The Hamilton Project seeks to advance America's promise of opportunity, prosperity, and growth.

We believe that today's increasingly competitive global economy demands public policy ideas commensurate with the challenges of the 21st Century. The Project's economic strategy reflects a judgment that long-term prosperity is best achieved by fostering economic growth and broad participation in that growth, by enhancing individual economic security, and by embracing a role for effective government in making needed public investments.

Our strategy calls for combining public investment, a secure social safety net, and fiscal discipline. In that framework, the Project puts forward innovative proposals from leading economic thinkers — based on credible evidence and experience, not ideology or doctrine — to introduce new and effective policy options into the national debate.

The Project is named after Alexander Hamilton, the nation's first Treasury Secretary, who laid the foundation for the modern American economy. Hamilton stood for sound fiscal policy, believed that broad-based opportunity for advancement would drive American economic growth, and recognized that "prudent aids and encouragements on the part of government" are necessary to enhance and guide market forces. The guiding principles of the Project remain consistent with these views.

THE HAMILTON PROJECT

THE HAMILTON PROJECT

Leveling the Playing Field for Natural Gas in Transportation

Christopher R. Knittel
Massachusetts Institute of Technology

JUNE 2012

NOTE: This discussion paper is a proposal from the author. As emphasized in The Hamilton Project's original strategy paper, the Project was designed in part to provide a forum for leading thinkers across the nation to put forward innovative and potentially important economic policy ideas that share the Project's broad goals of promoting economic growth, broad-based participation in growth, and economic security. The authors are invited to express their own ideas in discussion papers, whether or not the Project's staff or advisory council agrees with the specific proposals. This discussion paper is offered in that spirit.

BROOKINGS

Abstract

Technological advances in horizontal drilling deep underground have led to large-scale discoveries of natural gas reserves that are now economical to access. This, along with increases in oil prices, has fundamentally changed the relative price of oil and natural gas in the United States. As of December 2011, oil was trading at a 500 percent premium over natural gas. This ratio has increased over the past few months. The discovery of large, economically accessible natural gas reserves has the potential to aid in a number of policy goals related to energy. Natural gas can replace oil in transportation through a number of channels. However, the field between natural gas as a transportation fuel and petroleum-based fuels is not level. Given this uneven playing field, left to its own devices, the market is unlikely to lead to an efficient mix of petroleum- and natural gas-based fuels. This paper presents a pair of policy proposals designed to increase the nation's energy security, decrease the susceptibility of the U.S. economy to recessions caused by oil-price shocks, and reduce greenhouse gas emissions and other pollutants. First, I propose improving the natural gas fueling infrastructure in homes, at local distribution companies, and along long-haul trucking routes. Second, I offer steps to promote the use of natural gas vehicles and fuels.

Table of Contents

Chapter 1: Introduction

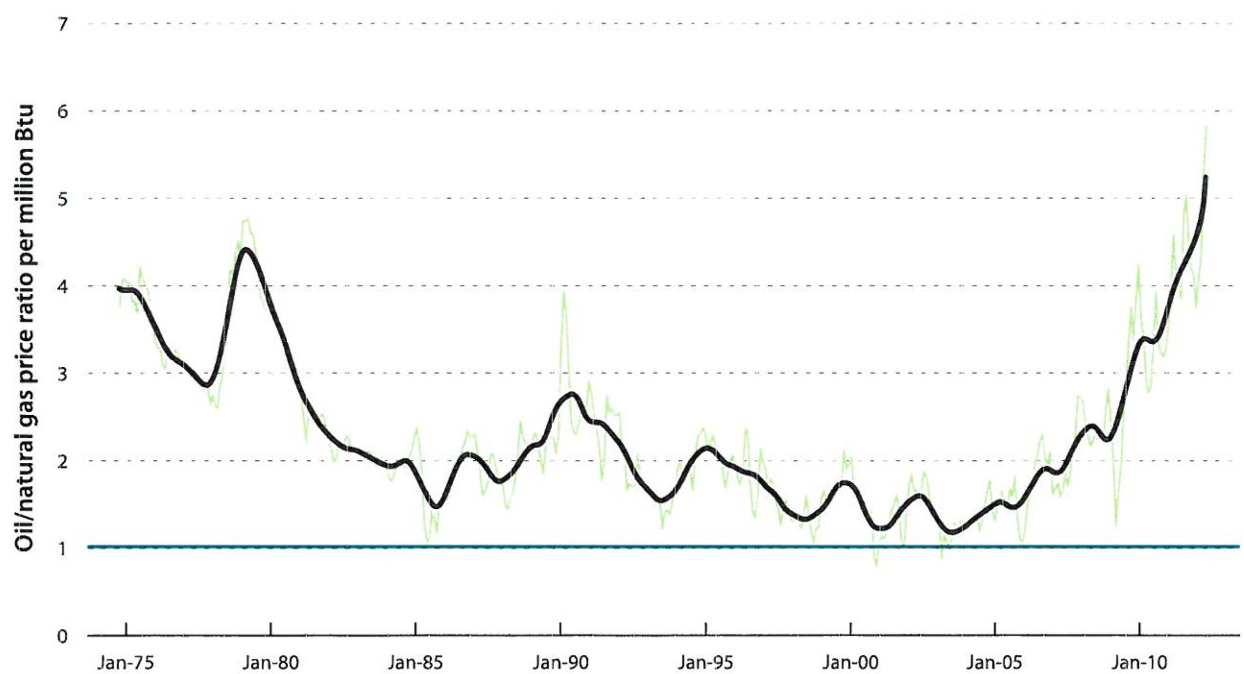
Technological advances in horizontal drilling deep underground have led to large-scale discoveries of natural gas reserves that are now economical to access. This, along with increases in oil prices, has fundamentally changed the relative price of oil and natural gas in the United States. To illustrate this, Figure 1 plots the ratio of the oil prices to natural gas prices on a per-energy basis from 1975 to the end of 2011.[1] As of December 2011, oil was trading at a 500-percent premium over natural gas. This ratio has increased over the past few months.

The discovery of large, economically accessible natural gas reserves has the potential to aid in a number of policy goals related to energy. For one, replacing oil with natural gas can reduce U.S. dependence on oil, thereby reducing the vulnerability of the U.S. economy to macroeconomic downturns caused by oil shocks. Second, because natural gas is cleaner in terms of greenhouse gas emissions and local pollutants compared to both coal and oil, replacing these other fossil fuels with natural gas can reduce U.S. greenhouse gas emissions and health problems associated with local pollution. Third, replacing oil with natural gas can increase U.S. profits associated with fossil fuel production and create excellent opportunities for the U.S. economy.

There are also compelling arguments for policymakers to consider policies designed to promote natural gas. However, we need to level the playing field between natural gas-based and petroleum-based fuels. Natural gas-based fuels carry lower, un-priced social costs than gasoline. For example, local pollution emissions are fewer from an engine burning natural gas compared to the same engine burning gasoline. If prices reflected true social costs, this would make petroleum-based fuels even more expensive than their natural gas counterparts. Petroleum therefore has an artificial advantage over natural gas

FIGURE 1.

Ratio of Oil and Natural Gas Prices per Unit of Energy



Source: U.S. Energy Information Administration.

because these other social costs are not included in the price that consumers pay. Additionally, the refueling infrastructure for natural gas is significantly less developed than the infrastructure for gasoline and diesel. While the costs of building such an infrastructure are true social costs and must be considered when comparing the merits of the two fuels, the lack of a refueling presence leads to what is known as a network externality, or a chicken-and-egg problem, that can lead to the efficient product not being selected in the market. Petroleum is then given an advantage from being part of the status quo. Given these two artificial advantages that gasoline and diesel have over natural gas-based fuels, left to its own devices, the market is unlikely to lead to an efficient mix of petroleum- and natural gas-based fuels.

Ethanol-based fuel and electric vehicles face many of the same problems as natural gas-based vehicles—they have, or may have, lower greenhouse gas emissions and lower local-pollutant emissions, and are not petroleum based, which could potentially lead to fewer oil-price-shock-induced recessions and military expenditures. Refueling infrastructure for these alternative energy sources is also lacking. Policymakers have already taken steps to address these challenges by adopting policies that encourage the use of ethanol-based fuel and electric vehicles. While these policies might begin to level the playing field between petroleum-based and ethanol- or electricity-based transportation, they distort the playing field between ethanol- and electricity-based transportation and natural gas-based transportation technologies. It is time to level this playing field.

This paper presents two sets of policy proposals designed to increase the nation's energy security, decrease the susceptibility of the U.S. economy to recessions caused by oil-price shocks, and reduce greenhouse gas emissions and other pollutants. First, I propose improving the natural gas fueling infrastructure in homes, at local distribution companies, and along long-haul trucking routes. Second, I offer steps to promote the use of natural gas vehicles and fuels.

Chapter 2: Opportunities for Natural Gas in Transportation

The United States consumes roughly 20 million barrels of oil per day. This is 50 percent more than the European Union, which has 60 percent more people, and is more than twice the rate of consumption in China (CIA n.d.). The United States also produces roughly 10 million barrels of oil per day, representing about 10 percent of global oil production (CIA n.d.).

When combined with the dramatic drop in natural gas prices, the use of natural gas in transportation (see Box 1) provides significant savings to consumers and reductions in external costs associated with petroleum usage. However, in the absence of policy interventions, a lack of refueling infrastructure may prevent consumers from realizing potential cost savings and an unequal playing field will prevent society from experiencing the benefits of lower gasoline consumption. Below, I lay out the potential private and external benefits of natural gas use in transportation.

PRIVATE BENEFITS OF LIGHT- AND MEDIUM-DUTY CNG AND HEAVY-DUTY LNG VEHICLES

At current prices for natural gas and gasoline, switching to CNG or LNG may make sense from a consumer's perspective if we ignore the lack of natural gas fueling stations. I examine private costs, or the costs that consumers pay for their vehicles and at the pump. A comparison of CNG and gasoline models (see Appendix A for details) suggests that the fuel economies of the gasoline version and the CNG version of the vehicle are more or less equal. Therefore there are two key differences between CNG and gasoline vehicles: a higher upfront cost for CNG vehicles, but a lower fuel cost. Table 1 presents the savings in a comparison of natural gas vehicles with four gas-powered vehicles.

The Department of Energy (DOE) reported that nationwide average retail prices for gasoline and CNG in January

BOX 1.

Natural Gas in Transportation

Natural gas can serve as an oil replacement in transportation markets in three ways. First, natural gas can be converted to methanol—an alcohol with similar properties to ethanol—that can be burned in internal combustion engines with slight vehicle modifications.

Second, light- and medium-duty vehicles using existing engine technologies can also burn compressed natural gas (CNG). Here the natural gas is stored at pressure, typically around 3000 psi. Because of the pressure, the CNG storage tanks are larger than existing gasoline storage tanks, so vehicles often have less trunk space and can cover less distance than conventional gasoline cars without refueling. The Honda Civic GX, currently sold in the United States, for example, has a CNG capacity equivalent to eight gallons of gasoline. A number of CNG vehicles sold in Europe are bi-fuel vehicles capable of burning both CNG and gasoline in their engines. When the CNG tank empties, the engine shift to the gasoline tank for fuel. Bi-fuel vehicles will frequently use gasoline first because the cold-start properties of gasoline are better than CNG.

Third, medium- and heavy-duty vehicles can run off of either CNG or liquefied natural gas (LNG), which is stored at very low temperatures (-260 degrees Fahrenheit). The advantage of LNG over CNG is that it requires 30 percent less space (although the tanks are bulkier) allowing for longer driving distances.[2] One disadvantage of LNG is that storing it for long periods is expensive, therefore LNG is often considered as a replacement fuel for vehicles that are in continuous use (e.g., heavy duty). Most industry followers envision LNG technologies as the likely replacement for diesel in the largest classes of heavy-duty vehicles.[3]

TABLE 1.

Lifetime Private Benefits of Switching from a Conventional Gasoline Vehicle to a Natural Gas Vehicle (Dollars)

	Pickup truck (15-MPG)	Sedan (30-MPG)	Heavy-duty truck (5-MPG)	Heavy-duty truck (7-MPG)
Savings on fuel	$15,171	$7,586	$186,828	$133,449
Extra cost of natural gas car	-$11,000	-$5,500	-$70,000	-$70,000
Total private benefits	**$4,171**	**$2,086**	**$116,828**	**$63,449**

NOTE: Costs do not include the inconvenience associated with fewer refueling stations. The table assumes a gasoline price of $3.46/gallon, a diesel price of $3.81/gallon and a CNG/LNG price of $2.09/gge. Calculations for the sedan and the pickup truck assume 15,000 miles driven annually and for a lifetime total of 200,000 miles. The heavy-duty truck is assumed to be driven 100,000 miles a year for a lifetime total of 500,000 miles. Future costs and benefits are discounted at 4 percent.

2012 were $3.46 and $2.09 per gallon of gasoline equivalent (gge), respectively. At these prices, the private incentive for purchasing a CNG vehicle is considerable. After subtracting the price premium associated with buying a CNG vehicle, the net private savings is almost $2,100 for a sedan and almost $4,200 for a pickup truck.

As with light-duty vehicles, there are also private benefits from shifts to natural gas in the heavy-duty industry. While the upfront cost of conversion—about $70,000[4]—is large, the average miles travelled for combination trucks (those that tow trailers) was roughly 70,000 miles in 2010, while the average fuel economy was 5.9 miles per gallon (MPG) (FHWA 2012). Table 1 shows the resulting net savings of almost $117,000 for a 5-MPG, class 8 truck and nearly $64,000 for a 7-MPG, class 8 truck.

EXTERNAL COST BENEFITS FROM CNG AND LNG

Replacing petroleum with natural gas also could reduce many of the costs associated with petroleum use that are borne by society, but are not borne by the individuals making decisions regarding fuel use. These costs, such as the effects of global warming and pollution, are not included in the price at the gas pump. Economists call them negative externalities. Because they are not factored into the decisions of individual consumers, the market over-consumes petroleum. While markets usually lead to the efficient, or nearly efficient, mixture of goods and services, in the presence of a negative externality, basic microeconomic principles tell us that the market will be inefficient. This opens the door for public policy to improve upon market outcomes.

A variety of negative externalities exist in markets for petroleum products. Natural gas as a transportation fuel does not eliminate all of these externalities, but it reduces many of them significantly. The following discussion provides estimates of these externalities and how natural gas use may mitigate their costs.

Military Interventions. U.S. dependence on oil may increase the required size of our military and influences decisions on whether to engage in military conflicts, which lead to loss of life. Natural gas, on the other hand, does not suffer from military-related externalities because its production is domestic or based in Canada. A wide range of estimates exists as to the size of this externality, with some estimates as high as $1.50 per gallon (ICTA 1998). However, it is unclear whether these represent a true *marginal* cost.

Macroeconomic Shocks. As we saw in 2008, dependence on oil increases our economy's susceptibility to oil-price-shock-driven recessions.[5,6] For the Regulatory Impact Analysis associated with corporate average fuel economy (CAFE) standards, the National Highway Traffic Safety Association (NHTSA) estimates that the increased risk of recession costs society between 8 and 27 cents per gallon of gasoline, with a "most likely" value of 17 cents per gallon (NHTSA 2010). Natural gas would not carry this cost.

Greenhouse Gases. Burning petroleum releases greenhouse gases in atmosphere, which has been shown to lead to increased climate temperatures. While they are not without debate, estimates for the cost of greenhouse gas emissions are about 35 cents per gallon of gasoline and 39 cents per gallon of diesel.[7] Natural gas does not completely eliminate greenhouse gas emissions, but it reduces them relative to petroleum. The U.S. Environmental Protection Agency (EPA) has suggested greenhouse gas emissions from CNG vehicles are roughly 25 percent lower than from equivalent vehicles running on gasoline.[8]

Local Pollution. Finally, consumption of oil also leads to local pollution, which has been shown to lead to increases in health care costs and increased mortality.[9] The health costs associated with local pollution are about 30 cents per gallon for gasoline and 60 cents per gallon for diesel (NRC 2010). The evidence suggests that natural gas light-duty vehicles create significantly less local pollution than their gasoline counterparts on a per-gallon-of-gas equivalent (gge).[10] On the heavy-duty side, natural gas is also likely to reduce the 60 cent externality because local pollution emissions from diesel engines are particularly high.

Combined these suggest that the externalities of CNG are roughly 39 cents less than gasoline per gge.[11] Table 2 reports the savings in external costs associated with switching to a natural gas vehicle and combines these benefits with the private benefits to show the total social benefits of converting. Reductions in external costs are $4,448 over the life of a pickup truck; for the more fuel-efficient sedan, reductions are half of this amount given that it consumes half of the fuel. As with private benefits, external cost reductions are larger for heavy-duty industry vehicles. For these trucks, the reduction in external costs is nearly $60,000.

CNG VERSUS ELECTRIC VEHICLES

There are considerable potential private and social benefits from CNG adoption relative to existing gasoline vehicles. Another natural comparison is between CNG and battery electric vehicles, either hybrid or all-electric (see Appendix B for detailed comparison of models). The hybrid version has 14

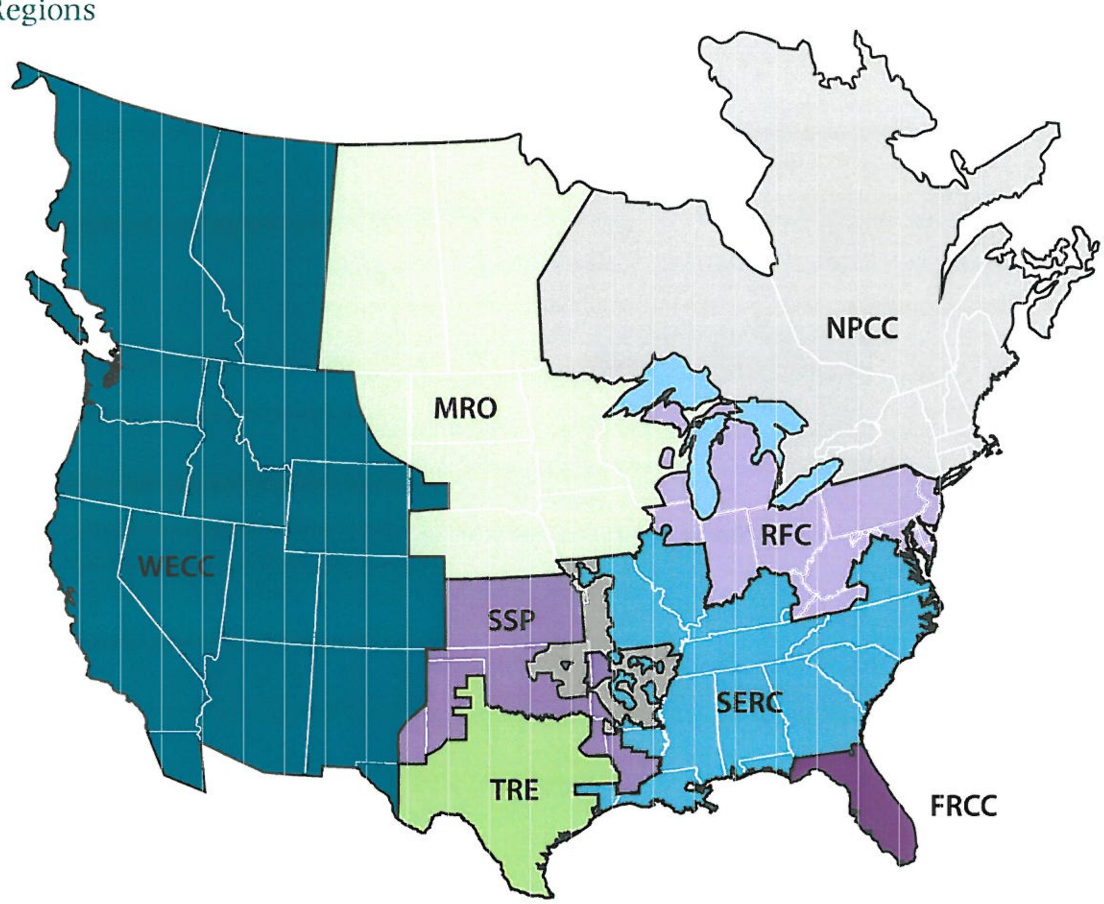
TABLE 2.

Lifetime Private and External Benefits of Switching from a Conventional Gasoline Vehicle to a Natural Gas Vehicle (Dollars)

	Pickup truck (15-MPG)	Sedan (30-MPG)	Heavy-duty truck (5-MPG)	Heavy-duty truck (7-MPG)
Private Benefits				
Savings on fuel	$15,171	$7,586	$186,828	$133,449
Extra cost of natural gas car	-$11,000	-$5,500	-$70,000	-$70,000
Total private benefits	**$4,171**	**$2,086**	**$116,828**	**$63,449**
External Benefits				
Reduction in external costs				
From lower carbon emissions	$1,093	$546	$8,768	$6,263
From fewer local pollutants	$1,661	$831	$32,586	$23,276
From lower macroeconomic externalities	$1,694	$847	$18,466	$13,190
Total external benefits	**$4,448**	**$2,224**	**$59,820**	**$42,729**
Total social benefit	**$8,620**	**$4,310**	**$176,648**	**$106,177**

Note: Social cost of carbon (SCC) of $35 per ton of carbon dioxide (CO_2), local pollution externality of 30 cents per gallon of gasoline and 60 cents per gallon of diesel, macroeconomic externality of 17 cents per gallon, and a military externality of 0 cents per gallon. The macroeconomic externality is reduced by 10 percent since approximately 10 percent of light-duty fuel is ethanol. Calculations for the sedan and the pickup assume 15,000 miles driven each year and for a lifetime total of 200,000 miles. The heavy-duty truck is assumed to be driven 100,000 miles a year and for a lifetime total of 500,000 miles. Future costs and benefits are discounted at 4 percent.

FIGURE 2.
NERC Regions



percent lower carbon dioxide (CO_2) emissions than the CNG version. If we believe that the social cost of these emissions is 35 cents per gge, then the hybrid version has a 5-cent per gge advantage over the CNG version. However, the hybrid version still suffers from the petroleum-based externalities (military and macroeconomic), so the CNG version has fewer total external costs.

The relative emissions of CNG and all-electric vehicles depend heavily on where the electric vehicles are recharged. Using the marginal greenhouse gas emission rates from Graff Zivin, Kotchen, and Mansur (2012), the per-mile emissions for both vehicles in each of the five electricity regions are shown in Table 3. Both the Nissan Leaf and Chevrolet Volt, two electric vehicles, are dirtier than the Civic CNG and Hybrid versions in two major electrical power system (North American Electric Reliability Corp. [NERC]) regions: the Midwest Reliability Organization (MRO) region and the Reliability First Corp. (RFC) region, which includes Pennsylvania, Ohio, and a large portion of Michigan (Figure 2). Emissions by NERC region and population-weighted average emissions are reported in Table 3.

As a whole, this analysis suggests that CNG vehicles can provide real tailpipe CO_2 emissions reductions compared to traditional gasoline engines and may also provide reductions comparable to all-electric vehicles. Table 4 compares the lifetime private and external benefits of switching from a traditional gasoline sedan to a CNG, hybrid, or all-electric sedan. Given the higher direct social costs of electric vehicles, further analysis suggests that the total social cost for CNG vehicles is lower than that of all-electric vehicles under a wide range of assumptions on the value of externalities.

TABLE 3.

Nissan Leaf and Chevrolet Volt Emissions by NERC Region (Grams of CO_2 per Mile)

NERC Region	Nissan Leaf	Chevy Volt, Electric	Chevy Volt, 50/50	Honda Civic, CNG	V. Passat, CNG*
NPCC	120	124	182	251	192
MRO	344	354	297	251	192
WECC	133	137	188	251	192
ERCOT	171	176	208	251	192
SERC	193	198	219	251	192
SPP	194	200	220	251	192
RFC	275	283	261	251	192
Population-weighted average	**196**	**202**	**221**	**251**	**192**

TABLE 4.

Lifetime Private and External Benefits of Switching from a Conventional Gasoline Vehicle to a Natural Gas, Hybrid, or Electric Vehicle

	CNG	Hybrid	All-Electric, Average	All-Electric in MRO	All-Electric in MPCC
Private Benefits					
Savings on fuel	$7,586	$5,474	$12,298	$12,298	$12,298
Extra cost of car	-$5,500	-$3,500	-$15,500	-$15,500	-$15,500
Total private benefits	**$2,086**	**$1,974**	**-$3,202**	**-$3,202**	**-$3,202**
External Benefits					
Reduction in external costs					
From lower carbon emissions	$546	$625	$696	-$371	$1,246
From fewer local pollutants	$831	$475	$804	$804	$804
From lower macroeconomic externalities	$847	$242	$820	$820	$820
Total external benefits	**$2,224**	**$1,341**	**$2,319**	**$1,253**	**$2,869**
Total social benefit	**$4,310**	**$3,315**	**-$883**	**-$1,949**	**-$333**

Note: Private costs of all-electric calculation assumes average U.S. retail price for electricity and uses a 31-MPG gasoline vehicle for comparison.

Chapter 3: Detailed Policy Proposal

Realizing the benefits of natural gas in transportation for consumers and for society as whole will require policymakers to attack two challenges. The first barrier to adoption of natural gas in transportation—which Table 1 and Table 2 ignore, and which may prevent many consumers from realizing these private savings—is the lack of a refueling infrastructure for both CNG and LNG.[12] As of 2007, there were roughly 120,000 gasoline stations in the United States, according to the U.S. Census Bureau; in contrast there are fewer than 400 public CNG refueling stations—a clear disadvantage for natural gas vehicles. Large-scale adoption of natural gas vehicles requires coordination between vehicle manufacturers, consumers, and refueling stations—either existing gasoline stations or replacements. This creates a chicken-and-egg problem, or a network externality issue. Consumers are unwilling to purchase natural gas vehicles before a refueling infrastructure is built, but businesses will not invest in natural gas refueling stations until there is consumer demand. Each side would be better off if the other side acted first, but neither is willing to move without the other. Left alone, network externalities continue the dominance of the status quo technology when, from society's perspective, it should be replaced with a new technology (Farrell and Saloner 1986).

The second barrier to realizing benefits from natural gas is the costs that petroleum impose on society that are not factored into prices. Because of these costs, people will over-consume petroleum while under-consuming natural gas because natural gas prices understate its advantage relative to gasoline. The ideal starting point for addressing these externalities is for policymakers to set taxes for the externalities associated with consumption of all fuels, known as Pigouvian taxes, so that external costs are included in individual decisions. However, these are unlikely to be implemented, and further policy action would still be justified by the presence of network externalities.

Below are two policy proposals in seven steps. In the first are three steps for creating natural gas fueling infrastructure in the United States. In the second are four steps to promote the use of natural gas vehicles. Each step includes background information and an economic rationale for the policy. These steps do not need to be executed in order, but together, they form parts of a larger whole, pushing on both sides of the network externality problem and creating a more level playing field for natural gas vehicles.

INFRASTRUCTURE-BASED POLICIES

Step 1: Encourage home refueling by pricing natural gas for CNG vehicles at efficient rates.

As with electric vehicles, one of the advantages of CNG over gasoline vehicles is the ability to refuel at home. State utility commissions should require local distribution companies (LDCs) to price natural gas for refueling at marginal cost, or the cost of producing and distributing an additional unit of natural gas. The Federal Energy Regulatory Commission could, perhaps, provide guidance for these changes. Besides the upfront costs, which are roughly $4,000, a second disincentive for consumers to leverage home refueling is that retail rates for natural gas are well above marginal cost.

The high cost of natural gas delivery in homes can overwhelm the price advantage of natural gas, making natural gas artificially more expensive than petroleum. According to the U.S. Energy Information Administration (EIA), natural gas prices at the wellhead were $2.46 per thousand cubic feet in February of 2012, but the average residential price was $9.40 per thousand cubic feet. The average city gate price was $4.75 per thousand cubic feet.

Utilities likely use this pricing structure to help them recover the high costs of building pipelines to distribute gas, but such a price distortion may lead to inefficiently low amounts of adoption of CNG vehicles.[13] The preferential rates recommended are analogous to the preferential electricity rates charged for electric vehicle charging. Gasoline and diesel prices also reflect state and local taxes. To keep the three fuels (gasoline, diesel, and CNG) on an equal footing, natural gas used for CNG and electricity used for recharging electric vehicles should also include these taxes.

Step 2: Encourage local distribution companies to offer CNG stations.

State utility commissions should also allow LDCs to build natural gas fueling stations and to re-coup their investments by including them in their rate base. Again, the Federal Energy Regulatory Commission could provide guidance for these changes. According to DOE's Alternative Fuels and Advanced Vehicles Data Center (AFDC)[14] a number of CNG stations already exist at natural gas LDC facilities, presumably to refuel fleets. A rapid way to open up the infrastructure would be to turn these into retail stations.

This would solve a second potential problem with alternative fuels—the potential for market power. Not only does a small refueling network increase inconvenience and costs associated with alternative fuels, it also means that there is little competition in the CNG retail markets. This allows refueling stations to price above marginal costs. Step 2 would guard against this because state utility commissions would regulate retail prices at the LDC stations on a cost-of-service basis.

Step 3: Establish an industry consortium to investigate and coordinate on LNG refueling infrastructure.

One potential advantage of transitions in the heavy-duty industry is that the relevant stakeholders are concentrated and thus an industry consortium with vehicle manufacturers, large vehicle consumers, and fuel providers may be more effective. DOE could create such a consortium to establish so-called blue corridors—networks of refueling stations along widely used interstate routes—with provisions to ensure that LNG is priced fairly.[15]

...although methanol made from natural gas is not a renewable fuel, EISA's preamble states that a major goal of the act is to increase energy security and independence. Methanol produced from natural gas clearly meets these goals. Not only is it a domestic source for energy used in transportation, but it also diversifies our transportation energy sources and thus decreases the susceptibility of the U.S. economy to oil price shocks.

VEHICLE- AND FUEL-BASED POLICIES

Step 4: Include methanol in the Renewable Fuel Standard.

Step 4 is for Congress to expand the Energy Independence and Security Act (EISA), which established the second phase of the federal Renewable Fuel Standard (RFS). The RFS requires certain amounts of biofuels to be sold each year. Biofuels are classified in three groups based on what they are made from and based on their lifecycle greenhouse gas (GHG) emissions. The three groups, in order from highest to lowest GHG emissions, are Conventional Fuels, Advanced Biofuels, and Cellulosic Biofuels.[16] Each has a separate quota. Quotas for the Advanced and Cellulosic groups have been eased. Conventional biofuels are essentially capped at 15 billion gallons, at least as they apply to the RFS.

The goals of the Act are clearly stated in its preamble. EISA begins with the following language:

> To move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes.

Besides the quantity requirements for biofuels, EISA included several provisions, ranging from energy efficiency standards for automobiles, buildings, and light bulbs; research and development subsidies; and biofuel infrastructure subsidies.

The rationale for this step is that although methanol made from natural gas is not a renewable fuel, EISA's preamble states that a major goal of the act is to increase energy security and independence. Methanol produced from natural gas clearly meets these goals. Not only is it a domestic source for energy used in transportation, but it also diversifies our transportation energy sources and thus decreases the susceptibility of the U.S. economy to oil price shocks.

Another goal of the Act is to reduce greenhouse gas emissions. Otherwise, EISA would not have differentiated fuels by their lifecycle emissions. Delucchi (2003) estimates that the lifecycle greenhouse gas emissions of methanol, made from natural gas, are more than 11 percent lower than gasoline. In contrast, Delucchi estimates that the lifecycle emissions of corn-based ethanol when distilled using the average electricity generation mix in the United States are 10 percent higher than gasoline. Other estimates suggest that the gap between corn-based ethanol and natural gas-based methanol is even larger (Argonne 2011). While it is unlikely that natural gas-based methanol would qualify for the Advanced and Cellulosic categories in terms of its lifecycle emissions, treating it as a Conventional Biofuel is entirely consistent with the goals of the Act. Furthermore, by expanding the scope of fuels included within the RFS, this recommendation could reduce the costs of compliance.[17]

Step 5: Mandate a significant share of vehicles manufactured to be able to burn gasoline, ethanol, and methanol.

Internal combustion engines are able to burn not only gasoline, but also ethanol and methanol, both of which are alcohols. A number of flex-fuel vehicles that can burn both gasoline and ethanol already exist on the road partly because of a provision in the CAFE standard that treats the fuel economy of these vehicles as much higher than vehicles that cannot burn ethanol.[18] Creating a tri-fuel mandate would require similar Congressional action.

As with ethanol, engines must be modified to burn methanol in large proportions. Some estimates suggest that an open fuel standard would cost, on average, $100 per vehicle for new vehicles (Open Fuel Standard of 2011 Fact Sheet).[19] Other estimates suggest that requiring vehicles to be able to burn both ethanol and methanol would add an additional $200 over vehicles that can burn gasoline and ethanol (MIT 2011).

A flex-fuel mandate is designed to overcome a network externality associated with natural gas fuels. It is conceivable that if the methanol infrastructure were in place, more consumers (and automobile manufacturers) would find it in their interest to purchase (or produce) vehicles that operate on gasoline, ethanol, and methanol. Similarly, if vehicles that could operate on methanol were to exist, it is conceivable to think that firms would find methanol infrastructure investments profitable. However, without the infrastructure, the automobiles do not exist, and without the automobiles, the infrastructure does not exist.

The small investment in each vehicle also has "option value" for the U.S. economy. Such a fuel standard would allow Americans to diversify their fuel sources if gasoline prices continue to rise. While this, by itself, is not a rationale for government intervention, this strengthens the network externality issues discussed above.

I am not the first to suggest policies requiring greater flexibility in fuel uses. Another example is a recent bill introduced by Congressmen John Shimkus (R-IL), Eliot Engel (D-NY), Roscoe Bartlett (R-MD), and Steve Israel (D-NY)—the Open Fuel Standard (OFS) Act (HR 1687). Senators Maria Cantwell (D-WA) and Dick Lugar (R-IN) have recently introduced a similar measure into the Senate (SA 1657). HR 1687 would require 50 percent of new automobiles in 2014 to be able to run on at least one alternative fuel group. This would increase to 80 percent in 2016 and 95 percent in 2017.

A qualified vehicle is defined as

- A vehicle that operates solely on natural gas, hydrogen, or biodiesel
- A flexible fuel vehicle capable of operating on gasoline, E85 (a mix of 85 percent ethanol and 15 percent gasoline), and M85 (a mix of 85 percent methanol and 15 percent gasoline)
- A plug-in electric drive vehicle
- A vehicle propelled solely by fuel cell or by something other than an internal combustion engine

I recommend two changes to the Open Fuel Standard. First, the time frame needs to be adjusted. Given the design cycle of vehicles—namely that manufacturers are often working today on vehicles that will be produced five years in the future—requiring 50 percent of vehicles to be tri-flex fuel within two years is too aggressive. Second, the language of the Act does not provide justification for the 85/15 split. Methanol or ethanol are unlikely to scale up to 85 percent of fuel consumed. A more modest fuel standard may be just as effective and less costly because vehicle costs are increasing in the maximum amount of ethanol or methanol that can be burned. Widening the range of fuels that a vehicle can accept increases the programming required and may increase the costs of other modifications. A more cost-effective implementation strategy would call for a greater number of vehicles capable of burning a lower amount of alternative fuel, rather than a high maximum amount of alternative fuel allowed with fewer vehicles. That is, requiring 80 percent of vehicles to be able to burn up to 40 percent methanol would be more cost-effective than requiring 40 percent of vehicles to be able to burn 80 percent methanol.

I would encourage a timeline that requires 50 percent of new automobiles in 2016 to be able to run on up to 50 percent of both ethanol and methanol, 80 percent of new vehicles by 2018, and 95 percent by 2020.

Step 6: Provide subsidies for natural gas vehicles commensurate with the reduction in external costs associated with their use.

Currently electric vehicles (EVs) with battery packs larger than four kilowatt-hours qualify for a federal income tax credit of $7,500. A recent budget proposed by the Obama administration calls for this to increase to $10,000.[20] The current subsidy for CNG vehicles is $4,000. CNG sedans should qualify for the same level of federal income tax credits as EVs. In addition, medium-duty CNG pickups should receive more federal tax credits than both CNG and EV sedans.

As discussed in the section of this paper on CNG versus all-electric vehicles, both types of vehicles have similar greenhouse gas emissions when comparing the direct emissions of the

TABLE 5.

Lifetime External Benefits of Switching from a Conventional Gasoline Vehicle to a CNG, All Electric, or M85 Vehicle (Dollars)

	CNG Replacement	M85 Replacement	EV Replacement, Average	EV Replacement in MRO	EV Replacement in MPCC
Pickup truck (15-MPG)	$4,448	$612			
Sedan (30-MPG)	$2,224	$306	$2,319	$1,253	$2,869

power plants used to charge electric vehicles and the tailpipe emissions from CNG. Also, neither type of vehicle carries the negative externalities associated with macroeconomic movements and military costs and losses. The savings in greenhouse gases from all-electric vehicles depend heavily on where the electric vehicle is charged. Despite this, the federal tax credit does not differentiate based on the location of the electric vehicle.

Step 6 is part of a larger recommendation regarding tax subsidies for alternative-technology vehicles—policies should not pick winners; tax subsidies should be based on a vehicle's reduction in externalities relative to the vehicle that the consumer would have purchased in the absence of policy action. Even if policy does not differentiate electric vehicles by the source of their electric charges, it is clear that CNG vehicles can lead to larger reductions in externalities if the alternative traditional vehicle is a low-mileage pickup truck; the relative levels of the two vehicles' subsidies does not reflect the relative reduction in externalities.

A more general framework for defining the level of vehicle subsidies based on the savings in externalities allows the policy to be consistent across alternative vehicles. Anything other than this is implicitly, or explicitly, picking winners. For example, such a framework could be applied to vehicles that run on methanol. Table 5 reports the potential savings in external costs for CNG vehicles, electric vehicles, and vehicles running on M85 (again, 85 percent may be an arbitrary percentage).

The current subsidy for electric vehicles is roughly three times the reduction in externalities for an electric vehicle driven 15,000 miles per year and recharged using power plants with average emissions. Based on externalities and this three-times guideline, a 15-MPG vehicle running on M85 would qualify for a subsidy of roughly $1,800. Using the electric-vehicle subsidy as a guide, an argument could be made that a 15-MPG CNG vehicle should receive a subsidy of more than $13,000.

Perhaps, more importantly, such a framework would allow policymakers to apply consistent principles to the heavy-duty industry. Table 2 makes clear the large potential social benefits from the heavy-duty industry adopting LNG vehicles. As a point of reference, the New Alternative Transportation to Give Americans Solutions (NATGAS) Act of 2011 calls for a $7,500 subsidy for CNG light-duty vehicles and up to a $64,000 subsidy for heavy-duty vehicles. Despite the large subsidy for heavy-duty vehicles, the subsidy is a much smaller percentage of the external costs savings compared to the subsidy for all-electric vehicles. In terms of reducing external costs, the $64,000 has a much higher rate of return than both the $7,500 for CNG vehicles and the current subsidy for electric vehicles.

Step 7: Streamline the retrofitting certification process for gasoline vehicle conversion to CNG.

This step would allow consumers to take advantage of the fact that, in principle, existing gasoline-powered vehicles can be retrofitted. Because new vehicles comprise roughly 8 percent of the vehicle stock in any one year, the ability to retrofit existing vehicles can increase the savings in external costs. The EPA and California Air Resource Board (CARB) have certification programs for CNG conversions. According to Natural Gas Vehicles for America,[21] there are thirteen engine families for which certified conversions are offered; all of these are General Motors, Chrysler, or Ford engines. Non-certified conversions also are offered for many more.

One reason offered for why non-certified conversions are common is the claim that the EPA and CARB certification process is unduly expensive. The Web site GreenCar.com suggests that certification for conversion systems costs as much as $200,000 per engine family.[22] These costs might be appropriate, but if not, the EPA and CARB should look at ways to streamline the process.

Chapter 4: Implementation Costs and Benefits

Step 1: Encourage home refueling by pricing natural gas for CNG vehicles at efficient rates.

The benefits of efficient rates will allow consumers to take advantage of the lower costs of natural gas, relative to gasoline, and provide the incentives for consumers to install home refueling infrastructure.

There are potential costs. Because natural gas LDCs are subject to cost-of-service regulations, reductions in retail rates for CNG vehicle consumers may lower the rate-of-return earned on capital. If the return on capital fell, it would require an increase in retail rates for other consumers. Another way to keep LDCs at their current returns on capital is to charge a fixed monthly fee for access to the CNG rates. This is the standard "two-part tariff" that increases the efficiency of the rate structure. The advantage of this is that the rates of other LDC products would not have to increase, and CNG owners would still have the correct incentives on the margin.

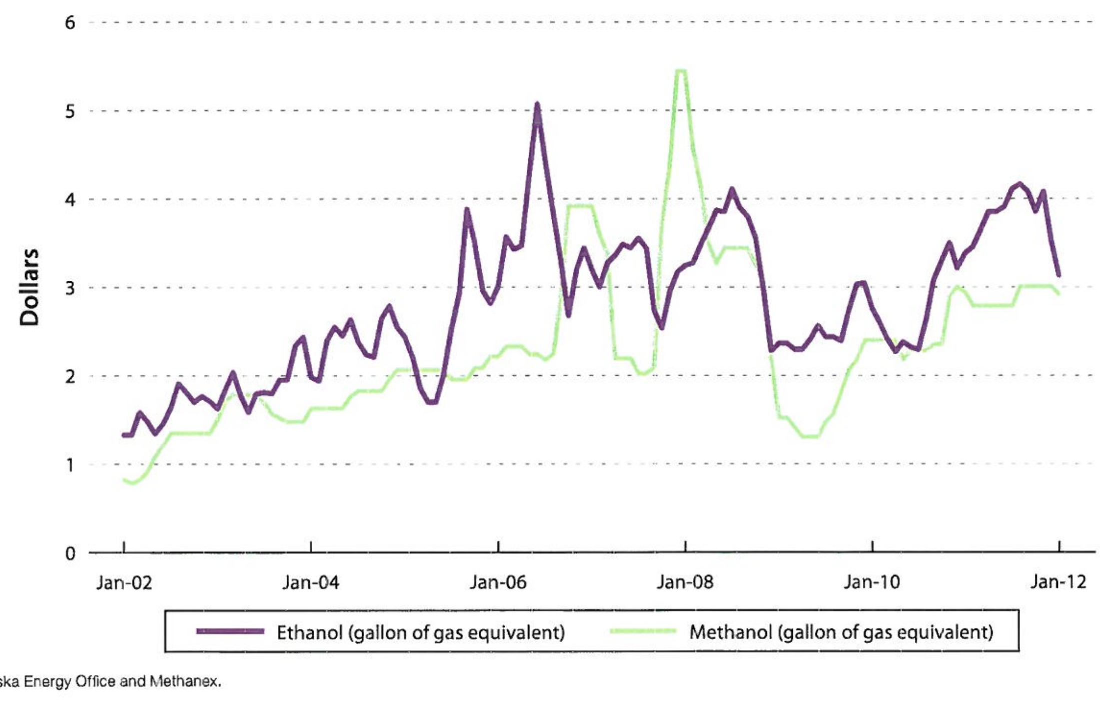
Step 2: Encourage local distribution companies to offer CNG stations.

As noted in the previous section, there are two major benefits from allowing local distribution companies to open CNG refueling stations to the public. It is a step toward solving the network externalities associated with alternative fuels and technologies. The other benefit is that it supplies a set of CNG refueling stations operated via a cost-for-service model to alleviate some of the potential market power that retail CNG stations may enjoy in the early part of the market.

The costs associated with this recommendation are the costs of the refueling centers. Given the regulatory structure of LDCs, it is straightforward to ensure that these costs are borne by the consumers using the service and not all natural gas consumers.

FIGURE 3.

Wholesale Prices of Methanol and Ethanol Over Time



Source: Nebraska Energy Office and Methanex.

TABLE 6.

Lifetime External Benefits of Switching from a Conventional Gasoline Vehicle to a CNG or Methanol Vehicle (Dollars)

	CNG Replacement	M50 Replacement	M85 Replacement
Pick-up truck (15-MPG)	$4,448	$282	$612
Sedan (30-MPG)	$2,224	$141	$306

Step 3: Establish an industry consortium to investigate and coordinate on LNG refueling infrastructure.

Establishing an industry consortium to coordinate the creation of blue corridors is an effective way to solve the network externality issues associated with LNG. Such consortia appear to have been effective in Europe; a number of LNG refueling terminals exist and many more are being proposed.[23] The cost of coordinating efforts among industry stakeholders seems to be minimal.

Step 4: Include methanol in the Renewable Fuel Standard.

There are no direct costs of this recommendation, but there are indirect cost reductions. The benefits will depend on how scalable methanol is from current production levels and how "binding" the RFS regulation is—that is, by how much the RFS incentivizes shifts to ethanol and methanol. Current wholesale ethanol and methanol prices suggest that the benefits may be large. Figure 3 plots wholesale ethanol and methanol prices since 2002 on a gge basis. The average price difference over this time has been 84 cents and $1 since 2009. While it is doubtful such a price difference would continue if we ramped methanol production to the entire RFS level (and ethanol production down to zero), these data suggest that methanol may reduce the compliance costs of the RFS.

Step 5: Mandate a significant share of vehicles manufactured to be able to burn gasoline, ethanol, and methanol.

The social benefits of this recommendation come from both solving the network externality market failure associated with fuel and vehicles, as well as reducing the external costs of driving. Table 6 lists the reduction in external costs from shifting a vehicle from gasoline to M50 or M85. Even if we were to ignore the benefits associated with alleviating the network externality, the social benefits from a reduction in external costs exceed the estimated increase in the cost of the vehicle, especially for a 15-MPG vehicle.

TABLE 7.

Aggregate Benefits of Natural Gas Vehicle Penetration (Billions of Dollars)

	Scenario	Savings in private costs	Savings in external costs
CNG replacement of light-duty vehicles	5 percent	8.4	2.4
	10 percent	16.8	4.8
	25 percent	41.9	12.0
	50 percent	83.8	24.0
CNG/LNG replacement of medium- and heavy-duty vehicles	5 percent	3.9	1.3
	10 percent	7.7	2.6
	25 percent	19.3	6.4
	50 percent	38.7	12.8

Step 6: Provide subsidies for natural gas vehicles commensurate with the reduction in external costs associated with their use.

We can also place bounds on the social benefits from subsidizing CNG by measuring the reduction in externalities over the life of the vehicles. This is a lower bound on the benefits since it ignores the network externality justifications for subsidizing alternative technologies. These are repeated in Table 6. As discussed in the previous section, the reduction in external costs for CNG vehicles with a fuel economy of 30 MPG, relative to the $7,500, is similar in magnitude to today's subsidies for all electric vehicles; the reduction in external costs for CNG vehicles with a fuel economy of 15 MPG is twice as large.

The social benefits from incentivizing shifts from diesel-based, heavy-duty trucks to LNG are even greater. The upfront investment also is greater. However, a more important comparison is the social rate of return, that is, the ratio of the benefits to the subsidy. While a heavy-duty subsidy does not currently exist, for all-electric vehicles the social benefits are roughly one-third the subsidy. For a high fuel economy CNG (say, 30 MPG) vehicle, the social returns are roughly 60 percent of current subsidies; for a low fuel economy CNG (say, 15 MPG) vehicle, the social return of a $4,000 subsidy is 110 percent.

These simple calculations underline the point that the current structure of subsidies is not uniform across technologies, at least when we focus on the social benefits of shifts to the different technologies. The payoffs range from 110 percent of the subsidy for low fuel economy CNG vehicles to 33 percent for electric vehicles. If we were to apply this range to LNG vehicles, the range of subsidies would be roughly $55,000 using current subsidies for CNG medium-duty vehicles ($60k/1.10), to more than $180,000 ($60k/0.33) using current subsidies for electric vehicles, for 5-MPG heavy-duty trucks, and $39,000 to $130,000 for 7-MPG heavy-duty trucks ($43k/1.10 to $43k/0.33).

These calculations suggest that recent proposals to offer subsidies of up to $64,000 for the heavy-duty industry (NATGAS Act) have a high rate of return relative to existing subsidy programs. Therefore, shifts away from low rate-of-return subsidies to high rate-of-return subsidies can actually decrease the aggregate budget associated with subsidy programs, while keeping the reduction in external costs constant. Alternatively, holding fixed the aggregate subsidy budget, we can increase the reduction in external costs by making such shifts.

Step 7: Streamline the retrofitting certification process for gasoline vehicle conversion to CNG.

The direct costs associated with this recommendation are the added manpower required to investigate the certification process. The potential benefits come from reducing the costs of retrofitting the existing fleet. Because, in any given year, only 8 percent of all vehicles are new, reducing costs associated with retrofits can have large benefits.

Combined private and external benefits.

Projections as to how these policies would change the adoption of natural gas vehicles are difficult to make, since the evolution of the fleet depends on many things. One could, however, calculate the savings in private and external costs under different penetration rates of natural gas. Here, I focus on the penetration of CNG and LNG.

Table 7 reports the aggregate savings in private and external costs under penetration levels of 5, 10, 25, and 50 percent. To calculate these, I use gasoline and diesel consumption for 2010 broken down by vehicle type, reported by the Bureau of Transportation Statistics. The table illustrates that even under modest penetration rates, given the sheer size of the transportation sector significant private and external costs savings would occur. A 10 percent penetration rate, alone, would reduce annual private costs by nearly $25 billion and external costs by over $7 billion.

Chapter 5: Questions and Concerns

Recently there has been a focus on so-called fugitive methane emissions—methane leaks along the transportation network. Fugitive emissions undermine the greenhouse gas benefits from shifting to CNG vehicles, and the lifecycle emissions of methanol. Because of the higher radiative force of methane relative to CO_2, methane emissions have a global warming potential that is twenty-five times that of CO_2 over a 100-year period and seventy-two times that of CO_2 over a 20-year period (Shindell et al.). Alvaraz et al. (2011) find that if the EPA's estimate of fugitive emissions is 2.4 percent of total production (and this figure is applied to scaling up natural gas production) shifts to natural gas in the light-duty market increase global warming for the first 80 years and shifts to natural gas in the heavy-duty market increase global warming for the first 280 years. They also find that if fugitive emissions are reduced to roughly 1.5 percent, shifts to CNG lead to immediate global warming benefits in the light-duty market; if fugitive emissions fall to 1 percent, immediate benefits are found for the heavy-duty industry.

Three points are worth noting. First, the current level of emissions may reveal little about the cost of reducing them. It may be relatively costless to do so. The EPA has recently taken steps to reduce fugitive emissions by altering air regulations. Future fugitive emissions and the success of these changes should be monitored.

Second, the EPA's assumption that 2.4 percent of natural gas is leaked into the atmosphere is not without controversy. The natural gas industry, not surprisingly, contends that actual emissions are much lower and noted that the EPA's figure is based on data taken from old natural gas wells; the implication is that newer wells will have a smaller rate of lifetime fugitive emissions.

Finally, greenhouse gas emissions reductions are only one benefit from shifts to natural gas as a transportation fuel. The private benefits discussed above do not depend on greenhouse gas reductions. In addition, there are three additional market failures. If I estimate the reduction in external costs assuming that greenhouse gas benefits are zero, the reduction in external costs is still substantial, falling only 25 percent from the previous external benefits of CNG vehicles. The reduction in external costs for heavy-duty vehicles remains high as well, falling by roughly 15 percent (see Table 8).

A second issue is that the first recommendation (including methanol in the RFS) is likely to shift economic rents or profits from firms inside the corn-based ethanol supply chain to firms inside the methanol supply chain. While this is not a cost to society, such a transfer is likely to lead to resistance of this recommendation from firms involved in the corn-ethanol supply chain.

TABLE 8.

Lifetime External Benefits of Switching from a Conventional Gasoline Vehicle to a CNG Vehicle, Assuming No Greenhouse Gas Benefits (Dollars)

	Pick-up truck (15-MPG)	Sedan (30-MPG)	Heavy-duty truck (5-MPG)	Heavy-duty truck (7-MPG)
Reduction in external costs				
From fewer local pollutants	$1,661	$831	$32,586	$23,276
From lower macroeconomic externalities	$1,694	$847	$18,466	$13,190
Total external benefits	**$3,355**	**$1,678**	**$51,052**	**$36,466**

Chapter 6: Conclusion

Recent advances in natural gas drilling as well as increases in oil prices appear to have made natural gas competitive with oil in the long run. For many reasons, such a change in price may not be enough to cause the United States to substitute natural gas for oil in the transportation sector, even when it is socially beneficial to do so. The playing field across alternative transportation fuels is simply not level. While policy has promoted ethanol and electric vehicles as the future substitute for petroleum-based vehicles, methanol CNG vehicles offer similar, if not greater, benefits at a lower cost. In this paper, I lay out a proposal for leveling the playing field between petroleum, ethanol, electricity, and natural gas.

Appendices

APPENDIX A. COMPARISON OF CNG AND GASOLINE VEHICLES

Currently, while a number of CNG and bi-fuel (vehicles that run on both CNG and gasoline) vehicles are sold in Europe, only one CNG vehicle is sold in the United States—the Honda Civic. Chrysler, Ford, and GM have all recently announced plans to offer CNG pickup trucks and vans in the medium-duty classes. Appendix Table 1 reports the fuel economy of the CNG version Civic (on a gallon-of-gas-equivalent [gge] basis) and the gasoline version. On a combined-fuel-economy basis, they have the same fuel economy.

To calculate the price premium for the Civic CNG and hybrid sedans, I used Honda's on-line comparison tool and compared the CNG version to the EX version with cloth seats. The tool adjusts for differences in standard features. To calculate the price comparisons with the Nissan Leaf and Chevrolet Volt, I used truedelta.com's price comparison tool. This too adjusts for differences in features.

APPENDIX TABLE 1.

Comparison of Honda and Volkswagen CNG Models to Their Closest Gasoline Counterpart

	Honda Civic CNG	Honda Civic Gasoline	Honda Civic HEV	Volkswagen Passat CNG, running on CNG	Volkswagen Passat CNG, running on gasoline
Engine Type	4-Cylinder	4-Cylinder	4-Cylinder	4-Cylinder Turbocharged	4-Cylinder Turbocharged
Displacement (cc)	1798	1798	1497	1390	1390
Horsepower	110	140	110	150	150
Torque (lb.-ft.)	106	128	127	220	220
Transmission	5-Speed Auto	5-Speed Auto	CVT	7-Speed Auto	7-Speed Auto
Weight	2848	2705	2853		
Length (in)	177.3	177.3	177.3	187.8	187.8
Width (in)	69.0	69.0	69.0	71.7	71.7
Wheelbase (in)	105.1	105.1	105.1	106.8	106.8
EPA Mileage Estimate					
City (MPGge)	27	28	44	26	27
Highway (MPGge)	38	36	44	44	42
Combined (MPGge)	31	31	44	36	35
Range (miles)	249	409	581	303	283
CO_2 Emissions (g/mi, electricity/tailpipe)	251	306	217	192	254
Price relative to gasoline version	5,500		3,500		

APPENDIX B: COMPARISON OF CNG AND ELECTRIC VEHICLES

The Honda Civic, Nissan Leaf, and Chevrolet Volt compare favorably to each other. Appendix Table 2 shows specifications for the Nissan Leaf, Chevrolet Volt, and the three versions of the Honda Civic. The three vehicles are similar in length, width, and wheelbase. The weight is difficult to compare because the Leaf's battery and control module weigh approximately 400 pounds, while the Volt has both an internal combustion engine and electric technologies. The Leaf and CNG Civic have identical horsepower, although the Leaf's torque is much higher, a benefit of electric motors. The Volt and Civic gasoline versions have similar horsepower, and again, the Volt has much more torque. The distance range of the CNG Civic is over three times the Leaf's; the range for the Volt is very high considering that it has access to the internal combustion engine to recharge the batteries. The upfront cost of the vehicles is the key difference. Using truedelta.com's comparison tool, which allows the user to control for different features, both the Leaf and the Volt are over $10,000 more expensive than the comparably equipped CNG Civic.

APPENDIX TABLE 2.

Comparison of Nissan Leaf and Chevrolet Volt to Honda Civic CNG, Gasoline, and Hybrid Versions

	Nissan Leaf	Chevrolet Volt	Honda Civic CNG	Honda Civic Gasoline	Honda Civic HEV
Engine Type	—	4-Cylinder	4-Cylinder	4-Cylinder	4-Cylinder
Displacement (cc)	—	1400	1798	1798	1497
Horsepower	110	149	110	140	110
Torque (lb.-ft.)	207	273	106	128	127
Transmission			5-Speed Auto	5-Speed Auto	CVT
Weight	3366	3755	2848	2705	2853
Length (in)	175	177.1	177.3	177.3	177.3
Width (in)	69.7	70.4	69.0	69.0	69.0
Wheelbase (in)	106.3	105.7	105.1	105.1	105.1
EPA Mileage Estimate					
City (MPGge)	106	95/35	27	28	44
Highway (MPGge)	92	93/36	38	36	44
Combined (MPGge)	99	94/35	31	31	44
Range (miles)	73	36/310	249	409	581
CO_2 Emissions (g/mi, electricity/tailpipe)	124-354	127-364/240	251	306	217
Price relative to gasoline version			5,500		3,500
TrueDelta Value Comparison to Volt			-11,240	-16,740	-13,240
TrueDelta Value Comparison to Leaf			-9,625	-15,125	-11,625

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Christopher Knittel is the William Barton Rogers Professor of Energy Economics in the Sloan School of Management at the Massachusetts Institute of Technology. He joined the faculty at MIT in 2011, having taught previously at UC Davis and Boston University. Professor Knittel received his B.A. in economics and political science from the California State University, Stanislaus in 1994 (*summa cum laude*), an M.A. in economics from UC Davis in 1996, and a Ph.D. in economics from UC Berkeley in 1999. His research focuses on environmental economics, industrial organization, and applied econometrics. He is a Research Associate at the National Bureau of Economic Research in the Productivity, Industrial Organization, and Energy and Environmental Economics groups and a Research Associate at MIT's Center for Energy and Environmental Policy Research. Professor Knittel is an associate editor of *The American Economic Journal—Economic Policy*, *The Journal of Industrial Economics* and *Journal of Energy Markets*. His research has appeared in *The American Economic Review*, *The American Economic Journal*, *The Review of Economics and Statistics*, *The Journal of Industrial Economics*, *The Energy Journal* and other academic journals.

Endnotes

1. The figure also includes a Lowess smoothed line, which is similar in nature to a moving average, but smooths both backwards and forwards.
2. See NGVAmerica.org.
3. Peterbilt and Kenworth both offer LNG versions of class 8 trucks using the Westport LNG fuel system (http://www.westport-hd.com).
4. Personal conversations with Westport suggest that the LNG feature adds roughly $70,000 to the cost of a tractor trailer.
5. See, for example, Hamilton (1983, 2009, and 2011).
6. A common misconception is that if the United States produced enough oil to satisfy its consumption, the country would be insulated completely from oil price shocks. This is not the case. Because oil is easily transported across the world, the oil market is a global market. Imagine that U.S. production matched consumption. If the world price of oil increased either through an increase in world demand or a supply shock, the oil prices faced by the United States would also increase because U.S. producers have the option to sell on the world market. Absent large trade barriers in the form of export taxes, the U.S. economy would still face world oil price shocks. While domestic profits for oil-producing firms would increase and thus reduce the shock to some degree, prices for products based on oil (e.g., gasoline and diesel) would still increase.
7. These estimates include tailpipe emissions but not upstream emissions. Greenstone et al. (2011) have an average social cost of carbon (SCC) at a 3 percent discount rate of $24 per ton of carbon dioxide (CO_2) in 2015 and an average of $35 in 2015 using a 2.5 percent discount rate. A gallon of gasoline generates roughly 20 pounds of CO_2 when burned, while a gallon of diesel generates roughly 22 pounds.
8. This is consistent with several side-by-side comparisons of bi-fuel vehicles—vehicles that are designed to burn and carry both gasoline and CNG—offered in Europe. For example, Volkswagen offers a bi-fuel Passat that carries both 21 kg of CNG (equivalent to 8.5 gallons of gasoline) and 8.3 gallons of gasoline. (Appendix Table 1 describes the details of this vehicle.) Volkswagen reports tailpipe emissions from the Passat are 192 g/mile when burning CNG and 254 g/mile when burning gasoline, a 24.4 percent reduction. In many ways, this is the ideal experiment since every other feature of the vehicle is held constant. Unlike the Passat, the Civic runs only on CNG, but we can compare the Civic CNG and Civic gasoline versions. Appendix Table 1 suggests that the tailpipe emissions from the CNG version are 18 percent lower than the gasoline version. This is somewhat of an overstatement of the emission reductions since the gasoline version has 30 more horsepower than the CNG version (140 HP v. 110 HP).
9. There is a long literature in economics documenting the link between criteria pollutants and health. See, for example, Chay and Greenstone (2003a and 2003b). For studies that directly relate health outcomes to driving, see Currie and Walker (2011) and Knittel, Miller, and Sanders (2011).
10. See, for example, http://www.afdc.energy.gov/afdc/pdfs/epa_cng.pdf, which reports reductions in carbon monoxide emissions of 90 percent to 97 percent, reductions in nitrogen oxide emissions of 35 percent to 60 percent, and potential reductions in non-methane hydrocarbon emissions of 50 percent to 70 percent, as well as other local pollution benefits. The Web site http://www.fueleconomy.gov/feg/bifueltech.shtml reports CNG vehicles have 60 percent to 90 percent less smog-forming emissions.
11. 0 + 17*.9 + 30*.5 + 35*.25. Since roughly 10 of light-duty fuel is ethanol, I reduce the macroeconomic externality by 10 percent. And, if LNG or CNG cuts diesel criteria pollutant emissions to those of gasoline-power vehicles, natural gas has externalities that are $0.55 less than a gallon of diesel.
12. It also ignores any additional maintenance costs associated with CNG vehicles, although a study of CNG taxis in New York suggests that maintenance costs might be lower. See http://www.consumerreports.org/cro/2012/03/the-natural-gas-alternative/index.htm.
13. This markup may also be viewed as a tax that prices some of the externalities associated with natural gas, but a recent paper by Lucas Davis and Erich Muehlegger (2010) suggests that the average residential and commercial markup over marginal costs exceeds 40 percent; this is equivalent to a tax of $50 per ton of CO2 (Davis and Muehlegger 2010). This exceeds the external costs estimates of Greenstone et al. (2011). In the absence of a tax for gasoline of the same size, this will distort the decision to use home refueling.
14. See http://www.afdc.energy.gov.
15. DOE has been active in encouraging fleets of heavy-duty vehicles to convert to natural gas as part of its Clean Cities initiative (http://energy.gov/articles/national-clean-fleets-partnership-moves-forward), and so could be well-placed to do something similar for long-haul trucks.
16. Advanced biofuels can be made from a variety of feed stocks but must have lifecycle greenhouse gas emission at least 50 percent less than the baseline fuel. Cellulosic biofuels must be made from cellulose, hemi-cellulose, or lignin derived from renewable biomass and have lifecycle emissions at least 60 percent less than the baseline fuel. Conventional biofuels are derived from cornstarch.
17. Holland et al. (2011) illustrate that the RFS is an expensive way to reduce greenhouse gas emissions and oil consumption, relative to Pigouvian taxes.
18. These vehicles are capable of burning up to 85 percent ethanol; the EPA recently ruled that non-flex fuel vehicles are able to safely burn fuel with up to 15 percent ethanol.
19. See http://openfuelstandard.blogspot.com/2011/05/ofs-fact-sheet.html.
20. See http://content.usatoday.com/communities/driveon/post/2012/02/president-obama-budget-electric-car-subsidies-chevrolet-volt/1#.T2jM-DVGi5sQ.
21. See NGVAmerica.org.
22. See http://www.greencar.com/articles/can-convert-natural-gas.php.
23. See http://www.gie.eu/maps_data/downloads/2011/GLE_LNG_August2011_MAP.pdf.

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Highlights

Christopher R. Knittel of MIT puts forward policies to support the development of natural gas fueling infrastructure and to encourage the use of natural gas fuels and vehicles. These measures take advantage of the opportunity offered by the shale gas revolution to substitute natural gas for petroleum, increasing U.S. energy security and reducing the environmental and health costs of our energy choices.

The Proposal

A. Support the development of natural gas fueling infrastructure

- Step 1: Encourage home refueling by pricing natural gas for CNG vehicles at efficient rates.
- Step 2: Encourage natural gas local distribution companies to offer CNG stations.
- Step 3: Establish an industry consortium to investigate and coordinate on LNG refueling stations.

B. Encourage the use of natural gas fuels and vehicles

- Step 4: Include methanol in the Renewable Fuel Standard.
- Step 5: Mandate a significant share of vehicles manufactured to be able to burn gasoline, ethanol, and methanol.
- Step 6: Provide subsidies for natural gas vehicles commensurate with the reduction in external costs associated with their use.
- Step 7: Streamline the retrofitting certification process for gasoline vehicle conversion to CNG.

Benefits

These proposals will help overcome obstacles in establishing a critical mass of natural gas fueling stations and generating the initial demand necessary to sustain these stations. The creation of this network of stations allows consumers to realize the cost savings promised by cheap natural gas. An overall shift to natural gas will also benefit society, because natural gas emits fewer greenhouse gases and local pollutants than petroleum. Finally, these proposals will reduce U.S. dependence on oil, increase U.S. energy security, and diversify our energy sources.

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Business Case for Compressed Natural Gas in Municipal Fleets

Caley Johnson

Technical Report
NREL/TP-7A2-47919
June 2010

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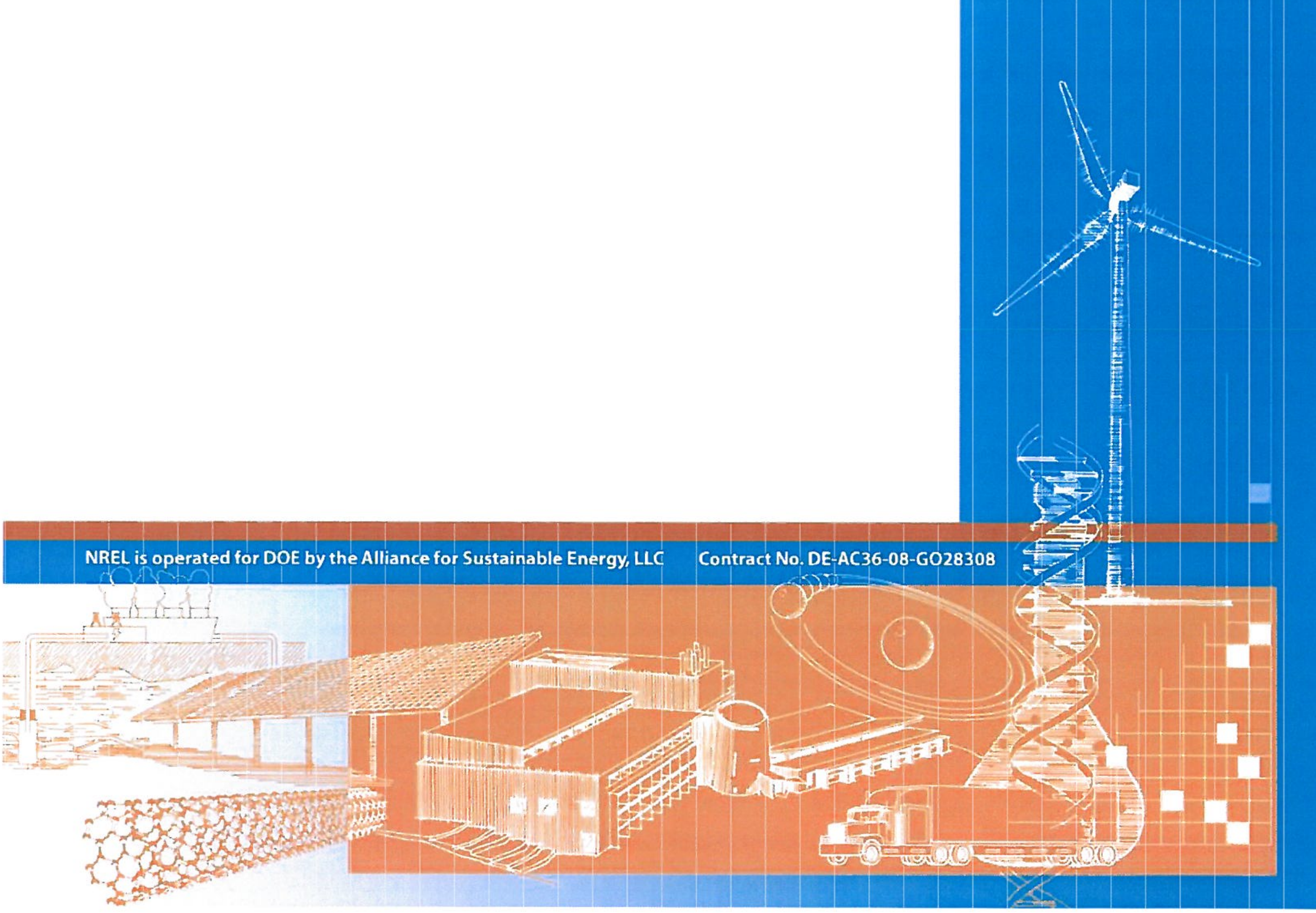

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All assumptions and any inaccuracies are the responsibility of the author and not the experts acknowledged above.

Introduction

Compressed natural gas (CNG) vehicle projects can be highly profitable, or they can lose money, depending on numerous aspects of the fleet and station. To assist fleets and businesses in evaluating the profitability of potential CNG projects, the National Renewable Energy Laboratory (NREL) built the CNG Vehicle and Infrastructure Cash-Flow Evaluation (VICE) model. The VICE model demonstrates the relationship between project profitability and fleet operating parameters. This report describes how NREL used the VICE model to establish guidance for fleets making decisions about using CNG.

The first section establishes a base-case scenario for three fleets that commonly use CNG—transit buses, school buses, and refuse trucks. This base-case tries to represent the average or most-common parameters affecting the CNG project's profitability for average fleets of each type.

The second section uses the model to show how specific project parameters (such as station cost or price of fuel) change profitability from the base-case. The section then prioritizes these parameters to help fleet operators understand the most important factors affecting the business case of the project. Through a question-and-answer format, this section presents common CNG-related questions answered by NREL using the VICE model.

The business case targets municipal governments, which operate fleets suited well for CNG vehicles because they drive circular routes that enable refueling at the same station. These fleets are transit buses, school buses, and refuse trucks. Municipal governments are also targeted because their primary goal is to improve their residents' quality of life. This goal allows the government to utilize all the advantages of CNG, including long-term cost-effectiveness, more-consistent operational costs, increased energy security, reduced greenhouse gas emissions, reduced local air pollution, and reduced noise pollution. A forthcoming report will focus on private fleets that are suited well for CNG, such as taxi cabs and delivery trucks.

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VICE Model Baseline Parameters

This analysis uses multiple input variables to simulate the financial circumstances faced by municipal fleets. In this section, average or common values are used to establish a baseline scenario for common operating circumstances. This scenario provides a snapshot from which we can test the sensitivity of CNG project economics to changes in various parameters.

CNG Station Cost

Station cost is derived by a cost calculator constructed by Rob Adams with Marathon Technical Services (Marathon). The calculator replicates a buffered fast-fill station, which is best suited for quickly fueling large numbers of heavy-duty, high-fuel-capacity vehicles. It is recognized that under scenarios with low throughput and large refueling windows, a time-fill station might be preferred. However, under these scenarios, the calculator takes into account the reduction in equipment needed by reducing the overall cost of the station close to that of a comparable time-fill station. Therefore, the cost estimate is realistic over a wide range of station sizes.

Constants in the calculator are as follows:

- Spare ratio is 10%. This means that 10% of the fleet is expected to not refuel on any given day.
- Station inlet pressure is 100 pound-force per square inch gauge (psig)
- Compressor package is a fully enclosed electric drive
- Dryer consists of a single manual tower for stations dispensing fewer than 30,000 diesel-gallon equivalents (DGE) per month (depending on fleet type) and a fully automatic twin tower for stations dispensing more than 30,000 DGEs per month.
- The system is designed to store CNG at 5500 psig
- Installation costs are assumed to be 50% of the equipment costs based on numerous Marathon projects of a variety of sizes.

Variables in the station cost calculator are throughput (amount of fuel dispensed per month), refueling window (number of hours per day when vehicles are available to refuel), and peak capacity (flow required to keep the fleet fueled). These parameters affect the size and number of tanks, compressors, and supporting equipment. Throughput is calculated from the VICE model by dividing the number of vehicles by the average fuel economy of the fleet. The refueling window is fleet-dependent, and the following scenarios were used for the calculator:

- Transit bus fleets were assumed to have a refueling window of 6 hours based on significant Marathon industry project experience.
- School bus fleets were assumed to have a refueling window of 12 hours. This figure comes from interviewing school fleet managers (Andre 2009 and Linder 2009).
- Refuse truck fleets were assumed to have a refueling window of 12 hours. This figure comes from the director of numerous refuse fleets (Lemmons 2009).

- Combining two fleets allows them to keep the larger of the two refueling windows. This assumption is conservative; in actuality, it would probably expand the refueling window and lower station requirements further for a given number of vehicles. We used a conservative assumption because we do not know of anybody who has optimized this refueling window (by staggering their fleets) to date.
- The scenario where three fleet types share a central refueling station assumes the refueling window is 12 hours a day. This is a conservative assumption when the schedules of all three fleets are taken into account, but it is used because it retains flexibility for the fleets to refuel at more-convenient times.

Test runs were then done with the calculator, and the results were plotted to establish a relationship between the size of the station and its cost. A linear trendline was then fitted to these lines, and equations were derived to represent the best relationship between a station's size and cost. The trendlines are shown in Figure 1, and their matching equations were entered in the VICE model to derive station cost.

It should be noted that the school station is less expensive for the practical range of a school fleet, yet its costs rise at a steeper rate than the others because it uses equipment that cannot be scaled up as efficiently. The school station is only charted up to 65,000 DGEs per month because school fleets use less fuel, so no scenarios were modeled that involved a school fleet using more than this amount of fuel. Refuse stations achieve greater economies of scale than transit stations—presumably because their larger refueling window allows for greater increase of throughput without a corresponding increase in equipment.

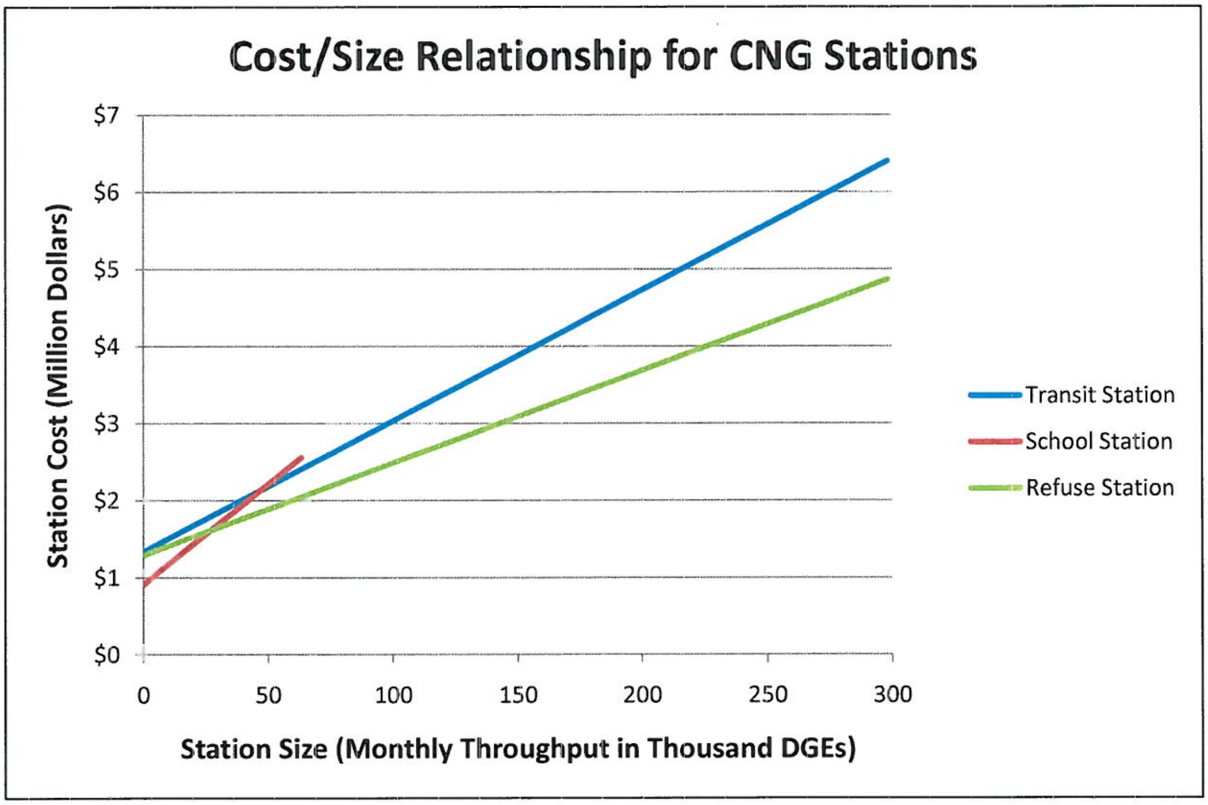

Figure 1. The relationship between the size of a CNG station and its cost. It should be noted that the upper end of the station throughput range (300,000 DGE) is uncommon.

Fleet Scenarios

The VICE model considers seven different fleets with the following parameters:

Table 1. Seven Modeled Fleets and Their Parameters

Scen-ario	Fleet Type	Avg. VMT	FE Diesel (mpg)	FE CNG (mpDGE)	Incremental Cost	Vehicle Life
1	Transit Buses	35,286	3.27	3.02	$50,502	15
2	School Buses	12,000	7.00	6.13	$31,376	15
3	Refuse Trucks	25,000	2.80	2.51	$30,295	12
4	1/2 Transit, 1/2 School	23,643	5.14	4.57	$40,939	15
5	1/2 Transit, 1/2 Refuse	30,143	3.04	2.76	$40,399	14
6	1/2 School, 1/2 Refuse	18,500	4.90	4.32	$30,836	14
7	1/3 Each	24,095	4.36	3.88	$37,391	14

The parameters for the combination fleets (scenarios 4 through 7) are weighted averages according to their composition by the first three fleets. Parameters for the first three fleets are listed below.

Transit Buses

- The average vehicle-miles traveled (VMT) of transit buses is 35,286 miles/year derived from tables 8 and 9 in American Public Transit Association (APTA) 2009.
- The average fuel economy of diesel buses in the United States is 3.27 mpg, which is calculated from tables 8, 9, and 12 in APTA 2009.
- The average fuel economy of CNG buses is 3.02 miles per DGE (mpDGE), which is calculated from tables 8, 9, and 15 in APTA 2009.
- Incremental cost ($50,502) is an average of the incremental costs found in Chandler et al. 2006 (Table 6 adjusted for inflation) and from an interview with Bob Antila (Antila 2009).
- Bus lifetime (15 years) is the average retirement age of buses as reported in table ES-2 in the Federal Transit Administration's study on the useful life of buses (FTA 2007).

School Buses

- Average VMT of a school bus is 12,000 miles/year (American School Bus Council 2009).
- Average fuel economy of a diesel school bus is 7 mpg (American School Bus Council 2009 and Andre 2009).
- Fuel economy of a CNG bus is 6.13 mpDGE, which is calculated as a 12.5% reduction in efficiency from diesel school buses (Linder 2009).
- Incremental cost is $31,376 (average of four sources—Linder 2009, Leonard et al. 2001, Cohen 2005, and USCS 2003—where the latter three sources have been adjusted for inflation).
- Bus lifetime (15 years) is taken from *School Bus Fleet Magazine*'s 2009 Maintenance Survey.

Refuse Trucks

- Average VMT of a refuse truck is 25,000 miles/year (Gordon et al. 2003).
- Fuel economy of a diesel refuse truck is 2.8 mpg (Gordon et al. 2003).
- Fuel economy of a CNG refuse truck is 2.51 mpDGE, which is calculated as a 10.5% reduction in efficiency from diesel refuse trucks (Gordon et al. 2003).
- Incremental cost of a CNG refuse truck is $30,295 (average of three sources: Lemmons 2009, Andrews 2009, and San Antonio 2009).
- Useful life of a refuse truck is 12 years (Gordon et. al. 2003 and Lemmons 2009).

Maintenance and Operation Costs

This section describes some maintenance and operation (M&O) costs associated with vehicles and CNG stations.

Vehicle M&O

Maintenance and operation costs for a CNG bus are considered the same as those for a diesel bus because evidence supports both a cost decrease (Chandler et. al 2006) and a cost increase (CVEF 2010) when switching from CNG to diesel. The unclear cost signal portrayed in these studies represents a factor that is in flux due to maintenance learning curves, new diesel emissions equipment, a sub-competitive CNG parts market, and other factors. This cost parity for CNG buses is assumed to apply to CNG refuse trucks as well, which is supported by Engle (2010).

CNG Station M&O

The VICE model assumes that M&O costs for a diesel refueling station are wrapped into the retail price of diesel fuel because the fuel retailer needs to cover these costs to stay in business. Natural gas prices, on the other hand, do not include CNG station costs because most natural gas is sold to the non-transportation market. Therefore, all M&O costs for the CNG station are incremental.

Maintenance costs of a CNG station include the cost of parts, consumables, labor, breakdowns, and on-call staff to keep a station functioning properly. The labor is generally provided by a technician that is "on call" for a number of stations in a given area. The estimated annual maintenance costs used in the model are 5% of the upfront cost of a large station, rising to 8% of the upfront costs of a small station. This assumption came from Rob Adams, who uses this as a rule of thumb when bidding on maintenance contracts. A rule-of-thumb estimate was needed because maintenance costs vary so widely according to station, and the rule of thumb takes most of these variations into account. This estimation technique is based on the idea that when more money is spent on equipment, more money must be spent to keep up and replace the equipment. It also takes into account economies of scale.

Rob Adams' estimation technique was chosen not only for its logic and simplicity, but because it splits the difference between two other maintenance estimates that we received from other sources. Figure 2 compares the three estimates on a monthly cost-per-station-size scale. It is not surprising that the three estimates are so different because the contractors rely heavily on station-specific circumstances that were not available for these general estimates. Given the choice between three qualified industry experts, we selected the middle estimate.

Next, the "8% to 5%" was distilled into an equation so it could be inserted into the model. As shown in Figure 2, a polynomial equation fit the line very well for the range from 0 to 300,000 DGE throughput. After that, it was set to rise 0.06% per DGE. The polynomial equation used in the model is:

$$Y = -2.225 * 10^{-7} X^2 + 0.1257X + 7{,}014.3$$

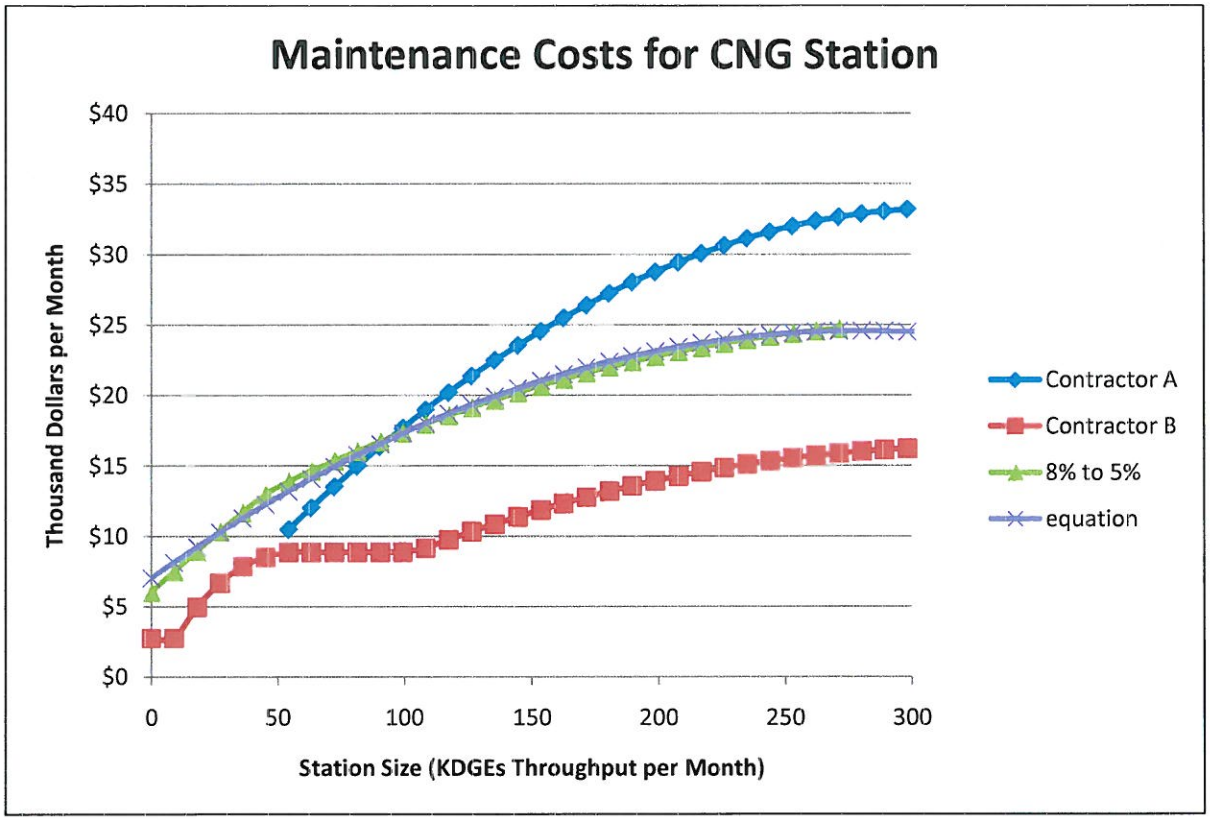

Figure 2. Three M&O contractors' estimates at maintenance costs according to station size with the equation used in the VICE model

Electricity is the primary operation cost considered in the base-case scenario. "Commercial" electricity clients in most states pay both an energy charge and a capacity charge (often called demand charge) for electricity. The capacity charge reflects how much electricity the utility needs to be prepared to produce for you and therefore depends on how quickly you draw electricity from the grid, which is especially important for CNG stations because they can have a very large ampere draw. The model assumes the energy charge to be $0.10/kWh, which is between the mid-peak and on-peak prices in California in January 2009. The assumed capacity charge is $12/kW/month for the same reasons. The combined electricity charges result in different monthly electricity prices for the three fleets based on throughput, as seen in Figure 3. The two trendlines were converted to equations and inserted into the model. It should be noted that the transit station's electric costs start higher than the refuse and school's cost because its smaller refueling window requires larger compressors, which leads to higher electric capacity requirements. This demand charge represents a fixed cost portion of the electric bill. This difference is minimized as throughput increases because the variable cost portion of the electrical bill (the energy charge) becomes more pronounced, which decreases the previous advantage that these stations had over the transit station.

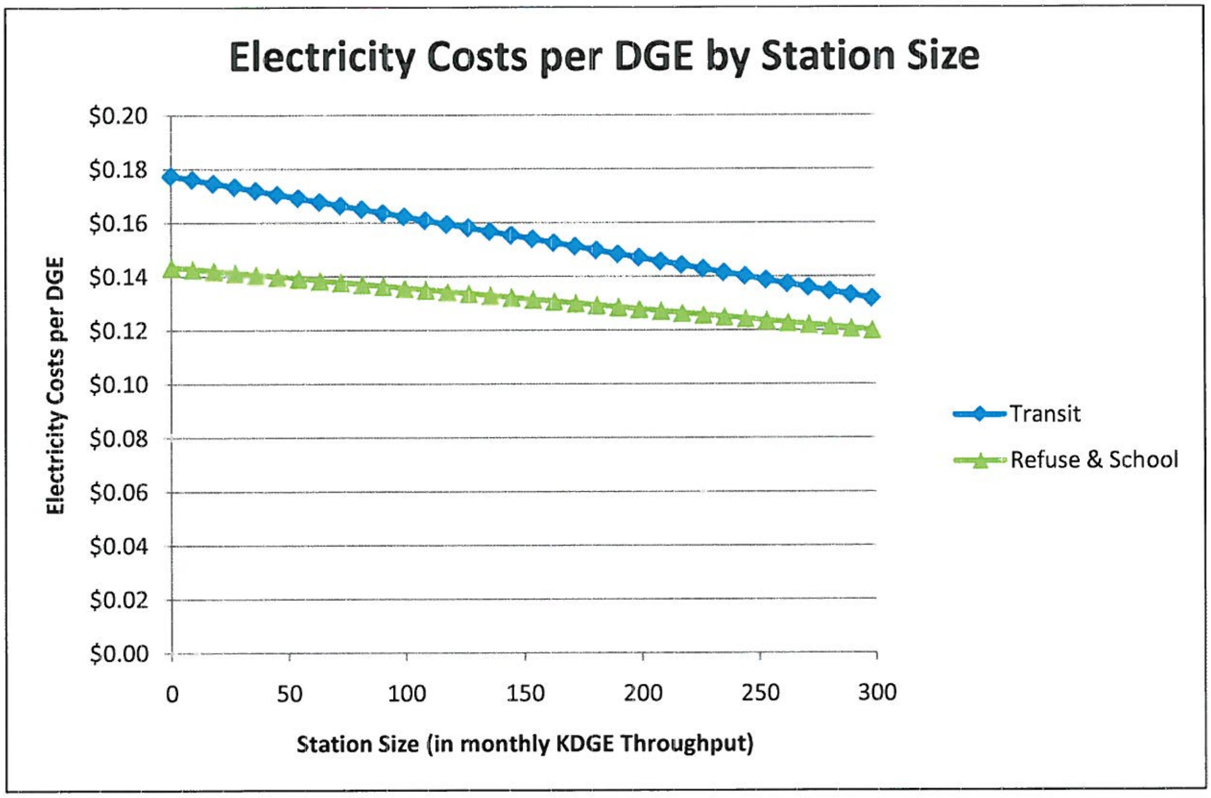

Figure 3. Electrical costs per DGE by station size

Labor for hostlers (people who refuel, clean, and maintain fleets) is not considered an additional cost in the base case because diesel vehicles need them also. Furthermore, hostlers are not an additional cost because it is generally more economical to use a hostler than to have drivers or other staff refuel the vehicles. Even though they are not included in the base case, additional hostlers will be considered in the sensitivity analysis.

Fuel Price and Rate of Increase

The VICE model's diesel fuel price of $2.563/gal is the average of the most recent 12 months (ending February 2010) listed by EIA (2010a). The natural gas price of $1.183/DGE is taken as the commercial price listed by EIA (2010b) and converted from cubic feet to DGEs using EIA's conversion factor of 1,028 Btu per cubic foot. Both diesel and natural gas fuel prices are averaged over the most recent 12 months to take into account seasonal changes.

It should be noted that fleet operators frequently purchase their natural gas for less than the commercial price mentioned above. They can do this by purchasing from a gas marketer in deregulated markets, from a commodities market, or from a middle man that purchases from the market and sells a contract to provide fuel and optional services for a given amount of time. These other purchasing avenues are not used in the model because they are less common and have no common price that can be tracked and forecasted.

Diesel fuel is projected to increase at a linear rate of 5.6% per year, and natural gas is projected to increase at 1.6% per year. These are the rates that EIA projected for the 15 years between 2010 and 2025 (EIA 2010c), as shown in Figure 4 below.

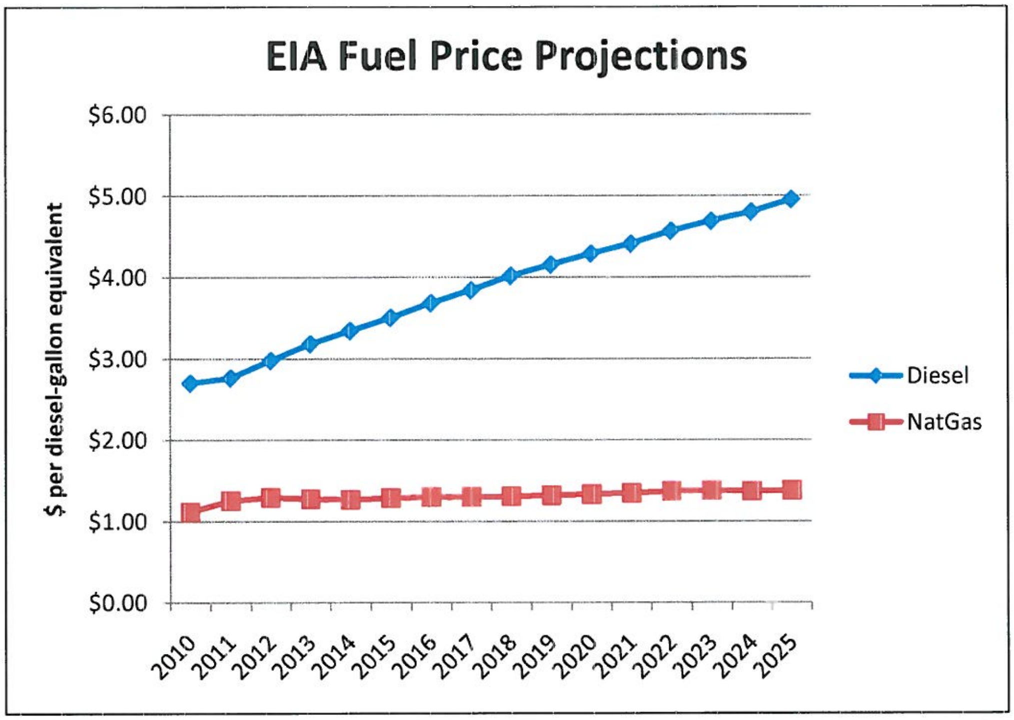

Figure 4. EIA fuel price projections

Taxes and Incentives

The federal government taxes fuel use and provides incentives for CNG use through tax credits. These credits are intended to reduce the overall cost of installing the CNG refueling station, to purchase the CNG vehicles, and to purchase CNG. The incentives have been crafted so tax-exempt entities such as municipal governments can pass the credits to suppliers and therefore take advantage of the tax credits.

Refueling Station

The Alternative Fuel Infrastructure Tax Credit is available to reimburse 50% of the cost of installing a CNG station, up to $50,000. Tax-exempt entities are allowed to pass this credit onto the company that is building the station. The VICE baseline assumes that the builder reduces the purchase price by an amount equal to this tax credit.

Vehicles

The Alternative Motor Vehicle Credit provides a tax credit equal to 80% of the incremental cost of a CNG vehicle, to a maximum of $32,000 per vehicle. The VICE model assumes that this tax credit is fully capitalized on by passing to the vehicle manufacturer in exchange for a lower purchase price.

Fuel

The VICE model assumes CNG and diesel are taxed at the same level, which treats tax-exempt and non-exempt fleets the same. To do this, we had to subtract the $0.183 federal or $0.20 average state motor fuels excise tax on diesel or CNG fuel (IFTA 2008) from the projected retail price of diesel, which included these motor fuel taxes.

The SAFETEA-LU Act of 2005, the Tax Extenders Act of 2009, and the two NAT GAS Acts currently under consideration provide a $0.50 motor fuels excise tax credit for each gasoline-gallon equivalent (GGE) (or $0.55 per DGE) of CNG purchased. This credit is applicable to both taxable and tax-exempt fleets through a rebate provision in the Act (NGVAmerica 2008) and is applied to both in the VICE model.

Financing

The analysis assumes that municipal governments will fund the CNG project through their annual budgets without taking a loan or issuing bonds. This assumption is supported by the experience of a number of Clean Cities coordinators whereby an ordinance was passed one year and the funds allocated for a CNG project the following fiscal year.

When looking at the payback period and net present value (NPV) of a CNG project, we need to consider the discount rate. The discount rate is considered 6%—the upper limit for a key municipal bond index since 1997 (WM Financial 2009). This rate is assumed because it is the upper end of the cost of capital for municipal governments.

Garage Cost

The facility upgrade costs associated with upgrading a fleet from diesel to CNG are considered zero. This is in agreement with the fact that the incremental cost of making a new garage and maintenance facility compatible with CNG is minimal (Marathon 2006). Therefore, the model implicitly assumes the fleet already has well-ventilated facilities or that they are building new facilities that would be the same cost regardless of fuel type. However, garage upgrade costs will be modeled in part two of this analysis to explore their effects on the economics of a CNG project.

Project Life and Salvage Value

The project life, or investment period, is the same duration as the vehicle's useful life. As discussed above, this is 15 years for transit and school buses, 12 years for refuse trucks, and 14 years for any fleet that combines refuse trucks with buses.

The station is assumed to be used throughout the entire project period (vehicle life) and then salvaged at the end of that period. The salvage value of the station is assumed to be 20% regardless of how many years (12, 14, or 15) it has been in service. This number is static throughout time because the value is more a function of demand for components than it is the age of the components. The 20% value was chosen after interviewing two CNG station technicians that have overseen dozens of projects.

The difference between diesel and CNG salvage values of all three vehicle types is considered zero (Linder 2009 and Lemmons 2009). This means that at the end of the vehicle's life, a CNG vehicle is worth no more than a diesel vehicle.

CNG Project Q&A

The base case represents an average or common CNG project. Every project deviates from this base case, which is why fleet operators question the specific parameters of their projects. The questions and answers in this section are organized to first give fleet managers their bearings and show how profitable the base-case project is. The following questions go on to address changes in fuel expenditures, changes in operating costs, and changes in upfront costs.

How do I know if a CNG project makes financial sense?

Most investors use three indicators of financial viability, which all stem from a discounted cash-flow analysis performed by models such as the VICE model. These indicators are:

1. Net Present Value (NPV). This is the total present value of a CNG project, including the cost of CNG equipment purchased now along with future costs and cost savings from fuel and operations throughout the lifetime of the project. These costs and cost savings are called "cash flow," with costs being a negative cash flow and savings being a positive cash flow. Please see the baseline parameters section (pp. 1–9) for all cash flows that are included in the VICE model. All future cash flows are discounted at a "discount rate" to compensate for the fact that money is worth more today than it is in the future because it can be invested today and increased. If the NPV of the project is positive or zero at the desired discount rate, the project makes financial sense. The NPV of the hypothetical investment in Figure 5 is $7.2 million, where cumulative cash flows stop increasing at the end of the project life.
2. Rate of Return (ROR). The ROR is the desired annual return on investment. When choosing a target ROR, many companies compare it to what they could make if they invested their money in another project with similar risk. Ten percent is often considered a good baseline in the private sector because that is what the stock market has averaged over the long term. In municipal governments, 6% is generally considered the baseline because that is what it costs a government to raise money through bonds. ROR is also the discount rate on money if one sets the NPV to equal zero.
3. Payback Period. This lets an investor know when the investment has broken even and is starting to turn profits. At this point, an investment no longer carries the risk of losing money. When assessing the payback period, the investor uses the same discount rate as used when looking at the NPV. In Figure 5, it takes the fleet manager 4 years to pay back the initial investment of $2.6 million. Stable, progressive fleets can have a target payback of 7 years while more risk-adverse fleets can require a 3-year payback. The payback period seems to be the metric of choice for fleet managers despite its drawback of not being able to quantify losses on a bad investment.

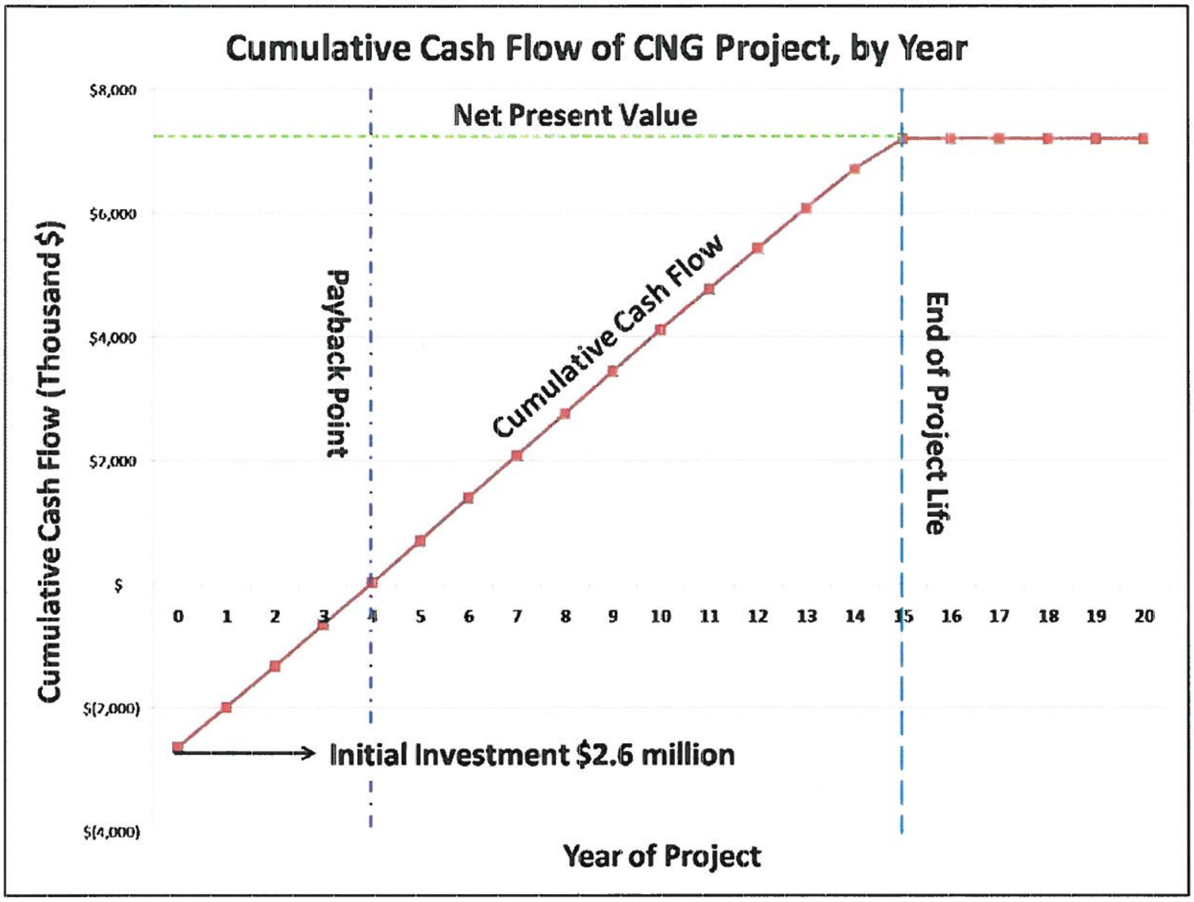

Figure 5. Cumulative cash flow of an example CNG project, by year

Base-Case Results

This section answers three questions about the base-case results.

What will my payback period be?

NREL ran the VICE model under a base-case or most-probable scenario for a transit fleet, school fleet, and refuse fleet (as described in Section 1). The results of this run show that the payback periods depend largely on fleet size and fleet type (Figure 6). Transit and refuse projects have a precipitous drop in payback period at around 30 vehicles. Any fleet larger than this will have a payback period of less than 7 years.

School bus fleets need to be larger than the other two fleets for a given payback period because each school bus uses less fuel. A fleet of 250 school buses pays back in about 7 years, but there is no clear dropoff the way there is for the other two fleets. Please note that the maximum payback period for a refuse truck is 12 years because that is the average life of these trucks while transit buses and school buses have an expected 15-year life.

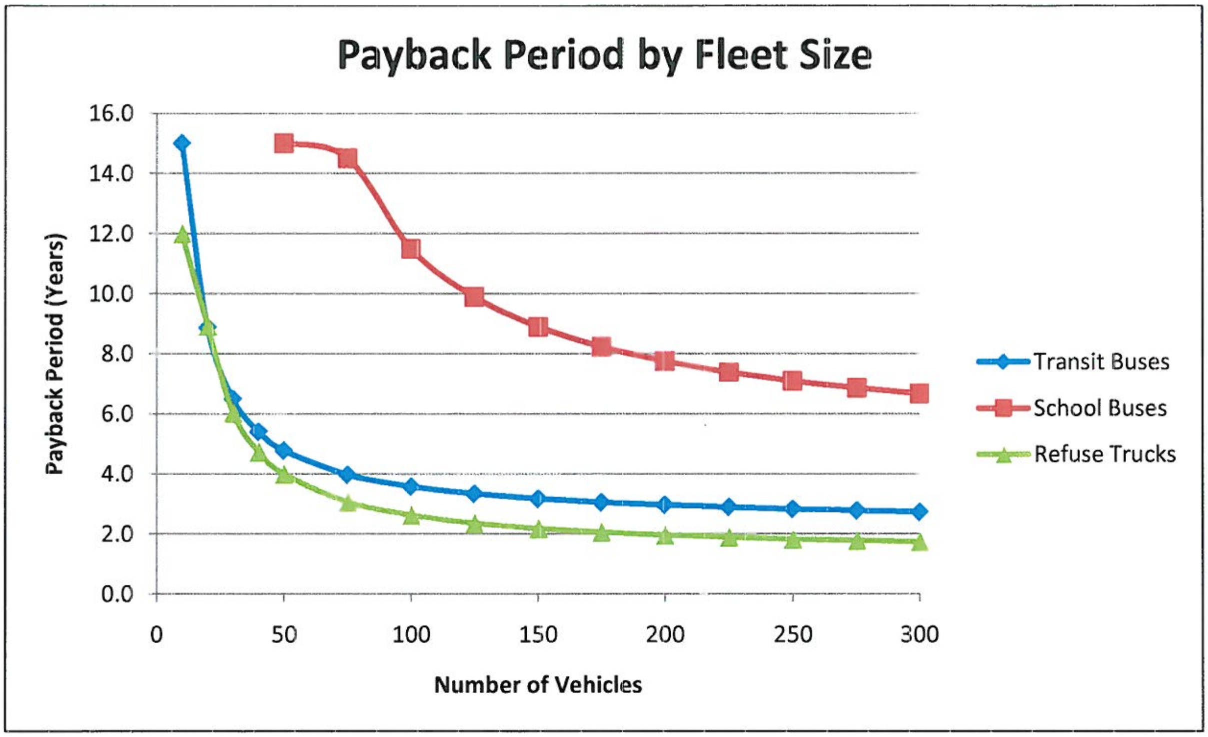

Figure 6. Payback period by fleet size

What will my ROR be?

Base-case refuse and transit projects look very profitable when judged on the basis of ROR. With fleets as small as 25 buses, they can provide returns that are deemed acceptable by any organization, and large fleets yield extraordinary returns. Refuse projects become more profitable than transit projects as the fleet size increases—probably because the larger refueling window allows increased vehicle usage without increasing fueling capacity.

School bus projects require large fleets to provide a good ROR. The ROR surpasses 6% with a 75-vehicle fleet and 10% with a 100-vehicle fleet. It then maxes out at 21% ROR, which is quite a good investment for a municipal government.

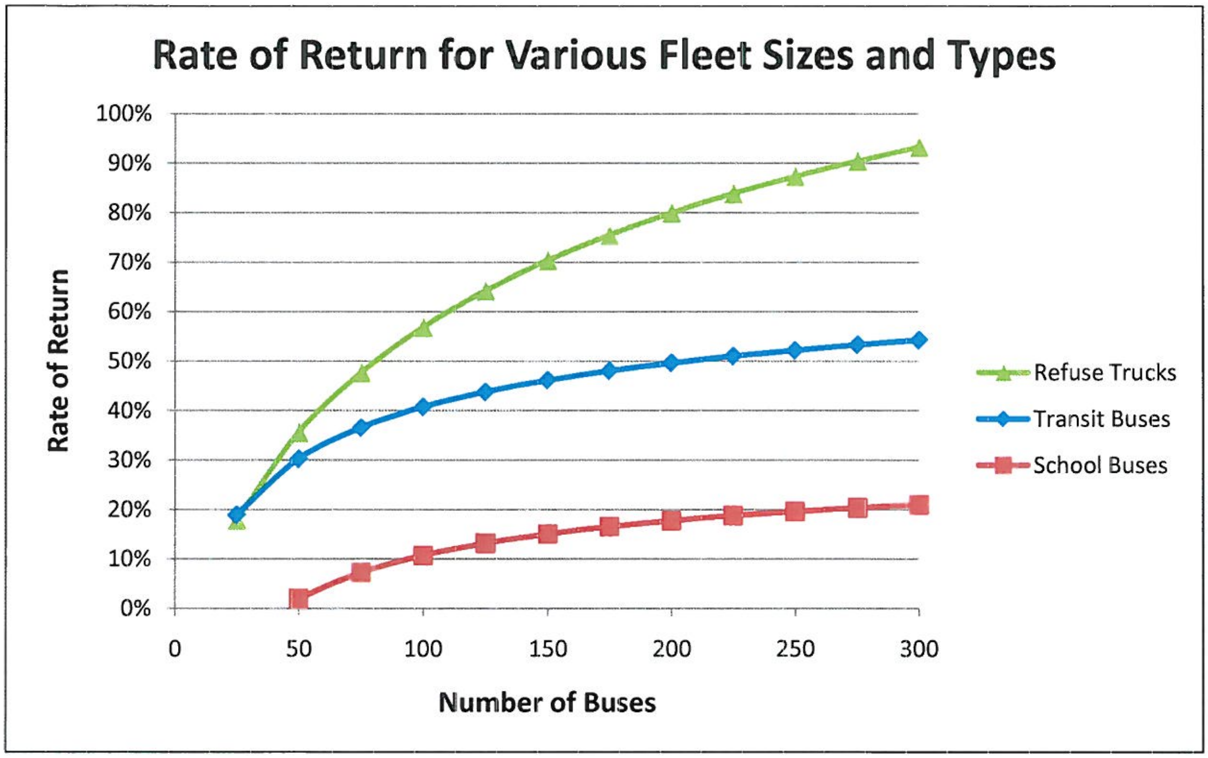

Figure 7. Rate of return for various fleet sizes and types

What is the NPV of my investment?

Transit buses are the best fleets to convert when judged by the NPV metric because they use more fuel than the other fleets, which results in greater fuel savings by the end of the project's life. The reason why transit fleets are more profitable than refuse fleets when looking at NPV but less profitable when looking at ROR is that they require a larger upfront investment. As shown in Figure 8, a 300-transit-bus fleet, which requires an initial investment of $11.8 million, has an NPV of $55 million. The NPV for transit fleets turns positive at 11 buses, for refuse fleets at 14 trucks, and at 68 school buses.

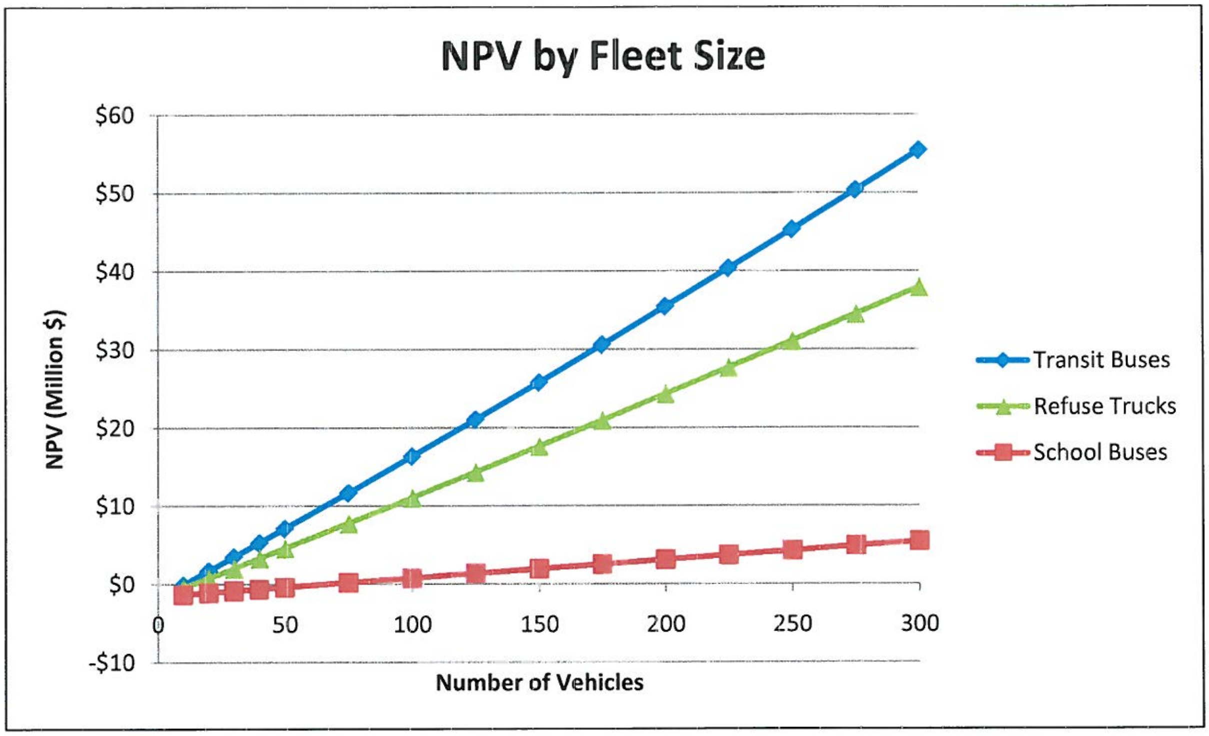

Figure 8. Net present value by fleet size

What is the minimum number of vehicles required to break even?

The minimum goal of an investor is to break even when taking into account the cost of tying his money up for the life of the project. This is the point in Figure 8 where the NPV of a project crosses from negative to positive, and it is also the point in Figure 7 where the ROR reaches 6% (the discount rate for municipal governments). Table 2 summarizes the minimum number of vehicles to break even for the three main municipal fleets and various combinations where vehicles of different types share municipal infrastructure.

Table 2. Minimum Number of Vehicles to Have a Positive NPV or 6% ROR

Type of Vehicle	# of Vehicles
Transit Buses	11
School Buses	68
Refuse Trucks	14
1/2 Transit, 1/2 School	26
1/2 Transit, 1/2 Refuse	12
1/2 School, 1/2 Refuse	32
1/3 Each	22

Variations in Fuel Expenditures

The base case has already shown that project profitability is very dependent on fleet size. This is one factor affecting the fuel expenditures of a project. Fuel expenditures are very influential on project profitability because upfront costs are largely paid for by a reduction in CNG expenditures below those of diesel. Therefore, to achieve maximum benefit from the use of CNG, negotiating and securing low long-term natural gas prices is critical. Other questions that explore fuel expenditures follow.

How many miles per year do I need to drive my vehicles to break even?

Fuel costs are dependent on both the price of the fuel and the number of miles driven by the fleet. Because natural gas is generally less expensive than diesel, the greater the number of miles a vehicle drives, the more savings a fleet will see compared to conventional fuel. Figure 9 shows the relationship between average VMT and the number of vehicles needed to pay off a CNG investment. The area above the curve is profitable for the fleet, and the area below the curve is not profitable.

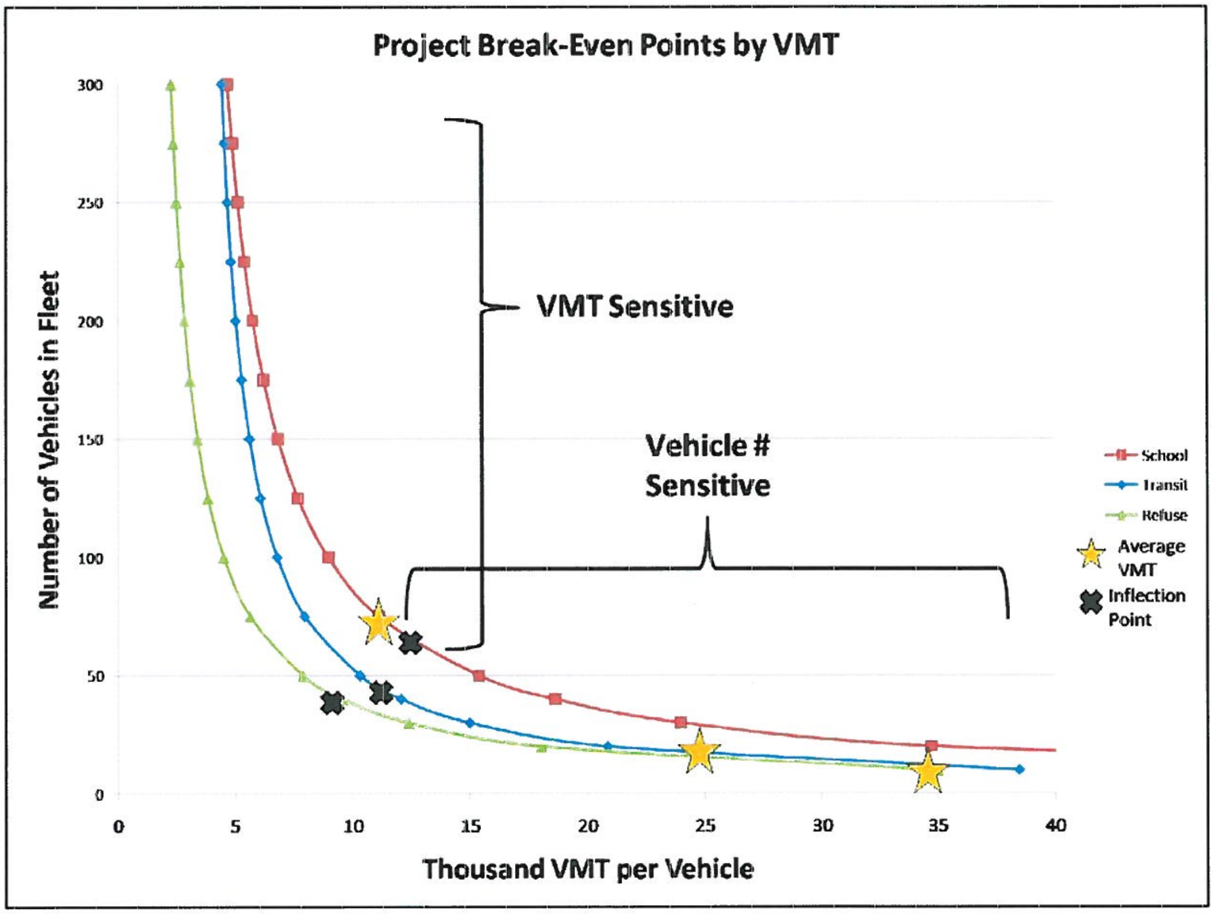

Figure 9. Project break-even points by VMT

The most noteworthy part about Figure 9 is how steep the transit and refuse fleet lines drop between 2,500 and 10,000 VMT and how flat they are after 10,000 VMT. The point of transition is labeled as the inflection point. The inflection of the school bus fleet is less pronounced than the other two but still there. The profitability of any point above the inflection point is more sensitive to the VMT changes, and any point to the right of the inflection point is more sensitive to changes in the number of vehicles. Given where the average VMTs of transit and refuse fleets fall, their economics are much more sensitive to their vehicle number than VMT. Average school fleets are barely above the inflection point, so they should be only slightly more concerned with their VMT than the number of vehicles when considering a CNG project. Keep in mind that any VMT-vehicle combination to the right or above the curves is considered a profitable project.

What will a change in diesel prices do to my payback period?

Diesel prices are highly variable. Over the past two years, they have varied 0.8 standard deviations from the mean, as opposed to 0.2 for CNG (Laughlin 2010). Therefore, it is very important to find out what effect a change in diesel price will have on project economics. To answer this question, NREL compared the baseline price of natural gas at $1.18/DGE against different diesel prices. Both CNG and diesel were set to increase 3% per year to keep up with inflation. The effect that diesel price has on payback period is shown in Figure 10 for the three municipal fleets at 50 and 100 vehicles each.

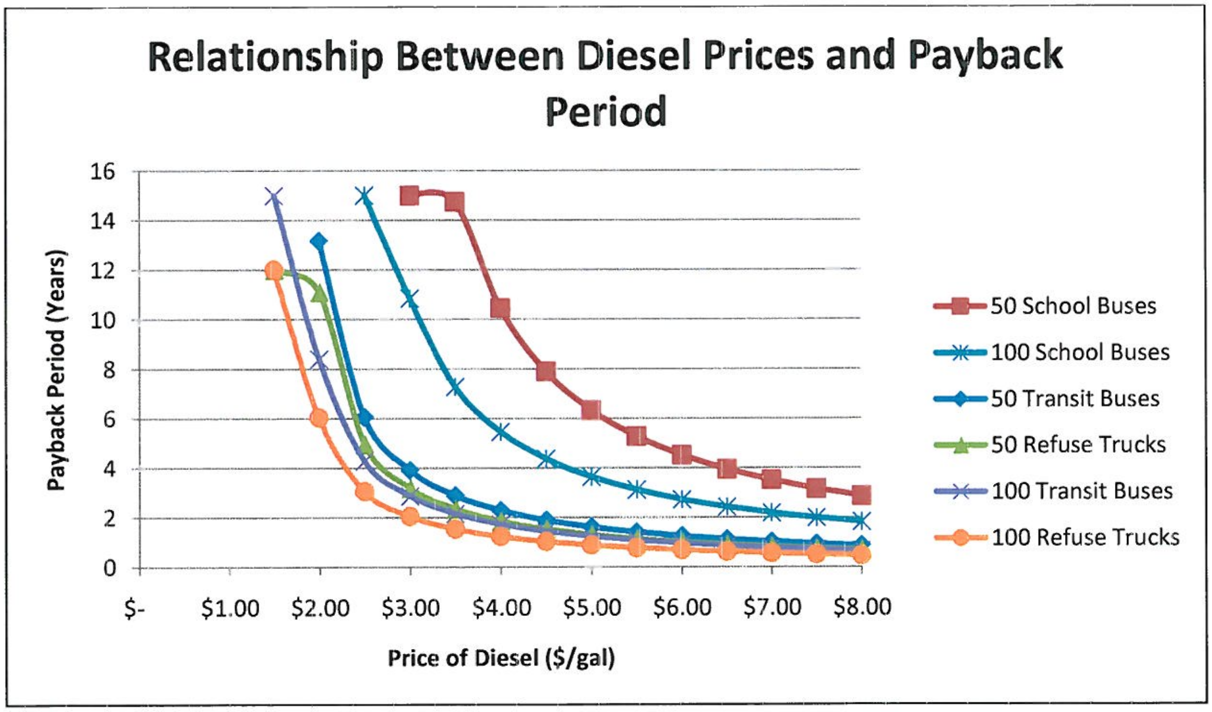

Figure 10. Relationship between diesel prices and payback period

Figure 10 reiterates that the economics for a school bus fleet under the base-case scenario are very dependent on the size of the fleet. A school bus project appears to achieve only a reasonable payback once diesel prices approach $4/gallon for 100-bus fleets and $5/gal for 50-bus fleets.

The main observations when considering fluctuating diesel prices (shown in Figure 10) for refuse and transit fleets are:

1. Project economics look strong for transit and refuse fleets of either size if the price of diesel is $2.50 or greater. This responds to a payback period between 3 and 6 years, depending on fleet type and size.
2. As the price of diesel increases past $2.50, the size and fleet type (transit or refuse) become increasingly irrelevant. For prices below $2.50, larger fleets are favored, and refuse fleets are favored over transit.
3. Recent diesel price of $2.56 is on the inflection point of this graph. If diesel prices rise, project economics look very good, and if they fall to $2.00, they do not look very good.

What does the composition of my fleet do to my project economics?

Some municipal governments have a unique capability to fuel multiple fleets/vehicle types from one CNG station. This offers the primary advantage of staggering refueling times and expanding the station's refueling window because different fleet types can refuel at different times of the day. NREL modeled combination fleets by taking the weighted average of the vehicle attributes such as VMT, fuel economy, efficiency penalty, and incremental cost. NREL then assumed these fleets would use a refuse-style CNG station because of its 12-hour refueling window and ability to be scaled up in a cost-efficient manner. Multi-purpose fleets used the transit fleet electricity cost assumptions if there were any transit buses involved (because they raise the capacity charges), and non-transit combinations used the refuse-school electricity charge assumptions. The payback periods for these combined fleets are shown in figure 11.

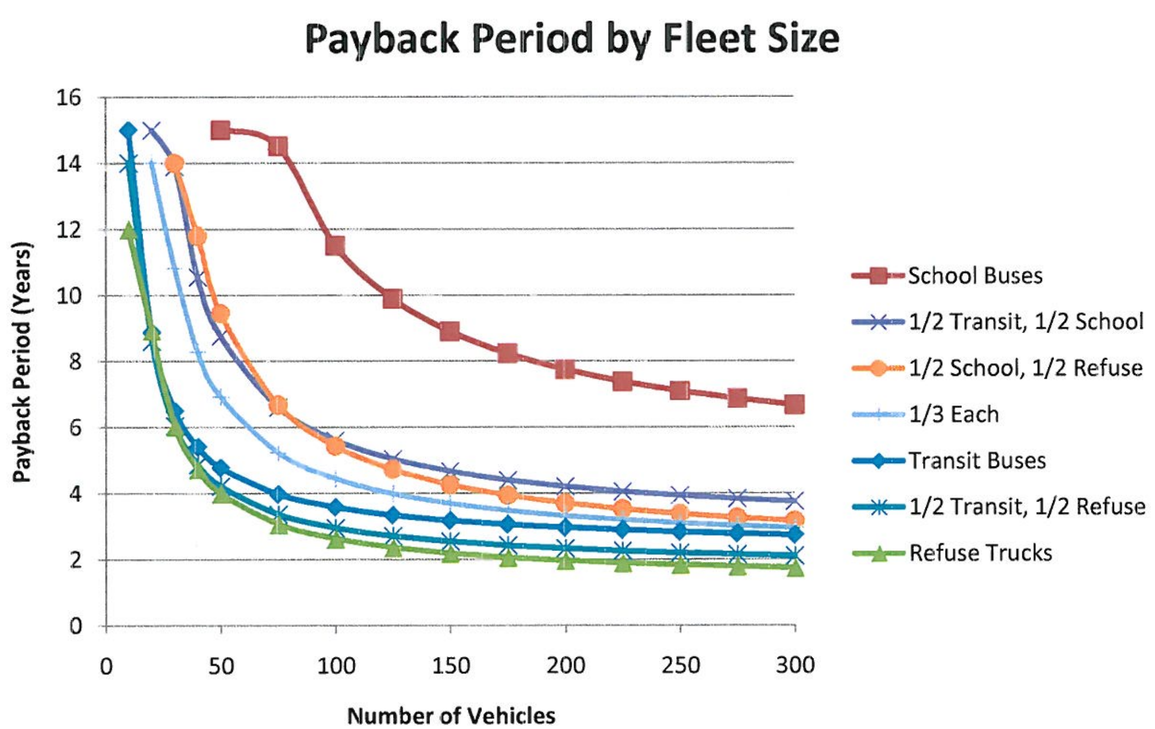

Figure 11. Payback period by fleet size for main and combination fleets

The most conspicuous feature of Figure 11 is how much a school bus fleet's economics improve by combining with a transit or refuse fleet. The payback for a fleet of 100 is 2.9 years if a school has combined with a refuse fleet, compared to 11.5 years if they don't combine.

A second important point to be learned from Figure 11 is that the combined fleets' payback periods are always less than the midpoint between the two fleets. This means that combining the fleets tends to capitalize on the relative economic advantages of each fleet while minimizing each fleet's disadvantages. This advantage holds for the fleet that combines all three vehicle types and has payback periods well below the weighted average of the three individual fleets.

What happens as my vehicle efficiency changes?

CNG vehicles are generally less efficient than diesel vehicles when compared on a BTU (or DGE) basis. However, this drop in efficiency varies widely, depending on the specific engines and vehicles being compared. Furthermore, this drop is being reduced as CNG technology improves and as diesel engines strive to comply with new emissions standards. It is plausible, but unlikely, that some fleets could compare vehicles where the CNG vehicle is more efficient than its diesel counterpart.

To test the effect of this efficiency change in CNG fleets, NREL ran the VICE model with varying assumptions in the diesel-to-CNG efficiency change. The results are shown in Figure 12, where a negative efficiency change means that the CNG vehicle is less efficient than the diesel vehicle. This efficiency change was found to not have much effect on the transit and refuse fleets—on average, a 10% improvement in relative efficiency reduced the payback period by 0.43 years. Efficiency change had more of an effect on 100-school bus fleets, where a 10% increase in efficiency subtracted 1.2 years off the payback period. The change had no effect on 50-school bus fleets because none of them had a payback period of less than the project life.

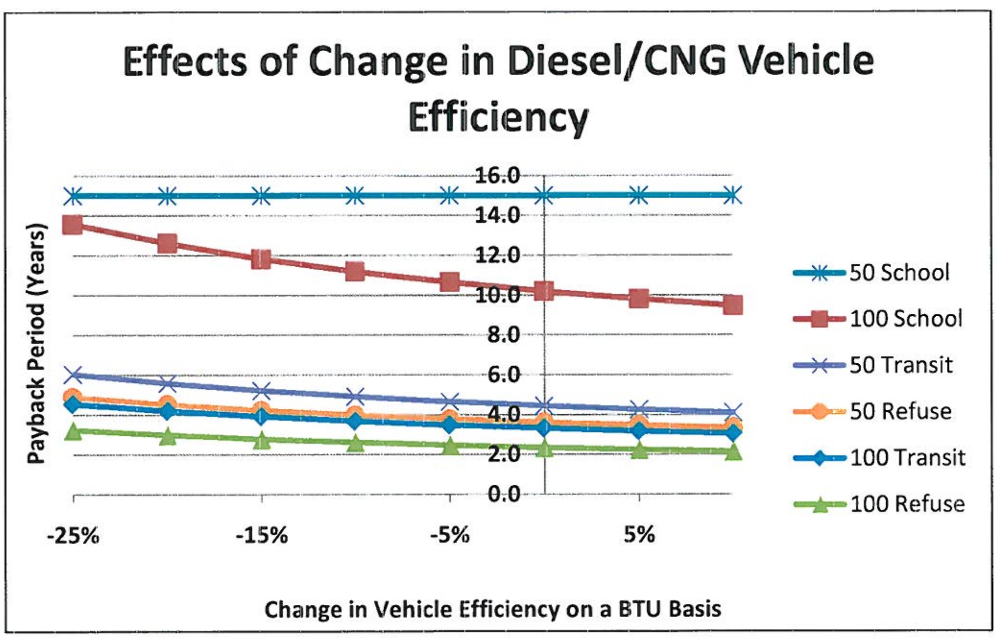

Figure 12. Effects of a change in diesel/CNG vehicle efficiency

What if the $0.55/DGE, 80% vehicle incremental cost, or $50,000 station tax credit is taken away or not passed along?

The base case takes into account government subsidies that encourage the use of CNG. These include a $0.50 credit for every GGE ($0.55 per DGE) purchased, a credit to cover 80% of the incremental cost of a CNG vehicle, and a credit of $50,000 for installing a CNG station. These are tax credits that, as discussed in the model parameters section of this report, are supposed to be made accessible to tax-exempt entities through certificates and pass-alongs. However, they are often not made available to the fleet. Table 3 shows what happens if these credits are not made available.

Table 3. Payback Period (Years) with Various Tax Credits Missing

Fleet (100 Vehicles)	All Credits	No Fuel Credit	No Vehicle Credit	No Station Credit	No Credits
Transit Buses	3.6	5.9	5.5	3.6	9.1
School Buses	11.5	≥15.0	≥15.0	11.8	≥15.0
Refuse Trucks	2.6	4.6	4.8	2.7	7.8

Note that taking away the two tax credits from the transit (or refuse) scenario only increases payback period 4.2 (2.3 + 1.9 + 0.0) years independently, yet they increase 5.5 years combined. Therefore, there are synergies between the three tax credits that result in additional benefits, making it important to consider the relationships between tax incentives when evaluating the benefits of them. It is also important to note that taking either one of the first two tax credits away makes school projects not pay off.

What if I have to pay fuel excise taxes on diesel but not CNG?

The base case assumes that a fleet pays the same excise tax on diesel as on CNG. However, this is not always the case. Fleets might refuel at various private diesel stations where they have to pay excise taxes while their future CNG station would be tax-free. There are also cases where a tax-paying entity (such as a contractor) gets state tax breaks for CNG but not diesel. Table 4 shows how this lopsided taxation decreases the payback period for CNG projects by over 20% for all three fleets.

Table 4. Payback Period for 100-Vehicle Fleet

Fleet Type	Both Fuels Exempt	Only CNG Exempt	% Reduction
Transit Buses	3.6 years	2.8 years	22%
School Buses	11.5 years	9.0 years	22%
Refuse Trucks	2.6 years	2.0 years	23%

How does vehicle life affect my project economics?

The VICE model sets project duration to the same length as vehicle life, so a change in vehicle life essentially influences how much fuel is used over the course of a project. The model found, however, that a change in vehicle life had only a small effect on project profitability. As vehicle life changed from 10 years to 20 years, the ROR for 50-vehicle transit and refuse fleets increased less than 4%. A 50-vehicle school fleet showed the greatest improvement with an 11% increase in ROR over the same range of vehicle life.

Changes in Upfront Costs

Many profitability questions focus on upfront costs because these are the costs that need to be paid back for the ROI, NPV, or payback period to be acceptable to the fleet manager.

What happens if the price of my station changes?

Station prices vary widely depending on location, specific fleet requirements, lot characteristics, and many other factors. To test the effect of this variation on project economics, NREL modeled three CNG projects with baseline cost, baseline +50%, and baseline -50%. The school and refuse stations are shown in Figure 13; transit is not shown because it was so similar to refuse that it obscured the curves.

Figure 13 reveals the effects of changing the station cost, such as:

- The influences of increasing/decreasing 50% are symmetrical. Increasing the station cost 50% has an equal and opposite effect on payback years as decreasing it 50%.
- The school bus fleet is much more sensitive to changes in station cost than the other fleets. A 50% reduction in cost reduces payback by 4.9 years in a 75-bus fleet and 1.7 years in a 300-bus fleet.
- In the refuse fleet, a 50% reduction in cost reduces the payback period by less than a year if the fleet is over 100 buses. It can make up to a 4-year difference in very small (20-truck) fleets.

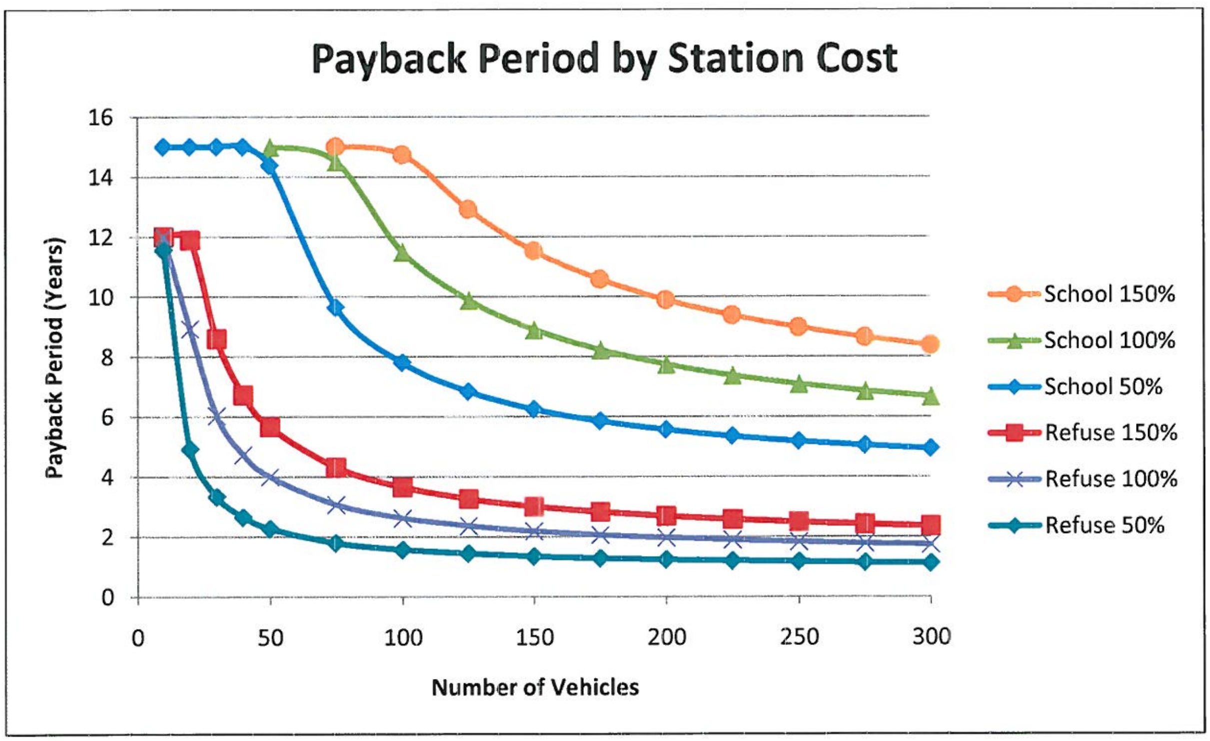

Figure 13. Payback period by station cost

What happens as my vehicle incremental cost changes?

There is a distinct possibility that manufacturing efficiencies will decrease the cost of a CNG vehicle or that 2010 emissions requirements will increase the cost of a diesel vehicle. Either of these events would reduce the incremental cost of a CNG vehicle (over a diesel vehicle). There is also a possibility that the CNG vehicle purchased by your fleet has a higher incremental cost than the averages used in the base case. To explore the impact of these scenarios on project profitability, NREL modeled one case where the incremental cost of a CNG vehicle is zero, one scenario where it is at the baseline, and one where it is double the baseline. The results are shown in Figure 14.

For both fleets shown in Figure 14, the base-case line is much closer to the zero-incremental-cost line than it is to the double-incremental-cost line. This is largely due to the fact that incremental costs are displaced by the tax incentive up to approximately the base incremental cost. Beyond the base incremental cost, the government's incentive helps very little because it caps out when the incremental cost is greater than $40,000.

The doubling of incremental costs is particularly damaging to the school bus fleet for two reasons. Foremost, each bus uses less fuel over its lifetime, so there is less opportunity for fuel cost savings to make up for this cost. Secondly, the baseline incremental cost is slightly more expensive for a school bus than for a refuse hauler.

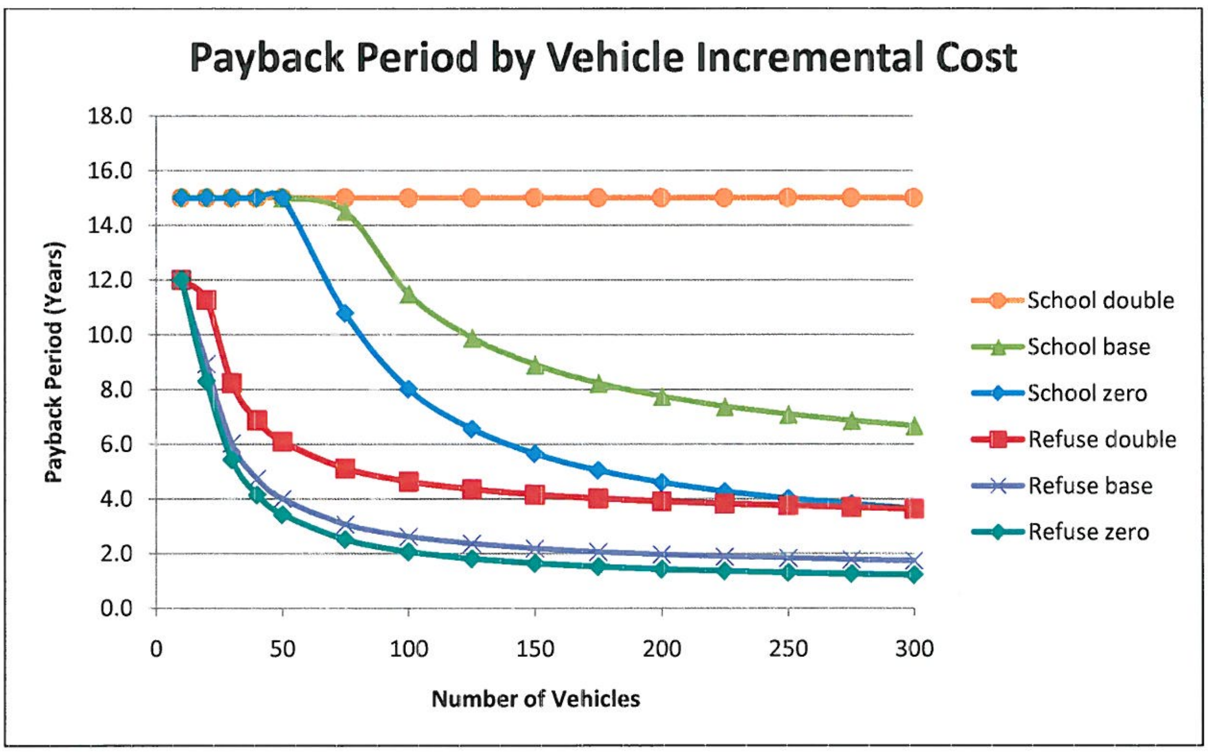

Figure 14. Payback period by vehicle incremental cost

What if I receive a grant from the Federal Transit Administration?
The Federal Transit Administration (FTA) offered grants for transit buses in urban areas through its Urbanized Area Formula Program and Clean Fuels Grant Program. The funding for these programs has recently expired but is expected to resume through upcoming legislation. The grants are expected to pay for 80% of the cost of a diesel bus and 83% of the cost of a CNG bus to those eligible recipients. This funding scenario results in the CNG buses actually being $2,700 less than the diesel buses in the VICE model. FTA grants nullify the previously mentioned vehicle tax credit, so those were not factored into the cost. When this scenario was modeled, it reduced the payback period for transit buses by approximately 1.6 years for all fleet sizes over 10 vehicles, as shown in Figure 15.

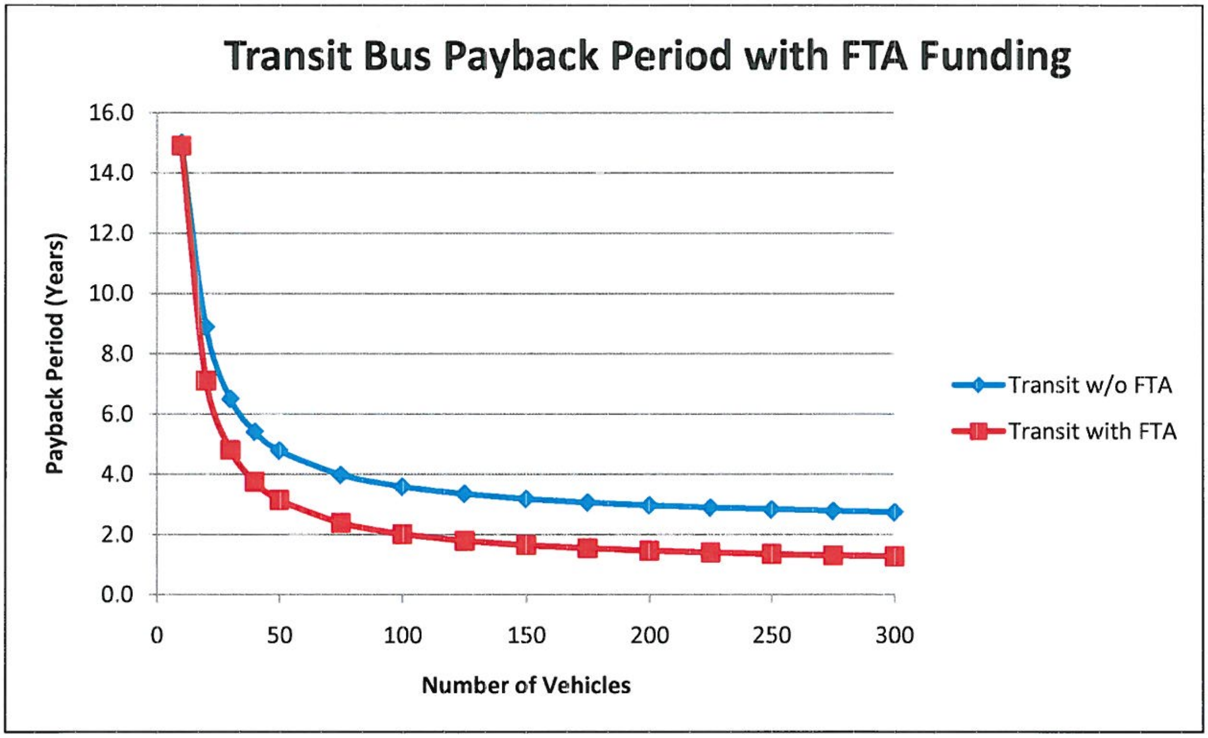

Figure 15. Payback period of a transit bus with and without FTA funding

What happens as I have more or less time to refuel?
A fleet's refueling window (the time in which vehicles are available to refuel) increases if the fleet's schedule is more relaxed or staggered. This staggering usually increases as the station's fleet is diversified by serving different types of vehicles or by opening to the public.

To test the impact of an increased refueling window, NREL ran the VICE model with identical fleets of refuse trucks being refueled by stations with a 6-hour and 12-hour refueling window. The stations were automatically sized, equipped, and priced to accommodate their respective refueling windows. As shown in Figure 16, the CNG project with the 12-hour refueling window provided an increasingly larger ROR as the fleet size increased.

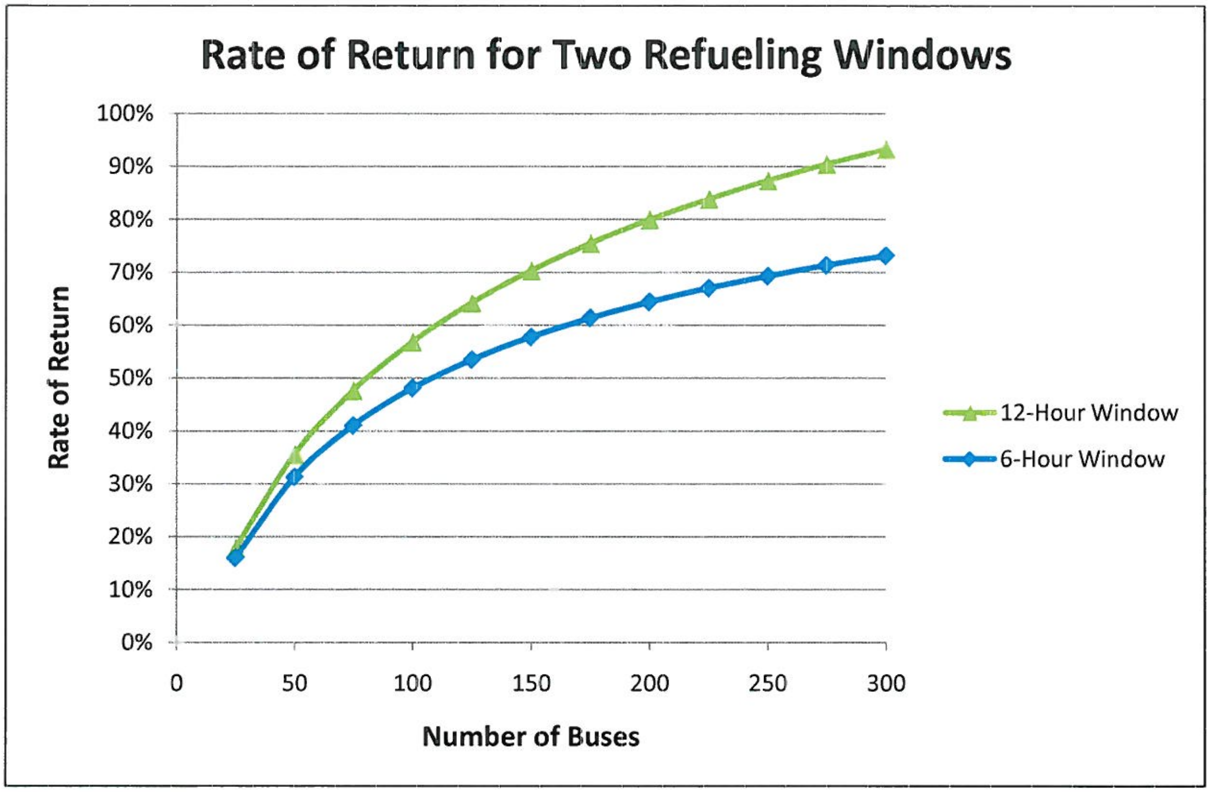

Figure 16. Rate of return for a 6-hour and 12-hour refueling window

What if I have to upgrade my garage?

Some garages are not equipped to store CNG vehicles. Upgrades to the garage are part of the upfront costs for the fleet, such as infrastructure. The cost to retrofit a garage varies widely, as explained by Adams (2006). In one scenario, a garage required a gas-detection system that cost $3,750 per bus plus $40,000 for a control panel. The VICE model indicated this garage cost had no significant impact on transit and refuse fleets. However, it increased the payback time to school fleets 1.8 years to 2.3 years depending on the size of the fleet.

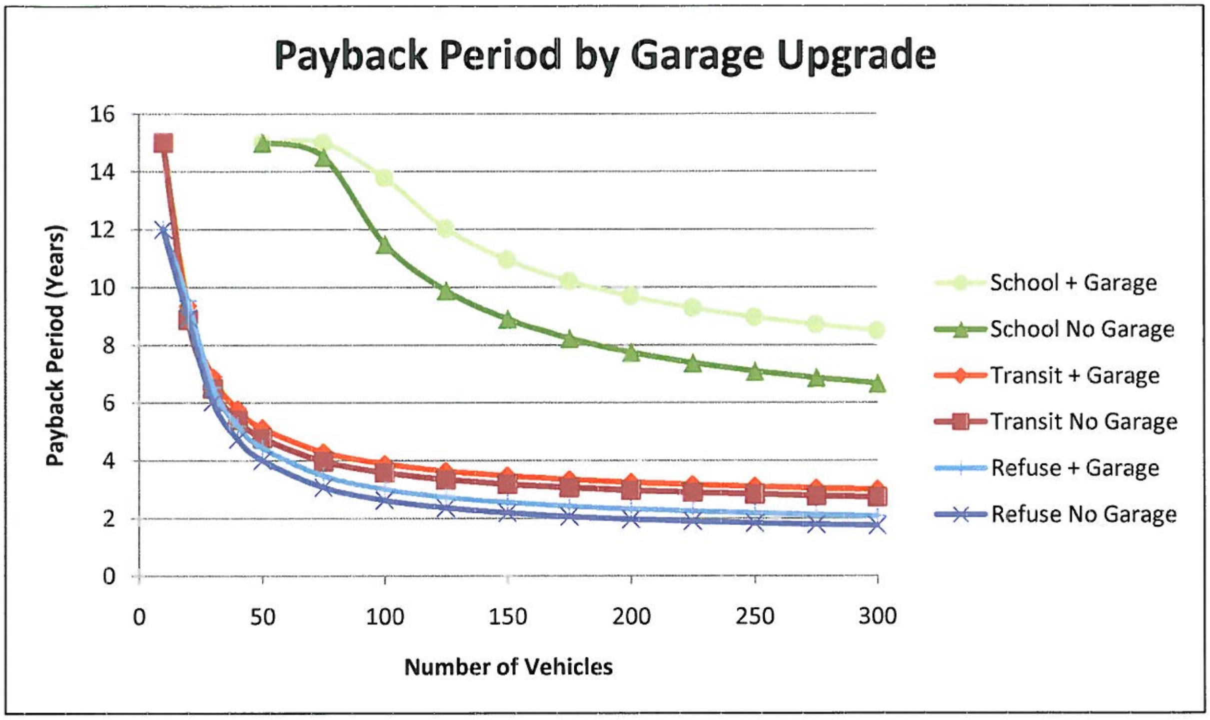

Figure 17. Payback period by garage upgrade

Changes in Operating Costs

What happens if my vehicle maintenance costs change?

Switching to CNG can increase or decrease maintenance costs, depending on the particular vehicle, application, and mechanic (Lemmons 2009). NREL models both scenarios by setting both CNG and diesel maintenance costs equal (at $0.50 per mile), then increasing CNG maintenance cost to $0.75 per mile (150%), and then decreasing them to $0.25 per mile (50%).

Figure 18 shows that a 50% change in vehicle maintenance cost makes a big difference in project profitability. These costs are tracked on a per-mile basis, so they quickly add up to some very large costs in fleets where there are a lot of miles driven. This is one of the few costs that, by changing up or down 50%, can make a school CNG fleet more profitable than a refuse fleet. This is also one of the few costs that can make a school project not pay off no matter how large the fleet is. So school bus fleets that travel a lot of miles realize more cost benefits from CNG.

Notice that the 100% line is much closer to the 50% line than the 150% line, which indicates a given reduction in maintenance costs has a larger impact on project economics if the starting CNG maintenance cost is greater than the diesel maintenance costs.

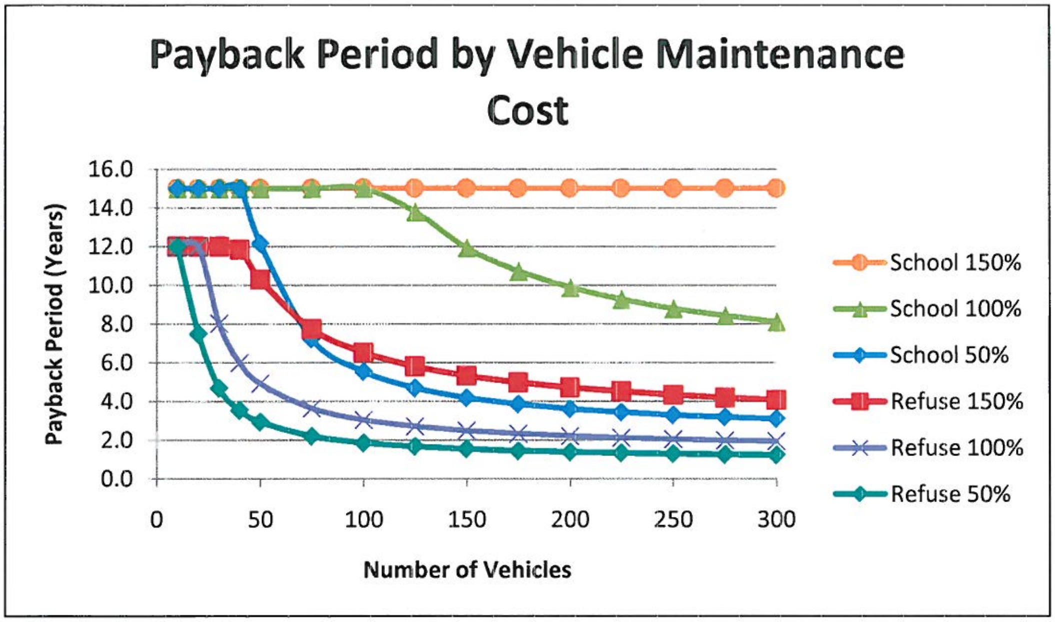

Figure 18. Payback period by vehicle maintenance cost

What if I have to hire a hostler or attendant?

The VICE model's baseline assumes that fleets will not encounter additional staff costs when they switch from diesel to CNG. However, numerous circumstances can contribute to the need for more hostlers or attendants at the CNG station. There is also a case where a fleet can eliminate hostlers if they use slow-fill. To test the effect of hiring or firing personnel, NREL ran the model from a two-hostler reduction to a four-hostlers addition and looked at how that affects the number of vehicles a fleet needs for a 7-year payback. The results are shown in Figure 19.

The hostler is assumed to cost $24 per hour when benefits are added. He is assumed to work an 8-hour shift 5 days a week, and additional refueling is done by the drivers before or after their routes. Therefore, the addition of a hostler costs school and refuse fleets $4,200 per month or about $50,000 per year.

For the transit and refuse fleets, each hostler required 4 additional vehicles to pay himself off in 7 years. Because both of these numbers are less than a hostler can handle, these fleets should never limit their number of CNG buses based on what their current staff can handle. It seems to be a sound decision to increase staff to accommodate as many CNG vehicles as possible.

Each hostler for a school fleet required 55 additional buses. Therefore, it would only make sense to hire an additional hostler if he can service 55 buses or more.

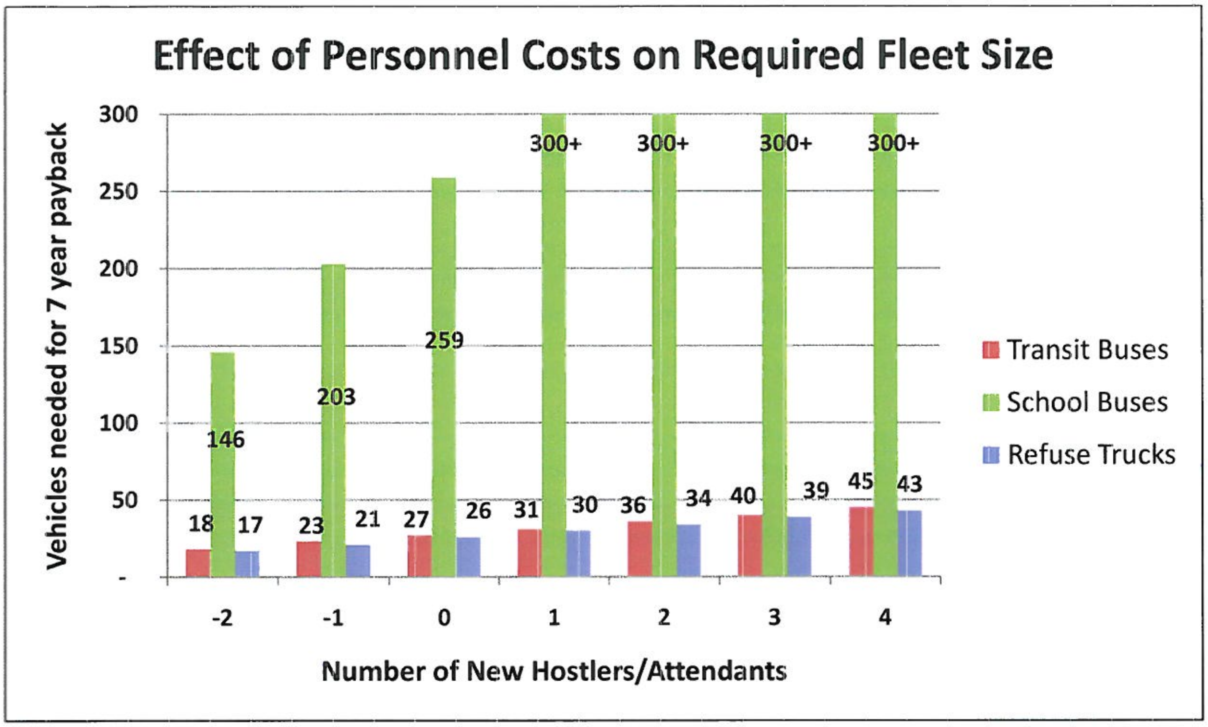

Figure 19. Effect of personnel costs on required fleet size

What if I open my refueling station to the public?

Opening a refueling station to the public changes the project economics in a number of ways that are listed below. There is too much variability to model all of these factors in one scenario, but each factor was modeled independently in response to questions earlier in the report.

1. Many project grants are tied to the station opening to the public. This is the same as if the upfront station cost was reduced, as modeled for this question: "What happens if the price of my station changes?"
2. Excess capacity may be added to the station to accommodate public vehicles refueling at the same time as the primary fleet. Other equipment such as card readers may also be necessary. These both add to the upfront cost, which is also modeled in the "What happens if the price of my station changes?" section.
3. The refueling window might need to be expanded to accommodate public vehicles. Increased refueling windows were modeled when answering this question: "What happens as I have more or less time to refuel?"
4. The number of attendants must be increased to facilitate sales to the general public. This increase is also modeled in the "What if I have to hire a hostler or attendant?" section.
5. Opening to the public will likely increase wear and tear on station equipment. This increase is explored under this question: "What if my maintenance costs increase or decrease?"

6. A profit can be made on each GGE of CNG sold to the public. The profit on each gallon affects the firm's finances the same as if the price of diesel went up so the firm saved more money on each gallon of CNG used. This impact is very significant, as shown in the "What will a change in diesel prices do to my payback period?" section.

How do electricity prices change my project economics?

Not much. Increasing electricity prices 50% increased the payback period a maximum of 0.7 years (for a 100-bus school fleet) or 0.5 years (for a 20-truck refuse fleet).

How do station maintenance costs change my project economics?

Maintenance costs affect project economics more than electricity prices, but they are still not very influential. Increasing maintenance costs 50% increased payback time for a 100-school bus fleet by 2.7 years and a 300-school bus fleet by 0.7 years. The same cost increase resulted in one additional year to pay back for a 30-truck refuse fleet and only 0.1 additional years to pay back a refuse fleet of 125 or more trucks.

Conclusions

As with all fleet projects, predicting whether a project is financially sound is challenging but critically important. Decisions made on equipment purchases, capital upgrades, and fuel contracts have long-term impacts on the operational success of the fleet. NREL has modeled the impact of these decisions and other fleet parameters with its VICE model and analyzed fleet projects. When these parameters are compiled as a fleet, the fleet can be classified as "Resilient," "Marginal," or "No-CNG." Resilient fleets tend to use a lot of fuel and are profitable enough to be resilient to multiple changes in fleet parameters. Marginal fleets are profitable but can quickly become unprofitable if parameters change. No-CNG fleets are ones for which CNG would be an unprofitable proposition.

Larger transit and refuse fleets (75+ vehicles) tend to be profitable and resilient to variations in project parameters. This is because the miles driven by the fleet overall use enough fuel to magnify the benefits of the lower-price CNG to offset the entry costs of CNG (vehicle incremental costs and infrastructure costs). Their payback period only rises above 5 years when diesel drops below $2.25/gallon, vehicle incremental costs are doubled, CNG vehicle maintenance costs increase 50%, VMT drops below 26,000 miles/year (transit) or 14,000 miles a year (refuse), vehicle incremental costs are doubled, or when these factors combine.

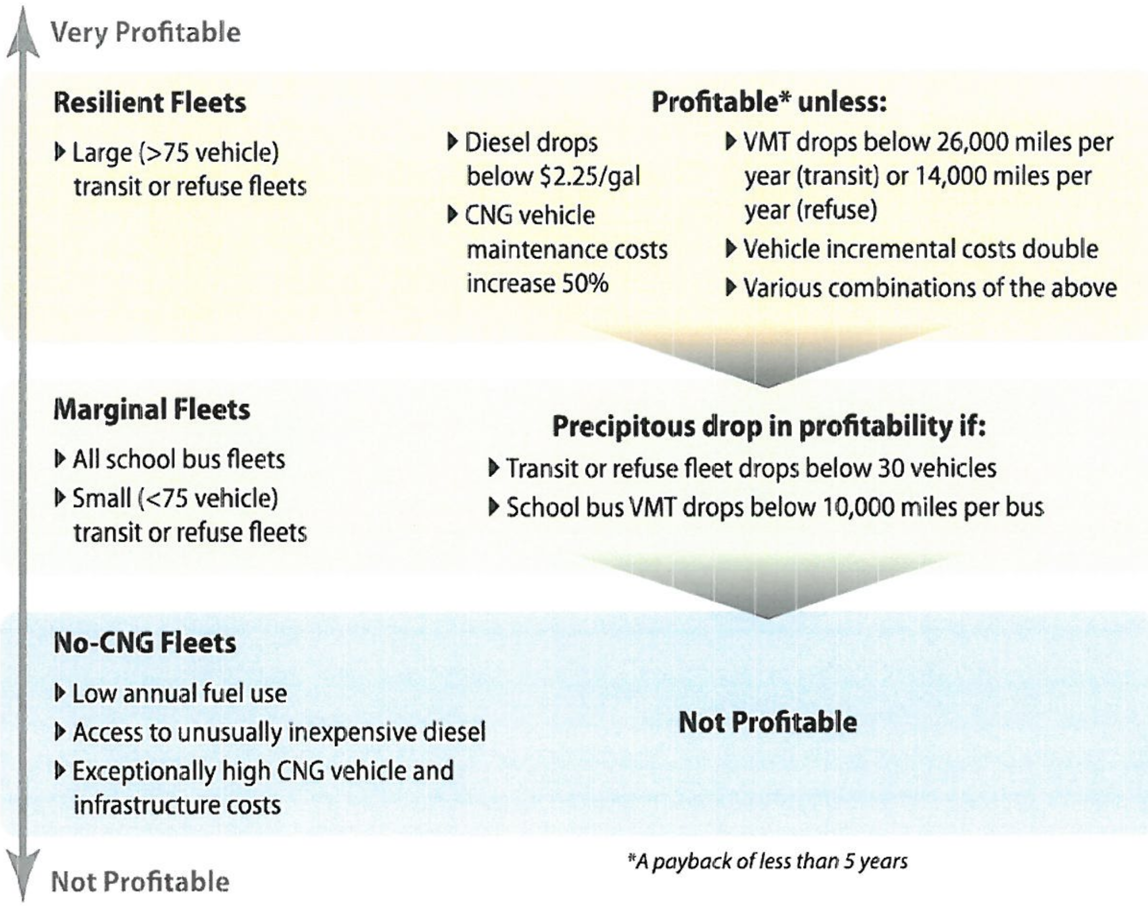

Figure 20. Largest factors affecting the profitability of marginal and resilient fleets

In general, school fleets and small transit/refuse fleets tend to be marginal. Marginal fleets are heavily influenced by many factors, but their profitability drops precipitously if the number of transit/refuse vehicles drops below 30. School fleets have no clear cutoff point for the number of buses, but their profitability deteriorates rapidly if the VMT drops below 10,000 miles per bus because of the overall low fuel use of the fleet.

Fleet type makes a large difference in profitability. At any given fleet size, refuse projects are slightly more profitable than transit projects, and both are much more profitable than school buses. Mixed fleets are more profitable than the mid-point between the individual component fleets, which is particularly helpful for school buses.

Diesel prices are a powerful indicator of profitability given that natural gas prices are relatively consistent. A school bus project appears to only make economic sense once diesel prices approach $4/gallon for 100-bus fleets and $5/gallon for 50-bus fleets. For transit and refuse fleets, the size and fleet type become increasingly irrelevant as the price of diesel increases past $2.50. For prices below $2.50, larger fleets are favored, and refuse fleets are favored over transit. Our current diesel price of $2.56 is on a transitional point of the payback curve for transit and refuse fleets. If diesel prices stay where they are or rise, project economics look resilient, and if they fall, the economics look marginal.

Per-vehicle VMT is almost as strong an indicator of profitability as the number of vehicles for school fleets. However, VMT is not a relevant factor in transit or refuse fleets unless their VMT is reduced to 1/3 of the average fleet's VMT.

Project success is very sensitive to vehicle maintenance costs. Doubling these costs increases the payback period of the least-sensitive fleet from 1.7 years to 3.3 years. Doubling them can also make a school project not pay off no matter how large the fleet is.

An increase in vehicle incremental cost has a large effect on project profitability. A reduction in incremental cost has a much smaller impact on profitability because most of the amount up to the base case was subsidized by the government, and very little of the amount over the base case is subsidized.

Tax issues have a strong influence on profitability. There are synergies with the vehicle and fuel tax credits, so together, they reduce the payback period of a project more than the sum of both of their impacts. Taking either one of the tax credits away makes school projects not pay off. If a fleet has to pay taxes on diesel but not CNG, their payback period is reduced by 22%.

The cost of the station has a significant influence on the profitability of marginal projects. In general, a 50% increase in station cost results in a 30% increase in payback years. This could be make-or-break for many school fleets and smaller (<50 vehicle) transit and refuse fleets.

Factors that don't have much effect on project profitability over the range tested are:

- Efficiency difference between CNG and diesel engines (-25% to +10%)
- Change in vehicle/project life (10 years to 20 years)
- Electricity prices (50% and 150% baseline)
- Maintenance costs for CNG station (50% and 150% baseline)
- Garage upgrade (for minimal-upgrade scenario)
- Number of new attendants/hostlers (-2 to +4 personnel).

These conclusions were derived from testing parameter changes on what NREL deemed a common or average fleet. Synergies between these parameters were not tested and could have surprising effects. To account for these synergies and the specific operating conditions of individual fleets, we encourage fleet managers to use the VICE model when it is posted on the Alternative Fuels and Advanced Vehicles Data Center (www.afdc.energy.gov/afdc/) or to have a CNG infrastructure contractor do an individual assessment of their fleet.

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Glossary and Acronyms

Capacity charge—Also termed "demand charge," it is the charge that an electric utility charges a customer to be ready to meet the customer's demands immediately. It is therefore dependent on how quickly the customer pulls electricity out of the grid.

Compressed natural gas (CNG)—A gas, consisting primarily of methane, that is compressed to allow more energy to fit into a smaller fuel tank.

Diesel-gallon equivalents (DGE)—The amount of energy that is in 1 gallon of diesel fuel. This is larger than a GGE.

Federal Transit Administration (FTA)—An agency within the United States Department of Transportation (DOT) that provides financial and technical assistance to local public transit systems.

Gasoline-gallon equivalents (GGE)—The amount of energy that is in 1 gallon of gasoline. CNG is typically measured in this unit.

Hostler—A person who refuels, cleans, and performs regular maintenance for a fleet of buses or trucks at the end of the day.

Net present value (NPV)—The difference between the present value of cash inflows and the present value of cash outflows. All present-value cash flows have been discounted so that recent flows are worth more than future flows.

National Renewable Energy Laboratory (NREL)—One of the U.S. Department of Energy's 16 national laboratories, NREL is the primary laboratory for renewable energy and energy efficiency research and development.

Rate of return (ROR)—The gain or loss on an investment over a specified period expressed as a percentage increase over the initial investment cost (investopedia.com).

Refueling window—The period of time in which vehicles are available to refuel.

Vehicle-miles traveled (VMT)—The number of miles traveled by 1 vehicle in 1 year.

Vehicle and Infrastructure Cash-Flow Evaluation (VICE) model—An NREL-built model that assesses the profitability of investing in alternative fuel infrastructure under for various fleets. NREL plans to expand the VICE model to assess more fuels than CNG.

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14. ABSTRACT *(Maximum 200 Words)*
This report describes how NREL used the CNG Vehicle and Infrastructure Cash-Flow Evaluation (VICE) model to establish guidance for fleets making decisions about using compressed natural gas.

15. SUBJECT TERMS
compressed natural gas; CNG; municipal fleets; CNG Vehicle and Infrastructure Cash-Flow Evaluation model; Vehicle and Infrastructure Cash-Flow Evaluation; VICE; VICE model

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Attachment I

US Energy Information Administration

Sector and Fuel	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Motor Gasoline 4/	2.352	2.756	3.499	3.429	3.425	3.645	3.812	3.918	4.041	4.143	4.246	4.358	4.461	4.555	4.677	4.8	4.946	5.081	5.172	5.312	5.477	5.644	5.86	6.084	6.081	6.198	6.388
Diesel Fuel (distillate fuel oil) 6/	2.445	2.998	3.879	3.876	3.592	3.872	4.069	4.196	4.329	4.454	4.552	4.667	4.79	4.91	5.037	5.167	5.348	5.498	5.592	5.751	5.931	6.119	6.39	6.65	6.662	6.789	7.029

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NEPI
National Energy Policy Institute

NEPI Working Paper

What Set of Conditions Would Make the Business Case to Convert Heavy Trucks to Natural Gas? – a Case Study

Anna Lee Deal

May 1, 2012

Abstract

Benefits to national security, the trade deficit, and the environment of a nation that uses natural gas trucks are attractive to society, but it is the trucking industry who would make the capital investment and take on the risk of this transition. We ask the question: "What set of conditions would make the business case to convert to natural gas trucks?" As a case study, we developed a financial model that takes into account the economic and operational factors of converting a heavy truck fleet to compressed (CNG) and liquefied (LNG) natural gas. Lynden Inc,. a Pacific Northwest - Alaska based trucking company, participated in this process and provided financial modeling and operational insight from a trucking industry perspective. This paper provides a detailed overview of what it means to run heavy trucks on natural gas and a summary of the economic and operational factors that a trucking company must consider. We modeled for three of Lynden's operations: pick-up and delivery (CNG), farm pick up (CNG and LNG), and line haul (LNG spark and HDPI engines) to look for the minimum number of annual miles per truck needed for an investment in natural gas trucks to be economically attractive. At today's fuel prices, conditions are right for many high mileage (>70,000 miles per truck per year) fleets to begin testing natural gas trucks where fuel is available. If those tests are successful, then fleets will begin to purchase new natural gas trucks as old diesel trucks are retired. Some significant barriers still remain to the mainstream adoption of natural gas trucks, but barriers related to fueling infrastructure and available engines are beginning to see major breakthroughs. Policy incentives that address remaining barriers can help accelerate this transition and make natural gas attractive to lower mileage fleets.

Summary

This is an exciting time for heavy-duty natural gas trucks. Refueling infrastructure is finally beginning to be developed, the price differential between natural gas and diesel has reached a tipping point where running natural gas is now profitable for high mileage fleets, and a higher powered spark-ignited engine that will fit a much larger number of heavy truck operations will soon be available.

Policy makers, the trucking community, and environmental groups share a common interest in running heavy trucks on natural gas for three compelling reasons:

1. Natural gas will remain less expensive and less volatile than diesel for the foreseeable future.
2. Natural gas is domestic and abundant. This benefits national security and reduces the trade deficit.
3. Natural gas is cleaner burning and emits fewer greenhouse gas emissions than diesel.

This is an attractive possibility for society, but it is the trucking industry that would make the capital investment and take on the risk of this transition. This paper asks the question, "What set of conditions would make the business case to convert heavy trucks to natural gas?" We address the risks and rewards of converting a heavy truck fleet from diesel to natural gas from the point of view of a trucking company.

As a case study, Lynden Inc., a Pacific Northwest-Alaska based trucking company, has participated in this process to provide financial modeling and operational insight from a trucking industry perspective.

This paper provides a detailed overview, as well as the pro's and con's, of what it means to run heavy trucks on compressed (CNG) and liquefied (LNG) natural gas, including the physical properties of natural gas as a fuel, fuel tanks, available and future engines, refueling options, maintenance, and safety requirements.

There are a number of economic and operational factors that a trucking company must consider when deciding whether or not to convert a fleet of diesel trucks to natural gas. We address the current and future price of fuels, additional cost of natural gas trucks, reduced fuel economy of engines, reduced operating range, additional weight of natural gas trucks, LNG venting and tank issues, limited engine options, maintenance costs, safety upgrades for maintenance shops, and limited refueling infrastructure.

We developed a financial model that takes into account fuel price, annual miles per truck, payload, fuel economy, operating range, maintenance costs, and the additional weight and cost of a natural gas trucks for three of Lynden's operations: in-city pick-up and delivery (CNG), milk tanker farm pick-up (CNG and LNG), and line-haul (LNG spark-ignited and HDPI engines). We did not include upgrades to maintenance shops because costs and options to outsource maintenance vary greatly.

Based on the model, we estimated the minimum number of miles required to generate a 20% Return On Investment for each scenario at varying diesel fuel prices ($3.50, $3.75, $4.00, and $5.00/ gallon) while keeping natural gas prices consistent ($2.50/ Diesel Gallon Equivalent).

Since 2010, the price of natural gas ($2 to $5 per mcf) has dropped to roughly one quarter the price of oil ($80 to $120 per barrel) on an energy equivalent basis. At these prices, where natural gas is approximately $1.50/ DGE less expensive than diesel at the pump, the line haul and farm pick-up LNG operations required a minimum of around 70,000 miles per truck per year using a spark-ignited engine and 140,000 miles for the HDPI engine to reach a 20% ROI. Pick-up and delivery operations that are not weight sensitive, required only 60,000 miles per year.

Not surprisingly, at lower priced diesel, the minimum number of miles required for an attractive ROI, increases. Once the price differential decreases to $0.75 per DGE, natural gas becomes impractical because the number of miles required to be profitable exceeds the number of miles that can be driven in a year.

At the other end of the spectrum, when diesel is \$2.50/ DGE more expensive than natural gas, natural gas becomes an attractive option for fleets traveling 30,000-40,000 miles per year (70,000 miles for the HDPI engine). At these prices, the model was much less sensitive to differences in the additional weight and price of natural gas trucks.

Based on this model, conditions are right for many high mileage fleets to begin testing natural gas trucks where fuel is available in the next few years, even without government subsidies. If those tests are successful (i.e. trucks are profitable and reliable), then fleets will begin to purchase new natural gas trucks as old diesel trucks are retired. This is likely to be a gradual process as fleets learn to navigate the remaining barriers:

1. **Limited fueling infrastructure** means a loss of flexibility for "go anywhere" fleets to meet customer needs. Operating range is limited by the tanks that can fit on a truck at an economical price and reasonable weight. Until infrastructure is widely available, fleets will be limited to centrally-fueled operations and routes where fuel is available.
2. **Limited engine options**. Available engines are either too small (8.9L spark) or too expensive (15L HDPI) for most operations. However, larger spark-ignited engines that can meet the needs of many long-haul fleets will be available soon.
3. **Natural gas trucks are more expensive,** mainly because of the specialized high pressure or super-insulated fuel tanks. This is a significant barrier to fleets and owner-operators with limited access to capital.
4. **The high cost of upgrading a maintenance shop** can make an investment in natural gas trucks considerably less attractive. Full service leases and maintenance packages are available, but this is not always practical for fleets in rural areas and is generally less desirable than performing maintenance "in-house."
5. **LNG use is limited to operations where trucks are refueled every 1-2 days** so that venting of fuel is not an issue.
6. **Additional weight of fuel tanks** detracts from available payload and revenue. This is a concern for fleet managers who are constantly looking for ways to reduce weight.
7. **Fleets are apprehensive about new technology.** It takes time to learn about and carefully test a new kind of truck and fuel.

Interest from fleets is likely to increase in the first quarter of 2013 as two primary barriers, lack of refueling infrastructure and limited engine options, see major breakthroughs. Policy incentives that address remaining barriers can help accelerate this transition and make natural gas attractive to lower mileage fleets.

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List of Figures

Acknowledgements

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What Set of Conditions Would Make the Business Case to Convert Heavy Trucks to Natural Gas? – a Case Study

1. Introduction

There is a great deal of interest in running heavy trucks on natural gas from the trucking industry, policy makers, and environmental groups. However, there are some significant barriers to its mainstream adoption.

Running heavy trucks on natural gas is appealing for three main reasons.

1.) **Natural gas will remain less expensive and less volatile than diesel for the foreseeable future.** Natural gas is approximately $1.50 to $2.00 per gallon less expensive than diesel on an energy equivalent basis. Futures commodity markets for crude oil and natural gas predict that natural gas will remain substantially less expensive than diesel in the future. Natural gas represents a savings of 20 to 25 cents per mile in fuel costs over diesel. Because it is produced domestically, natural gas is not impacted by foreign supply and prices are less volatile. This price savings and stability has caught the attention of the trucking industry where fuel is often the largest expense.

2.) **Natural gas is domestic and abundant. This benefits national security and reduces the trade deficit.** Recent discoveries of shale gas resources have fueled predictions that the U.S. will be a net exporter of natural gas by 2030. If all heavy trucks in the U.S. converted to natural gas, we would reduce oil use by approximately 2 million barrels of oil per day, 12% of total U.S. oil consumption. At $85 per barrel, this translates to reducing our trade deficit by over $150 million per day.

   The National Energy Policy Institute (NEPI) has identified that the transition of heavy trucks to run on natural gas is one of the most cost effective potential energy policies studied. This transition also reduces oil consumption more than any other policy measured.

3.) **Natural gas is cleaner burning and emits fewer greenhouse gas emissions than diesel.** Natural gas burns cleaner than diesel. This allows some natural gas powered trucks to meet EPA 2010 standards for criteria air pollutants (PM and NO_x emissions) without heavy after-treatment emissions systems (e.g. diesel particulate filters and SCR) found on EPA 2010 compliant diesel engines.

   From "well to wheels" natural gas vehicles reduce greenhouse gas emissions by 12-23% (LNG) and 28% (CNG) compared to ultra-low sulfur diesel. Vehicles that use natural gas sourced from landfill gas, wastewater treatment, and farm waste "biomethane" generate 85-90% fewer GHG emissions. The magnitude of this advantage depends on the fuel's source and processing method.

   Natural gas emits fewer greenhouse gases when used as a fuel, however its impact can become detrimental if leaked into the atmosphere where it can be 25 times more potent than CO_2 as a greenhouse gas.

Benefits to both national security and the environment make this an attractive possibility for society, but it is the trucking industry that would make the investment and take on the risk of this transition.

This paper addresses the risks and rewards of converting a heavy truck fleet from diesel to natural gas from the point of view of a trucking company. We ask the question: *"what set of conditions would make the business case to convert heavy trucks to natural gas?"*

As a case study, Lynden Inc., a Pacific Northwest-Alaska based trucking company, has participated in this process to provide financial modeling and operational insight from a trucking industry perspective.

2. What Does it Mean to Run Heavy Trucks on Natural Gas?

Converting a heavy truck (class 8, greater than 33,000 gross vehicle weight) fleet to run on natural gas means adjusting to a new fuel. This section explains the differences between diesel and natural gas fuels and a gives an overview of natural gas heavy-duty tractor trailers, engines, fuel systems, maintenance, and safety requirements.

Natural Gas Fuel Characteristics

Natural gas is composed primarily of methane with smaller amounts of propane, ethane, helium, and water. It is "lighter than air" at temperatures above 160° F. Natural gas is either compressed (CNG) or super cooled (LNG) so that it can be stored in tanks on a truck.

CNG is stored as a gas under high pressure (3,600 psi), which reduces its volume to less than 1/100th of the space it would otherwise occupy. Liquefied natural gas (LNG) is cryogenically cooled to approximately -260° F where it condenses to a liquid that occupies 1/600th the space it would occupy at standard temperature and pressure.

Natural gas contains less energy than diesel on a per gallon basis. When comparing LNG and CNG to diesel, it is often described in terms of diesel gallon equivalent (DGE's) to account for the lower energy content. Figure 1 compares the physical properties of diesel to LNG and CNG.

Property	Diesel	LNG	CNG
Energy Content (Btu/ gal)	128,700	74,700	20,300
Diesel Gallon Equivalent "DGE" (gal)	1 gal	1.72 gal	3.7 gal
Diesel Gallon Equivalent "DGE" (gal)	1 gal	0.23 cu ft	0.49 cu ft
Density (lbs./ gal)	6.8	3	1
Energy Density (Btu/lb)	18,250	28,266	28,266

Figure 1. Natural Gas & Diesel Physical Properties

One gallon of diesel contains 128,700 Btu's, the amount of energy in 135 cubic feet of natural gas.

At atmospheric pressure natural gas would fill a container nearly 1000 times larger than a gallon of diesel to get the same amount of energy. Compressed to 3,600 psi (CNG), the container would be 4 times larger, and cooled to -260 degrees F (LNG) the container would be 1.7 times as large. In other words, to carry the same amount of energy as diesel, CNG tanks take up 4 times and LNG tanks take up 1.7 times as much space.

Natural gas has less energy per gallon than diesel, but it is lighter. The energy density (energy per pound) of natural gas is higher than diesel, however the heavy tanks required to store CNG and LNG offset this energy to weight advantage. Figure 2 summarizes the benefits and disadvantages of natural gas fuels.

Natural Gas Pro's	Natural Gas Con's
Less expensive than diesel on an energy equivalent basis. National Average (October '11): - Diesel: $3.81/ DGE - CNG: $2.33/ DGE - LNG: $2.17/ DGE	New distribution and refueling infrastructure is required.
Prices are less volatile than oil because natural gas is produced domestically and is not impacted by foreign supply.	
Prices are listed in DGE to account for the difference in energy content. - 1 DGE = .23 cu ft LNG - 1 DGE = 6.3 gallons CNG	Contains less energy (Btu's) on a per gallon basis so it requires more space on a truck to get the same range.
Compression-ignited natural gas engines are as efficient as diesel engines.	Spark ignited natural gas engines are less efficient (10%) than a diesel engine.
Cleaner burning fuel allows spark-ignited natural gas to use less expensive, lighter weight after-treatment devices to meet EPA standards.	Natural gas engines are currently limited to few available options (7.6L, 8.9L, and 15L).
Lighter than diesel on a per gallon basis. - energy density (Btu/ pound) is 50% higher	Tanks are heavier.

Figure 2. Pro's and Con's of Natural Gas Fuel Properties.

Fuel Tanks

Fuel storage for natural gas is considerably different from that of diesel and accounts for the bulk of the additional weight and higher cost of natural gas trucks.

CNG is typically stored at 3,600 psi and 70 degrees F. These high pressures require very robust cylinders. The cylinders typically used in heavy trucks are made of a plastic gas-tight container and a full composite wrap in order to optimize weight, however, these tanks are very expensive.

An LNG fuel tank is essentially a giant thermos constructed as a ¼" thick stainless steel "tank within a tank" with a vacuum and super-insulation between the two walls. This vacuum thermos design is intended to prevent ambient heat from entering the tank and causing evaporation of fuel and achieves the highest known thermal efficiency (R value exceeds 5000). LNG is typically stored at near atmospheric pressure, but the tank design must compensate for heat gain and higher pressure when not in use. The inner tank is usually made of nine percent nickel steel and the outer tank is usually made of carbon steel.

Tanks are generally described by their diesel gallon equivalent (DGE) volume. This accounts for the lower energy content of natural gas. "Usable fuel" is less than actual volume because of the need to maintain vapor space in the tank (LNG) and the fact that fuel does not flow below pressures of about 150 psi (CNG). In other words, you cannot use every molecule of fuel in a tank. Figure 3 compares key variables in CNG and LNG fuel systems. Figure 4 summarizes the advantages and disadvantages of CNG and LNG systems.

Fuel	Tank Configuration and Nominal Size	Effective Size[1] "Usable Fuel"	Range[2]	Fuel System Weight (full fuel)	Additional Cost of Fuel System Installed[4]
Diesel	75 gallon	75 DGE	450 miles	1,200 lbs[3]	--
CNG	(5) 15 DGE tanks behind cab	68 DGE	367 miles	2,050 lbs	$27,000
CNG	(2) 41 DGE side mounted	74 DGE	400 miles	1,650 lbs	$35,000
LNG	(1) 119 gallon side mounted	60 DGE	324 miles	1,200 lbs	$22,000
LNG	(1) 150 gallon side mounted	75 DGE	405 miles	1,400 lbs	$26,000
LNG	(2) 150 gallon side mounted	150 DGE	810 miles	2,800 lbs	$45,000
LNG Westport HD 15L	(1) 119 gallon side mounted	58 DGE	365 miles	1,600 lbs[5]	$70,000[6]

Figure 3. Typical CNG and LNG Fuel Systems.

1. Effective size is "usable" fuel in diesel gallon equivalents. This accounts for the vapor space (LNG tanks) and the "heat of compression" and residual fuel at low pressure (CNG tanks) which reduces the amount of fuel that is "usable". Westport GX LNG storage tanks volume is reduced due to pump displacement for 5% diesel mixture.
2. Range assumes 6 mpg for diesel and 10% fuel economy penalty for "spark" natural gas engines. Compression-ignited natural gas engines have approximately the same fuel economy as diesel and account for 5% diesel mixture.
3. Diesel weight includes diesel tank, fuel and after-treatment system (DPF + SCR + Urea Storage with solution = 546 lbs).
4. Does not include Federal Excise Tax (FET).
5. Westport HD weight assumes that 45 gallon diesel tank, hydraulic pump and diesel weigh 400 lbs.
6. Westport HD fuel system includes HDPI engine, hydraulic pump, and fuel tank.

Compressed Natural Gas (CNG) Pro's	Compressed Natural Gas (CNG) Con's
- Infrastructure is more readily available. - Trucks can sit idle for weeks without losing pressure or "venting."	- Space and heavy tanks required to store CNG make this impractical for long distances. - Tanks are heavier compared to LNG.
Liquid Natural Gas (LNG) Pro's	**Liquid Natural Gas (LNG) Con's**
- LNG is more dense than CNG, so is more practical for long distances. - Tanks are lighter compared to CNG.	- Infrastructure is very limited outside of California, but is expanding. - LNG should only be used in applications where the truck is working (and being refueled) daily to avoid warming fuel and "venting."

Figure 4. Pro's and Con's of Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG).

Another important factor to consider when comparing CNG to LNG is the duty cycle. LNG works well in applications where trucks have very little down-time so that new cold LNG is continually added to the system. If a tank sits idle, the gas inside will warm and expand; after about five days it will begin to vent into the atmosphere.

Tank valves are designed to release this pressure, so it is not a safety issue. But this equates to lost fuel and represents an added cost. In addition, the environmental benefits of using natural gas are negated (methane is 25 times more potent as a greenhouse gas than carbon dioxide). CNG tanks do not vent over time because the tanks are designed to contain gas under high pressure.

LNG tank life should exceed the life of the vehicle, however the vacuum will slowly decay over time as gasses diffuse into the tank materials causing the tank to lose some of its super-insulation properties. Once the vacuum within the tank decays to a point where the pressure increases by more than 40 psi over the course of a day, then the tank is no longer considered adequate and needs to be re-evacuated by a competent maintenance facility. This is typically required after the first 4-5 years and every 2-3 years thereafter. The cost is approximately $1,000 per unit and would include other minor parts replacement or refurbishment.

Fuel tanks require visual inspections only. No other maintenance is required over the life of the tank.

Fuel System:

Natural gas is stored as CNG or LNG, but all engines burn natural gas as a vapor.

In a spark-ignited natural gas engine, which can operate on CNG or LNG, the CNG flows from the storage tanks into a fuel line, then into a regulator to reduce the pressure to engine specifications. Delivery of LNG to a spark-ignited engine is provided by the fuel pressure. There are no pumps in the system. When the engine demands fuel the pressurized LNG flows out of the tank toward the engine. The cold pressurized fuel then passes through a heat exchanger, using engine coolant to warm and vaporize the liquid into a gas. From this point on, the process is the same for CNG and LNG. Gas is mixed with air and the exhaust gas recirculation (EGR) system before it is introduced to the intake manifold system and delivers power via a four-stroke internal combustion engine.

In contrast, Westport's compression ignited HPDI (High Pressure Direct Injection) engine uses an engine driven hydraulic pump, located in the fuel tank to move fuel. The pump pressurizes the LNG to about 4,500 psi. The pressurized liquid travels through a heat exchanger, using engine coolant to vaporize the pressurized liquid into a pressurized gas which is then supplied to the engine.

Engines:

The "spark" in a diesel engine comes from the compression of the diesel fuel. Natural gas engines can be either spark-ignited or compression-ignited with pilot injection of diesel fuel. This can be a source of confusion for those learning about natural gas trucks. Figure 5 summarizes advantages and disadvantages of spark-ignited versus compression-ignited engines.

Spark ignited engines use spark plugs similar to a gasoline engine and meet EPA 2010 emission standards using only a 3-way passive catalyst that is lightweight and maintenance free. These engines use "stoichiometric" combustion where the chemically ideal ratio of fuel and air is burned by the engine without any excess of fuel or air left over. Like their diesel counterparts, they are able to use cooled Exhaust Gas Recirculation (EGR) NO_x control where the EGR system takes a measured quantity of exhaust gas, passes it through a cooler before mixing it with the incoming air charge to the cylinder to lower the in-cylinder temperature and reduce oxygen concentration in the combustion chamber by diluting the incoming ambient air with cool exhaust gases. The Cummins-Westport spark ignited engines use EGR, but this is not necessarily true for all spark-ignited engines. They are approximately 10% less fuel-efficient than a comparable new diesel engine due to the lower compression ratio.

Compression ignited engines are virtually the same as a diesel engine, except that they are able to run on natural gas. Westport's HD system injects both diesel (~5%) and the natural gas (~95%) into the combustion chamber of the engine where the diesel ignites under pressure, which in turn ignites the natural gas. These engines operate with LNG only, due to the common rail pressure (constant 4500 psi) required by the engine. Even though these engines operate with 95% cleaner burning natural gas, EPA emissions requirements call for diesel particulate filters (DPF) and liquid urea Selective Catalytic Reduction (SCR) after-treatment to meet 2010 emission standards. This requirement and the additional diesel tank, make this engine system heavier and more expensive than the spark-ignited system. However, these engines maintain the same fuel efficiency as their diesel counterparts.

"Dual-Fuel" is a term that is sometimes inaccurately applied to compression-ignited engines that require both diesel and natural gas. The term was originally used to describe Clean Air Power's "dual-fuel" engine that can run on 70% natural gas and 30% diesel and has the ability to run on 100% diesel. It is currently in use in Europe and is under development for the U.S.

There are currently only two natural gas engines on the market for use in heavy-duty trucks. 1.) the spark ignited Cummins-Westport ISL-G 8.9 L and 2.) the compression-ignited Westport Innovations HD 15L engine. Figure 6 shows engine specifications for these engines compared to their diesel counterparts. ESI- Navistar has a 7.6L spark-ignited engine available today for lighter-duty applications.

There are also a handful of new engines currently under development and being field tested that are expected to be "game changers" by filling the niche for higher-powered, lighter weight spark-ignited engine systems. Among these are spark ignited Cummins-Westport 11.9 L and ESI Navistar 13L engines. Also under development are an ESI Navistar 9.3 L spark-ignited engine and the Clean Air Power (CAP) 13L compression-ignited "dual-fuel" engine, which will be able to run on 100% diesel if natural gas is not available. Cummins has also announced that it will be developing a 15L spark-ignited engine. (Figure 7)

Retrofit kits are also available that convert existing diesel engines to run on natural gas (CNG or LNG). Eco-Dual's conversion kit is approved for the 2004-2009 Cummins ISX 15L engine platform. Converted engines use 60-80% natural gas with diesel pilot injection and can default to run on 100% diesel at any time if natural gas is not available.

Spark Ignited Engine Pro's	**Spark Ignited Engine Con's**
No DPF or SCR after-treatment necessary to meet 2010 emission standards - Maintenance Free - Lighter Weight - No diesel tank required - Less expensive - Engine braking capability and manual transmission available with the 11.9 L - Available with CNG or LNG	Lower Compression Ratio means: - Less fuel efficient (7-10%) - Limited options available in the near term (7.6L, 8.9L, 11.9L, and 15L) - Engine braking is currently not available with the 8.9L. - Automatic transmission (8.9L) is expensive. - More frequent maintenance intervals
Compression Ignited Engine Pro's	**Compression Ignited Engine Con's**
Maintains partial attributes of a diesel engine: - Same compression ratio as diesel - Same fuel efficiency as diesel - 475 hp max - Engine braking - Manual transmission options - Same maintenance intervals SCR after-treatment provides 5% better fuel economy over engines without it. Greenhouse gas emissions per mile are lower: - Well-to-wheels reduction compared to ULSD is 25% (HD) vs. 16% (ISL-G LNG).	Heavier system: - Requires diesel after-treatment systems and a diesel fuel tank - After-treatment system ~ 500 lbs - Diesel tank and fuel weighs ~400 lbs Space is required for diesel and diesel exhaust fluid (DEF) tanks, so dual 58 DGE (116 DGE) is the maximum fuel capacity. After-treatment maintenance is required. More expensive than spark-ignited systems ($20,000-$40,000) and $70,000 more than diesel. LNG only. Currently not available with CNG.

Figure 5. Pro's and Con's of Existing Spark-Ignited and Compression-Ignited Natural Gas Engines.

	6.7-7.6 L		ISL-G 8.9 L		ISX 11.9 L		HD 15 L	
	Diesel	Natural Gas	Diesel	Natural Gas	Diesel	Natural Gas*	Diesel	Natural Gas
Manufacturer	Navistar DT466	ESI Navistar Phoenix	Cummins	Cummins-Westport	Cummins	Cummins-Westport	Cummins	Westport Innovations
Displacement	6.7 L	7.6L	8.9 L	8.9 L	11.9 L	11.9 L	15 L	15 L
Ignition	Compression	Spark	Compression	Spark	Compression	Spark	Compression	Compression HPDI
Cylinder Head	4 valve	4 valve	4 valve	2 valve	4 valve	4 valve	4 valve	4 valve
Fuel System	Common rail system	Throttle Body Intake Manifold	Common rail system	Intake manifold	Common rail system	Intake manifold	Common rail system	Common rail system
2010 Emissions Strategy	Particulate Filter and advanced EGR after-treatment	Passive 3-Way Catalyst	Particulate Filter and SCR after-treatment	Passive 3-Way Catalyst	Particulate Filter and SCR after-treatment	Passive 3-Way Catalyst	Particulate Filter and SCR after-treatment	Particulate Filter and SCR after-treatment
Weight (dry)	1,425 lbs.	1,290 lbs	1,850 lbs	1,625 lbs	2,888 lbs	~2,700 lbs	3,286 lbs	3,243 lbs
Horsepower	210-300 hp	300 hp	330-380 hp	260-320 hp	310-425 hp	320-400 hp	400-600 hp	400-475 hp
Peak Torque	520-869 lb-ft	250-860 lb-ft	1,150-1,300 lb-ft	660-1,000 lb-ft	1,150-1,650 lb-ft	1,450 lb-ft	1,450-2,050 lb-ft	1,450- 1,750 lb-ft
Peak Torque RPM	1,300 RPM	1,300 RPM	1,400 RPM	1,300 RPM	1,200 RPM	1,200 RPM	1,200 RPM	1,200 RPM
Clutch Engagement Torque	400 lb-ft	400 lb-ft	550 lb-ft	550 lb-ft	800 lb-ft	800 lb-ft	1000- lb-ft	1000- lb-ft
Engine Braking	Exhaust brake -yes	No	Yes	No	Yes	Yes	Yes	Yes

Figure 6. Specifications for available heavy-duty natural gas engines and comparable diesel engines.

* The 11.9 L Cummins-Westport will not be available until January 2013, however a limited number are available for testing in 2011 and 2012.

Make	Cummins-Westport ISX	ESI Navistar	ESI Navistar	Clean Air Power
Displacement	11.9	9.3	13	13
Ignition	Spark	Spark	Spark	Compression
Fuel	CNG, LNG Biogas	CNG, LNG, Biogas	CNG, LNG, Biogas	CNG, LNG, Biogas, or 100% diesel
HP	320-425 hp	350 hp	TBA	430 hp
Torque	1,450 lb ft	850-1,200 lb ft	TBA	1,150 lb ft
EGR	Yes	No	Yes	Yes
Test Engine	Complete	Underway 2011	2012	Complete
Field Test	Underway 2011	2012	TBA	2012
Available	Q1 2012	TBA	TBA	TBA
OEM Partner	Kenworth, Peterbilt, Freightliner, Volvo, Autocar	International	International	International

Figure 7. Natural Gas Engines for Heavy Trucks Currently Under Development.

* Cummins Inc. has also announced the development of a 15L spark-ignited engine.

Transmissions and Braking:

Truck OEM's offer automatic transmissions with torque converter technology for use with spark-ignited natural gas engines. This transmission multiplies engine torque at start to deliver adequate power to the drive wheels and makes the most efficient use of fuel. Current (8.9L) spark-ignited natural gas engines are designed for use with automatic transmissions to enable performance over a wide range of applications, including heavy duty applications, that would not otherwise be possible.

Spark-ignited engines must reduce the compression ratio in order for gas to burn and provide a richer mixture. Currently, engine braking is not available in the 8.9L engine, but this is partially compensated by the auxiliary braking provided by an automatic transmission. Spark-ignited engines are capable of engine braking and this will be available with the 11.9 liter engine.

Compression ignited natural gas engines maintain the attributes of a diesel engine such as a high compression ratio and engine braking. Box 1 has additional discussion of power and efficiency of natural gas engines.

POWER AND EFFICIENCY:

Spark-ignited natural gas engines are not able to achieve the high compression ratio (and associated efficiency) or horsepower of a diesel engine because of the need to prevent pre-ignition and engine damage. Most spark-ignited natural gas engines on the market today suffer a fuel penalty of about 10%, but this is improving. Horsepower is limited by the amount of gas that can be supplied to the cylinder without creating "engine knock". This is referred to as a "knock limit" (38 hp/ L for natural gas). Westport's compression-ignited engine can achieve the same compression ratio, fuel economy, and horsepower rating as a diesel engine because it uses direct injection of both diesel and natural gas. Current 8.9L natural gas spark-ignited engines can achieve a max 320 hp and 15L compression ignited engines achieve a max 475 hp. However, these ratings were chosen based on market demand and the technology is capable of developing engines with higher power.

Box 1. Power and Efficiency of Natural Gas Engines.

Maintenance:

Maintenance requirements differ between spark ignited natural gas engines and their diesel counterparts, but the overall cost is roughly the same. Spark-ignited engines require more frequent valve adjustments, spark plug replacement, and specialized oil. This means up to approximately 3 cents per mile in additional maintenance costs. However, spark-ignited engines do not require diesel after-treatment systems or maintenance (DPF and urea) which is estimated to cost 4-5 cents per mile, so overall maintenance costs are expected to be similar to or slightly lower than diesel.

Compression-ignited engines follow the same maintenance intervals as their diesel counterparts, however the engine and fuel system require additional fuel filters and inspections. This adds approximately 1.4 cents per mile using outside labor and 0.9 cents per mile using internal labor. They require the same after-treatment system maintenance as a diesel truck, but use less DEF. Figure 8 compares the maintenance intervals of diesel and natural gas engines.

Some fleets use an accelerated oil change interval for the 8.9L engine because it is being used in a more severe duty-cycle than it was designed for. But this is a product of using a smaller engine, not natural gas. The 11.9L engine will better suit these types of operations.

The maintenance costs for a natural gas truck are comparable to a new diesel truck, but the upgrades required for shops servicing natural gas vehicles can be substantial.

LNG units will start to vent if the tanks are warm for more than a few days (CNG tanks do not vent). To deal with this potential fire hazard, natural gas compliant shops may be required to have sloped roofs, methane detection systems, automated ventilation systems, and explosion proof lighting. These improvements can be very expensive. Price estimates range between $200,000 and $1 million dollars depending on local code requirements and size of the shop.

	Diesel Cummins ISL 8.9L	CNG/ LNG Cummins ISL-G 8.9L	Diesel Cummins ISX 15L	LNG Westport HD 15L
Oil & Filter	15,000	15,000	25,000	25,000
Fuel Filter	15,000 (primary) 30,000 (secondary)	30,000	25,000	High Pressure Diesel 125,000 Low Pressure Diesel 31,250 High Pressure LNG 125,000
Spark Plugs	N/A	45,000	N/A	N/A
Coolant Filter	15,000	15,000	50,000	50,000
Coolant Change	80,000	60,000	250,000	250,000
Valve Adjustment	150,000	60,000	500,000	500,000
DPF (PM Trap)	200,000	N/A	300,000	300,000
DEF Dosing Filter	200,000	N/A	200,000	200,000

Figure 8. Maintenance Intervals of Heavy Duty Diesel vs. Natural Gas Engines.

Many maintenance procedures (tires, oil changes, etc.) can be done without modifications to the shop. Bringing trucks into the shop with low or empty LNG tanks minimizes the risk of venting and associated fire danger. Performing maintenance outdoors may be practical alternative in some cases.

Many fleets choose to operate under full service lease agreements or outsource the maintenance of natural gas trucks in order to remove the uncertainty of maintenance costs and shop upgrades.

Heavy Trucks:

Heavy-duty natural gas trucks are available in the U.S. from Daimler-Freightliner (M2), Paccar's Kenworth (T800, T440), Peterbilt (384, 386, 388, 367), Navistar, and Volvo (VNM).

A natural gas (CNG or LNG) heavy truck with the ISL-G 8.9L spark ignited engine is $30,000-$45,000 more expensive than a comparable diesel. LNG tanks are slightly less expensive than CNG tanks assuming equal range requirements. An LNG truck with the Westport HD 15L engine is about $70,000 more expensive than a comparable diesel. This is primarily due to the cost of the fuel system.

The best way to determine an accurate price and weight differential for a specific application is to obtain a quote. This will also ensure that the fuel tanks will work with specific chassis length, positioning of the 5th wheel, required turning radius, and other necessary equipment.

Conversion kits are also beginning to become available. These kits retrofit existing diesel engines so that they are able to run on compressed or liquefied natural gas and include natural gas fuel tanks and fuel system. Kits cost between $25,000 and $40,000 depending on the size and type of the natural gas fuel tank.

Refueling Process:

Filling up the "gas tank" may be the most obvious difference between a natural gas and diesel truck.

A CNG filling station typically takes natural gas from the local pipeline at low pressure and compresses it to be stored in above ground storage tanks at high pressure. In rural communities, the pipeline may not have adequate capacity for a CNG filling station.

CNG refueling equipment can either be "fast fill" or "time fill". A "fast fill" system uses a large compressor and a high-pressure storage tank to fill the truck tank in about the same amount of time as a typical diesel truck, however filling beyond 75% requires a slower trickle. These systems require a significant amount of electricity to run the compressor. A "slow-fill" system is typically used where fleets are able to fill over a few hours. In both systems, natural gas nozzles lock onto the receptacles and form a leak-free seal, similar to the coupling on an air compressor nozzle. The receptacles are designed so that when the nozzle is removed the gas is prevented from escaping. Basic driver training is required, but personalized protective equipment is not necessary.

LNG is typically delivered to the station via tanker truck and stored in cryogenic storage tanks. An LNG filling station consists of a liquid nitrogen (refrigerant) storage tank and a large (~16,000 gallon) LNG storage tank. LNG is pumped into the vehicle like any other liquid fuel, but with more sophisticated cryogenic fueling equipment. Employee training and protective equipment (gloves, mask, and apron) are necessary.

According to one LNG user, "refueling the truck is different, but simple". The tank looks like a regular diesel tank on the side of a truck. The nozzle looks like a "race car" nozzle. Drivers put on safety equipment (gloves, face shield, and apron) to protect their skin from the super-cooled fuel. They swipe their cards, hook up the nozzle, and hit a button. The computer knows how much fuel the truck needs and tells the driver when the tank is full. It takes about five minutes to refuel.

Compression-ignited engines require diesel in addition to LNG; although the diesel only needs to be refilled about 1 out of every 20 times it is refueled.

Fueling Infrastructure:

Natural gas refueling infrastructure has been a classic "chicken and egg" scenario, where fueling stations will not risk the $1.5M investment without a strong customer base and fleets are not willing to purchase natural gas vehicles without refueling infrastructure in place.

There are currently 47 LNG stations in the U.S. (Figure 9), however only about 1/3rd of those are open to the public (i.e. you do not need prior access or approval) and until recently, there were essentially no LNG filling stations outside of California. CNG is more widely available (936 public and private stations nationwide) with the majority in the Mid-West (Figure 10), but is still limited compared to diesel.

State	# of LNG Fueling Stations
California	36
Texas	5
Utah	1
Nevada	1
Alabama	1
Louisiana	1
Arizona	1
Connecticut	1

Figure 9. Number of LNG Fueling Stations by State. Includes private and public stations. Alternative Fuels and Advanced Vehicles Database

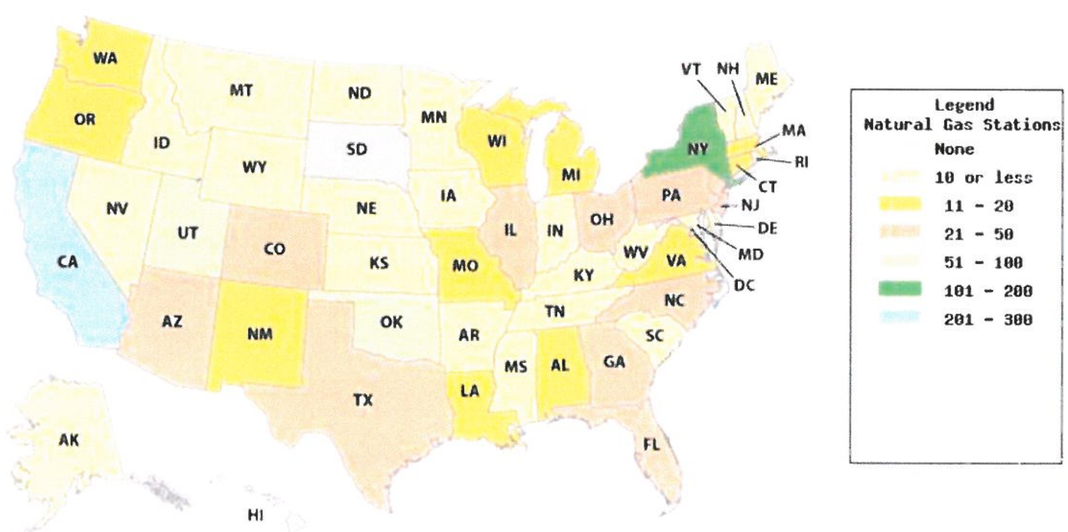


Figure 10. Natural Gas Fueling Station Locations. Includes CNG and LNG stations. Alternative Fuels and Advanced Vehicles Database

Clean Energy (an LNG producer who builds natural gas refueling stations) has partnered with Pilot-Flying J truck stops to build 150 LNG fueling stations along major interstate corridors. They anticipate having an LNG fueling station every 200 to 300 miles by July 2013 and double that to 300 or 400 stations by 2015 to serve all regional routes. Chesapeake Energy and Temasek Holdings have each invested $150 million in this effort to construct a foundational grid of LNG stations for heavy-duty trucks. Figure 11 shows the proposed locations of LNG stations to be built in 2012 and 2013.

Infrastructure will first expand from California into a Southwest LNG truck re-fueling corridor with stations now present in Northern California, Arizona, Nevada and Utah. Efforts are also underway to create a natural gas vehicle corridor in Texas, the "Texas Triangle", connecting Austin, Dallas/ Fort Worth, Houston, and San Antonio. Also planned for early opening include stations linking Houston with Chicago, Chicago to Atlanta, and highways in the mid-west with high truck traffic.

Local utilities can also be a source of both CNG and LNG. Many utilities produce LNG in order to store excess natural gas in the summer months for use in the winter and are willing to sell both CNG and LNG as transportation fuel. Some utilities are already seeking out discussions with the trucking community as they consider building fueling stations. Because natural gas rates from utilities are regulated, they can provide some of the least expensive fuel available.

Until more natural gas refueling infrastructure is built, fleets may consider building their own refueling stations. A CNG or LNG fueling station can cost between $400,000 and $1.5M.

Groups such as Clean Energy or Vocational Energy will partner with fleets to design and build, and in some cases, operate and maintain a station.

Fleets can pay for the capital cost of a station or Clean Energy will pay for a station and recoup the cost over 10-15 years. To be economically feasible, fleets should be using 25,000 to 30,000 gallons of diesel per month, minimum, assuming the station is in a desirable location with public access. Twice that amount of fuel would be needed for a dedicated fleet location.

Mobile LNG fueling units are also available for fleets operating on temporary jobs. These units hold approximately 3,000 DGE. This is about half the volume of a delivered load of LNG fuel, so it is not economical in the long term. Like all LNG storage tanks, they will vent if not used or refilled every 4-5 days.

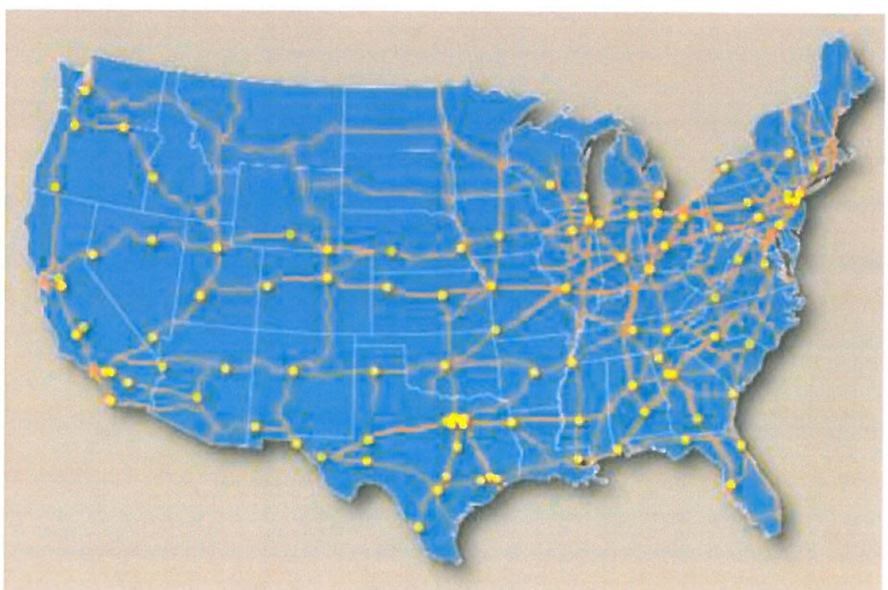


Figure 11. Proposed 2012-2013 LNG Fueling Station Network.
Clean Energy

Safety:

Natural gas is noncorrosive and nontoxic. Because it is lighter than air, it will rise under normal atmospheric conditions rather than pooling like a liquid fuel. This eliminates the potential for ground or water contamination and reduces the probability of a fire in the event of a leak, but creates additional hazards for the area around the ceiling of confined spaces. LNG and CNG are about as flammable as diesel, but ignite only under concentrations between 5-15%.

Truck cabs are equipped with methane detectors to alert drivers if gas has vented into the cab. These warnings need to be taken seriously in order to avoid drowsiness and associated safety issues.

Natural gas vehicles are safe and have a proven track record. Based on a survey of over 8,000 natural gas fleet vehicles traveling nearly 180 million miles, there were a total of seven fire incidents in the natural gas fleet, only one of which was directly attributable to a failure of the natural gas system.

Natural gas vehicles, fuel systems, maintenance facilities, and refueling facilities are heavily regulated from a safety standpoint.

CNG and LNG fuel tanks and fuel systems undergo rigorous safety testing and must comply with federal standards. They are made of high-strength materials designed to withstand impact, puncture and, in the case of fire, their pressure relief devices (PRDs) provide a controlled venting of the gas rather than letting the pressure build up in the tank. CNG tanks are designed to "leak before breaking" so that if a tank stays in service beyond the design life, and experiences excessive fill cycles, they will only fail by leakage.

The fuel systems in a natural gas vehicle must conform to NFPA standards for safe design, installation, inspection, and testing. The CNG vehicle fuel containers must meet the Federal Motor Vehicle Safety Standard.

LNG has its own safety considerations

- *Flammable:* While it is not flammable as a liquid, if exposed to air, LNG will rapidly expand to 600 times its original liquid volume, so small leaks can present a significant fire hazard near the leak.
- *Large Expansion Ratio*: When warmed, LNG can build to extremely high pressures (over 3,000 psi) if trapped in lines causing lines to fail. Care must be taken in the design of piping systems and during maintenance operations to assure that liquid cannot become trapped between two valves.
- *Cryogenic Temperatures*: Liquid LNG is stored at very cold temperatures (-260° F) so presents a risk of "cryogenic burning" if skin comes in contact with a pressurized liquid stream or by touching a fuel line. Eyes and skin should be covered when working on LNG systems.

There are also special fire safety requirements for repair garages servicing CNG or LNG vehicles. Fleets servicing their own vehicles will require upgrades to comply with these requirements.

- Natural gas presents an asphyxiation hazard at concentrations higher than 21%. Because this can present a hazard in indoor environments, shops require an air evacuation system.
- LNG does not have an odor, so an approved gas detection system in the garage as well as lubrication or chassis repair pits is required.
- No open flame heaters or heaters with exposed surfaces hotter than 750° F are allowed.
- The area within 18" of the ceiling is designated a Class I, Division 2 hazardous location. This means modified lighting and electrical systems may be required unless ventilation with at least four air changes per hour is provided.

Repair garages servicing CNG vehicles that are not performing major fuel system repairs may only require explosion proof lighting.

NFPA 30A and state fire, mechanical, and electrical codes provide guidance, but allow for site specific modifications. The local fire department is generally the Authority Having Jurisdiction (AHJ).

Fleets that have on site natural gas refueling equipment must comply with NFPA codes 52, 55, and 57 for equipment requirements, design, construction, site, ventilation, installation, testing, emergency equipment, and maintenance and with code 52 and 57 for LNG fire protection, personnel safety, security, LNG fueling facilities and training. See Appendix for a list of National Fire Protection Administration Codes related to CNG and LNG vehicles, facilities, and fueling equipment.

Figure 12 summarizes the advantages and disadvantages of natural gas fuel from a safety perspective.

Natural Gas Safety Pro's	**Natural Gas Safety Con's**
Non-toxic and non-corrosive	Asphyxiation hazard in enclosed spaces (air evacuation and methane detection systems are required)
Does not pool on the ground: - Reduced fire hazard at ground level - No ground or water contamination - Flammable only at concentrations between 5% and 15%	Rises "lighter than air": - Increased fire hazard indoors at ceiling level (modified lighting and electrical systems may be required)
- Rigorous design and testing standards - Safe and proven track record for vehicles	Heavily Regulated
	- Rapid expansion creates significant fire (i.e. explosion) hazard near a leak - Very high pressures can build if gas becomes trapped between two valves causing lines to fail (follow proper maintenance procedures) - LNG: cryogenic burn can occur if skin is exposed to liquid gas or fuel line (cover eyes, skin)

Figure 12. Pro's and Con's of Natural Gas from a Safety Perspective.

3. Fuel Prices

The price differential of natural gas to diesel is the single most important factor to consider in modeling the business case for converting a fleet to natural gas. Retail prices at the pump are generally listed in diesel gallon equivalents (DGE's) to account for the lower energy content of natural gas compared to diesel. The commodity futures market trades wellhead natural gas in MMbtu's or Mcf units. Figure 13 shows conversion factors for comparing natural gas to diesel.

Fuel Type	Units	Conversion Factor
Wellhead Gas	1000 ft^3 (Mcf)	Mcf x 5.8 = equivalent energy in a barrel of oil
Wellhead Gas	MMbtu	$ MMbtu x 1.028 Btu per ft^3 = $ Mcf
CNG	Gallons	Gallons CNG x 0.16 = diesel gallon equivalent (DGE)
LNG	Gallons	Gallons LNG x 0.58 = diesel gallon equivalent (DGE)

Figure 13. Conversion Factors for Comparing Natural Gas to Diesel.

Until 2005, crude oil prices and U.S. natural gas prices moved together, supporting the conclusion that the two commodities were connected. However, current spot prices and futures markets show a persistent disparity between oil and gas prices.

The commodity futures market predicts natural gas prices to be 65-70% less expensive than oil on an energy equivalent basis over the next five years. Figure 14 compares historical spot prices and commodity futures for West Texas Intermediate (WTI) Crude Oil and Henry Hub wellhead natural gas.

The U.S. Energy Information Administration predicts that crude oil prices will increase to about 2.8 times the price of natural gas by 2035 on an energy equivalent basis. Recognizing the extreme volatility of oil prices and the difficulty in predicting future prices, they recognize that the price of oil could increase to as high as 4.8 times the price of natural gas.

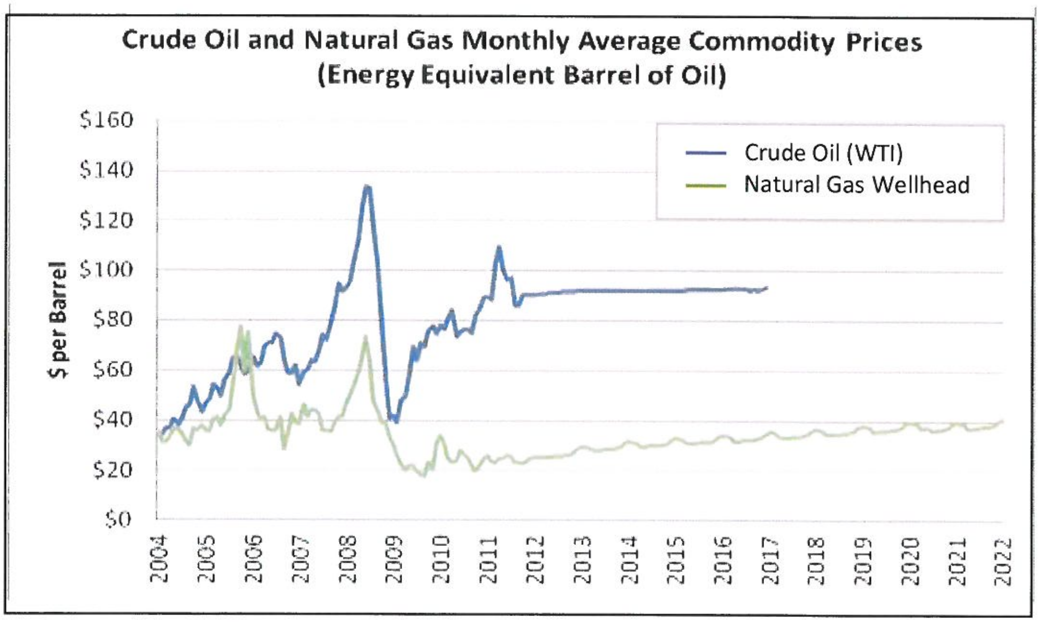


Figure 14. Crude Oil and Natural Gas Monthly Average Historical and Commodity Futures Prices.

Sources: Historical: U.S. Energy Information Administration
Gas: Henry Hub NYMEX Gulf Coast Spot Price
Oil: Crude Oil (West Texas Intermediate) Spot Price
Futures: NYMEX Near-Month Contracts www.cmegroup.com
Gas: Henry Hub Natural Gas Trade Date 09/12/11
Oil: Crude Oil (West Texas Intermediate) Trade Date 09/12/11

Conversely, if demand for natural gas increases as it enters the transportation, liquid fuels, and overseas markets, then the price of natural gas could increase to a point where oil is only 1.1 times the price of natural gas.

The price differential at the retail end is slightly narrower than the commodity prices, accounting for the cost of refinement, distribution, and refueling infrastructure.

Recent retail, at-the-pump sale prices (October 2011) at 320 CNG stations shows CNG an average $1.65 less expensive than diesel (42% less) and LNG $2.10 less expensive (53% less). These average prices are somewhat misleading as retail prices vary regionally. At a given location, LNG is generally 50 cents more expensive than CNG. Figures 15 and 16 show the price differential of CNG and diesel (October 2011) for the continental U.S.

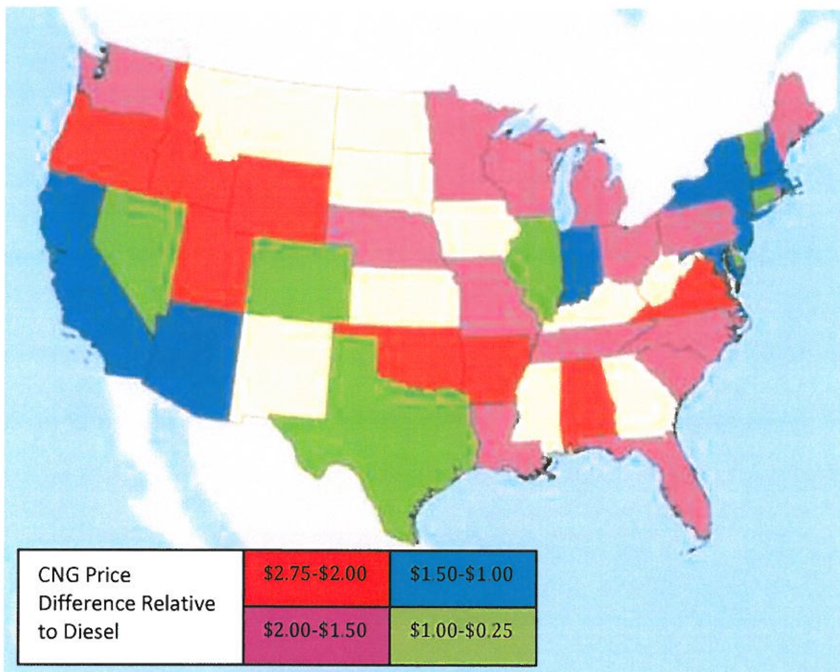


Figure 15. CNG and Diesel price difference Clean Cities Alternative Fuel Price Report Oct 2011

	Natural Gas (CNG) Information Reported by Clean Cities ($/DGE)		Diesel Information Reported by Clean Cities ($/gal)	
	Average Price/ Standard Deviation	Number of Data Points	Average Price/ Standard Deviation	Number of Data Points
New England	$2.74 / 1.00	14	$3.91 / 0.19	43
Central Atlantic	$2.54 / 0.64	76	$3.80 / 0.23	50
Lower Atlantic	$1.80 / 0.54	10	$3.71 / 0.17	50
Midwest	$1.94 / 0.53	28	$3.72 / 0.15	112
Gulf Coast	$1.96 / 0.62	7	$3.65 / 0.13	23
Rocky Mountain	$1.66 / 0.66	70	$3.85 / 0.15	29
West Coast	$2.69 / 0.59	120	$4.06 / 0.28	56
NATIONAL AVERAGE	**$2.33 / 0.77**	**325**	**$3.81 / 0.23**	**363**

Figure 16. CNG and Diesel Retail "at the pump" sale prices. September 30th - October 14th, 2011
Includes federal and state motor fuel taxes
A total of 12 LNG price points were collected with an average fuel price of $2.17 per DGE
Clean Cities Alternative Fuel Price Report October 2011

4. Summary of Economic and Operational Factors:

Natural gas is likely to remain significantly less expensive in future years, but a number of economic and operational challenges exist for the use of natural gas as a transportation fuel in heavy trucks.

Figure 17 presents a summary of the factors discussed in previous chapters.

These assumptions are used in our financial model to determine savings for converting a fleet to run on natural gas. Advantages of natural gas over diesel are shown in green, disadvantages in blue, and factors that are neutral in grey.

Fuel	Diesel	LNG	CNG
Natural gas contains less energy per gallon	128,700 Btu/ gal	74,700 Btu/ gal	20,300 Btu/ gal
Fuel prices are listed in energy equivalent "Diesel Gallon Equivalents" DGE's	1DGE	1.72 gal 0.23 cu ft	3.7 gal 0.49 cu ft
Natural gas is likely to remain substantially less expensive than diesel in the foreseeable future	$4 / DGE $0.68/ mile	$2.50/ DGE $0.42-$0.47/ mile	$2.50/ DGE $0.42-$0.47/ mile
Natural gas is produced domestically and prices are not impacted by foreign supply	Extremely volatile price	Less price volatility	Less price volatility
Natural gas is lighter than diesel	6.8 lbs/ gal	3 lbs/ gal	1 lbs/ gal
Natural gas has more energy per pound	18,250 Btu/ lb	28,266 Btu/ lb	28,266 Btu/ lb
Eliminate environmental risk of fuel spill	Pools on ground	Evaporates	Evaporates
Natural gas has a risk of explosion (enclosed spaces)	Non-explosive	Explosive	Explosive
LNG tanks vent after sitting 4-5 days	Does not vent	Vents- lost fuel	Does not vent
It is more difficult to steal natural gas			
Truck	**Diesel**	**LNG**	**CNG**
Natural gas trucks are more expensive (primarily due to fuel system)	--	Spark $30-40,000 HD $60-70,000	$30-40,000
Salvage value end of useful life	25%	25%	25%
Depreciable life of tractor	48 months	48 months	48 months
Engine	**Diesel**	**Spark** 8.9L, 11.9L	**Compression**
Spark-Ignited natural gas engines are less fuel efficient compared to a new diesel engine	--	10% less	--
Available natural gas engines have limited hp	600 hp max	400 hp max	475 hp max
Maintenance costs are higher for spark engines (spark plugs and specialized oil)	--	Up to $0.03/ mi	--
Spark-ignited engines do not require DPF or urea diesel after-treatment systems	$0.04-$0.05/ mi	200 lbs. lighter maintenance free	$0.04-$0.05/ mi
Natural gas engines are quieter than diesel		10 dB quieter	10 dB quieter
Operations	**Diesel**	**LNG**	**CNG**
Operating range is limited to available infrastructure, wheelbase, and tank configurations	Max 200 +200 = 400 DGE; Typical 50-100 DGE	Max 75 +75 = 150 DGE usable; Typical 50-75 DGE	Max 75 +40+40 = 126 DGE usable; Typical 75-80 DGE
Cost of additional fueling stop	--	$25 per stop	$25 per stop
Available payload is usually diminished	--	50 to 600 lbs heavier	400 to 1,600 lbs heavier
Maintenance shops require safety upgrades (lighting, venting, gas detectors)	--	Up to $200,000 per bay	Up to $200,000 per bay
New technology presents a risk	Stable technology	New technology	New technology

Figure 17. Summary of Economic and Operational Factors. Pro's (green), Con's (blue), and Neutral (gray)

Price of Natural Gas:

Natural gas price is listed in DGE to account for the reduced energy content of natural gas compared with diesel. It is currently $1.50-$2.25 less expensive than diesel and is likely to remain less expensive in the foreseeable future. Prices currently range between $1.85 and $2.20 per DGE. We assumed $2.50 per DGE in our model as a conservative estimate.

Additional Cost of Natural Gas Heavy Trucks:

A natural gas heavy truck with the ISL-G 8.9L spark-ignited engine is $30,000-$40,000 more expensive than a comparable diesel. LNG is slightly less expensive than CNG because the robust tanks required for CNG are more material intensive than the thermos design for LNG. A truck with the ISX-G 15L engine is $70,000 more expensive than a comparable diesel and is available with LNG only. Natural gas engines are approximately $10,000 more expensive than a comparable diesel engine. The higher cost of the truck is primarily due to the cost of the fuel system and in the case of compression-ignited engines, the diesel after-treatment system. Prices have come down substantially in the last few years due to economies of scale.

Fuel Economy Penalty:

Spark ignited engines are 10% less fuel efficient than a comparable new diesel engine. The Westport HD 15L compression-ignited engine has approximately the same fuel efficiency as a comparable new diesel engine.

A truck that averages 6 mpg will save 21 cents per mile in fuel costs with a spark-ignited engine (10% loss in fuel economy) and 26 cents per mile with a compression ignited engine (no loss in fuel economy).

Operating Range:

The operating range that can be achieved with a given natural gas tank must account for three factors: 1.) Account for the reduced energy content of natural gas compared to diesel by using the rated capacity listed in diesel gallon equivalents (DGE). 2) Deduct approximately 10% from a CNG tank to determine "usable fuel." CNG does not flow at low pressures so there is always some residual fuel in the tank that cannot be used. LNG tanks require vapor space which reduces the effective storage space, however, this is already accounted for in the listed DGE capacity, so does not need to be discounted. 3.) Spark ignited natural gas engines suffer a 10% fuel economy penalty. Compression ignited engines (HD 15L) get the same fuel economy as diesel.

Standard tank configurations provide a range of 250-350 miles with CNG and 300-375 with LNG.

Some fleets are experimenting with using additional tanks for increased range, but this adds another $20,000-$30,000 to the price of the truck. For CNG, the maximum tanks used to date include three 25 gallon tanks behind the cab (75 DGE) and two side-rail tanks (41 DGE) which gives a total *usable* fuel capacity of 143 DGE and (700-800 mile range), but this configuration is very heavy (nearly 3,000 pounds full of fuel). For LNG, two 150 gallon tanks (75 DGE each) would give an 810 mile range (assuming 6 mpg with diesel reduced by 10%, 5.4 mpg for a spark ignited engine).

Westport's 15L HDPI requires additional space for the diesel tank, DEF tanks, and hydraulic pump inside the LNG tank. Currently, the largest LNG tank available with the integral LNG pump is a 120 LNG tank, so the 150 gallon tank is not an option. Maximum fuel capacity with dual 120 gallon tanks is 116 DGE. However, there is no fuel economy penalty with this engine and 5% diesel provides additional energy (730 mile range with dual 120 gallon tanks).

Weight Penalty:

The total "tires to tailpipe" weight of a natural gas truck depends upon the type of engine (ISL-G 8.9L or HD 15L), the type of fuel (CNG or LNG) and size of fuel tanks (depending on needed fuel capacity).

The table below shows the estimated weight differential of the most common natural gas configurations based on variables: engine, after-treatment, fuel system, and fuel. Actual weight differential will vary by a few hundred pounds, depending on which diesel truck is used as a base case. A good rule of thumb says that an LNG or CNG truck will be 300-600 pounds heavier. However, the weight can be very close to diesel weights if the natural gas truck is configured with lightweight components.

Fuel Type	CNG	CNG	LNG	LNG	LNG
Engine	8.9L "spark"	8.9L "spark"	8.9L "spark"	11.9L "spark"	HD 15L
Tank Configuration and Nominal Capacity	(5) 15 DGE Behind Cab 75 DGE	(2) 41.2 DGE Side-Rail 82.4 DGE	(1) 150 gal Side-Rail 75 DGE	(1) 150 gal Side-Rail 75 DGE	(1) 120 gal Side-Rail 58 DGE
Usable Fuel (DGE)	68 DGE	74 DGE	75 DGE	75 DGE	58 DGE
Fuel Economy Penalty	10%	10%	10%	10%	No
Range (6mpg)	367 mi	400 mi	338 mi	338 mi	365 mi
Engine Weight	1,625 lbs (vs. 1,800 lbs diesel)	1,625 lbs (vs. 1,800 lbs diesel)	1,625 lbs (vs. 1,800 lbs diesel)	2,700 lbs (vs. 2,888 lbs diesel)	3,243 lbs (vs. 3,286 lbs diesel)
Fuel System Weight (Full Fuel)	2,050 lbs (vs. 510 lbs diesel)	1,650 lbs (vs. 510 lbs diesel)	1,400 lbs (vs. 510 lbs diesel)	1,400 lbs (vs. 510 lbs diesel)	1,802 lbs (vs. 510 diesel)
After-Treatment System Weight	100 lbs (vs. 550 diesel)	100 lbs (vs. 550 diesel)	100 lbs (vs. 550 diesel)	100 lbs (vs. 550 diesel)	550 lbs (vs. 550 diesel)
Weight Differential of Variables (engine, fuel system, after-treatment)	-175 +1,540 -450	-175 +1,140 -450	-175 +890 -450	-188 +890 -450 lbs	-43 +1,292 -0
Total Weight Differential natural gas vs. diesel	915 lbs heavier	515 lbs heavier	265 lbs heavier	252 lbs heavier	1,249 lbs heavier

Figure 18. Estimated range and weight differential for common natural gas configurations. (Compared to diesel truck with 75 gallon fuel tank - weight differential will vary depending on base truck).

1. Range assumes 6mpg for diesel and LNG HD 15L compression ignited engine and 5.4 mpg for 8.9L and 11.9L spark-ignited engines

2. Fuel system for HD 15L LNG configuration assumes LNG fuel system weighs 1,400 lbs full fuel, 45 gallon diesel tank and accessories weighs 96 lbs and diesel weighs 6.8 lbs per gallon (1,802 lbs total).

3. Weight differential is compared to a 75 gallon diesel tank (81 lbs) and diesel weighs 6.8 lbs per gallon (510 lbs).

4. After-treatment system for spark ignited engines is a simple 3-way catalyst (100 lbs) and for compression (HD 15L) and diesel engines includes DPF, SCR, and urea storage with solution (550 lbs).

LNG Venting, Weathering, and Tank Issues:

Venting or "off-gassing" occurs when LNG warms and expands to the point that the tank releases excess pressure to the atmosphere through the pressure relief valve. This equates to lost fuel and reduced savings. It also negates the environmental benefit of using natural gas because methane is 25 times more potent as a greenhouse gas than carbon dioxide.

If new cold LNG fuel is added to the system on a daily basis this is not a problem, so LNG should only be used in operations where the truck has very little down time. Gas will warm to the point that it will begin to vent only after about 4 to 5 days of not being refilled. The tanks are designed to release this pressure, so it is not a safety issue.

The super-insulation properties of an LNG tank gradually degrade over time, decreasing the amount of time that a tank can sit idle without venting. When the amount of pressure that builds over the course of a day exceeds 40 psi, the vacuum in the tank needs to be re-evacuated. This generally occurs after about 5 years and every 1-2 years thereafter. Loss of vacuum can also occur if there is damage to the tank from a collision or other accident.

If venting occurs on a regular basis, "weathering" can become an issue. When LNG vents, the lighter methane molecules vent first. Over time, the residual fuel will contain a higher proportion of heavier butane, propane, ethane, and helium, than would otherwise exist and will be of lower fuel quality.

There have been some reports of LNG fuel lines freezing and causing problems. However, this is thought to be related to LNG pump replacement where the LNG pump is removed and the empty LNG tank becomes exposed to the environment, not from everyday use.

Venting and icing is not an issue with CNG.

Fuel Quality:

As with diesel, fuel quality is important. Fuel should have a high methane content, or drivers may feel loss of power. Impure fuel can cause plugged filters.

Loss of flexibility:

Loss of flexibility and loss of a "go anywhere" fleet is a concern for a fleet that converts to natural gas. Fleets want to be able to respond to customer needs wherever those might be. Until widespread infrastructure is developed, natural gas fleets will be limited to operations within range of a limited number of natural gas fueling stations.

Limited engine options:

There are currently only two natural gas engines available for heavy trucks: the Cummins Westport 8.9L spark-ignited engine and the Westport 15L compression-ignited engine (LNG only, heavier, and more expensive). Medium duty delivery trucks are currently limited to the ESI Navistar 7.6 L engine. A typical 80,000 GVW truck is pushing the limits of the 8.9L engine and is limited to flat terrain. However, the 11.9L spark-ignited engine will be available 1st quarter of 2013 and will fit a much larger number of heavy truck applications. As demand for natural gas trucks increases, more options will become available. Additional engines are also currently under development (Figure 7).

Limited Space for Tanks and Other Equipment:

LNG and especially CNG tanks take up more space than diesel tanks. This can limit the amount of space available on the truck for pumps or other equipment that might be required. On a 3-axle tractor, side-rail mounted CNG/ LNG tanks can fit on as short as a 177" wheelbase, but this is very tight and makes tank servicing more difficult. A 190" wheelbase is a more typical wheelbase for side-rail mounted tanks. Some drivers have complained that it is difficult to see when backing up with the "back-of-cab" CNG tanks.

Maintenance Costs:

Maintenance costs are $0.025 to $0.03 more per mile for the spark-ignited engines (due to spark plugs, overhead valve adjustments, and specialized oil). However, they require no diesel after-treatment system maintenance ($0.04-$0.05 per mile), so overall represent a cost savings of approximately $0.01-$0.02 per mile.

Maintenance for a compression-ignited engine is the same as for a diesel engine, but with approximately $0.01 per mile in additional fuel filters and inspections. However, less DEF is used compared to a diesel, so this additional cost may be negated.

Shop Upgrades:

Upgrades required for shops servicing natural gas vehicles can be substantial. Natural gas compliant shops may be required to have methane detection systems, automated ventilation systems, and explosion proof lighting. This can cost up to $200,000 per bay depending on local code requirements. Shops servicing only CNG vehicles that are not doing major fuel system repairs may require only explosion proof lighting, however this will vary depending on local fire code requirements.

Many fleets choose to operate under full service lease agreements or outsource the maintenance of natural gas trucks in order to remove the uncertainty of maintenance costs and shop upgrades. Outdoor, unenclosed shop bays may be another practical alternative.

Leasing:

Natural gas trucks are available under a full-service lease. This reduces the burden of the high incremental cost and the uncertainty around maintenance and shop upgrades and allows for immediate savings for high mileage fleets. It also allows fleets to test natural gas in their operations now, while they wait for the 11.9L engine to become available. However, the monthly lease charge for a natural gas truck can be nearly double that of a comparable diesel truck and operating charge is $0.03 per mile higher.

Refueling:

Refueling with LNG is as fast as refueling with diesel, but safety equipment (gloves, goggles, apron) is required to protect skin from cryogenic burns that would result from contact with the super-cooled fuel.

CNG filling times depend upon the size of the compressor and high pressure storage tank. New stations with large compressors and storage tanks can pump at 8 gallons per minute, but filling time will increase if a number of CNG trucks refuel back-to back. At older CNG stations or stations with smaller compressors, it can take 30 minutes or more to fill as the compressor fires up to trickle fill the tanks to full capacity.

Dedicated Fleet Refueling Stations:

A fleet that is interested in refueling "on-site" should be using approximately 250,000 DGE per year for CNG and 500,000 DGE per year for LNG in order to make the investment in a refueling station economically viable and in the case of LNG, to minimize venting issues. A delivery of LNG to the refueling station should be made about every 3-4 days to minimize venting issues and lost fuel. If other fleets are involved, or if the station is in a desirable location for public-private use, then lower volumes may be viable (i.e. the station could be built at no cost to the fleet by the natural gas fuel supplier).

Side Benefits:

Ultimately, the decision to invest in natural gas is an economic and functional decision, but there are a handful of side benefits to its use.

- Engines are quieter (about 10 decibels) than a diesel.
- There is no need for #1 diesel in the winter which is a more expensive and less efficient fuel than #2 diesel.
- It is much more difficult to steal natural gas, as can sometimes be a problem with diesel.
- It adds a new dimension to customer relations. Fleets can help customers reduce costs and meet their sustainability goals. Bio-methane sourced from landfill gas, wastewater treatment, and farm waste presents an opportunity to be "carbon negative" and in some cases partner with customers to use their waste as fuel.
- If future air quality regulations become more stringent, natural gas has more potential to improve air quality cost-effectively compared to diesel.

5. Lynden Inc. Case Study: What Set of Conditions Make the Business Case for an Investment in Natural Gas Heavy Trucks?

The large fuel price differential between natural gas and diesel is very attractive, but is it enough to overcome the economic and operational factors that come with natural gas heavy trucks?

Lynden Inc., a Pacific Northwest-Alaska based transportation company partnered with the National Energy Policy Institute on this project to develop a financial model and gain insight into the economic and operational conditions that would lead a heavy truck fleet to invest in natural gas trucks.

The Lynden family of companies capabilities include: truckload and less-than-truckload transportation, scheduled and charter barges, rail barges, intermodal bulk chemical hauls, scheduled and chartered air freighters, domestic and international air forwarding, international ocean forwarding, customs brokerage, trade show shipping, remote site construction, sanitary bulk commodities hauling, and multi-modal logistics.

About the Model:

We use a profit-and-loss model to find annual cost or savings per mile, per truck, and per fleet. The model accounts for the economic and operational factors summarized in figure 17.

1. **Fuel price.** We modeled for cost of diesel at \$3, \$4, and \$5 per gallon while leaving the cost of natural gas constant at a conservatively estimated \$2.50 per diesel gallon equivalent (DGE).
2. **Weight differential**. Weight differential comes from OEM quotes and compares natural gas to a comparable new diesel truck using design specifications for trucks used in each operation. The additional weight of a natural gas truck translates to a percentage of reduced payload and additional miles needed to travel per year to make up for the loss in payload (cost per mile estimated at \$3.10 per mile). We used full fuel weights and full urea (diesel after-treatment system) weights.
3. **Fuel Economy and Operating Range.** Operating range is based on "usable" fuel and accounts for a 10% fuel efficiency penalty for spark-ignited engines. For the HDPI engine, there was no fuel economy penalty. Each additional fuel stop needed to compensate for reduced fuel range is estimated to cost \$25 to account for additional time and labor.
4. **Price differential, depreciable life, and salvage value of the truck.** Truck prices came from actual OEM quotes and compare natural gas to a comparable new diesel truck including Federal Excise Tax (FET). We assumed a depreciable life of 4 years for the truck (conservative estimate) and equal salvage values (25%) for diesel and natural gas trucks at the end of their useful life.
5. **Maintenance costs.** We assumed maintenance costs to be equal between natural gas and diesel trucks. This is based on a \$0.03/ per mile increased cost for spark-ignited engines (spark plugs and specialized oil) and a \$0.01-\$0.04/ mile savings by eliminating maintenance costs associated with diesel after-treatment systems.
6. **Shop upgrades.** We did not include the cost of maintenance shop upgrades in this model. Costs vary greatly depending on the size and location of the shop and options for outsourcing maintenance may be more practical.

Lynden Scenario Operational Characteristics (we modeled 3 operations, a total of 5 scenarios):

1. In-City Less-Than-Truckload (LTL) Pick-Up and Delivery: CNG
2. Milk Tanker Farm Pick Up: CNG and LNG
3. Truckload and Less-Than-Truckload Line Haul: LNG 11.9L "Spark" engine and LNG 15L HDPI

Key variables are summarized in figure 19; results are presented in figures 20-26.

LTL Pick-Up & Delivery (CNG):

This is a 15 tractor fleet based in the Seattle area. The 69,000 GVW tractor with semi-van trailer operates within a 50 mile radius to provide pick-up and delivery service from a central terminal and travels an average 14,000 miles per year. There are currently four CNG fueling stations in the Seattle area with enough space available for a truck to refuel. CNG quote is for an 8.9L spark-ignited engine. This operation is not weight sensitive because truck is rarely loaded to full capacity, so the weight penalty was removed from the model for this scenario.

Farm Pick Up (CNG & LNG):

Tractors with tank trailers pick up milk from the dairy farm and deliver to the processing plant. The 8 truck fleet carries loads up to 105,500 GVW within a 30 mile radius of the terminal on flat terrain. The 8.9L engine is beyond its upper limit for this application. Each truck averages 60,000 miles per year. Refueling infrastructure is currently not available, but annual fuel use and terminal location make this a potentially feasible public/private refueling site. We compared the diesel to CNG and LNG trucks. This is an extremely weight sensitive operation.

Line Haul (LNG):

Line haul refrigerated trucks with team drivers specialize in transporting seafood and other refrigerated freight from the Pacific Northwest to Central and Southern California, Portland, Boise, Salt Lake City, Denver, Minneapolis, Chicago, and Boston. GVW is 80,000 pounds and trucks average 150,000 miles per year. The 11.9L engine is at its upper limit for this application. For the model, we assume LNG refueling infrastructure is available for these corridors. We compared the diesel and LNG 11.9L engine and HDPI 15L. This operation is also weight sensitive.

	LTL Pick Up & Delivery CNG	Farm Pick Up CNG	Farm Pick Up LNG	Line Haul LNG 11.9	Line Haul LNG HDPI
Engine Size	8.9L	8.9L	8.9L	11.9L	HDPI
Fleet Size	15 trucks	8 trucks	8 trucks	50 trucks	50 trucks
Annual miles per truck	14,000 miles	60,000	60,000	150,000	150,000
MPG Diesel **MPG Natural Gas**	5.91 mpg 5.32 mpg	4.7 mpg 4.23 mpg	4.7 mpg 4.23 mpg	5.89 mpg 5.28 mpg	5.89 mpg 5.89 mpg
Additional Cost of Natural Gas Tractor	$29,000	$40,000	$43,000	$34,000	$67,000
Additional Weight of Natural Gas Tractor	n/a	1,556 lbs	555 lbs	68 lbs	500 lbs
Payload Diesel **Payload Natural Gas**	n/a	75,000 lbs 73,444 lbs	75,000 lbs 74,450 lbs	45,000 lbs 44,932 lbs	45,000 lbs 44,500 lbs
Tank Size Diesel	50 gallons	75 gallons	75 gallons	90 gallons	90 gallons
Tanks Size NG Nominal **Tank Size NG DGE** **Tank Size NG Usable**	(2) 25 DGE 50 DGE 45 DGE	(5) 15 gallon BOC 75 DGE 68 DGE	150 gallon 75 DGE 75 DGE	150 gallon 75 DGE 75 DGE	120 gallon 58 DGE 58 DGE
Range Diesel **Range NG**	296 miles 240 miles	353 miles 288 miles	353 miles 296 miles	531 miles 396 miles	531 miles 354 miles

Figure 19. Operational Characteristics for 5 Lynden Scenarios Diesel vs. Natural Gas

Model Summaries:

LTL In City Pick Up and Delivery 8.9L - CNG Incremental Annual and Per Mile Cost
Comparative Model

Assumptions:	$3	$4	$5
Diesel Price per Gallon	$3.00	$4.00	$5.00
CNG Price per Diesel Gallon Equivalent (DGE)	$2.50	$2.50	$2.50
Difference in Fuel Price per Diesel Gallon Equivalent (DGE)	$0.50	$1.50	$2.50
Incremental Cost of CNG Tractor Unit, net of incentives	$ 29,000	$ 29,000	$ 29,000
Miles per Year Per Tractor	14,000	14,000	14,000
Payload, in Pounds	45,000	45,000	45,000
Range in miles (natural gas tractor vs. 295 miles diesel)	239	239	239
Fleet Size, in Units	15	15	15

Unit Costs Scenario:	$3	$4	$5
Operating Costs			
Incremental Fuel (Savings)/Cost	$ (527)	$ (2,900)	$ (5,273)
Incremental Maintenance (Savings)/Costs	$ -	$ -	$ -
Additional Fuelings	$ 275	$ 275	$ 275
Payload (Savings)/Cost	$ -	$ -	$ -
Capital Costs			
NG Tractor Annualized Incremental Cost	$ 5,438	$ 5,438	$ 5,438
Shop	$ -	$ -	$ -
Incremental Annualized (Savings)/Cost	$ 5,185	$ 2,812	$ 439
Incremental (Savings)/Cost Per Mile	$ 0.37	$ 0.20	$ 0.03

Fleet Costs Scenario:	$3	$4	$5
Operating Costs			
Incremental Fuel (Savings)/Cost	$ (7,910)	$ (43,503)	$ (79,096)
Incremental Maintenance (Savings)/Costs	$ -	$ -	$ -
Additional Fuelings	$ 4,125	$ 4,125	$ 4,125
Payload (Savings)/Cost	$ -	$ -	$ -
Capital Costs			
NG Tractor Annualized Incremental Cost	$ 81,563	$ 81,563	$ 81,563
Shop	$ -	$ -	$ -
Incremental Annualized (Savings)/Cost	$ 77,778	$ 42,185	$ 6,591
Incremental (Savings)/Cost Per Mile	$ 0.37	$ 0.20	$ 0.03

Figure 20. Comparative Model Summary: In-City Pick Up & Delivery 8.9L Spark-Ignited CNG vs. Diesel

Farm Pick Up - 8.9L CNG 75 DGE - Incremental Annual and Per Mile Cost
Comparative Model

Assumptions:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Diesel Price Per Gallon	$	3.00	$	4.00	$	5.00
CNG Price per Diesel Equivalent Gallon (DGE)	$	2.50	$	2.50	$	2.50
Difference in Fuel Price per Diesel Equivalent Gallon (DGE)	$	0.50	$	1.50	$	2.50
Additional Cost of CNG Tractor Unit	$	40,000	$	40,000	$	40,000
Miles per Year Per Tractor		60,000		60,000		60,000
Payload, in Pounds (natural gas tractor vs. 75,000 lbs. diesel)		73,403		73,403		73,403
Range in miles (natural gas tractor vs. 353 miles diesel)		288		288		288
Fleet Size, in Units		8		8		8

Per Tractor Costs Scenario:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Annual Operating Costs (per tractor)						
Incremental Fuel (Savings)/Cost	$	(2,837)	$	(15,603)	$	(28,369)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Cost of Additional Fuelings at $25 each	$	950	$	950	$	950
Payload (Savings)/Cost of additional miles $3.10 per mile	$	3,960	$	3,961	$	3,961
Capital Costs (per tractor)						
NG Tractor Annualized Incremental Cost	$	7,500	$	7,500	$	7,500
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	9,574	$	(3,192)	$	(15,958)
Incremental (Savings)/Cost Per Mile	$	0.16	$	(0.05)	$	(0.27)

Fleet Costs Scenario:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Annual Operating Costs						
Incremental Fuel (Savings)/Cost	$	(22,695)	$	(124,823)	$	(226,950)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Additional Fuelings	$	7,600	$	7,600	$	7,600
Payload (Savings)/Cost	$	31,684	$	31,685	$	31,687
Capital Costs						
NG Tractor Annualized Incremental Cost	$	60,000	$	60,000	$	60,000
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	76,589	$	(25,537)	$	(127,663)
Incremental (Savings)/Cost Per Mile	$	0.16	$	(0.05)	$	(0.27)

Figure 21. Comparative Model Summary: Farm Pick Up 11.9L Spark-Ignited CNG vs. 11.9L Diesel

Farm Pick Up - 8.9L LNG 75 DGE - Incremental Annual and Per Mile Cost
Comparative Model

Assumptions:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Diesel Price Per Gallon	$	3.00	$	4.00	$	5.00
LNG Price per Diesel Gallon Equivalent (DGE)	$	2.50	$	2.50	$	2.50
Difference in Fuel Price per Diesel Gallon Equivalent (DGE)	$	0.50	$	1.50	$	2.50
Additional Cost of LNG Tractor Unit	$	42,500	$	42,500	$	42,500
Miles per Year Per Tractor		60,000		60,000		60,000
Payload, in Pounds (natural gas tractor vs. 75,000 lbs. diesel)		74,445		74,445		74,445
Range in miles (natural gas tractor vs. 353 miles diesel)		317		317		317
Fleet Size, in Units		8		8		8

Per Tractor Costs Scenario:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Annual Operating Costs (per tractor)						
Incremental Fuel (Savings)/Cost	$	(2,837)	$	(15,603)	$	(28,369)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Cost of Additional Fuelings at $25 each	$	475	$	475	$	475
Payload (Savings)/Cost of additional miles $3.10 per mile	$	1,376	$	1,377	$	1,377
Capital Costs (per tractor)						
NG Tractor Annualized Incremental Cost	$	7,969	$	7,969	$	7,969
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	6,983	$	(5,783)	$	(18,548)
Incremental (Savings)/Cost Per Mile	$	0.12	$	(0.10)	$	(0.31)

Fleet Costs Scenario:		**$3 / gal**		**$4 / gal**		**$5 / gal**
Annual Operating Costs						
Incremental Fuel (Savings)/Cost	$	(22,695)	$	(124,823)	$	(226,950)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Additional Fuelings	$	3,800	$	3,800	$	3,800
Payload (Savings)/Cost	$	11,010	$	11,012	$	11,014
Capital Costs						
NG Tractor Annualized Incremental Cost	$	63,750	$	63,750	$	63,750
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	55,865	$	(46,261)	$	(148,387)
Incremental (Savings)/Cost Per Mile	$	0.12	$	(0.10)	$	(0.31)

Figure 22. Comparative Model Summary: Farm Pick Up 11.9 L Spark-Ignited LNG vs. 11.9L Diesel

Line Haul - 11.9L Spark-Ignited 75 DGE - LNG Incremental Annual and Per Mile Cost

Comparative Model

Assumptions:		**$3**		**$4**		**$5**
Diesel Price Per Gallon		$3.00		$4.00		$5.00
LNG Price per Diesel Gallon Equivalent (DGE)		$2.50		$2.50		$2.50
Difference in Fuel Price per Diesel Gallon Equivalent (DGE)		$0.50		$1.50		$2.50
Additional Cost of LNG Tractor Unit, net of incentives	$	35,000	$	35,000	$	35,000
Miles per Year Per Tractor		150,000		150,000		150,000
Payload, in Pounds (natural gas vs. 45,000 lbs diesel)		44,932		44,932		44,932
Range in miles (natural gas tractor vs. 531 diesel)		398		398		398
Fleet Size, in Units		50		50		50

Unit Costs Scenario:		**$3**		**$4**		**$5**
Operating Costs						
Incremental Fuel (Savings)/Cost	$	(5,650)	$	(31,073)	$	(56,497)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Additional Fuelings	$	2,350	$	2,350	$	2,350
Payload (Savings)/Cost	$	703	$	703	$	703
Capital Costs						
NG Tractor Annualized Incremental Cost	$	6,563	$	6,563	$	6,563
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	3,965	$	(21,458)	$	(46,882)
Incremental (Savings)/Cost Per Mile	$	0.03	$	(0.14)	$	(0.31)

Fleet Costs Scenario:		**$3**		**$4**		**$5**
Operating Costs						
Incremental Fuel (Savings)/Cost	$	(282,486)	$	(1,553,672)	$	(2,824,859)
Incremental Maintenance (Savings)/Costs	$	-	$	-	$	-
Additional Fuelings	$	117,500	$	117,500	$	117,500
Payload (Savings)/Cost	$	35,132	$	35,141	$	35,149
Capital Costs						
NG Tractor Annualized Incremental Cost	$	328,125	$	328,125	$	328,125
Shop	$	-	$	-	$	-
Incremental Annualized (Savings)/Cost	$	198,271	$	(1,072,907)	$	(2,344,085)
Incremental (Savings)/Cost Per Mile	$	0.03	$	(0.14)	$	(0.31)

Figure 23. Comparative Model Summary: Line Haul 11.9L Spark-Ignited LNG vs. 11.9L Diesel

Line Haul 15L HDPI 58 DGE - LNG Incremental Annual and Per Mile Cost

Comparative Model

Assumptions:	$3	$4	$5
Diesel Price Per Gallon	$3.00	$4.00	$5.00
LNG Price per Diesel Gallon Equivalent (DGE)	$2.50	$2.50	$2.50
Difference in Fuel Price per Diesel Gallon Equivalent (DGE)	$0.50	$1.50	$2.50
Additional Cost of LNG Tractor Unit, net of incentives	$ 67,000	$ 67,000	$ 67,000
Miles per Year Per Tractor	150,000	150,000	150,000
Payload, in Pounds (natural gas tractor vs. 45,000 lbs diesel)	44,500	44,500	44,500
Range in miles (natural gas tractor vs. 531 miles diesel)	354	354	354
Fleet Size, in Units	50	50	50

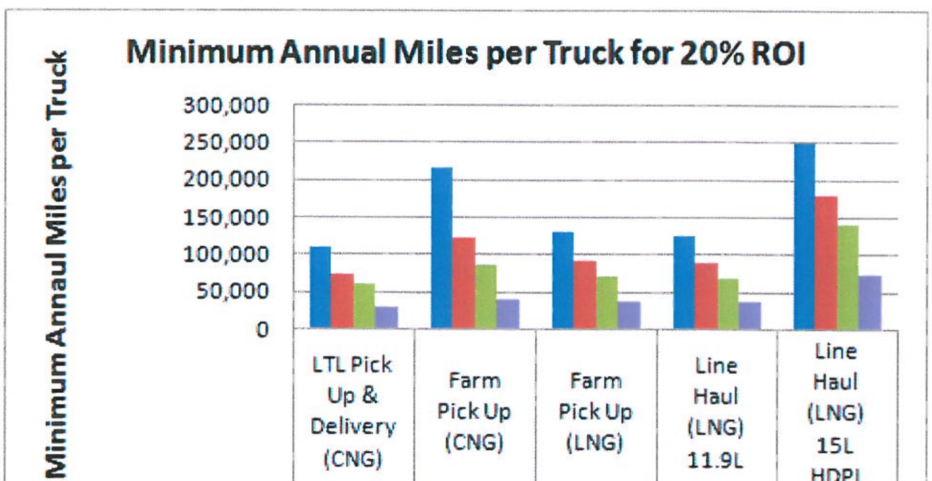
Unit Costs Scenario:	$3	$4	$5
Operating Costs			
Incremental Fuel (Savings)/Cost	$ (12,070)	$ (37,494)	$ (62,917)
Incremental Maintenance (Savings)/Costs	$ -	$ -	$ -
Additional Fuelings	$ 3,525	$ 3,525	$ 3,525
Payload (Savings)/Cost	$ 5,167	$ 5,167	$ 5,167
Capital Costs			
NG Tractor Annualized Incremental Cost	$ 12,563	$ 12,563	$ 12,563
Shop	$ -	$ -	$ -
Incremental Annualized (Savings)/Cost	$ 9,184	$ (16,239)	$ (41,663)
Incremental (Savings)/Cost Per Mile	$ 0.06	$ (0.11)	$ (0.28)

Fleet Costs Scenario:	$3	$4	$5
Operating Costs			
Incremental Fuel (Savings)/Cost	$ (603,493)	$ (1,874,679)	$ (3,145,865)
Incremental Maintenance (Savings)/Costs	$ -	$ -	$ -
Additional Fuelings	$ 176,250	$ 176,250	$ 176,250
Payload (Savings)/Cost	$ 258,332	$ 258,340	$ 258,349
Capital Costs			
NG Tractor Annualized Incremental Cost	$ 628,125	$ 628,125	$ 628,125
Shop	$ -	$ -	$ -
Incremental Annualized (Savings)/Cost	$ 459,214	$ (811,964)	$ (2,083,142)
Incremental (Savings)/Cost Per Mile	$ 0.06	$ (0.11)	$ (0.28)

Figure 24. Comparative Model Summary: Line Haul 15L HDPI LNG vs. 15L Diesel

	In City Pick Up and Delivery CNG	Farm Pick Up CNG	Farm Pick Up LNG	Line Haul LNG 11.9L Spark	Line Haul LNG HDPI
Annual (Cost) and Savings per mile					
Diesel $3 per gallon	($0.37)	($0.16)	($0.12)	($0.03)	($0.06)
Diesel $4 per gallon	($0.20)	$0.05	$0.10	$0.14	$0.11
Diesel $5 per gallon	($0.03)	$0.27	$0.31	$0.31	$0.28
Annual (Cost) and Savings per truck					
Diesel $3 per gallon	($5,185)	($9,574)	($6,983)	($3,695)	($9,184)
Diesel $4 per gallon	($2,182)	$3,192	$5,783	$21,458	$16,239
Diesel $5 per gallon	($439)	$15,958	$18,548	$46,882	$41,663
Annual (Cost) and Savings per fleet					
Diesel $3 per gallon	($77,778)	($76,589)	($55,865)	($198,271)	($459,214)
Diesel $4 per gallon	($42,185)	$25,537	$46,261	$1,072,907	$811,964
Diesel $5 per gallon	($6,591)	$127,663	$148,387	$2,344,085	$2,083,142
Return on Investment (ROI) = annual savings/ additional cost of tractor					
Diesel $3 per gallon	(18%)	(24%)	(16%)	(12%)	(14%)
Diesel $4 per gallon	(8%)	8%	13%	63%	24%
Diesel $5 per gallon	(2%)	40%	43%	137%	62%

Figure 25. Summary of Model Results for 5 Lynden Scenarios.
(Cost) and Savings includes operating costs and annualized capital costs
ROI = annual profit/ additional cost of the natural gas tractor



	LTL Pick Up & Delivery (CNG)	Farm Pick Up (CNG)	Farm Pick Up (LNG)	Line Haul (LNG) 11.9L	Line Haul (LNG) 15L HDPI
$3.50 / gallon diesel	110,000	215,000	130,000	125,000	250,000
$3.75 / gallon diesel	75,000	123,000	93,000	90,000	180,000
$4.00/ gallon diesel	60,000	87,000	72,000	70,000	140,000
$5.00 / gallon diesel	31,000	40,000	37,000	37,000	73,000

Figure 26. Minimum Annual Miles per Truck for 20% Return On Investment for 5 Lynden Scenarios.
(Assume Natural Gas is $2.50/ DGE)

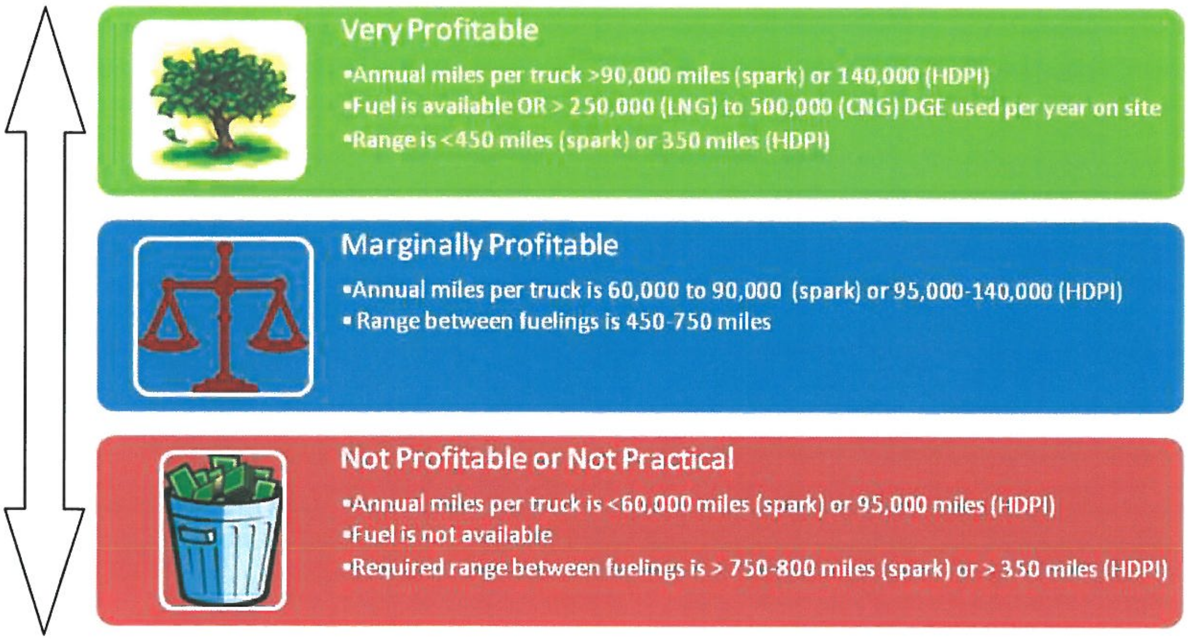


Figure 27. Operational Characteristics that are Profitable, Marginally Profitable, and Not Profitable or Practical. Assumes a $1.50/ DGE fuel price differential between diesel and natural gas.

Model Conclusions:

No model is perfect, however this model is a useful tool for predicting which operations make business sense for natural gas. Figure 26 shows the minimum number of miles per truck needed at various fuel price differentials to achieve a 20% Return on Investment (ROI) while taking into account the high incremental cost of the natural gas truck, loss of fuel economy, loss of payload, maintenance costs, and reduced operating range.

Return objectives are set by each company based on their unique circumstances such as cost of capital, amount of leverage, shareholder return expectations, and perceived risk of the investment. The Return On Net Asset threshold for four publicly traded trucking companies over the last 5 years ranged from 5.7% to 25.6% (average 12.1%.) A 20% threshold is on the high end of what a business would use as an investment criteria for this type of model, but is in line with the high perceived risk of investing in new technology like natural gas trucks.

Assuming $4.00 per gallon diesel and $2.50 per DGE natural gas (today's approximate prices), LNG fleets traveling more than 70,000 miles achieve a 20% Return on Investment. The minimum number of miles for a fleet of CNG trucks to achieve a 20% ROI ranges between 60,000 and 90,000 miles per year, depending on the actual cost of the tractors and the sensitivity of the operation to weight.

Modeling for the Westport HDPI 15L:

We also modeled the Westport HDPI 15L for the Line Haul scenario. For a truck with a single 120 gallon (58 DGE) tank, this added approximately 500 lbs and $67,000 to the weight and price of a comparable 15L diesel truck with 90 gallon tanks and required 140,000 miles per truck per year to reach 20% ROI. Adding an additional 35 DGE tank increased the incremental cost to $103,000 and added another 700 pounds. Trucks with this additional tank required 260,000 miles per truck per year to achieve a 20% ROI. The best fit for operations using the HDPI engine are those with short range, high miles, and high horsepower requirements.

Importance of Fuel Price:

There seems to be a critical point in the price difference between diesel and natural gas where diesel is between $1.25 and $1.50 more expensive than natural gas per diesel gallon equivalent (Figure 28). At these prices, small changes in the price differential have a large impact on profitability. In other words, when the price differential is between $1.25 and $1.50/DGE, natural gas suddenly becomes profitable to a relatively large number of heavy truck operations when it was not profitable before.

When the price differential increases to above $2.00 per DGE, natural gas becomes attractive to an even greater number of fleets (those traveling 30,000 to 40,000 miles per year) although the increase in the number of fleets is relatively less. At these higher diesel prices, factors such as the capital cost of the tractor and additional weight of the tractor have less of an impact on the minimum miles traveled to reach a 20% ROI threshold.

Even with very high priced diesel (price differential greater than $3.50 per DGE), there remains a bottom limit for an investment in natural gas trucks. Very low mileage fleets (those traveling less than about 20,000 miles per year) simply do not travel enough miles to reach a 20% return on their investment, unless the price of natural gas trucks decreases. Hybrid and electric trucks might better suit these types of operations.

At the other end of the spectrum, when the price differential between natural gas and diesel narrows to less than $0.75 per DGE natural gas becomes impractical because the miles required to achieve 20% ROI exceed the miles that can possibly be driven by a truck in one year.

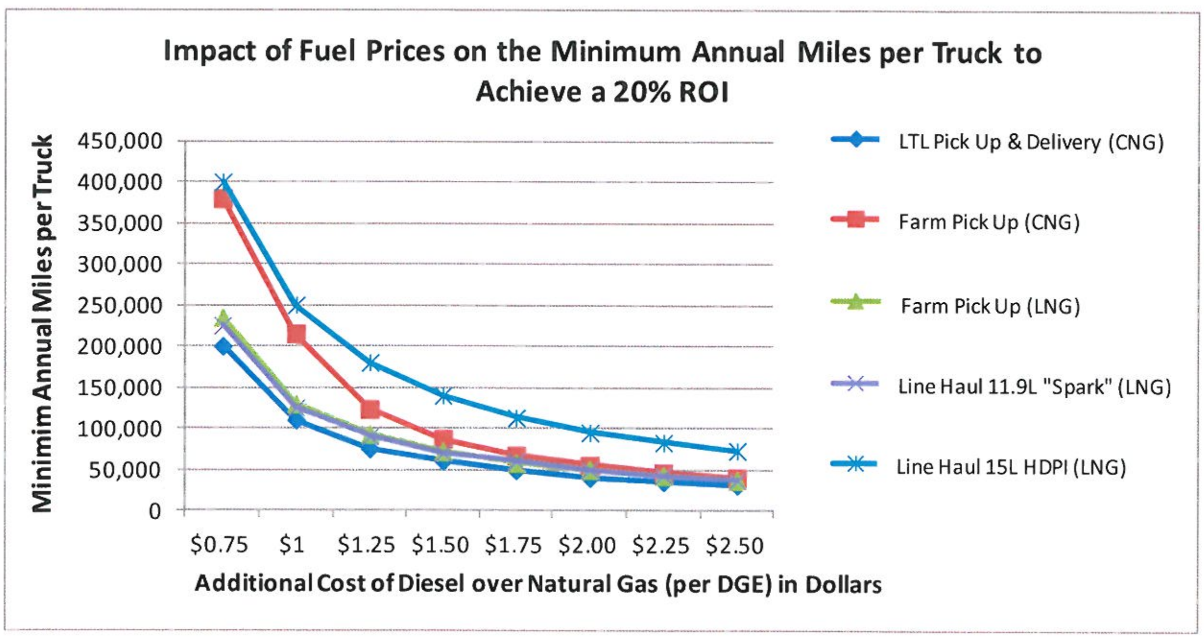


Figure 28. Impact of Fuel Prices on the Minimum Annual Miles per Truck to Achieve a 20% ROI.

Model Limitations and Alternative Approaches:

These conclusions (minimum number of miles per year per truck to be economically attractive) should be viewed as a rough estimate only. The numbers will vary by company based on the desired return on investment, truck mission and utilization, the sensitivity of the operations to truck weight, the size of the tanks required to meet a given fuel range, and the capital investment of each alternative (price of each truck).

There are limitations and alternative approaches to any model. For this paper, we used a Profit-and-Loss or Return on Net Assets (RONA) approach where the annual, pre-tax, pre-interest profit is divided into the depreciated, additional cost of a tractor over the life of that tractor. One alternative approach often used by a business to evaluate the attractiveness of an investment looks at after-tax cash flows over the life of the investment: Discounted Cash Flows Return On Investment (DCF-ROI).

In contrast to the RONA approach the DCF-ROI approach considers the impact of taxes and the time value of money. Because the RONA approach is a pre-tax measurement, the threshold of minimum return should be higher than the threshold for minimum return on the DCF-ROI approach. For instance, if one used a minimum return target of 20% for RONA, and one assumed a 40% tax rate (combined federal & state), the equivalent after tax return threshold for the DCF-ROI approach would be 12%.

While technically more correct from a finance perspective, we opted to use the RONA model in this analysis because the RONA approach is easier to model and understand.

There is value in simplicity, particularly at this stage where fleets are asking whether or not it is worthwhile to further investigate and possibly test a natural gas vehicle in their fleet rather than replace an entire fleet with natural gas trucks. Once a fleet gains some experience with natural gas trucks, then it might be more appropriate to use the more in-depth DCF-ROI approach to see if it makes sense to convert an entire fleet to natural gas.

In the end, the decision to replace a fleet with natural gas trucks is not based on a model. It is based on the reliability and operational performance of the trucks and on actual savings seen in real tests of real trucks.

Feedback from Lynden's People:

We expect the combination of accelerating demand in emerging markets for oil overseas and abundant domestic natural gas will keep oil prices high and natural gas prices low over the long term. Get used to gas. Whether we like it or not, and I can think of a lot of reasons why not, the future is going to be natural gas and batteries. - ***Jim J.*, CEO, Lynden Inc.**

There are a lot of "con's". The only "pro" seems to be the price differential between natural gas and diesel. Without the model it is very hard to know the impact of all of these factors. But, there is value to looking at this. If we can get a competitive advantage, then it is worth it.

Weight is a huge concern because additional weight equates to loss of payload and additional miles (cost) to make up for lost revenue. If we could get a credit for the additional weight of running natural gas, this would eliminate the weight concern.

If we move forward with a natural gas vehicle, it will first involve a test in a lane where there is fuel. Lynden is still looking for the best place to test a natural gas vehicle: high miles, compatible with the 8.9L engine, and available fuel. If tests are successful and fuel becomes more available, then we may begin to purchase natural gas trucks as old trucks are retired.
- ***Alex M.*, Chief Operating Officer, Lynden Inc.**

We may make a capital investment decision based on various issues, primarily oriented towards meeting a customer's needs. From a

financial standpoint, we may take one of two approaches. The RONA approach is a pre-tax measurement of earnings generated from the associated net assets. The DCF-ROI approach measures after tax cash flow returns on an associated investment. Regardless of which approach we take, the amount of risk we perceive in making the investment may influence our decision on what minimum return we will require. Companies who are successful over the long term will generally try to achieve a return on invested capital that exceeds their cost of capital, which varies by company.
- ***Brad M. CFO, Lynden Inc.***

This may make sense financially, but it also has to work from a practical standpoint. We don't know for sure if the 11.9L engine will work for us and fuel is not yet available for our routes.
-Jason J., **President, Brown Line**

As the model points out, there could be huge potential. We need to look first at areas that have the highest miles and consume the most fuel per unit. The Farm Pick Up scenario is not necessarily the best choice because we do not know if the 8.9L will be approved for these kinds of weights, so we are looking at other scenarios. There is a lot to learn and many factors to consider so we need time to make a good decision. Lack of infrastructure means that we are limited to local routes rather than being able to respond to extraordinary events with our go-anywhere type fleet. We are always concerned with the first generation of any new engine (11.9 L Cummins-Westport in this case). As much as we like to lead our industry, the leading edge can be the "bleeding edge" if we rush. ***-Brad W.,*** **President, LTI Inc.**

[After test driving a CNG 8.9L for 30 miles], the power of the truck was good considering it was an 8.9L engine. This wouldn't work for our operations, but the new 11.9L should work. The truck was quieter, you could hardly hear it running. It burns clean, the exhaust was just steam with no smell. The truck was heavy (16,000 lbs. compared to our 13,500 lbs. but was not set up with lightweight components. I wouldn't have a problem with driving these trucks in the future. ***Frank S.*** **- Driver**

From a maintenance perspective, there are a lot of unknowns (shop upgrades, maintenance technician training, shop tools, life of spark engines, tank issues, and safety concerns). Biogas is "neat", but without very expensive scrubbers, we can end up with a maintenance nightmare. Diesel is a stable technology and we understand it. ***Dave S.*** **Director of Maintenance, LTI, Inc.**

I had always thought that natural gas added a lot of weight, good to clear this up. We wet-hose (refuel on-site) to reduce man hours at the pump. This makes it challenging to test a truck without committing to a large investment (on-site refueling station) or sacrificing man hours to refuel elsewhere. ***Charlie M.,*** **Director of Maintenance, Lynden Transport**

Lessons Learned from this Exercise:

1. Look for lanes with high mileage, high fuel use per unit and available fuel for vehicle tests.
2. Don't "over spec" the tanks. These are very expensive and heavy, so should be spec'ed with the smallest tank practical to get required range.
3. Many dealerships are still learning about natural gas. California dealerships currently have more experience, especially with LNG trucks.
4. Make sure the tractor weight includes full fuel and urea for accurate weight comparison with diesel.
5. 2012-2013 is a logical time to invest in natural gas vehicles with the availability of the 11.9L spark ignited engine and infrastructure becoming available on major interstate corridors.

6. Who is Currently Using Natural Gas and What Have They Learned?

CNG is being used successfully in short and medium range applications such as refuse trucks, straight trucks, and busses. Natural gas in Class 8 tractors is only beginning to be adopted as LNG refueling infrastructure and larger natural gas engines are now beginning to become available.

There are currently about 1,800 natural gas Class 8 tractors in operation in the United States, mostly in California, Arizona, and Texas. They primarily run "return-to-base" operations with a 150 mile radius because of limited infrastructure. Most (95%) operate on LNG and some (5%) on CNG. Figure 29 summarizes some of the current users of natural gas heavy trucks.

Business	Year	Location	Natural Gas Truck Description	Commodity	Gov't Funding
Early Tests - Prototype					
Liquid Carbonic	1994	TX	4 Freightliner LNG Detroit Diesel S60G Prototype	Natural Gas	Yes
Norcal	2004	CA	14 Cummins-Westport GX LNG	Solid Waste	Yes
California-Based LNG and CNG					
Total Trans Services	2008	CA	8 Kenworth T800 LNG	Drayage	Yes
Ryder Systems Inc.	2011	CA	182 Freightliner M2 CNG 20 Peterbilt LNG	Truckload	Yes
Schneider National	2011	CA	4 Freightliner M2 CNG and LNG	Truckload, LTL	Yes
C.R. England	2011	CA	5 Kenworth T800 LNG Full service lease PacLease	Truckload, LTL	No
UPS	2011	CA to NV	48 Kenworth T800 LNG (+11 previously converted trucks)	LTL	Yes
CNG Outside of California					
Paper Transport	2010	WI to IL	7 Freightliner CNG 8.9L	Truckload, LTL	5 of 7
Ruan	2011	IN, TN, KY	42 Kenworth T440 CNG biomethane Full service lease PacLease	Raw Milk	Yes
Foodliner	2011	IL	6 Freightliner M2 CNG	Truckload Food	Yes
Hribar Logistics	2011	WI	2 Kenworth T440 CNG	Fly Ash	Yes
Saddle Creek Corp.	2011	FL	40 Freightliner M2 CNG (130 DGE) 40 more in 2012	Truckload, LTL	No
LNG Outside of California					
TriMac	2008	TX, CA, AZ	43 to date 14 Kenworth T800 LNG in 2010	LNG & Chemicals for Natural Gas Producers	Yes
Dillon Transport	2009	TX, OH	24 Peterbilt 384 LNG 8.9L	Temperature sensitive bulk liquid tanker	Yes trucks No station
Robert Transport	2010	QC (CAN)	180 Peterbilt 367 and 386 LNG 15L deployed over the next 3 years	Truckload, LTL	No
EnviroExpress	2011	CN	18 Kenworth T800 LNG	Incinerator Ash to landfill	Yes
Heckmann Corporation	2011	LA	200 Peterbilt 367 LNG on order	Water for Natural Gas Producers	No
Vedder Transport	2011	BC (CAN)	50 Peterbilt 386 LNG	Bulk Liquid and Dry Food	No
Sysco	2011	UT	9 Kenworth T800	Truckload Food	Yes

Figure 29. Examples of heavy duty truck fleets using natural gas in North America.

Initial Tests:

Not surprisingly, some of the first businesses to test LNG are those who work closely with the natural gas industry.

Liquid Carbonic, an LNG producer and distributor in Texas, worked with the National Renewable Energy Laboratory from 1994 to 1997 in the first test to run LNG in a heavy trucks fleet. This test provided a valuable example showing that LNG could be used in heavy trucks. Operating costs were substantially higher at that time, but improvements to engines and price of equipment have improved dramatically since then.

TriMac hauls LNG and chemicals used in natural gas production. In 2008, they began testing three demo tractors in Houston and one in California. They took delivery of 19 more tractors in 2010; seven haul LNG on their California to Arizona lane, one hauls LNG in their Texas lane, and 14 work local lanes hauling chemicals. They now have a total of 42 LNG tractors.

California-Based LNG:

California tax incentives and air quality rules have spurred the development of LNG infrastructure and adoption of LNG within the state. This has dramatically taken off in the last year with Ryder's natural gas leasing program and a new natural gas compliant maintenance facility in the state and a number of businesses who have taken advantage of state and federal grants.

Ryder System Inc. joined the San Bernadino Associated Government's Natural Gas Vehicle Project to purchase 202 heavy duty natural gas vehicles, upgrade three natural gas compliant maintenance shops, and build two fueling stations. The CNG and LNG vehicles are now available for lease or rent. Ryder has secured lease agreements for 87 heavy duty natural gas trucks. Customers include Staples, Pacer international, and Golden Eagle Distributors, Inc.

Schneider is testing four Freightliner M2's with 8.9L Cummins-Westport engines for use in California. Three are LNG and one is CNG. The trucks cost an up-charge of $30,000 to $40,000, most of which was covered by a California Air Resource Board (CARB) grant. They estimate the cost to upgrade their shop to be compliant with CALOSHA and FEDOSHA requirements for natural gas would cost approximately $1 million dollars per shop bay so they are outsourcing maintenance at this time. They expect an 11% increase in maintenance costs over diesel and a 7%-10% reduction in fuel economy.

C.R. England is leasing 5 Kenworth T800 LNG tractors under a full service lease from Paccar. The tractors will be used in their dedicated California refrigerated carrier operations.

LNG Outside of California:

Dillon Transport is currently running 14 Peterbilt 384 LNG bulk tankers based out of Dallas, Texas and has deployed 10 more in Lodi, Ohio. The Texas trucks haul 80,000 GVW liquid and industrial materials. Beginning in 2012 they will be used to haul product to a shingle roofing plant 125 miles away; each truck will make 2 trips per day. The high volume and short range fits well with the LNG model.

Dillon chose to use the 8.9L spark engine rather than the Westport HD 15L because they are extremely weight sensitive and wanted to eliminate the extra diesel tank and diesel after-treatment system required with the compression-ignited engine. They will be alpha testing the 11.9L spark ignited engine and think that this will be the right engine for the 80,000 GVW loads, the 8.9L engine works, but is at its upper limit with these kinds of loads.

They opted for LNG rather than CNG because the CNG would have required twice as much tank volume which would have been bulkier, heavier, and more expensive. In addition, LNG refueling is as fast as diesel, whereas CNG "fast-fill" stations will only fill quickly to 75%; the remaining 25% is filled as a trickle. They use an

81 DGE LNG tank and are experimenting with dual LNG tanks for longer hauls.

The main disadvantage of using LNG is that the trucks must get back to the station to refuel every night, "you can't just let a truck sit for 7 or 8 days" because when the fuel warms up it turns to gas, builds pressure, vents out of the tank and evaporates. This is lost fuel. In addition, the tanks work better when they are cold, the first couple of refuelings take a long time as the tank cools and "gets seasoned". For high-volume, short range applications, LNG works great.

Dillon partnered with Clean Energy to build LNG refueling stations in Texas and Ohio. They are currently using mobile refueling stations (3,000 DGE), provided by Clean Energy, until these stations are complete. Clean Energy has LNG plants in Willis, TX and Boron, CA. Fuel is trucked to fueling stations from those locations. Another potential source of LNG is local natural gas utility companies who sometimes store surplus natural gas as LNG during the summer months.

Refueling the truck is different, but simple. The tank looks like a regular diesel tank on the side of a truck. It takes about five minutes to refuel. If the fuel drips, it just evaporates - there is no diesel spill. As a side- benefit, "no one can steal your fuel" as can be a problem with diesel.

The trucks were purchased from a California dealership because the California dealers were more familiar with the natural gas trucks and Dillon Transport hopes to be able to resell the vehicles more easily in California. They would have preferred to lease until the 11.9L engine became available, but leasing was not an option at that time (it is now).

Normally, Dillon does the maintenance for their trucks "in-house", but maintenance for the LNG trucks is outsourced to a dealer who is located very near their Texas terminal. They have run accelerated oil changes (every 10,000 miles) because of the severe duty cycle for these 8.9L engines, but plan to stretch this out to every 12,000 miles. Drivers have had some anxiety over operating the new trucks and this sometimes manifests as maintenance concerns, but they have had no real issues with the trucks.

They are happy to be using a domestic fuel, believe the national security message is important, and do a lot of work for oil and gas customers in Texas, but ultimately, this was a business decision based on the price differential of oil vs. natural gas. It has also added a new dimension to their customer relations as they can help customers save money and meet their sustainability goals. Customers are now asking for it in other locations.

Robert Transport is the first genuine for-hire long-haul LNG operation in North America. They currently have 10 LNG trucks in service and plan to add at least 180 more by 2014. The trucks are Peterbilt models 386 with the Westport GX (15L) engine and two 119 gallon LNG tanks (116 DGE). The trucks run 600 miles between Mississauga, Ontario and Quebec City. Refueling infrastructure plans include three sites between Mississauga and Quebec City. Accelerated depreciation for natural gas trucks is 168% in Canada for a period of three years and helped justify the higher cost of the trucks. They needed to modify their repair garages in order to perform the maintenance on the trucks. Robert specs his trucks over a 10 year lifecycle. The trucks cost close to $225,000. They expect to break-even with the current fuel prices and save money over the long term as the price differential between natural gas and diesel diverges.

CNG in Close- Loop Applications:

Outside of California, natural gas use in heavy trucks has so far been limited to "closed-loop" applications, because LNG infrastructure is not yet available. In these operations trucks travel out and back to return to a "home" terminal or fueling station to refuel. CNG, however, is being used in both closed-loop and dedicated lane operations with ranges up to 350 miles. More tanks can provide even larger ranges but are heavy and expensive.

Paper Transport currently runs seven Freightliner CNG trucks with the Cummins-Westport 8.9L engine between Green Bay, Wisconsin and Chicago, IL. They are currently able to operate in a 300 to 350 mile range with the five 15 DGE CNG tanks mounted in the "behind the cab" configuration, but plan to add another 40 DGE side-rail mounted tank to further increase their range. The incremental cost of the trucks is approximately $50,000 and fuel savings are between $1.60-$2.90 per gallon. Maintenance costs are substantially higher because they are running the trucks significantly more miles than what they are designed for. Upgrades to the shop were not necessary because maintenance is contracted out to Cummins. They do not consider weight to be an issue, because the day cab is light and the engine is smaller and lighter than what they would normally use. Normally, Paper Transport would use a more powerful 13L or 15L engine for their 80,000 pound payload. The Cummins-Westport 8.9L ISL-G engine works well on the flat terrain in the Midwest, but would not be practical with this payload on hills of any significance. They have had no issues with the fuel or trucks and are "getting everything that they hoped." They received a Clean Cities grant for five of the seven trucks that they now operate and plan to add additional trucks in the future. Some will be the 8.9L engines, but most will be the 11.9L engines when they become available. Jeff Shefchik, President, says that the driving factors in using natural gas are economics (fuel savings), the environmental benefit, and the fact that natural gas is an American fuel and supports the U.S. economy.

Ruan, a bulk food transporter, and Fair Oaks Dairy farm recently announced the largest renewable CNG project in the United States. Ruan is running 42 Kenworth T440 CNG trucks with two 40 DGE side-rail tanks and 55 DGE mounted back of cab (600 mile range), the 8.9L Cummins-Westport ISL-G engine, and Allison 3000HS six-speed automatic transmission. The tractors' specifications are able to handle the 80,000-lb gross combination weight, though at its upper limit. The trucks are operated under a full service lease from PacLease.

The trucks haul raw milk from Fair Oaks Farms to processing plants in Indianapolis, Indiana, Kentucky, and Tennessee. The Indiana routes are "out-and-back", but the Kentucky and Tennessee routes are beyond the range of the fuel carried on board, so "relay-operations", where a driver hands off his entire rig, are required. The southbound driver with a load of milk trades off with a northbound driver transporting an empty milk trailer. The southbound driver takes the empty trailer back to Fair Oaks Farms, while the northbound driver takes the full load of milk south for delivery to the processing plants.

Federal and state grants helped offset the higher cost of the CNG tractors and the cost of building two CNG filling stations. In order for it to make financial sense, each tractor needs to get about 250,000 miles per year. Fair Oaks Dairy personnel preload the tank trailers for the Ruan drivers to reduce down-time at the farm.

The tractors weigh about 17,000 pounds with lightweight disc wheels, brake drums, air tanks, fifth wheels, jacketing, milk tankers, and eliminating the product pumps.

Fair Oaks Farms operates four bio-digesters that produce methane from cow manure. One of these digesters will supply methane to the new CNG filling station at Fair Oaks. As part of this project, another filling station was built 220 miles away as part of a State of Indiana effort to create a CNG corridor on I-65.

Saddle Creek Corporation has agreed to purchase 40 Freightliner M2 trucks in 2011 and 40 more in early 2012 for their Florida fleet. The trucks will use two 25 DGE CNG tanks behind the cab and two 40 DGE rail-mounted tanks and expect a usable range of 560 miles. President Mike DelBovo says, "because the cost of natural gas is less volatile than diesel, it allows us to have more control over our fuel costs and our customers to have a more stable fuel surcharge".

7. Policy Options to Support the Adoption of Natural Gas Heavy Trucks

1. **Weight Exclusion**. Trucks are limited to a certain Gross Vehicle Weight (GVW) on a given roadway. Any additional weight to the truck (e.g. natural gas fuel tanks) reduces the payload that they can carry. Fleet managers are constantly looking for ways to minimize weight and maximize payload.

A weight credit for the additional weight of natural gas truck fuel tanks would eliminate the concern and financial impact of a diminished payload. A credit for the empty weight of the CNG or LNG tanks would be easiest to determine because weight differential varies greatly depending on the diesel truck that is used for comparison. This would translate to a slight payload benefit for using natural gas because the natural gas itself is lighter (per Btu) than diesel and natural gas trucks do not require diesel after-treatment systems. This would hold no benefit for operations that are not weight sensitive (Pick Up and Delivery modeled here). Figure 31 shows a possible weight credit for various tank configurations.

2. **Eliminate the Federal Excise Tax (FET) for Natural Gas Heavy Trucks**: Federal Excise Tax accounts for roughly 10% of the incremental cost of a heavy duty natural gas truck. An FET exclusion for natural gas trucks reduces the high capital cost of the truck and makes an investment in natural gas trucks much more attractive. This would not impact trucks less than 33,000 GVW because they do not pay FET.

3. **Ensure a minimum $1.25-$1.50 price differential between diesel and natural gas.** A policy that maintains this critical price differential would ensure that the price spread between diesel and natural gas does not narrow below a point where it is not profitable for most fleets to invest in a fleet of natural gas trucks. (Figure 28). It would also reduce concern and risk associated with a large capital investment in natural gas vehicles followed by a narrowing in the price differential.

This policy could be an extension of the $0.50/DGE tax credit, although this would need to be guaranteed for at least 5 years to ensure confidence. A more effective approach could take the form of a "feebate" where a "fee" on oil pays for a natural gas "rebate" - this could be written to take effect only if the price differential between diesel and natural gas falls below the sensitive $1.50 per DGE level.

4. **Tax Credits and Grants for Infrastructure and Vehicles.** A tax credit for the additional cost of a natural gas tractor reduces the high cost and associated risk of investing in natural gas. Tax credits are not necessary to make an investment in natural gas attractive for high mileage fleets if the current price differential between natural gas and diesel persists. However, an 80% tax credit (as proposed in the NATGAS Act HR 1380 and S 1863) will accelerate the adoption of natural gas by high mileage fleets and make it attractive to lower mileage fleets.

The high capital cost to upgrade maintenance shops to be safe and compliant remains a financial and operational barrier. There are currently very few natural gas compliant shops available to service natural gas vehicles and it is not always practical or cost effective to travel long distances for maintenance. A tax credit for upgrades to natural gas maintenance garages would help mitigate this issue.

6. **Access to Capital.** The incremental cost of natural gas trucks is high because of the specialized tanks required. Most fleets have limited access to capital to make this investment. Banks may be unlikely to lend for new technologies like natural gas vehicles. In the absence of grants and tax credits, low interest loans would help fleets overcome this hurdle.

7. **Biogas Support.** The environmental benefit of using biogas (farm waste, wastewater treatment, and landfill gas) natural gas as a transportation fuel arguably justifies additional

government support. Box 2 discusses biogas in more detail; Box 3 discusses other alternative fuel technologies.

Biogas is one of the least expensive renewable sources of energy. It is cheaper than gasoline and diesel, but more expensive than fossil sourced natural gas due to the high cost of purification. It is not likely to be able to compete with low-priced fossil sourced natural gas prices without monetizing its environmental benefit. Again a "feebate" could be used where a fee on fossil sourced natural gas and/or oil would pay for a rebate on biogas to make it cost competitive with fossil sourced natural gas.

Figure 30 shows the estimated impact of policies on the minimum number of annual miles per truck to be economically attractive.

- With no policy changes, natural gas makes sense for high mileage trucks (>90,000 miles/year).

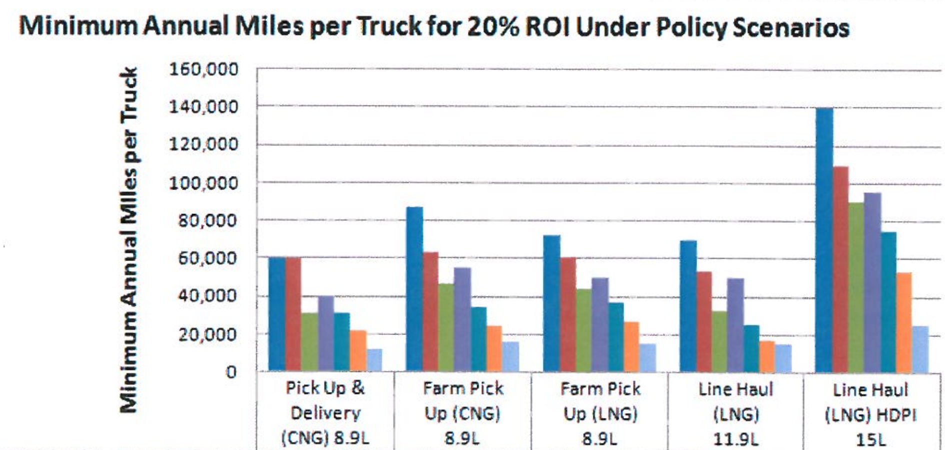
- Natural gas becomes attractive for lower mileage trucks (40,000-50,000 miles/ year) with a $0.50 per DGE tax credit for natural gas.

- A Federal Excise Tax Exclusion for natural gas vehicles reduces the minimum number of miles to between 30,000 and 50,000.

- A weight exclusion for the empty weight of CNG and LNG tanks would lower the minimum number of miles to include trucks traveling 53,000-63,000 miles per year, with a larger benefit for CNG. This would not benefit operations that are not weight sensitive.

- Combined, these policies would make natural gas attractive for trucks traveling 25,000 to 35,000 miles/ year.

- Alternatively, an 80% tax credit for the additional cost of a natural gas truck makes a spark-ignited natural gas truck attractive for low mileage fleets (those traveling around 15,000 miles/ year). It also becomes attractive for trucks with higher power requirements (HDPI 15L) traveling at least 25,000 miles per year.



	Pick Up & Delivery (CNG) 8.9L	Farm Pick Up (CNG) 8.9L	Farm Pick Up (LNG) 8.9L	Line Haul (LNG) 11.9L	Line Haul (LNG) HDPI 15L
No Policy Changes	60,000	87,000	72,000	70,000	140,000
Tank Weight Exclusion	60,000	63,000	61,000	53,000	109,000
FET Exclusion	31,000	47,000	44,000	33,000	90,000
$0.50/ DGE Tax Credit	40,000	55,000	50,000	50,000	95,000
Combined FET & Weight Exclusion	31,000	34,000	37,000	25,000	75,000
Combined $0.50 / DGE tax credit, FET, & Weight Exclusion	22,000	24,000	27,000	17,000	53,000
80% Tax Credit for Vehicle	12,000	16,000	15,000	15,000	25,000

Figure 30. Estimated Impact of Suggested Policies on the Minimum Number of Annual Miles per Truck to Achieve 20% ROI. Assumes $1.50 price differential for base case (Diesel $4.00/ gallon; Natural Gas $2.50 / DGE). Farm Pick Up and Line Haul are weight sensitive operations. Pick-Up and Delivery is not weight sensitive.

Tank Configuration	Weight Credit for Empty Tank
CNG (5) 15 gallon back of cab (75 DGE)	1,650 lbs
CNG (2) 40.5 gallon side rail mounted (81 DGE)	1,200 lbs
LNG (1) 119 gallon side rail mounted (60 DGE)	800 lbs
LNG (1) 150 gallon side rail mounted (75 DGE)	1,000 lbs

Figure 31. Proposed Weight Credit for Natural Gas Fuel Tanks (empty weight).

Biomethane or "biogas" is very attractive from an environmental perspective. Methane that would otherwise enter the atmosphere as waste from farms, landfills, and wastewater facilities can be used as a fuel in natural gas engines, thereby removing a methane source and displacing a fossil fuel source at the same time. Methane is 25 times more potent as a greenhouse gas than CO_2, so using it as a fuel dramatically reduces greenhouse gas emissions. It also allows fleets to partner with customers' sustainability initiatives by using their waste as a fuel.

Biogas, like fossil sourced methane, can be used in natural gas vehicles. Biogas has been used successfully in natural gas powered refuse trucks (landfill gas) for many years and more recently in trucks hauling milk (dairy farm waste). The perfect application for a biogas fueled truck is a return to base fleet that returns to the site of biogas production. As with any fuel, fuel quality must be ensured in order to avoid maintenance problems. Various processing techniques are used to "scrub" the biogas and remove impurities in order to bring the fuel to above pipeline quality. There is no warranty issue with using biogas in a natural gas engine.

Biogas is less expensive (per Btu) than other renewable fuels (solar and wind), but more expensive than fossil natural gas. A program called "RNG-10" under development by Clean Energy is designed to bring bio-methane to market at a more competitive price. Fleets willing to pay 10 cents more for natural gas will get credit for fueling their vehicles with biogas and cover the cost of biogas production elsewhere. This allows fleets that are not able to refuel with biogas directly to indirectly fuel their fleet with renewable biogas and reduce GHG emissions by 80-90%. This program can easily transfer to an optional surcharge for shipping customers interested in "green transportation" for their goods.

Box 2. Renewable Natural Gas: Bio-methane and Biogas.

OTHER ALTERNATIVE FUEL TECHNOLOGIES:

Hydrogen is considered the ultimate zero emissions, domestic, and renewable fuel. It can be generated by running an electrical current through water, splitting it into water and hydrogen. The electrical current can come from renewable sources of energy (solar, wind, landfill gas, or photosynthesizing microbes) and is sometimes thought of as a "battery" for its ability to store intermittent renewable sources of energy to be used later as fuel. More commonly, is it made from natural gas in a process called "steam-reformation" in which high pressure steam reacts with natural gas to form "synthesis gas" which then reacts with water to form hydrogen. When burned as a fuel, hydrogen emits only oxygen, water, and very few NO_x emissions. However, the high cost of production and vehicles means that hydrogen is at least a decade away from being commercially viable as a transportation fuel.

Hydrogen, as a transportation fuel, is faced with similar, or even more challenging issues than natural gas. 1.) It is less dense (Btu/gallon) so must be stored at even higher pressures (10,000 psi) or colder (-432° F) temperatures at high pressure in heavier, more expensive tanks. Hydrogen has the potential to be stored without tanks as a Polymer Electrolyte Membrane (PEM) where hydrogen atoms chemically bond to materials for storage, but this technology is still in the research and development phase. 2). It faces similar refueling infrastructure issues. 3.) It is more flammable than natural gas, so faces even more challenging safety issues.

Natural gas is considered to be the "technological bridge" to hydrogen because advances in natural gas vehicles, tanks, refueling infrastructure, safety solutions, workforce training, and business alliances directly or indirectly apply to hydrogen, lower the hurdles that must be overcome, and move it closer to being economically viable. For example, natural gas engines can burn a compressed hydrogen/CNG blend with only minor modifications; tanks used to store hydrogen use the same base technology as natural gas CNG and LNG tanks; shops that are upgraded to comply with natural gas safety guidelines, are well on their way to being hydrogen compliant as well; natural gas refueling infrastructure has the potential to be modified to fulfill hydrogen refueling needs and paves the way for similar permitting and business relationships; and as people begin to understand natural gas, hydrogen becomes easier to accept.

Hydrogen is not a near-term solution to our transportation energy needs, but will become economically feasible more quickly because of the technological and infrastructure advancements that will come with a transition to natural gas.

Hybrid-Electric Vehicles work best for low speed operations with frequent stops or engine idling such as in-city pick-up and delivery vehicles and service vehicles. They are not a practical solution for on highway heavy trucks because fuel efficiency gains are minimal at high speeds (> 35-45 mph) with little stop-and-go.

During braking, energy is captured and stored in the batteries (or in the case of hydraulic hybrids, stored as hydraulic pressure). This energy can be used exclusively to power the truck during take-off, power electrical equipment without engine idle, and to supplement diesel power during acceleration. This "regenerative braking" also extends brake life.

Hybrid tractors are usually used for applications below 33,000 GVW, but in some cases have been approved for up to 54,000 GVW. The incremental cost of a hybrid delivery tractor is similar to or slightly less than a natural gas tractor. The main benefit comes from a higher fuel economy (15-30%) compared to diesel in stop-and-go situations.

Payback on a hybrid vehicle depends on the amount of stop and go, time spent at low speeds, and time spent at idle, but under the right conditions, a hybrid truck can be a better alternative than natural gas.

Box 3. Other Alternative Fuel Technologies.

8. Conclusions

This is an exciting time for heavy-duty natural gas trucks.

1. **Refueling infrastructure is finally underway.** Clean Energy and Flying J-Pilot have partnered to build a foundational grid of LNG fueling stations for heavy -duty trucks along major interstate corridors, with $300 million dollars invested in this project. Plans are in place to have 80 new stations opened along coast-to-coast corridors by December 2012. They anticipate having an LNG filling station every 200-300 miles on major highways by June 2013 and 300-400 stations serving all regional routes by 2015.
2. **The price spread between natural gas and diesel has reached a tipping point** where natural gas has suddenly become profitable to a large number of heavy truck operations. High mileage fleets (those traveling 60,000-90,000 miles per truck per year) see an attractive ROI from fuel cost savings, even when considering maintenance costs, fuel economy penalty, loss in payload from additional weight of the tanks, and the higher cost of the tractor. This is true for both CNG and LNG trucks, but only for the lower cost spark-ignited engines. Existing compression - ignited engines are restricted to very high mileage fleets (140,000 miles per truck per year).
3. **The "game changer" 11.9L spark-ignited engine will be available in the first quarter of 2013.** This engine will fit a much larger number of class 8 truck operations than the existing 8.9L spark engine which was designed for refuse trucks and transit busses. It will not need the heavy diesel after-treatment technology and will offer a much more cost effective, lighter weight, higher fuel capacity alternative to the existing 15L compression-ignited engine. Also in 2013, the Navistar 13L dual-fuel engine will be entering test phases.

However, a handful of barriers still remain to the mainstream adoption of natural gas by heavy truck fleets.

1. **Refueling infrastructure is still limited compared to diesel.** Even with 300 new LNG refueling stations, fleets will be limited to routes where fuel is available. This means fleets using dedicated natural gas engines must sacrifice their ability to "go anywhere" to meet customer needs.
2. **Natural gas trucks are substantially more expensive than a diesel truck**. This is primarily due to the cost of the specialized CNG and LNG fuel tanks. This is a significant barrier to fleets and owner-operators with limited access to capital.
3. **The high capital cost of upgrading a maintenance shop** remains a factor that can make an investment in natural gas trucks considerably less attractive. Full service leases or maintenance packages are available, but this is not always practical for fleets in rural areas and is generally less desirable than performing maintenance "in-house."
4. **Operating range is limited by the tanks that can fit on a truck at an economical price**. This is generally the 75 DGE configuration (LNG) and 40 DGE side rail or 75 DGE back of cab (CNG). Although it is possible to fit 150 DGE (LNG, "spark" engine), 143 DGE (CNG, "spark" engine), and 116 DGE (LNG HDPI 15L) on a truck, the high cost of the additional tanks decreases the financial payback substantially. This means that until infrastructure is widely available, fleets will be limited to routes where fuel is available and centrally-fueled operations.
5. **LNG use is limited to operations where trucks are refueled every 1-2 days** so that venting of fuel is not an issue. This is not likely to be a large problem because natural

gas trucks do not make financial sense for low mileage fleets.

6. **Fleets are apprehensive about new "high risk" technology.** It takes time to learn about and carefully test a new kind of truck and fuel.

Despite these barriers, if oil prices remain high and natural gas prices remain low and stable, then high mileage fleets are likely to initiate tests of natural gas trucks where infrastructure is available in the next few years, even without government subsidies. If those tests are successful, then they will begin to purchase new natural gas trucks as old trucks are retired. Tax incentives can help accelerate this transition and make natural gas attractive to lower mileage fleets.

1. A weight exclusion for the additional weight of natural gas tanks would eliminate concern and cost associated with a loss of payload.
2. A Federal Excise Tax exclusion for natural gas trucks would reduce the incremental cost of a natural gas truck by around 10%.
3. A policy that ensures a $1.25-$1.50 price differential between natural gas and diesel would ease concern over the risk of a narrowing price spread and maintain a critical price difference for fleets who invest in natural gas trucks to achieve a desired ROI .
4. Tax credits for the additional cost of natural gas vehicles would help accelerate the transition to natural gas and make natural gas attractive to lower mileage fleets. This could be paid for via fuel tax.
5. Tax incentives or grants for upgrades to maintenance shops that service natural gas vehicles would help alleviate the high capital cost and practical issue of being able to maintain a fleet of natural gas vehicles.
6. Low-interest loans would help fleets with limited access to capital make the investment in natural gas trucks.
7. Support for biogas would help make this renewable, low carbon fuel cost competitive with fossil sourced natural gas.

In summary, conditions are right for many high mileage fleets to begin investing in natural gas in the next few years as refueling infrastructure expands, more engine options become available, and the price differential between natural gas and diesel remains persistent.

The most attractive fleets are those with high miles (>60,000-90,000 miles/truck per year), that have fuel available within a 350-450 mile operating range, and that have operations compatible with a spark-ignited engine (7.6L, 8.9L, or 11.9L) or very high miles (>140,000 miles per truck per year; 15L HDPI).

This is likely to be a gradual process that accelerates in Q1 2013 as two of the primary barriers: 1.) lack of infrastructure and 2.) limited engine options, see major breakthroughs. Where refueling infrastructure is available, fleets are likely to initiate tests of natural gas trucks and if these tests are successful (i.e. profitable and reliable), then fleets will begin to replace older diesel trucks with natural gas trucks through attrition.

Policy incentives that address remaining barriers: 1.) the high incremental cost of natural gas trucks, 2.) uncertainty over the cost and requirements of upgrades to maintenance shops, and 3.) the additional weight of natural gas fuel tanks would help mitigate these barriers and accelerate the transition to natural gas by heavy truck fleets.

Policy that is timed to coincide with the Q1 2013 release of the 11.9L engine and expanding refueling infrastructure would have the greatest impact by removing uncertainty over potential future policy and adding to the growing momentum of interest in natural gas as a transportation fuel.

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Appendix

NFPA CODE 30A: Motor Fuel Dispensing Facilities and Repair Garages		
7	Building Construction Requipments	Gas detection system required in repair garages and in lubrication or chassis repair pits; No heating equipment with tempertures > 750 degrees F
8	Electrical Installations	Repair garages for CNG vehicles the area within 18" of the ceiling is designated Class I Division 2 hazardous location unless ventilation greater than of equal to four air exchanges per hour is provided
12	Additional Requirements for NCG, LNG, Hydrogern and LPG	CNG, LNG, compressed or liquified hydrogen, LP-Gas, or combination of these are dispensed as motor vehicle fuels along with Class I or Class II liquids that are also dispensd as motoer vehicle fuels
NFPA CODE 52: Vehicular Gaseous Fuels Systems		
6	CNG engine fuel systems	Design, installation, inspection, and testing of CNG fuel supply systems for vehicular internal combustion engines
8	CNG compression, gas processing storage, and dispensing systems	Design, construction, installation, and operation of containers, pressure vessels, compression equipment, buildings and structures, and associated equipment used for storage and dispensing of CNG as an engine fuel in fleet and public dispensing operations
12	LNG Fueling Facilities	Design, siting, construction, installation, spill containment, and operation of containers, pressure vessels, pumps, vaporization equipment, buildings, structures, and associated equipment used for stroage and dispensing of LNG and L/CNG as engine fuel for vehicles of all types.
15	LNG Fire Protection	LNG fire protection personnel safety, security, LNG fueling facilities and training for LNG vehicles, and warning signs
16	Installation Requirements for ASMA Tanks for LNG	Installation, design, fabrication, and siting of LNG containers of 70,000 gal capacity and less and their associated equipment.
NFPA CODE 55: Compressed Gases and Cryogenic Fluids		
7	Compressed Gases	Storage, use, and handling of compressed gases in containers, cylindersn and tanks.
8	Cryogenic Fluids	Storage, use, and handling of cyrogenic fluids
4	Vehicle Fuel Systems	Design, installation, inspection, and testing of ING fuel supply systems for vehicle engines
NFPA CODE 57: Liquified Natural Gas Vehicular Fuel Systems		
5	LNG Fueling Facilities	Design, siting construction, installation, spill containment, and operation fo containers, pressure vessels, pumps, vapriation equipment, buildings, sturctures, and associated equipment for the strage and dispensing of LNG as and engine fuel for vehicles of all types
6	Installation Requirements for ASME Tanks	Installation, design, fabrication, and siting of LNG containers of 70,000 gal capacity and less and their associated equipment.
7	Fire Protection, Safety and Security	Fire protection, personnel safety, and trining for LNG vehicles, security, LNG fueling facilities for LNG vehicles, and warning signs.

Figure A-1. Fire Codes Related to Natural Gas Repair Garages and Fuel Systems.