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The University of Texas at San Antonio

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Economic Impacts of Natural Gas Fueling Station Infrastructure and Vehicle Conversions in the Texas Clean Transportation Triangle

Center for Community and Business Research at The University of Texas at San Antonio Institute for Economic Development

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Table of Contents

Executive Summary 7
Introduction 11
State Grant Information 13
Overview of Texas Adoption Opportunities 15
Clean Transportation Triangle and Alternative Fueling Facilities Program 16
Texas Natural Gas Vehicle Program 17
Conversion of Engines into Natural Gas Engines 18
Natural Gas Fuel Station Construction Supply Chain 19
Supplier Industries 20
Operational Supply Chain 23
Station Costs for CNG and LNG stations 29
Station Capital Costs 29
Station Operating and Maintenance Costs 29
Economic Impacts in the State of Texas 31
Total Impacts 31
Impacts by year 32
Assumptions for Construction and Equipment Expenditures in 2013, 2014, and 2015 34
Assumptions for fuel station impacts 35
Assumptions for vehicle related impacts: production/maintenance/service 35
Assumptions for production of natural gas 36
Detailed impacts by type for year 2013 36
Detailed impacts by type for year 2014 37
Detailed impacts by type for year 2015 38
Detailed impacts by type for year 2018 40
GIS mapping of Facilities in Texas 42
Workforce Analysis of Fueling Stations 47
2013 Station Construction Workforce Median Salary 47
Cost estimators 47
Construction managers 47
Construction equipment operators 48
Construction foremen 48
Purchasing agents 48
Architectural drafters 48
Mechanical engineers 48
Construction carpenters 48
Electricians 48
Pipe fitters 48
2013 Vehicle Fleet Workforce Median Salaries 49
Electromechanical equipment assemblers 49
Engine and other machine assemblers 49
Team assemblers 49
Machinists' 49
Industrial production managers 50
Occupation vehicle maintenance technicians 50
CNG fuel system inspectors 50
Analysis of Workforce Required for Natural Gas Vehicles and Stations 50

Conclusion 52
References 53
Appendix A: Grantee Company Highlights 56
Appendix B: Alternative and Renewable Fuel in California 61
Appendix C: CNG and LNG Fueling Station Infrastructure 64
CNG Station Components 64
CNG Station Configurations 66
LNG and LCNG Station Components 69
Bulk Delivery 69
LNG and LCNG Station Configurations 70
Appendix D: CNG Fast-Fill Fueling Station Component Costs 72
Primary Research: Interviews 72
Secondary Research: Industry Sources 73
Government Programs 74
Federal Incentive for Alternative Fuel Infrastructure 74
The Texas Commission on Environmental Quality Grant 75
Funding Opportunities for Alternative Fuel Vehicles in Texas 75
U.S. Department of Energy Efficiency & Renewable Energy 75
Natural Gas Vehicle (NGV) and Fueling Infrastructure Rebates 75
Utility/Private Incentives 75
Appendix E: Costs of Vehicle Conversions 77
Natural Gas Vehicles 77
Natural Gas Vehicle Engines 79
Types of Natural Gas-Auto Fuels 79
CNG 79
LNG 80
Conversion of Engines into Natural Gas Engines 80
LNG and CNG Truck Simple Payback 80
Appendix F: Freight Flows and Vehicle Usage 83

Table of Maps

Map 1- Texas Clean Energy Triangle vs. State of Texas with current and future CNG and LNG Fueling Stations. Source: Alternative Fuel Center, Department of Energy, CCBR GIS, H. Eid 7
Map 2: Emerging Megaregions; Source: America 2050 Organization, a project of the Regional Plan Association 12
Map 3 - Texas Clean Energy Triangle grant regions. Source: TCEQ, CCBR GIS, H. Eid 15
Map 4- TCTT Grantee Facility by Grant Type. Source: TCEQ, CCBR GIS, H. Eid 42
Map 5 - CTT & AFFP Grantee facilities by fuel type Source: TCEQ, CCBR GIS, H. Eid 43
Map 6 - CTT & AFFP Grantee by construction type. Source: TCEQ, CCBR GIS, H. Eid 44
Map 7 - CTT & AFFP Grantee by grant application year. Source: TCEQ, CCBR GIS, H. Eid 45
Map 8 - CTT & AFFP Grantee by grant award size. Source: TCEQ, CCBR GIS, H. Eid 46
Map 9: Truck Freight Flows Texas, 2007; Source: Federal Highway Administration; 2007 is the most current year, with an update due in 2015 86

Table of Figures

Figure 1: Grant Funded Public Facility completing access across the TCTT, San Antonio; Source; CCBR .. 10
Figure 2- Alternative Fuel Average Prices in the United States, April 2014 11
Figure 3: Natural Gas Fuel Tank and Regulator; Source: CCBR 17
Figure 4: Supplier Industries; Source: CCBR Graphic, M. Wells 20
Figure 5: LNG Vehicle Fueling; Source: CCBR 28
Figure 6: Key Components for Fueling Station Operating Costs; Source: AFDC 30
Figure 7: California Natural Gas Vehicle Fuel Consumption in Million Cubic Feet ; Source: EIA 61
Figure 8: California Consumption; Source: EIA 62
Figure 9: Facility infrastructure for LCNG Station; Source: CCBR 63
Figure 10: LNG Fueling: 3 hoses- fuel, pressure relief, and electrical ground; Source: CCBR 76
Figure 11: Alternative Fuel Average Prices in the United States, April 2014 ; Source: AFDC 78
Figure 12: Average U.S. Retail Fuel Prices ; Source: Westport.com 78
Figure 13: Alternative Fuel Vehicles in Use by State Rank, 2011, Source: EIA 83
Figure 14: Alternative Fuel Vehicle Use, Texas; Source: DoE 84
Figure 15 Truck Freight Flows Texas, 2007 86
Figure 16: Natural Gas powered heavy-duty truck; Source: CCBR 87

Table of Tables

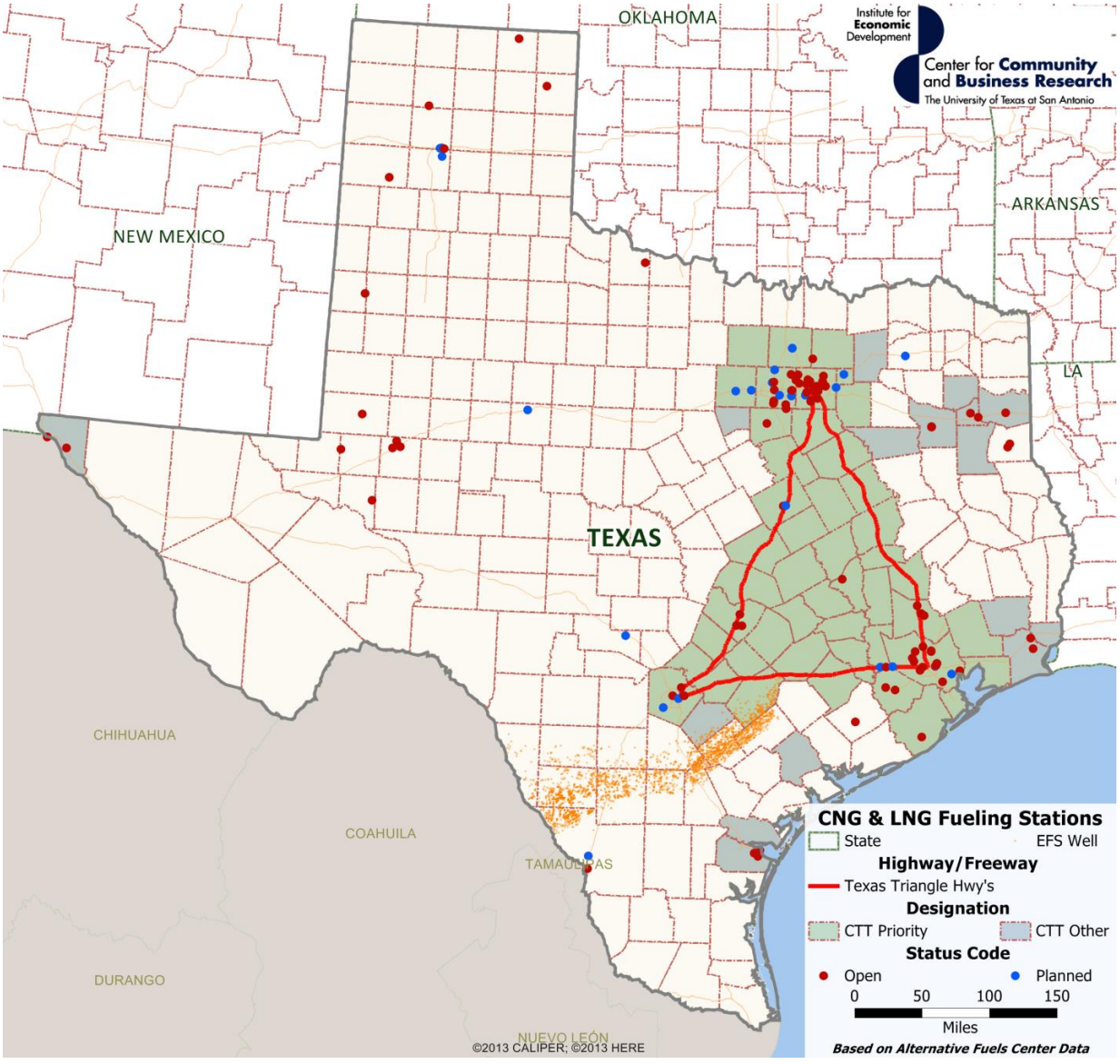
Table 1 - Economic impacts summary 10
Table 2 - CTT & AFFP Grant Totals and Averages 13
Table 3- Texas CNG & LNG Stations; Source: AFDC, CCBR 13
Table 4 - TNGVP Vehicle Grant Areas and Awards 14
Table 5 – Grant Application Acceptance Rate; Source TCEQ, CCBR 14
Table 6 - DGE Displacement 18
Table 7- DGE Displacement Assumptions from Economic Impacts 19
Table 8: Construction Sectors; Source: BLS 21
Table 9: Manufacturing Sectors; Source: BLS 22
Table 10: Distribution Sectors; Source: BLS 22
Table 11: Real Estate Sectors; Source: BLS 24
Table 12: Finance Sectors; Source: BLS 24
Table 13: Scientific Sectors; Source: BLS 25
Table 14: Retail Sectors Applicants; Source: BLS 26
Table 15: Distribution Sectors Applicants; Source: BLS 27
Table 16: Trade Sectors Applicants; Source: BLS 27
Table 17: Manufacturing Sectors Applicants; Source: BLS 27
Table 18: Rental Sectors Applicants; Source: BLS 28
Table 19: Estimated Operating Costs; Source: AFDC 30
Table 20 - CTT Total Impacts, Source: Javier Oyakawa M.A., MSc. CCBR 31
Table 21 - State & Local Government Revenue. Source: Javier Oyakawa, M.A., MSc CCBR 32
Table 22 - Severance Tax Collections and Natural Gas 32
Table 23 - 2013 Estimated Impact for Construction & Equipment Expenditures at State Level 32

Table 24 - 2014 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level 33
Table 25- 2015 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level 33
Table 26 – 2018 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level 34
Table 27 - 2013, 2014, & 2015 Construction Expenditures 34
Table 28 - 2013, 2014, 2015 Equipment Expenditures 35
Table 29 - Station and Related Jobs 35
Table 30 - Production, Maintenance, and Service Jobs 36
Table 31 - Natural Gas Production Source for rate: http://www.window.state.tx.us/taxinfo/nat_gas/ 36
Table 32 - 2013 Estimated Construction Impacts 36
Table 33 - 2013 Estimated Equipment Expenditures Impact 37
Table 34 - 2014 Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production 37
Table 35 - 2014 Estimated Construction Impact 37
Table 36 - 2014 Estimated Equipment Expenditures Impact 37
Table 37 - 2014 Estimated Station Operation Impact 38
Table 38 - 2014 Estimated New Truck Maintenance, Production, and Service Impact 38
Table 39 2014 Estimated Extraction of Natural Gas Impact 38
Table 40 - 2015 Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production 38
Table 41 - 2014 Estimated Construction Impact 39
Table 42 - 2015 Estimated Equipment Impact 39
Table 43 - 2015 Estimated Station Operation Impact 39
Table 44 - 2015 Estimated New Truck Maintenance, Production, and Service Impact 39
Table 45 - 2015 Estimated Natural Gas Extraction Impact 40
Table 46 - 2018 Estimated Operations, Maintenance, and Natural Gas Production 40
Table 47 - 2018 Estimated Station Operation Impact 40
Table 48 - - 2018 Estimated New Truck Maintenance, Production, and Service Impact 40
Table 49- 2018 Estimated Natural Gas Extraction Impacts 41
Table 50: Construction Workforce Median Salary; Source: Department of Labor 47
Table 51: Fleet Workforce Median Salary; Source: Department of Labor 49
Table 52: Summary for the Pennsylvania Clean Transportation Corridor; Source: GNA Associates 50
Table 53: California Energy Commission Summary of Previous, Upcoming, and Proposed Funding (In Millions); Source: CEC 62
Table 54: Alternative Fuel Infrastructure Funding Allocation; Source: CEC 62
Table 55: Natural Gas Fueling Stations; Source: California Natural Gas Vehicle Coalition, U.S. DOE Alternative Fuels and Advanced Vehicles Data Center 63
Table 56: CNG Fast-Fill Fueling Station Component Costs; Source: CCBR Grantee Interviews 73
Table 57: CNG Fast-Fill Fueling Station Component cCosts; Source: CCBR Secondary Research 74
Table 58: Comparison of Natural Gas Vehicle Engines (ISL G and C GAS Plus) and ISX 15 Diesel Engine ; Source: AFDC 79

Table 59: Vehicle Cost Tables; Source: Clean Energy Fuels. (n.d.). Clean Energy Fuels. Retrieved June 26, 2014, from http://www.cleanenergyfuels.com/ 81
Table 60: Example Business Case Analysis- Four Scenarios; Source: Case study – Compressed Natural Gas Refuse Fleets. U.S. Department of Energy Energy Efficiency & Renewable Energy 81
Table 61 - Incremental Truck cost based on grantee information 82
Table 62: Alternative Fuel Vehicles by State; Source: DoE 84
Table 63: Alternative Fuel Vehicle Use, Texas; Source: DoE 85

Executive Summary

With the advent of unconventional production techniques, the U.S. now has ready access to long-term domestic supplies of low-cost natural gas. This development has the potential to significantly transform passenger and commercial vehicle usage by decreasing reliance on imported fuels. In order to capitalize on this opportunity, conversion of refueling stations and vehicles to use natural gas should be addressed simultaneously in order to avoid the chicken-and-egg dilemma. As implementation of this strategy moves forward, the potential economic impact will be far-reaching.



Map 1- Texas Clean Energy Triangle vs. State of Texas with current and future CNG and LNG Fueling Stations. Source: Alternative Fuel Center, Department of Energy, CCBR GIS, H. Eid

Public investment in natural gas fueling stations and the vehicles they support will have impacts on the economy of Texas, develop industries that create jobs, and improve air quality for citizens of the state. This study provides a background and impacts of several Texas Emissions Reduction Plan (TERP) grants that are administered by the Texas Commission on Environmental Quality (TCEQ). The three grants included in this study are Clean Transportation Triangle (CTT), Alternative Fueling Facilities Program (AFFP), and Texas Natural Gas Vehicle Program (TNGVP). These grants support demand on a wide range of Texas industries and their workforce.

According to UT Austin Center for Sustainable Development, the Texas Triangle area comprises 60,000 square miles, less than 25 percent of the state total. The highway boundaries of the 'mega-region' include IH-10: 198 miles, IH-35: 271 miles, and IH-45: 241 miles. This mega-region, one of 11 in the U.S and Canada, is classified as such due to population estimates of up to 63 million per region by 2025.

The 2010 population and 2013/2022 forecasted populations of TERP eligible counties in the Texas Clean Transportation Triangle (not including El Paso), according to the 2010 Census and Texas State Demographer population forecasts are:

- 2010 population is 11,132,634
- 2013 estimated population is 11,823,188
- 2022 estimated population is 20,068,854

The total 2010 population in Texas was 25,145,561, with the triangle counties accounting for 44.3 percent of the state's population in that year. The Texas Clean Transportation Triangle is comprised of 64 total counties and multiple grants overlap in this area.

The TCEQ, through their CTT and AFFP annual grants, awarded almost $20.9 million to 54 natural gas station applicants between 2012 and 2014. In addition to the grant awarded funds, the 54 current grantees are committed to invest almost $85.9 million of their own money to build these natural gas fueling facilities. In 2012, 15 grantees were awarded $4.25 million. In 2013, 7 grantees were awarded $1.45 million. For the last round of grants in 2014, 32 grantees were awarded $15.16 million. This significant jump in grantees can be attributed to increased awareness of the grants and their benefits by the public and TCEQ adapting and constantly improving the grant process for each cycle. For the AFFP grants these figures count only natural gas related grants and no other alternative fuel grants.

The TCEQ, through their TNGVP grant (2 year cycle) supported 618 vehicle purchases and 4 vehicle conversions for 50 applicants from 2012 to August 2014. During the 2012-2013 cycle the TNGVP grants provided 31 grantees with $25.8 million in funding to replace and repower 477 natural gas vehicles in their fleets. In the current 2014-2015 cycle, 19 grantees have been given $6.2 million in grant money and have been approved for the replacement and repowering of 145 vehicles. The total state investment as of August 2014 is $32 million.

The 2014-2015 cycle data is based on data obtained from TCEQ in early August 2014. These numbers have significantly increased since then.

Of the three grant funding totals, which add up to almost $52.9 million, 60 percent was spent on vehicles and 40 percent on stations for all three years.

To estimate the grants economic impacts, the following activities were included in the analyses:

1. Construction expenditures from grantees (2013, 2014, and 2015)
2. Equipment expenditures from grantees (2013, 2014, and 2015)
3. Vehicle related impacts: production, maintenance, and service of trucks (2014, 2015, and 2018)
4. Operations from Compressed Natural Gas (CNG) and Liquid Natural Gas (LNG) stations (2014, 2015, and 2018)
5. Production from natural gas demanded by trucks (2014, 2015, and 2018)

The original amount of grantees for the years 2012 and 2013 was 22, but two of these have cancelled their projects. Of the 20 remaining grantees, several have delayed their plans and have not yet finished the construction of the stations. For the analysis, it was assumed that 11 of the grantees finished their construction plans in 2013 while the remaining nine finished their projects in 2014. In 2014, 32 new grantees were added to the list of stations and are assumed to finish the construction phase in early 2015. Based on information provided by the grantees, the numbers of trucks served by the new facilities were estimated for 2014, 2015, and 2018. The following table summarizes the total impacts from the programs under study.[1] Total impacts include direct, indirect, and induced effects. [2]

For 2013, the economic impacts are as follows:

- $30 million in total economic output
- 132 full time equivalent jobs
- $7.6 million dollars payroll
- $14.7 million gross state product

However, according to the analysis, the economic indicators experience a sharp ramp-up period between 2013 and 2014:

- $128 million in total economic output
- 927 full time equivalent jobs
- $38 million dollars payroll
- $79 million gross state product

Also, according to the analysis, the economic indicators experience a significant jump period between 2014 and 2015:

- $474 million in total economic output
- 3,333 full time equivalent jobs

[1] At the end of this chapter, more detailed impacts by type and year are presented.
[2] The impacts were estimated using IMPLAN version 3, database 2012, for the State of Texas.

- $141.4 million dollars payroll
- $288 million gross state product

Summary of Benefits from the Programs				
	2013 *	**2014 ****	**2015 *****	**2018 ******
Output Millions $	$30.2	$127.6	$473.9	$483.8
Employment Full-Time	132	927	3,333	3,076
Payroll Millions $	$7.6	$37.8	$141.4	$133.7
Gross State Product Millions $	$14.7	$79.1	$288.2	$301.9
State Government Revenues Millions º	$0.4	$3.5	$12.4	$14.6
Local Government Revenues Millions º	$0.4	$3.7	$12.9	$15.1
Value of Natural gas, Millions $	N/A	$7.8	$18.0	$67.1
Number of new stations from programs (2012-2014)	11	20	52	52
Estimate number of heavy-trucks served at stations	762	1,187	2,636	6,985
Severance tax, Millions $	N/A	$0.6	$1.4	$5.0

Table 1 - Economic impacts summary

* Includes construction of stations and equipment expenditures
** Includes construction of stations and equipment expenditures, operations of stations, natural gas production, and new NGV (new trucks) related jobs
*** Includes construction of stations and equipment expenditures, operations of stations, natural gas production, and new NGV (new trucks) related jobs
**** Includes operations of stations, natural gas production, and new NGV (new trucks) related jobs
º Does not include severance taxes

A forecast for 2018, using information from the grantees in terms of future operations of the gas stations and the number of trucks served at the stations, shows the following effects:

- $484 million in total economic output
- 3,076 full time equivalent jobs
- $134 million dollars payroll
- $302 million gross state product

Taking advantage of these grants, both Texas and national companies are benefiting from lower fuel prices to create opportunities for private and public fleets statewide.

Figure 1: Grant Funded Public Facility completing access across the TCTT, San Antonio; Source; CCBR

Introduction

Natural gas vehicles (NGVs) are the most popular alternative fuel vehicles in the state of Texas, according to newly released data from the Texas Railroad Commission.[3] Over 7,000 natural gas vehicles currently operate in the state. The popularity of natural gas as a fuel source is also reflected with the sale of CNG (compressed natural gas) and LNG (liquefied natural gas), which sold over 11.4 million gallon equivalents within the first nine months of fiscal year 2014. The Texas Comptroller reports that these sales figures surpass previous estimations by 72 percent and represent $1.7 million in natural gas motor-fuel tax collections thus far in fiscal year 2014.[4] According to the Department of energy, Natural gas burns cleaner than gasoline or diesel fuels because of its lower carbon content. Converting conventional vehicles as well as light-heavy duty commercial vehicles is a good option for incorporating alternative fuels into fleets and other engine applications.[5]

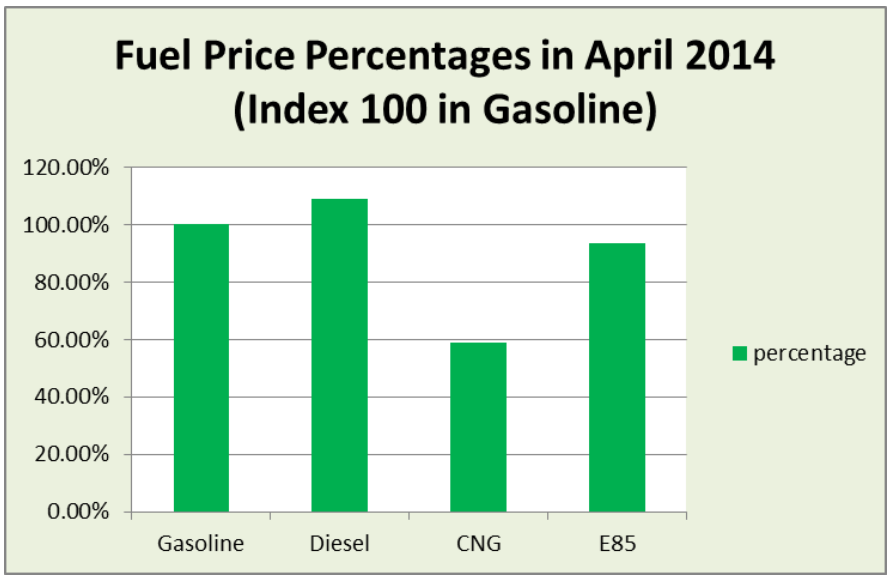
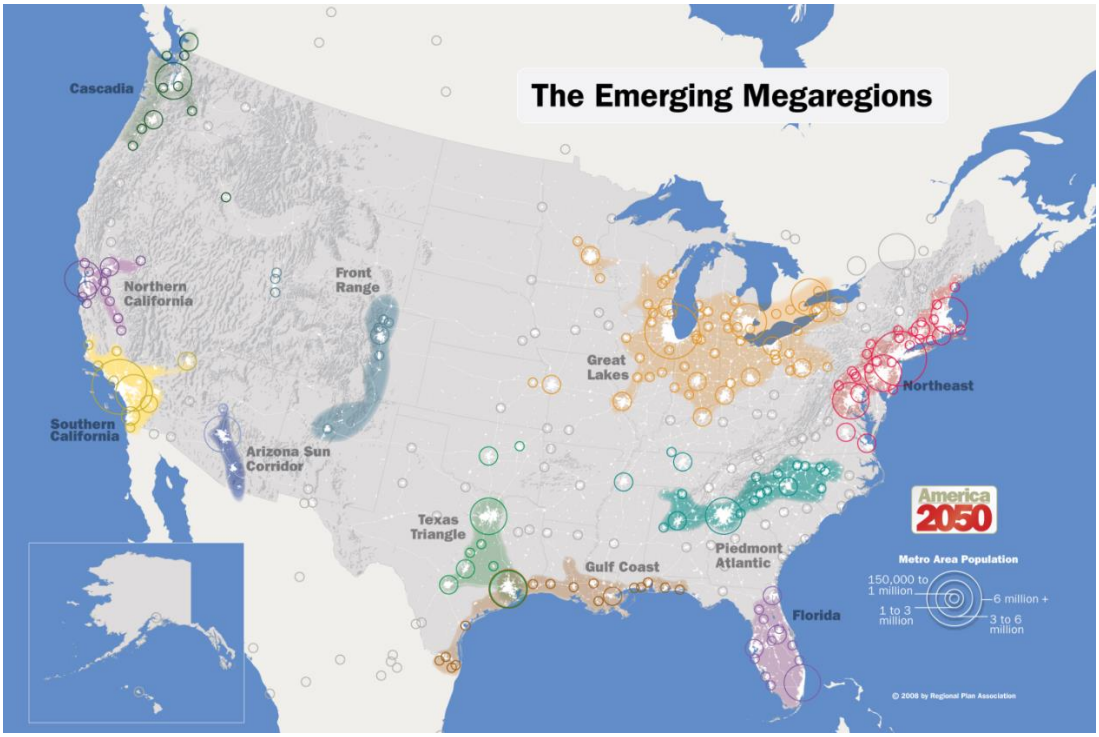


Figure 2- Alternative Fuel Average Prices in the United States, April 2014

Figure 2 illustrates the financial incentive provided by natural gas. The price of a gasoline gallon equivalent of CNG fuel is $1.50, which is 41 percent less than traditional gasoline and 50 percent less than diesel fuel.[6] Natural gas prices have remained stable relative to the high degree of fluctuation in the gasoline and diesel markets.[7] These characteristics provides CNG and LNG an advantage in the alternative fuels market.

[3] Heather Ball, Texas Railroad Commission, July 31, 2014.
[4] Ibid.
[5] Natural Gas Vehicle Emissions, Alternative fuels data center, Department of Energy, June 18, 2014, from http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html
8 Clean Cities Alternative Fuel Price Report. January 2014. Retrieved from http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2014.pdf
7 Economics of Natural Gas. (n.d.).Westport » Natural Gas for Transportation ». Retrieved June 18, 2014, from http://www.westport.com/is/natural-gas/economics

According to UT Austin Center for Sustainable Development, the Texas Clean Transportation Triangle area comprises 60,000 square miles, less than 25 percent of the state total. The highway boundaries of the 'mega-region' include IH-10: 271 miles, IH-35: 241 miles, and IH-45: 198 miles. This mega-region, one of 11 in the U.S and Canada, is classified as such due to population estimates of up to 63 million per region by 2025.



Map 2: Emerging Megaregions; Source: America 2050 Organization, a project of the Regional Plan Association

The population of TERP eligible counties in the Texas Clean Transportation Triangle (not including El Paso), according to the 2010 Census and Texas State Demographer population forecasts are:

- 2010 population is 11,132,634
- 2013 estimated population is 11,823,188
- 2022 estimated population is 20,068,854

The total 2010 population in Texas was 25,145,561 with the triangle counties accounting for 44.3 percent of the state's population in that year.

State Grant Information

As of September 2014, 54 facilities were awarded both CTT and AFFP grant funding, with an investment by the applicants of $85.9 million, and a grant investment from the State of $20.85 million, as shown in Table 2.

Facility Grant Types, Budgets, and Awards						
Category (2012, 2013, 2014)		Number of Grantees	Average Project Budget	Average Grant Award	Total Project Budget	Total Grant Awards
All Grants/Fuels	All	54	$1,304,733.68	$397,624.47	$85,892,964.96	$20,850,433.00
Grant Type	AFFP	17	$2,009,527.71	$540,636.29	$34,161,971.11	$9,190,817.00
	CTT	37	$1,398,134.97	$315,124.76	$51,730,993.85	$11,659,616.00
Fuel Type	CNG	45	$1,580,283.02	$383,342.96	$71,112,735.96	$17,250,433.00
	LNG	2	$623,814.50	$250,000.00	$1,247,629.00	$500,000.00
	LCNG	7	$1,933,228.57	$442,857.14	$13,532,600.00	$3,100,000.00

Table 2 - CTT & AFFP Grant Totals and Averages

According to the Alternative Fuel Data Center at the Department of Energy, there is a total of 66 public and 37 private stations currently operating in Texas, for a total of 103 active natural gas fueling stations while 26 are planned to become active in the near future.

AFDC Texas CNG & LNG Stations				
Pre-Grant Program 2012	**Current Grant Period 2012-2014**	**Planned**	**Total**	**Difference Pre 2012 - Current**
41	62	26	129	21
Station Breakdown				
Time Period	**Number of Stations**	Public	Private	**Notes**
1990's	14	9	5	Currently Open
2000 - 2011	27	15	12	Currently Open
Grant Period (2012 – 2014)	62	42	20	Currently Open
Planned to open in the future	26	18	*	*8 are planned but Public or private access is not mentioned

Table 3- Texas CNG & LNG Stations; Source: AFDC, CCBR

From 2012-2014, four vehicles were repowered or converted, and 618 were replaced through the TNGVP grant. Average grant investment for each of the 622 trucks is around $51,500, with grant awards ranging from $18,000 to $90,000. Over 75 percent of the trucks being replaced are operating or scheduled to operate in the Dallas/Fort Worth area (250) and the Houston/Galveston/Brazoria area (215), while 100 percent of all of the repowered vehicles that have applied for grant funding are also operating or scheduled to be operating in the same areas.

TNGVP Grant Awards			
Primary Area/ County	Number of Vehicles Repowered	Number of Vehicles Replaced	Total Grant Amount
Dallas/Fort Worth	3	250	$12,207,300
Houston/Galveston/Brazoria	1	215	$12,570,750
San Antonio	0	44	$1,462,500
IH 35	0	39	$1,758,000
El Paso	0	15	$1,350,000
Inside Clean Texas Triangle	0	42	$2,220,000
Beaumont/Port Arthur	0	3	$162,000
Tyler/Longview	0	10	$300,000
Total	**4**	**618**	**$32,030,550**

Table 4 - TNGVP Vehicle Grant Areas and Awards

As of September 2014 the percentage of grants accepted for:

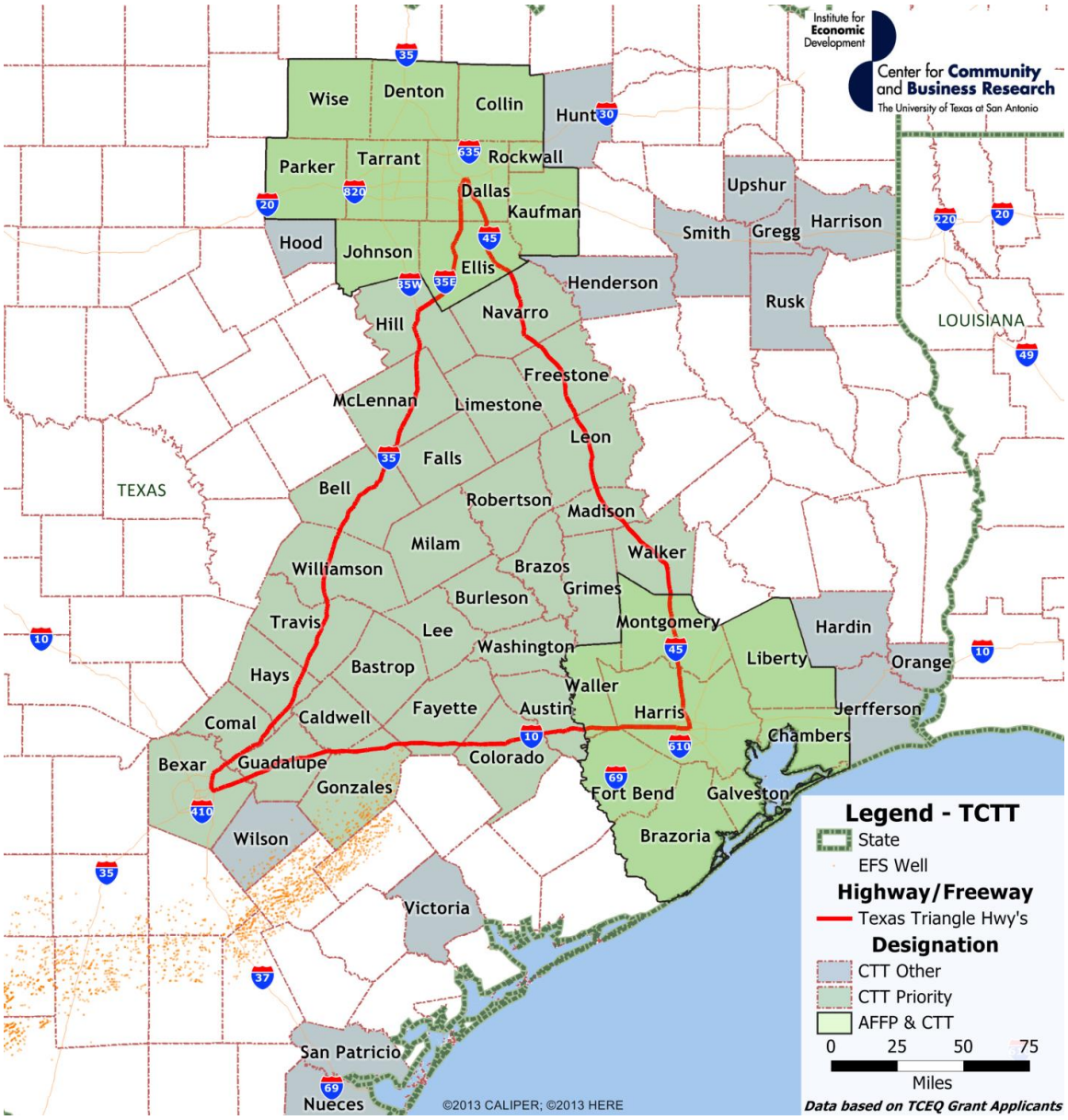
- TNGVP is over 60%
- CTT is over 58%
- AFFP is almost 30%

Grant Distribution as of September 2014 for Years 2012, 2013, 2014			
Grant Type	Applications Received	Accepted Grants	Acceptance Rate
TNGVP	139	84	60.43%
CTT	48	28	58.33%
AFFP	87	26	29.89%

Table 5 – Grant Application Acceptance Rate; Source TCEQ, CCBR

Overview of Texas Adoption Opportunities

The Texas Emission Reduction Plan (TERP) provides financial grants and opportunities to individuals, businesses, and local governments. These grants are designed to help reduce emissions by expanding and supporting the use of natural gas in vehicles and equipment that operate inside Texas Clean Energy Triangle, while increasing access to natural gas fueling options for the public.



Map 3 - Texas Clean Energy Triangle grant regions. Source: TCEQ, CCBR GIS, H. Eid

Grants include, but are not limited to, the Clean Transportation Triangle (CTT), the Alternative Fueling Facilities Program (AFFP), and the Texas Natural Gas Vehicle Grant Program (TNGVGP). For the purpose of this report, only natural gas facilities numbers are used from the AFFP numbers and results available from TERP.

The grants are awarded to carriers using heavy-duty/medium-duty trucks and potential facilities in areas classified by the Environmental Protection Agency (EPA) as nonattainment zones for nitrous oxide, or NOx. Grant related modifications to fleet vehicles must produce a cumulative net reduction in NOx. Coupled with grant funding for fueling infrastructure, grant modifications are aimed to encourage more widespread adoption of natural gas in vehicles and to have a cumulative net reduction in NOx emissions in these nonattainment areas.

Clean Transportation Triangle and Alternative Fueling Facilities Program

The Clean Transportation Triangle and the Alternative Fueling Facilities Program were established by Senate Bill 385 in the 82nd Legislature in 2011. The legislature overwhelmingly approved the bill with a 29-2 Senate vote, and a 132-6 House vote. The CTT and AFFP are strategic initiatives designed to encourage the building of natural gas fueling infrastructure to connect Dallas/Fort Worth, San Antonio, Austin, and Houston, and to support fleets and other drivers of alternative fuel vehicles with strategically planned high-volume public access stations. The project was developed in collaboration with over 300 companies, non-profit corporations, and academic institutions in Texas. It has expanded throughout the state and is leading connectivity through Texas to both coasts and to Mexico and Canada via IH-35. The CTT and AFFP were later modified by the Senate Bill 1727 in the 83rd Legislature in 2013.

The CTT enables grants for the creation of natural gas fueling stations in the 63-eligible CTT Texas counties.[8] The 2013 amended changes for the CTT include: removing the requirement that stations had to be no more than three miles from an interstate highway; removing the limit on the number of grants an entity may receive; requiring a certification of compliance with fuel tax laws; and increasing the maximum grant amounts to these various amounts per type: CNG: from $100,000 to $400,000, LNG: from $250,000 to $400,000, CNG+LNG: from $400,000 to $600,000.

The AFFP enables grants for the construction, reconstruction, or acquisition of facilities to store, compress or dispense alternative fuel within the 18 Texas nonattainment counties and El Paso County.[1] The 2013 amendment change for the AFFP increased the maximum grant amount from $400,000 to the lesser of $600,000 or 50 percent of eligible costs.

[8] "Clean Transportation Triangle (CTT) Program and Alternative Fueling Facilities Program (AFFP)." Clean Transportation Triangle (CTT) Program and Alternative Fueling Facilities Program (AFFP). http://www.tceq.texas.gov/airquality/terp/ctt.html (accessed June 2014).

Texas Natural Gas Vehicle Program

The TNGVP grant provides funding to encourage an entity that owns and operates a heavy-duty or medium-duty motor vehicle to repower the vehicle with a natural gas engine or replace the vehicle with a natural gas vehicle. The project must show to reduce NOx by at least 25 percent.[9] This grant was established by the Senate Bill 385, 82nd Texas Legislature in 2011, under the Texas Health and Safety Code (THSC), Chapter 394. The grant's award will pay up to 90 percent of incremental costs to purchase, lease, commercially finance, or repower with qualifying natural gas vehicles or engines. The predetermined grant amounts are based on the size of the natural gas fueling system and the usage of the funded vehicles. When receiving the grant, the applicant will be reimbursed after the purchase or installment of the new vehicle or engine.

After the reimbursement, the applicant must follow several guidelines. Applicants must operate grant funded vehicles in the eligible Texas counties for at least 75 percent of the annual mileage for the activity life (whichever comes first: four years or 400,000 miles of operation after date of grant). Recipients must monitor and report annual mileage and location of use at least annually over the activity life. Reimbursement is determined by the TCEQ. Recipients must permanently and properly dispose of or destroy old vehicles within 90 days of receiving reimbursement from the state. The standard destruction methods include crushing the vehicle and engine, drilling a hole in the engine block and cutting frame rails in half, or sending the engine to an authorized remanufacturing facility, unless the TCEQ decided that the applicants are allowed to keep their vehicle.

Figure 3: Natural Gas Fuel Tank and Regulator; Source: CCBR

[9] "Texas Natural Gas Vehicle Grant Program." Texas Natural Gas Vehicle Grant Program. http://www.tceq.texas.gov/airquality/terp/tngvgp.html (accessed June 2014).

Conversion of Engines into Natural Gas Engines

As mentioned in the previous section, fleet investors have the option to either purchase new vehicles or convert conventional-fuel engines to alternative-fuel. Conversion costs for natural gas vehicles range between $12,000 and $18,000, which covers the replacement and installation of fuel tanks, tubes, brackets, and retrofits.[10] Conversion pricing varies by brand, model year, and tank size[11].

The average incremental cost among TNGVP grant applicants for each medium-heavy duty CNG/LNG vehicle is $57,218. The grant covers up to 90% of the incremental cost. The operation of a natural gas truck results in a savings of $0.15 per mile in operational costs in comparison to diesel trucks. Natural gas vehicles under heavy usage (over 150,000 miles per year) have a payback period of 18 months (1.5 years), and NGVs with an operational usage of 100,000 annual miles possess a payback period of 28 months (2.3 years).

The 622 TNGVP grant vehicles are estimated to replace over 9.65 million gallons of diesel fuel per year, based on an average diesel gallon equivalent (DGE) consumption by CNG/LNG trucks of 15,540 gallons per year. The 476 trucks from the 2012-2013 cycle are estimated to have displaced almost 7.4 million DGE and over 2.25 million DGE for the 145 current vehicles from the 2014-2015 cycle.

Diesel Gallon Equivalent of CNG/LNG Vehicles Displaced by TNGVP Vehicles			
Grant Cycle Years	**2012-2013**	**2014-2015**	**Total Trucks**
Number of Trucks Replaced	476	145	622
Average DGE per truck per year	15,540	15,540	15,540
Amount of DGE displaced	7,397,040	2,253,300	9,665,880

Table 6 - DGE Displacement

The average comparative fuel costs for vehicles are estimated at $3.75/gal for diesel, $2.50/gal for natural gas, with an estimated average vehicle cost per mile of $0.58 for diesel, and $0.43 for natural gas.

Some assumptions were made for 2013 and 2018 values of the number of trucks served at grant funded stations. In 2013, there were some stations without an estimated number of trucks served. In one of these cases it was assumed that close to seven (7) trucks were served the initial year. On the other hand, one company, using other stations' information as a reference, was assumed to serve 387 trucks the first year. The majority of stations reported serving between 25 and 40 trucks the first year of operations. For 2013 the estimated number of trucks served is 762.

[10] CNG Frequently Asked Questions - OEM Systems. (n.d.). *CNG Frequently Asked Questions - OEM Systems*. Retrieved June 18, 2014, from http://www.oemsystems.net/faqs

[11] One of the participating dealerships for Texas Natural Gas Vehicle Grant Program in 2012 stated that the CNG conversion cost approximately $15,000.

For the year 2018, there were several stations without information for the number of trucks they estimate they will serve. When possible, the estimates available for 2015 were used again for 2018, making these stations' estimates relatively small when compared to other stations' values. The estimated amount of trucks served is 6,985.

For both years, when the values of DGE expected to be supplied at the stations were provided, the study assumed that each truck used 15,540 DGE per year. The value of 15,540 per year was obtained as an average from the stations that provided information for both the number of trucks served and the supply of DGE per year.

Some stations reported that the number of light vehicles to be served at the stations would be close to 460 for 2018. These light vehicles were converted to heavy duty vehicles by using a factor of 4.5 according to gas usage comparisons between light- and heavy-vehicles.
For the economic impacts, the estimated value for 2013 was used as a reference for projections of trucks served for the years 2014, 2015, and 2018, as explained in the economic impacts assumptions. Only the trucks served in 2014, 2015, and 2018 were used to estimate operations impacts.

Displaced Amount of Diesel Gallons Equivalents by New Trucks served at Stations			
	2014	**2015**	**2018**
Number of trucks (Estimates)	1,187	2,636	6,985
Average DGE per truck per year	15,540	15,540	15,540
Amount of DGE displaced	18,443,710	40,963,440	108,544,630

Table 7- DGE Displacement Assumptions from Economic Impacts

Natural Gas Fuel Station Construction Supply Chain

The construction and operation of public natural gas fueling stations have impacts on a variety of industries in Texas and beyond. The industries directly related to building a public or private natural gas station are construction, manufacturing, transportation and warehousing sectors. These industries perform different functions related to station construction and are supplied by an array of industries. The supply chain used in this industry contributes to the full impacts of natural gas vehicle investments for the state of Texas.

The construction industry plays an important role in the early development of alternative fuel stations. The construction process begins with planning, designing, and financing the site and continues until the station is built and ready to operate. Suppliers of commercial building construction industries include cement manufacturers, concrete pipe and block manufacturers, and heavy construction equipment rental companies. These companies supply the raw materials that are needed to build up the stations.

Supplier Industries

Figure 4: Supplier Industries; Source: CCBR Graphic, M. Wells

Oil and gas pipeline construction industry contractors are responsible for the construction of pipelines, mains, pumping stations, refineries and storage tanks. This industry installs new pipeline infrastructure, makes any alterations to existing pipeline and provides maintenance. The main suppliers of the oil and gas pipeline construction industry are concrete pipe and block manufacturers, construction machinery manufacturers, metal pipe and tube manufacturers, and heavy construction equipment rental companies.

Table 8: Construction Sectors; Source: BLS

Construction (23):	
23332a- Commercial Building Construction	
Design, bid, build contracts Turnkey contracts	Construction manager at- risk contracts Design- build contracts
23712 - Oil & Gas Pipeline Construction	
New pipeline infrastructure construction Pipeline additions and alterations	Pipeline maintenance

The manufacturing industry supplies materials and equipment for the construction and operation of natural gas fueling stations. Cement producers supply portland cement, masonry cement, blended cement, and specialty cement. Concrete pipe and block manufacturers supply block, pipes, pavers and bricks to local freight trucking and natural gas distributors. Iron and steel manufacturers produce hot-rolled bars, reinforced bars, steel plates, pipes, and tubing supplies that are transported to stations for use as building materials. The metal pipe and tube manufacturing sector supplies the energy sector with seamless pipes and tubes, welded pipes and tubes, and riveted pipes and tubes. Metal tank manufacturers supply some of the most important components for housing natural gas in vehicles and stations. The metal tanks known in the industry as “cylinders” must be certified by the U.S. Department of Transportation and are subject to strict manufacturing processes and mandated testing requirements.

Table 9: Manufacturing Sectors; Source: BLS

Manufacturing (31-33):	
32731- Cement Manufacturing	
Portland cement Blended and specialty cement Masonry cement	
32733 – Concrete Pipe & Block Manufacturing	
Concrete Block Concrete Pipes Concrete Pavers and Bricks	
33111 – Iron and Steel Manufacturing	
Hot-rolled sheets and strips Tin mill products Cold-rolled sheets and strips Hot-rolled and reinforced bars	Heavy structural shapes Pipes and tubing Steel plates
33121 – Metal Pipe and Tube Manufacturing	
Energy-sector seamless and welded pipes and tubes Riveted and other seamless pipes and tubes Welded pipes and tubes	
33242 – Metal Tank Manufacturing	
Metal tanks and vessels (custom fabricated and field erected) Metal tanks and vessels (custom fabricated at the factory) Pressure tanks Metal storage tanks Gas cylinders Pressure tanks (24 in/more out. diameter)	
33351 – Metalworking Machinery Manufacturing	
Special tool, die, jig and fixture manufacturing Cutting tool and machine tool accessory manufacturing Metal-cutting and forming machinery Rolling mill machinery Industrial mold manufacturing	
33391 –Pump and Compressor Manufacturing	
Industrial Pumps Measuring and Dispensing Pumps Air and Gas Compressors	

Table 10: Distribution Sectors; Source: BLS

Transportation and Warehouse (48- 49):	
48621- Gas Pipe Transportation	
Natural gas from gas wells Natural gas from oil wells Natural gas from shale gas wells	Natural gas from coalbed wells Brokering of natural gas Distribution of gas to final customers
48691 – Refined Petroleum Pipeline Transportation	
Gasoline transportation Natural gas liquid transportation Distillate fuel transportation Jet fuel transportation	Residual oil transportation Lubricant transportation Asphalt transportation

The transportation of the natural gas occurs in the transporting and warehouse industry. The gas pipeline and refined petroleum pipeline are the primary industries for the process of transporting natural gas. The main activities for these industries consist of natural gas pipeline operation and pipeline transportation of fuels. Transportation takes place from processing plants to local distribution systems using pipelines. When transporting natural gas, there are three major types of pipeline along the transportation route: the gathering system, the interstate pipeline system, and the distribution system.[12]

Operational Supply Chain

The supply chain for natural gas station operations is a system of inputs and outputs to and from the stations. The input industries such as real estate, advertising and utility services feed into the operation of these gas stations while output industries, such as fleet customers, use the gas stations for their own normal operating activities.

Inputs

The top five inputs to natural gas stations fall under the NAICS codes for real estate and rental leasing; finance and insurance; professional, scientific, and technical services; information; and utilities sectors, according to the economic impact analysis software IMPLAN. The IMPLAN analysis was based on the inputs for regular gasoline stations due to the similarity of their operational inputs. The top five NAICS categories are broken down into their component industries that affect gas station operations. The real estate industry is a major input to gas stations due to the need for acquiring land. Purchasing real estate is the largest single financial transaction that station owners or operators make in order to begin operating fueling stations.

[12] "Spectra Energy." Spectra Energy. http://www.spectraenergy.com/Natural-Gas-101/Transporting-Natural-Gas/ (accessed July 29, 2014)

Table 11: Real Estate Sectors; Source: BLS

Real Estate and Rental and Leasing (53):	
53112 – Commercial leasing	
Renting or leasing office property Renting or leasing retail property	Renting or leasing industrial property Renting or leasing arena, convention or stadium property

Table 12: Finance Sectors; Source: BLS

Finance and Insurance (52):	
52412 – Property, casualty, and direct insurance	
Directly underwriting automobile insurance Directly underwriting homeowners' insurance Directly underwriting title insurance	Directly underwriting workers' compensation insurance Directly underwriting medical malpractice insurance Reinsuring policies from other insurance companies
52311 – Investment banking and securities dealing	
Underwriting, originating or maintaining markets for securities issuance Providing corporate strategy advisory services	Principal and proprietary trading Providing corporate finance services
52421 – Insurance brokers and agencies	
Property and casualty insurance policy brokerage Reinsurance brokerage and administration Health and medical insurance brokerage	Life and accident insurance brokerage Annuity brokerage Risk management consulting

The finance and insurance industry is also a major input industry for gas station operations. These services provide the primary means of financing capital-intensive operations before revenues begin. Insurance is also required for business operation.

The services and consulting work industry is another major input to gas station operations. These activities include advertising, payroll and accounting, management, legal services, and market research. The information services industry, specifically telecommunication services, is another major input for natural gas stations. Stations require hard-wired telecommunications in order to process transactions, maintain communications, and service security systems.

We estimate that natural gas fueling stations would have additional utility costs, although such inputs are not identified as significant for gasoline stations by IMPLAN. Electricity costs could easily be seen to increase due to additional pumps and compression equipment. We expect that inputs may vary for each type of natural gas station. Compressed natural gas stations require a supply of CNG gas from a local utility, which would be an additional input. Liquid natural gas stations require supplies of LNG to be trucked in, as do LCNG stations that make CNG gas from locally stored and processed LNG.

Table 13: Scientific Sectors; Source: BLS

Professional, Scientific, and Technical Services (54):	
54181- Advertising agencies	
Creating advertising campaigns Providing advice and support covering most facets of the industry Disseminating of advertising campaigns through available mediums, such as TV and periodicals	
54121 – Payroll and bookkeeping services	
Payroll services Bookkeeping services	Employee benefits administration
54161 – Management consulting	
Actuarial, employee benefits and compensation consulting services Marketing consulting services Administrative and general management consulting services Human resources consulting services man resources consulting services	
54111 – Law firms	
Providing criminal law services Providing corporate law services Providing family law services Providing estate law services Providing personal injury services Providing family law services Providing commercial law services	Providing real estate law services Providing tax law services Providing commercial law services Providing property law services Providing intellectual property law services Provid
54191 – Market research	
Broadcast media rating Opinion research Marketing analysis or researchlitical opinion polling Statistical sampling	Political opinion polling Statistical sampling
Information (51):	
51711- Wired telecommunications carriers	
Providing local voice communication services Selling telecommunications equipment Providing long-distance and international voice communication services Providing internet access Wholesaling network access Providing video services	
Utilities (22):	
22112 – Electric power transmission	
Electric bulk power transmission and control Wholesale electricity brokering and marketing Electric power distribution	

Outputs

The outputs for these stations are the industries that use them in the course of business. This analysis assumes that the users of these stations will be fleets that are buying or converting their vehicles to natural gas. These industries were taken from the applicant list for the Texas Natural Gas Vehicle Program for 2014, and are representative of fleets interested in using natural gas vehicles for their operations. A majority of these industries are positioned to benefit from natural gas usage because of their high vehicle mileage used and organization of vehicles into fleets, which increases the efficiency of refueling operations.

Table 14: Retail Sectors Applicants; Source: BLS

Retail Trade (44):	
44112– Used car dealers	
Used automobile retail Used vehicle wholesale	Used light truck retail Vehicle financing
44132 – Tire dealers	
Automotive tire sales and installation Medium and heavy truck tire sales	Automotive repair and maintenance services
44419 – Other building material dealers	
Retailing building materials Retailing fencing Retailing cabinets Retailing floor coverings (wood or ceramic only) Retailing ceiling fans	Retailing doors and windows Retailing masonry (e.g. block, brick and stone) Retailing electrical supplies Retailing plumbing supplies Retailing lighting fixtures
44511 – Supermarket and other grocery (except convenience) stores	
Fruit and vegetables Frozen foods Fresh and frozen meat Other food items	Beverages (including alcohol) Drugs and health products Dairy products Other non-food items

The majority of the recent applicants for natural vehicle conversion are from the retail trade industry, particularly in the vehicle business, construction trade, and grocery business. General and specialized trucking companies and general purpose ground transportation fleets are among the top converters of vehicle fleets to natural gas.

Table 15: Distribution Sectors Applicants; Source: BLS

Transportation and Warehousing (48):	
48423– Tank and refrigeration trucking	
Long-distance automobile carrier trucking Long-distance refrigerated products trucking Long-distance bulk liquid trucking Long-distance garbage and waste hauling Long-distance tanker trucking Long-distance flatbed trucking	Long-distance hazardous and non-hazardous waste hauling services Long-distance gravel hauling services Long-distance agricultural products trucking (including livestock)
48411 – General freight trucking, local	
Local truckload delivery General freight trucking on a local basis	Local less-than-truckload (LTL) delivery Bulk mail truck transportation on a contract and local basis

Table 16: Trade Sectors Applicants; Source: BLS

Wholesale Trade (42):	
42393 – Recyclable material merchant wholesalers	
Waste bottle wholesaling Oil scrap wholesaling Waste box wholesaling Paper scrap wholesaling Plastic scrap wholesaling	Glass scrap wholesaling Textile waste wholesaling Metal scrap wholesaling General line scrap wholesaling
423850 – Janitorial equipment and supplies merchant wholesalers	
Amusement park equipment wholesaling Janitorial equipment and supplies wholesaling Undertakers' equipment and supplies wholesaling Car wash equipment and supplies wholesaling Dry cleaning equipment and supplies wholesaling Beauty parlor equipment and supplies wholesaling Upholsterers' equipment and supplies (except fabrics) wholesaling	
42448 – Fresh fruit and vegetable merchant wholesalers	
Fresh fruit wholesaling Fresh vegetable wholesaling	
42441 – General line grocery merchant wholesalers	
Wholesaling general-line groceries Wholesaling perishable food products Wholesaling dry groceries Wholesaling nonfood products	

Table 17: Manufacturing Sectors Applicants; Source: BLS

Manufacturing (32):	
325120 – Industrial gas manufacturing	
Manufacturing industrial organic gases Nitrogen manufacturing Manufacturing industrial inorganic gases Carbon dioxide manufacturing	Oxygen manufacturing Fluorocarbon gases manufacturing Helium manufacturing Hydrogen manufacturing Acetylene manufacturing
32731 – Cement manufacturing	
Portland cement manufacturing Masonry cement manufacturing	Blended and specialty cement manufacturing

Table 18: Rental Sectors Applicants; Source: BLS

Real Estate and Rental and Leasing (53):
53212 – Truck trailer rental and leasing
Truck rental and leasing Van rental and leasing Trailer rental and leasing
53211 – Passenger car leasing
Passenger car rental Passenger car leasing

The durable goods, recyclable material, service establishment equipment, fresh fruit and vegetable, and grocery wholesale industries are major customer sectors for conversion of vehicles to natural gas. These industries conduct external transportation of goods to clients, which mirrors the conversion trends in the transportation and warehousing sectors.

The industrial gas and cement manufacturing industries also apply for the TNGVP grants. Industries involved in the leasing of truck trailers, RV rentals, and passenger cars have an interest in NGV conversions. Truck trailer leasing interest may be related to a boost in demand for NGV truck trailers by their clients based on the TNGVP grantee application data.

Figure 5: LNG Vehicle Fueling; Source: CCBR

Station Costs for CNG and LNG stations

Station Capital Costs

Several important studies detail the potential cost of building a natural gas fueling station. CNG and LNG stations have been estimated to cost between $1 and $4 million, while another study lowered the range to between $400,000 and $2 million. [13] [14] A third study estimates a station cost of $2 million including all equipment, engineering, site work, project management, and installation and start-up costs. [15] All of these studies operate under the assumption that building a natural gas station is more expensive than a conventional gasoline facility, with one study calculating that natural gas stations cost three times as much as a conventional gas station. [16] These studies differ in how they interpret the dispensing rate of the station and the tank size needed.[17] [18]

Station Operating and Maintenance Costs

The operating costs of vehicle fueling stations include the costs of fuels, utilities, operations and taxes. While natural gas fueling stations share this basic cost structure, there are differences between the costs to stations that dispense CNG, LCNG, LNG, gas and diesel. The cost of crude oil and refining for gas and diesel stations is the most costly operating expense, accounting for 75 to 81 percent of the retail price of operating the station. The price of natural gas is also the largest expense for CNG stations, but at 59 percent of the operating costs, it represents a much smaller share than all other stations. The price of natural gas for LNG and LCNG stations is the greatest operating expense by a large amount, representing 82 percent of the total operating costs.

The cost of electric utilities, maintenance, and transportation are more important operating costs for CNG and LNG than gas and diesel stations. Electricity used in the compression of natural gas accounts for 21 percent of the operating cost for CNG stations. LCNG stations require more electricity than traditional LNG stations to regasify LNG into LCNG, but spend 16-18 percent less of the total operating cost on electricity than CNG stations.

Federal and State taxes are operating expenses for all vehicle fueling stations. Taxes levied on natural gas stations account for a higher percentage of the total operating expenses than traditional gas stations. While gas and diesel stations spend 12 percent of their total operating

[13] U.S. Energy Information Administration, “Annual Energy Outlook” (2010)
[14] California Energy Commission, “2010/2011 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program” (2010)
[15] Gladstein, Neandross and Associates (GNA), “NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air” (2011)
[16] Fuels Institute, “Tomorrow’s Vehicles: What will we drive in 2023?” (2013)
[17] In the California Energy Commission’s study, fast-fill station size is charted according to the station’s dispensing rate. In another study, the U.S. Department of Energy further adds to the chart by converting the dispensing rate from standard cubic feet per minute (scfm) to a gasoline gallon equivalent (GGE) using 126.7 scfm per 1 GGE for comparison.
[18] U.S. Department of Energy, “Issues Affecting Adoption of Natural Fuel in Light- and Heavy-Duty Vehicles” (2010)

expenses on taxes, natural gas stations spend between 13 and 20 percent of their operating expenses on taxes.

CNG	**LCNG**	**LNG**	**Gas**	**Gas and Diesel**
Natural Gas (59%)	Natural Gas (82%)	Natural Gas (82%)	Crude (69%)	Crude (60%)
Electric and Maintenance (21%)	Electric, Maintenance, and Transportation (5%)	Electric, Maintenance, and Transportation (3%)	Refining (12%)	Refining (15%)
			Distribution and Marketing (7%)	Distribution and Marketing (13%)
Taxes (20%)	Taxes (13%)	Taxes (15%)	Taxes (12%)	Taxes (12%)

Figure 6: Key Components for Fueling Station Operating Costs; Source: AFDC

Table 19: Estimated Operating Costs; Source: AFDC

	CNG ($GGE)	LCNG ($GGE)	LNG ($GGE)	Gas	Diesel ($GGE)
Retail Price	$2.19[19]	$2.60[20]	$1.66[21]	$3.43	$3.46[22]
Estimated Operating Percentage	75%	98%	99%	97%	97%
Estimated Operating Cost Per GGE	$1.64	$2.56	$1.64	$3.33	$3.36

[19] ibid

[20] ibid

[21] Retail price reflects national average. http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2014.pdf (April 2014) Converted $2.610 per gallon of LNG to GGE using 0.636 GGE conversion rate http://www.energyalmanac.ca.gov/transportation/gge.html (retrieved July 11, 2014)

[22] Retail price reflects national average. Converted $3.830 per gallon of Diesel to GGE using 0.877 GGE conversion rate http://www.energyalmanac.ca.gov/transportation/gge.html (retrieved July 11, 2014)

Economic Impacts in the State of Texas

The implementation of the Clean Transportation Triangle (CTT) program, Alternative Fueling Facilities (AFFP) program, and the Texas Natural Gas Vehicle Program (TNGVP) has had and will have important impacts in the State of Texas. To estimate their economic impacts, the following activities were included in the analyses:

1. Construction expenditures from grantees (2013, 2014, and 2015)
2. Equipment expenditures from grantees (2013, 2014, and 2015)
3. Vehicle related impacts: production, maintenance, and service of trucks (2014, 2015, and 2018)
4. Operations from CNG/LNG stations (2014, 2015, and 2018)
5. Production from natural gas demanded by trucks (2014, 2015, and 2018)

Total Impacts

The original amount of grantees for the years 2012 and 2013 was 22, but two of these have cancelled their projects. Of the 20 remaining grantees, several have delayed their plans and have not yet finished the construction of the stations. For the analysis, it was assumed that 11 of the grantees finished their construction plans in 2013 while the remaining nine finish their projects in 2014. In 2014, 32 new grantees were added to the list of stations and are assumed to finish the construction phase in early 2015. Based on information provided by the grantees, the numbers of trucks served by the new facilities, thanks not only but also to the TNGVP, were estimated for 2014, 2015, and 2018. The following table summarizes the total impacts from the programs under study. [23] Total impacts include direct, indirect, and induced effects. [24]

Clean Texas Triangle Total Impacts

	2013 *	2014 **	2015 ***	2018 ****
Output Millions $	$30	$128	$474	$484
Employment Full-Time	132	927	3,333	3,076
Payroll Millions $	$8	$38	$141	$134
Gross State Product Millions $	$15	$79	$288	$302

Table 20 - CTT Total Impacts, Source: Javier Oyakawa M.A., MSc. CCBR

** Includes construction of stations and equipment expenditures*
*** Includes construction of stations and equipment expenditures, operations of stations, natural gas production, and new NGV (new trucks) related jobs*
**** Includes construction of stations and equipment expenditures, operations of stations, natural gas production, and new NGV (new trucks) related jobs*
***** Includes operations of stations, natural gas production, and new NGV (new trucks) related jobs*

[23] At the end of this chapter, more detailed impacts by type and year are presented.
[24] The impacts were estimated using IMPLAN version 3, database 2012, for the State of Texas.

These programs also have impacts on State and local governments' revenues, like sales and property taxes, among others. The following table shows the yearly impacts of these programs.

State and Local Governments Revenues *

Agency/Year	2013	2014	2015	2018
State Government Revenues Millions	$0.4	$3.5	$12.4	$14.6
Local Government Revenues Millions	$0.4	$3.7	$12.9	$15.1

Table 21 - State & Local Government Revenue. Source: Javier Oyakawa, M.A., MSc *CCBR*

State and local governments have and will benefit from the additional demand for natural gas in the form of more production of natural gas and severance taxes collected by these agencies.

Severance tax collections and natural gas production impacts

	2014	2015	2018
Value of Natural gas, Millions $	$7.8	$18.0	$67.1
Severance tax, Millions $	$0.6	$1.4	$5.0

Table 22 - Severance Tax Collections and Natural Gas

The next sections describe the impacts by year for a better understanding of the results.

Impacts by year

The following tables show annual impacts for activities included in the study. In 2013, only 11 stations were included for the impacts as some of them had not implemented their construction and equipment plans at that time.

Estimated Impact for Construction and Equipment Expenditures at State level (2013)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$16	$8	$6	$30
Employment Full-Time	55	37	40	132
Payroll Millions $	$4	$2	$2	$8
Gross State Product Millions $	$7	$4	$4	$15

Table 23 - 2013 Estimated Impact for Construction & Equipment Expenditures at State Level

In 2014, nine stations were added to the analysis, completing the total of 20 grantees for the 2012-2013 programs. Due to the activities of the fuel stations from the previous year (11 stations), operations impacts were added to the analysis together with the impacts from

producing natural gas supplied in the stations, and the impacts related to the new trucks assumed to be produced in 2014 (production, maintenance, and service of these trucks).[25]

Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production at State level (2014)

Economic Impacts				
	Direct	**Indirect**	**Induced**	**Total**
Output Millions $	$71	$20	$37	$128
Employment Full-Time	584	109	234	927
Payroll Millions $	$22	$6	$10	$38
Gross State Product Millions $	$45	$12	$23	$79

Table 24 - 2014 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level

In 2015, there are 32 new grantees, and they are estimated to finish construction and equipment acquisitions early next year. As with the previous year, fuel stations operations, new trucks related jobs, and natural gas production impacts were included in the analysis. For this year, the nine remaining stations from the 2012-2013 programs were added to the operations of the new 2014 grantees.

Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production at State level (2015)

Economic Impacts				
	Direct	**Indirect**	**Induced**	**Total**
Output Millions $	$261	$77	$136	$474
Employment Full-Time	2,073	413	847	3,333
Payroll Millions $	$81	$22	$38	$141
Gross State Product Millions $	$159	$45	$84	$288

Table 25- 2015 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level

A projection of future impacts from trucks served by the 52 stations in 2018 was estimated, and together with operations of fuel stations and production from natural gas generate the following impacts.

[25] This type of impact was included in the GNA study for Pennsylvania, as each new natural gas truck implies manufacturing, maintenance, and service jobs.

Estimated Impact for Operations, Maintenance, and Natural Gas Production at State level (2018)

Economic Impacts				
	Direct	**Indirect**	**Induced**	**Total**
Output Millions $	$281	$71	$132	$484
Employment Full-Time	1,945	362	768	3,076
Payroll Millions $	$76	$20	$37	$134
Gross State Product Millions $	$178	$43	$81	$302

Table 26 – 2018 Estimated Impact for Capital Expenditure, Station Operations, Maintenance, & Natural Gas Production at State Level

Assumptions for Construction and Equipment Expenditures in 2013, 2014, and 2015

For the year 2014, only the grantees from 2012 and 2013 were considered as active or soon to be active were included. Some grants were cancelled or had not yet been executed. Based on that information, construction expenditures were estimated for 2013, 2014, and 2015. It was assumed that all of the grantees from the 2014 round would go ahead and build the new stations.

Construction Expenditures 2013, 2014, and 2015

Activity	NAICS	2013	2014	2015
Construction *	2362	$5,491,722	$1,879,208	$15,658,748

* Includes other costs related to construction activities

Table 27 - 2013, 2014, & 2015 Construction Expenditures

For expenditures on equipment, based on the grantees' information, several expenditures were allocated to different industrial sectors, as shown in the table below. To estimate the regional impacts, it is necessary to include only a percentage of the manufacturing activities related to the production of the equipment demanded by the grantees because several of these items are produced outside the State, and therefore, do not have economic impacts in Texas.

Equipment Expenditures 2013, 2014, and 2015

Type of equipment	NAICS	2013	2014	2015	Local Purchase
Compressor	33912	$2,572,830	$1,141,233	$13,608,923	26.91%
Dispenser	33321,333291-4	$1,548,510	$676,402	$4,294,534	21.88%
Dryer	33321,333291-4	$339,525	$145,855	$1,120,447	21.88%
Storage	33242	$2,108,444	$1,213,416	$3,275,479	53.19%
Card reader	335999	$63,000	$44,851	$442,408	10.61%
Vaporizer	33321,333291-4	$613,850	$400,000	$435,180	21.88%
Other	33321,333291-4	$3,412,067	$1,254,417	$5,313,661	21.88%
Total		$10,658,226	$4,876,174	$28,490,633	

Table 28 - 2013, 2014, 2015 Equipment Expenditures

Assumptions for fuel station impacts

Also, based on the GNA study, each fuel station will add one new full-time-equivalent (FTE) job to serve the trucks using the new NGV/ LNG facilities. For each year, the number of stations was calculated and used in the simulations of the impacts for the State of Texas.

Stations and New Related Jobs

Stations	2013	2014	2015	2018
New stations	11	9	32	0
Total active stations (end of year)	11	20	52	52
New jobs for fuel stations	11	20	52	52

Table 29 - Station and Related Jobs

Assumptions for vehicle related impacts: production/maintenance/service

For each truck there are 1.29 FTE related jobs. [26] For these impacts, the business sector ***maintenance and service of trucks*** was used as reference for the simulations. Because of the TNGVP, a large number of trucks will be produced; and will need service and maintenance not available previously.

Based on grantees' information, for 2013 it was estimated that close to 762 heavy-trucks[27] were using the stations services, and for 2018 it was estimated that close to 6,985 heavy-trucks are going to use the stations. An average growth of 1,244 trucks per year was calculated in order to establish how many new jobs were created every year. The calculations are shown in the table below:

[26] This section is based on the GNA study.

[27] Some grantees provided information for light- or medium-truck sales; these numbers were transformed to equivalent heavy-trucks numbers based on the volume of DGE/GGE of gas used.

Number of production/maintenance/service jobs

	2013	2014	2015	2016	2017	2018
Potential new trucks at fuel stations	762	1,244	1,244	1,245	1,245	1,245
Number of years	1	2	3	4	5	6
Accumulated number of trucks	762	2,006	3,250	4,495	5,740	6,985
Number of new related jobs	N/A	1,605	1,605	1,606	1,606	1,606

Table 30 - Production, Maintenance, and Service Jobs

Assumptions for production of natural gas

For the impacts from the production of natural gas, based on the grantees information, estimates of natural gas consumption were made for 2015 and 2018. Using prices forecasted by the Energy Information Agency, the value of the natural gas produced was estimated along with the severance taxes associated with that production.[28]

Natural gas production

	2014	2015	2018
Number of trucks	2,006	3,825	6,985
Natural gas production, mcf	4,105,516	6,651,509	14,295,627
Henry Hub nominal price forecast	$3.23	$3.34	$4.69
Value of Natural gas	$13,252,780	$22,214,888	$67,115,346
Severance tax, 7.5%	$993,959	$1,666,117	$5,033,651

Table 31 - Natural Gas Production Source for rate: http://www.window.state.tx.us/taxinfo/nat_gas/

Detailed impacts by type for year 2013

Estimated Impacts for Construction at State level (2013)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$5	$3	$3	$11
Employment Full-Time	31	15	18	64
Payroll Millions $	$2	$1	$1	$3
Gross State Product Millions $	$2	$2	$2	$6

Table 32 - 2013 Estimated Construction Impacts

[28] Based on a study, 1 GGE = 115.6 cubic feet of natural gas, and 1 DEG = 131.7 cubic feet of natural gas. http://www.anga.us/media/content/F7D3861D-9ADE-7964-0C27B6F29D0A662B/files/11_1803_anga_module5_cng_dd10.pdf

Estimated Impact for Equipment Expenditures at State level (2013)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$11	$5	$3	$19
Employment Full-Time	24	22	21	68
Payroll Millions $	$2	$1	$1	$4
Gross State Product Millions $	$4	$3	$2	$9

Table 33 - 2013 Estimated Equipment Expenditures Impact

Detailed impacts by type for year 2014

Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$71	$20	$37	$128
Employment Full-Time	584	109	234	927
Payroll Millions $	$22	$6	$10	$38
Gross State Product Millions $	$45	$12	$23	$79

Table 34 - 2014 Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production

Estimated Impact for Construction at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$2	$1	$1	$4
Employment Full-Time	10	5	6	22
Payroll Millions $	$1	$0	$0	$1
Gross State Product Millions $	$1	$1	$1	$2

Table 35 - 2014 Estimated Construction Impact

Estimated Impact for Equipment Expenditures at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$5	$2	$2	$9
Employment Full-Time	11	10	10	31
Payroll Millions $	$1	$1	$0	$2
Gross State Product Millions $	$2	$1	$1	$4

Table 36 - 2014 Estimated Equipment Expenditures Impact

Estimated Impact for Stations Operations at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$1	$0	$0	$2
Employment Full-Time	11	2	3	16
Payroll Millions $	$0	$0	$0	$1
Gross State Product Millions $	$1	$0	$0	$1

Table 37 - 2014 Estimated Station Operation Impact

Estimated Impact for New Trucks Maintenance, Production, and Service at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$56	$14	$33	$102
Employment Full-Time	548	83	209	840
Payroll Millions $	$20	$4	$9	$33
Gross State Product Millions $	$36	$8	$20	$65

Table 38 - 2014 Estimated New Truck Maintenance, Production, and Service Impact

Estimated Impact for Extraction of Natural Gas at State level (2014)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$8	$2	$1	$11
Employment Full-Time	3	10	5	18
Payroll Millions $	$0	$1	$0	$1
Gross State Product Millions $	$5	$1	$1	$7

Table 39 2014 Estimated Extraction of Natural Gas Impact

Detailed impacts by type for year 2015

Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$261	$77	$136	$474
Employment Full-Time	2,073	413	847	3,333
Payroll Millions $	$81	$22	$38	$141
Gross State Product Millions $	$159	$45	$84	$288

Table 40 - 2015 Estimated Impact for Capital Expenditures, Station Operations, Maintenance, and Natural Gas Production

Estimated Impact for Construction Expenditures at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$16	$9	$8	$33
Employment Full-Time	86	42	50	179
Payroll Millions $	$4	$3	$2	$9
Gross State Product Millions $	$7	$5	$5	$17

Table 41 - 2014 Estimated Construction Impact

Estimated Impact for Equipment Expenditures at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$28	$13	$9	$51
Employment Full-Time	59	58	56	173
Payroll Millions $	$6	$4	$3	$12
Gross State Product Millions $	$11	$7	$6	$24

Table 42 - 2015 Estimated Equipment Impact

Estimated Impact for Stations Operations at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$4	$1	$2	$8
Employment Full-Time	52	7	14	74
Payroll Millions $	$2	$0	$1	$3
Gross State Product Millions $	$3	$1	$1	$6

Table 43 - 2015 Estimated Station Operation Impact

Estimated Impact for New Trucks Maintenance, Production, and Services at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$195	$48	$115	$357
Employment Full-Time	1,869	283	715	2,867
Payroll Millions $	$69	$14	$32	$115
Gross State Product Millions $	$127	$29	$71	$227

Table 44 - 2015 Estimated New Truck Maintenance, Production, and Service Impact

Estimated Impact for Extraction Natural Gas at State level (2015)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$18	$5	$2	$25
Employment Full-Time	7	21	12	40
Payroll Millions $	$0	$1	$1	$2
Gross State Product Millions $	$11	$3	$1	$15

Table 45 - 2015 Estimated Natural Gas Extraction Impact

Detailed impacts by type for year 2018

Estimated Impact for Operations, Maintenance, and Natural Gas Production at State level (2018)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$281	$71	$132	$484
Employment Full-Time	1,945	362	768	3,076
Payroll Millions $	$76	$20	$37	$134
Gross State Product Millions $	$178	$43	$81	$302

Table 46 - 2018 Estimated Operations, Maintenance, and Natural Gas Production

Estimated Impact for Stations Operations at State level (2018)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$5	$1	$2	$8
Employment Full-Time	52	7	14	74
Payroll Millions $	$2	$0	$1	$3
Gross State Product Millions $	$4	$1	$2	$6

Table 47 - 2018 Estimated Station Operation Impact

Estimated Impact for New Trucks Maintenance, Production, and Services at State level (2018)

Economic Impacts				
	Direct	Indirect	Induced	Total
Output Millions $	$209	$51	$122	$383
Employment Full-Time	1,870	283	715	2,869
Payroll Millions $	$73	$15	$34	$123
Gross State Product Millions $	$135	$31	$76	$241

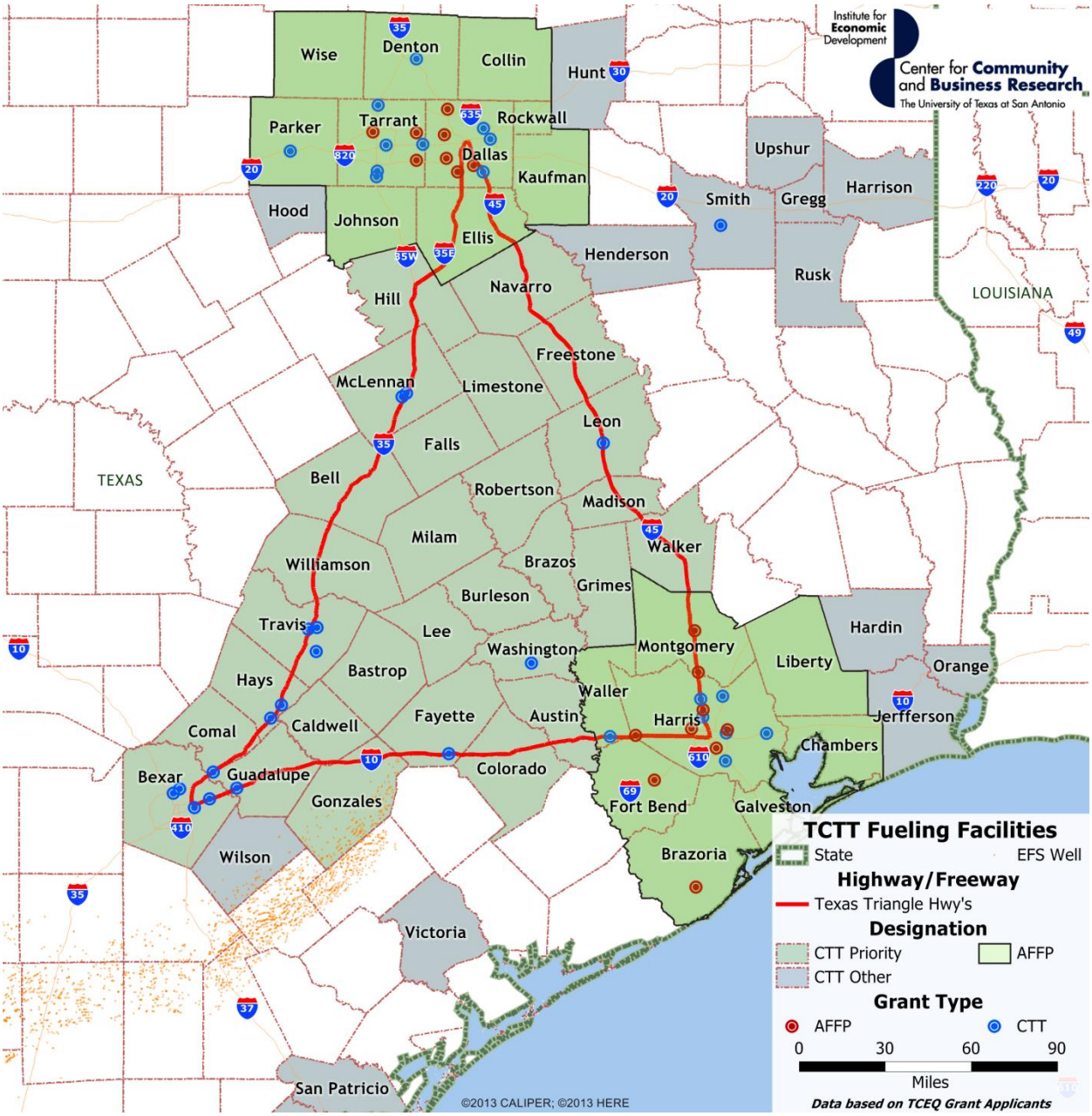
Table 48 - - 2018 Estimated New Truck Maintenance, Production, and Service Impact

Estimated Impact for Extraction of Natural Gas at State level (2018)

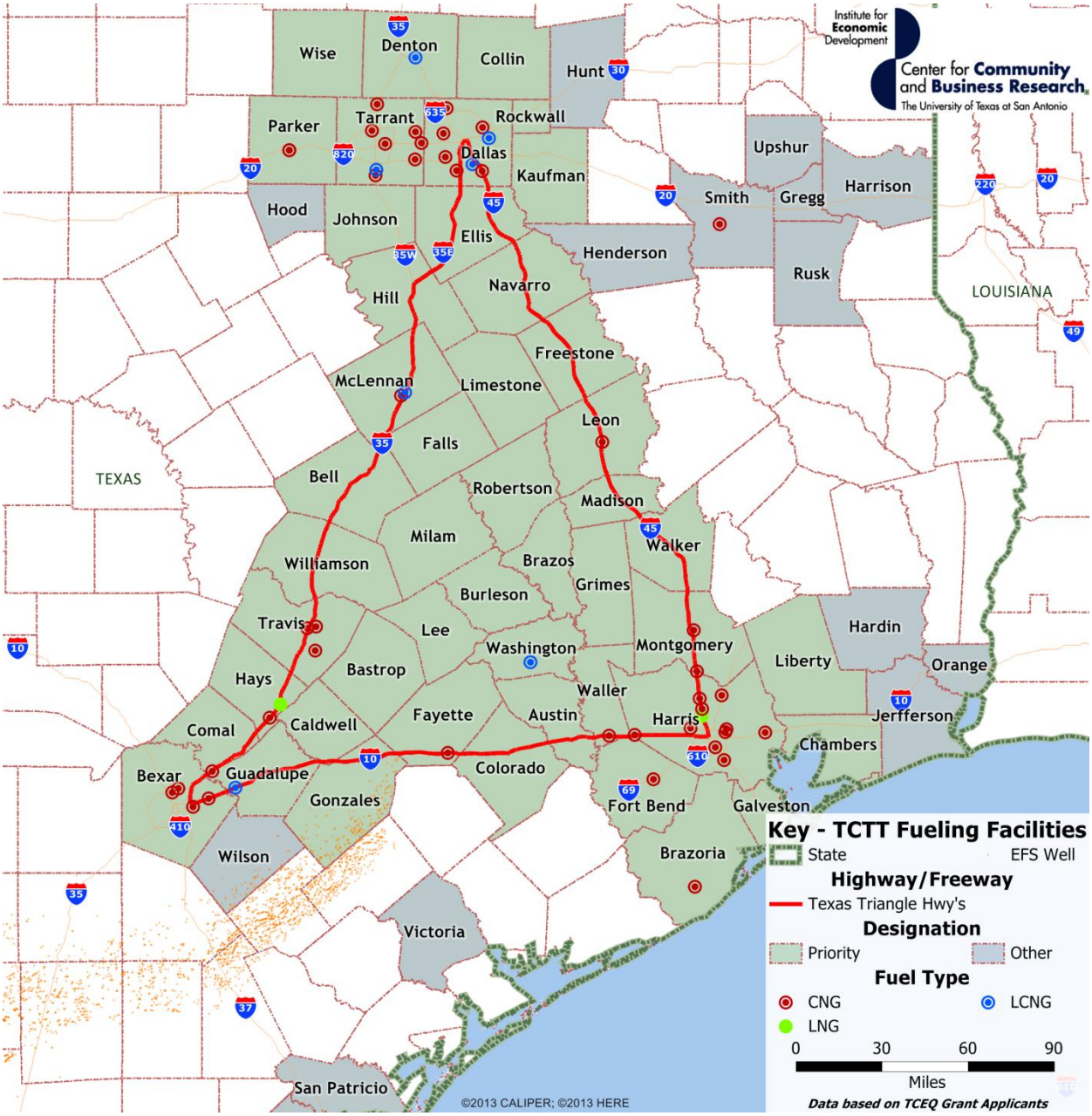
Economic Impacts				
	Direct	**Indirect**	**Induced**	**Total**
Output Millions $	$67	$19	$7	$93
Employment Full-Time	22	72	39	133
Payroll Millions $	$2	$5	$2	$8
Gross State Product Millions $	$39	$11	$4	$55

Table 49- 2018 Estimated Natural Gas Extraction Impacts

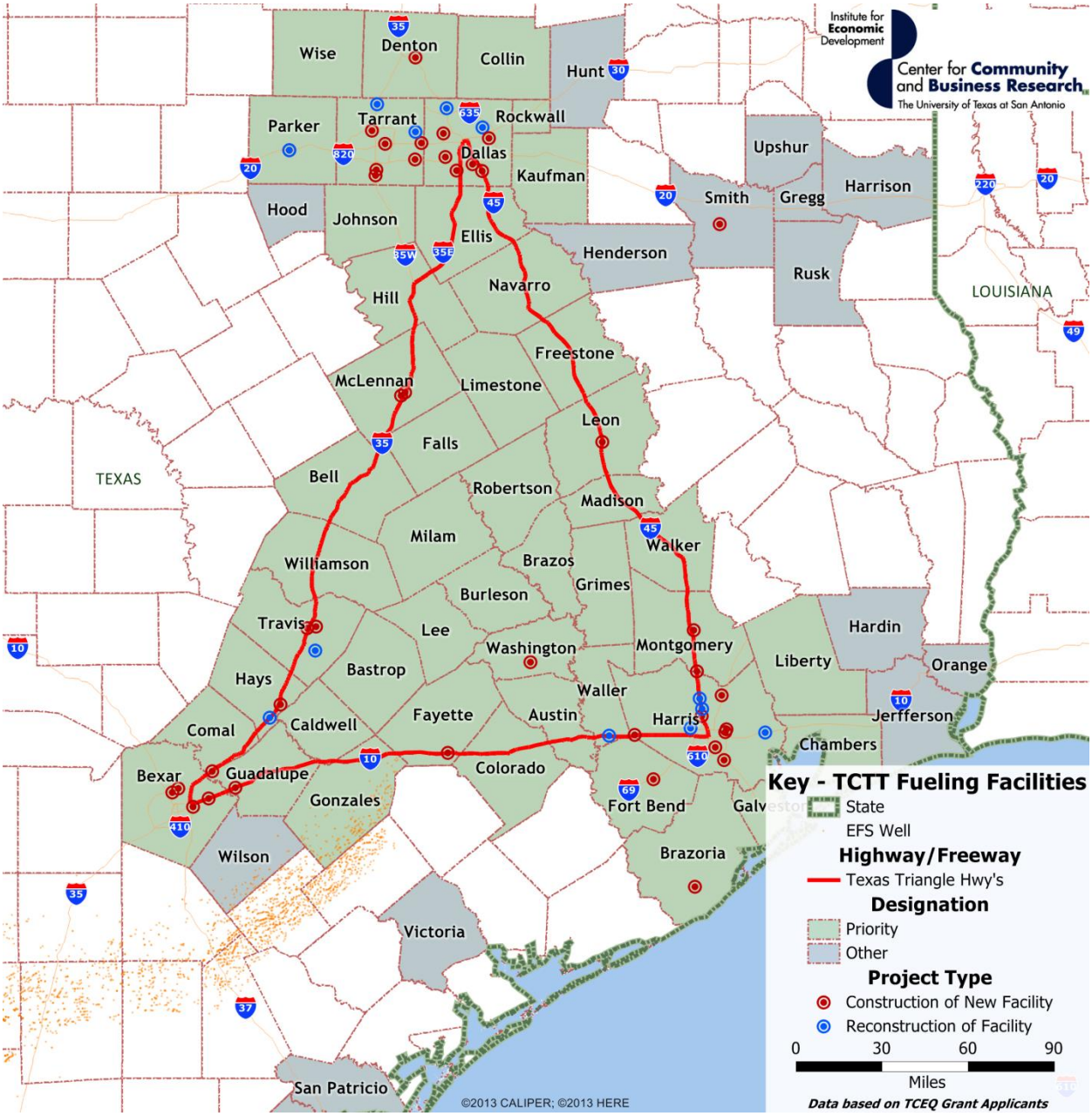
GIS mapping of Facilities in Texas



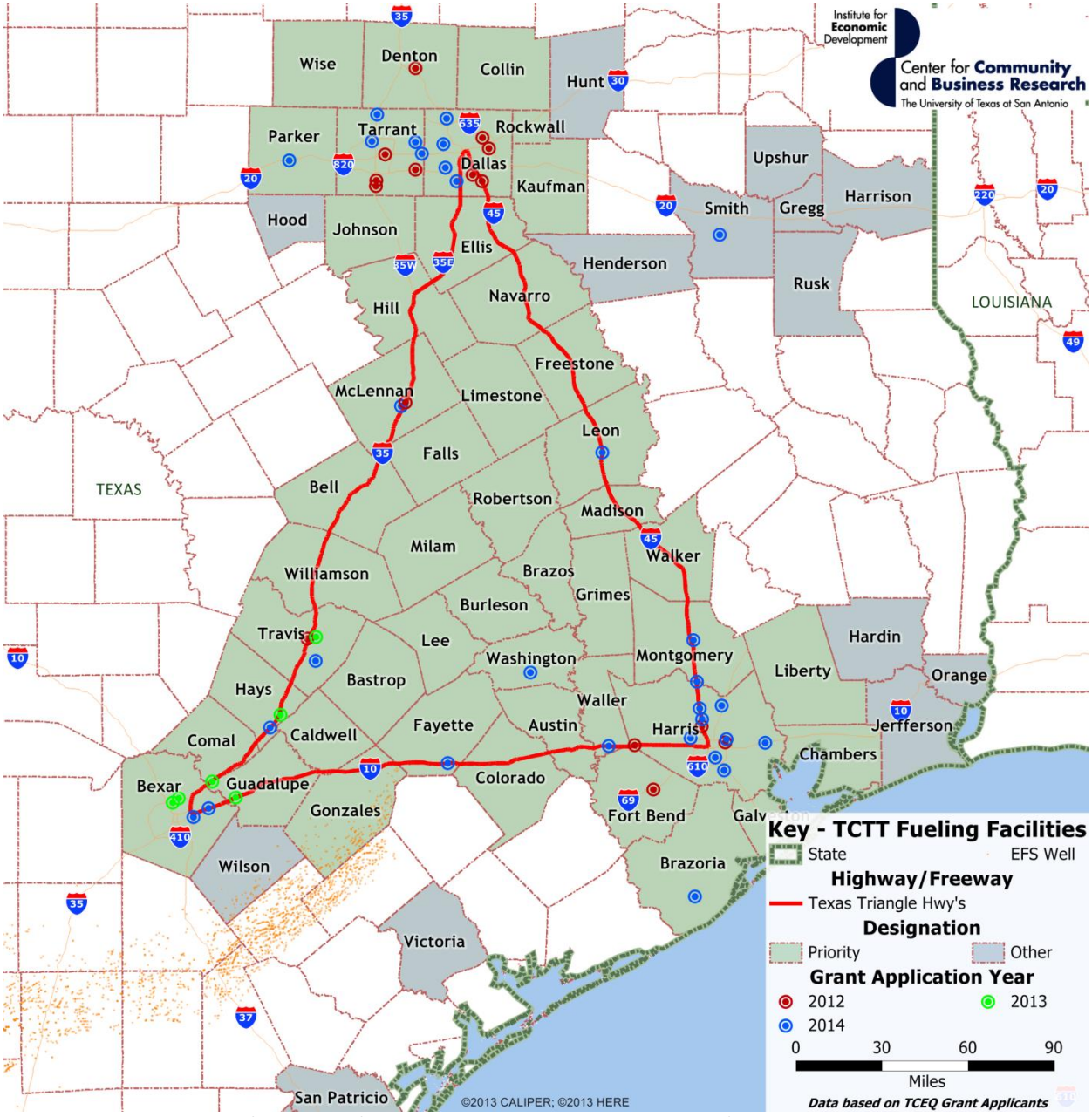
Map 4- TCTT Grantee Facility by Grant Type. Source: TCEQ, CCBR GIS, H. Eid



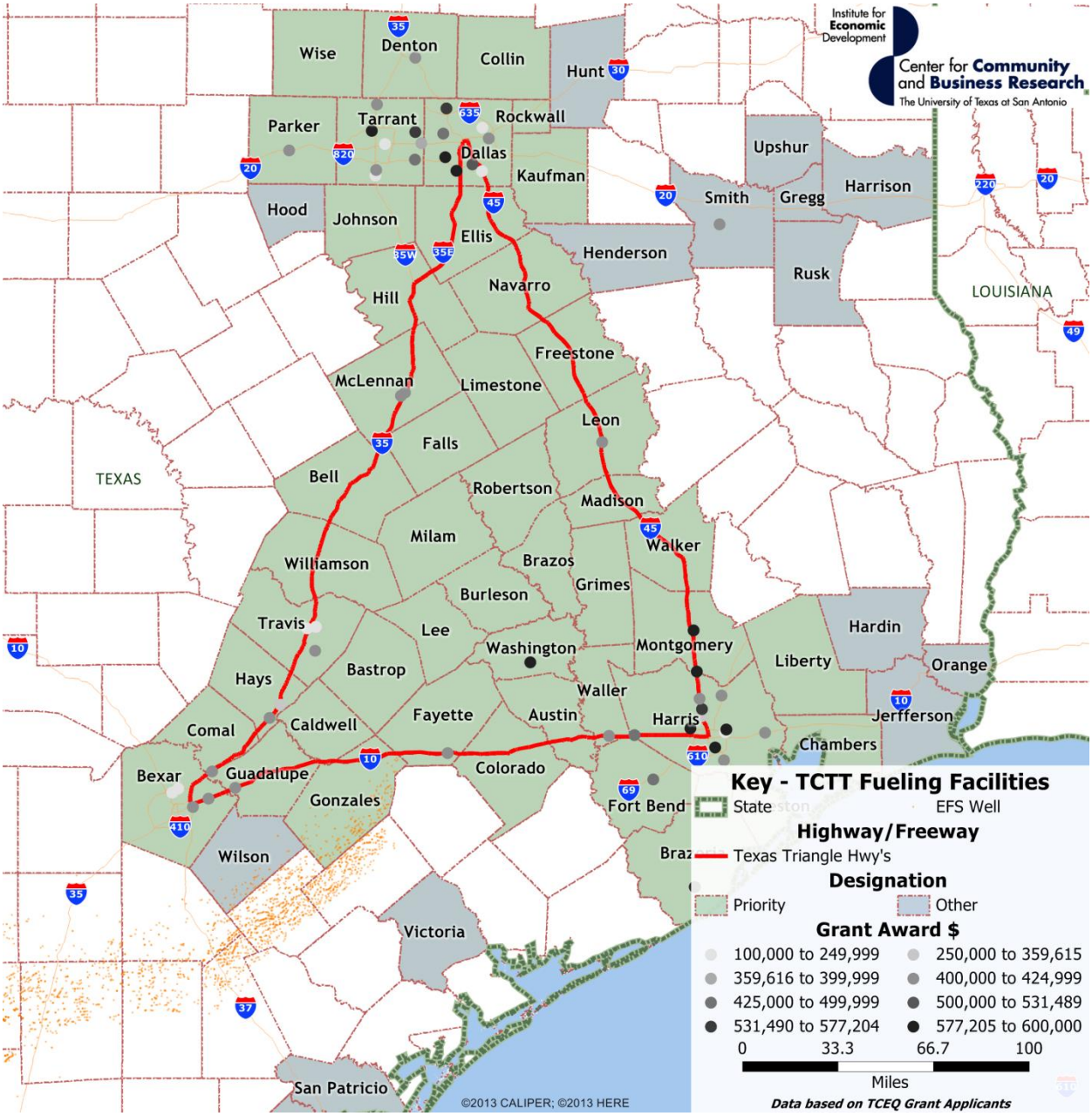
Map 5 - CTT & AFFP Grantee facilities by fuel type Source: TCEQ, CCBR GIS, H. Eid



Map 6 - CTT & AFFP Grantee by construction type. Source: TCEQ, CCBR GIS, H. Eid



Map 7 - CTT & AFFP Grantee by grant application year. Source: TCEQ, CCBR GIS, H. Eid



Map 8 - CTT & AFFP Grantee by grant award size. Source: TCEQ, CCBR GIS, H. Eid

Workforce Analysis of Fueling Stations

The production of natural gas vehicles and related infrastructure has tangible impacts on employment for workers in Texas. Occupations related to station construction, station operations, vehicle operations, and vehicle maintenance will be important components to those planning workforce and training programs in Texas. This section describes some of the most common jobs found working on the construction natural gas fueling stations and the production and maintenance of natural gas vehicles. Wage data is included in the table that precedes the description of the jobs. Although the Bureau of Labor statistics (BLS) does not publish wage data for natural gas vehicles specifically, the wages listed represent the larger industry group that would employ natural gas vehicle workers. The construction of natural gas vehicle stations requires a variety of occupations that provide a diverse set of duties.

2013 Station Construction Workforce Median Salary

Table 50: Construction Workforce Median Salary; Source: Department of Labor

Job	SOC Code	Average U.S. Salary	Average Texas Salary
Cost Estimators	13-1051.00	$59,500	$61,400
Construction Manag**ers**	11-9021.00	$84,400	$74,700
Technical Writers	27-3042.00	$67,900	$65,700
Construction Equipment Operators	47-2073.00	$42,500	$35,000
Construction Foremen	47-1011.00	$60,400	$57,000
Purchasing Agents	13-1023.00	$59,800	$57,400
Architectural Drafters	17-3011.01	$48,800	$48,300
Mechanical Engineers	17-2141.00	$82,100	$89,900
Construction Carpenters	47-2031.01	$40,500	$31,900
Carpenter Helpers	47-3012.00	$26,100	$27,200
Electricians	47-2111.00	$50,500	$43,000
Electrician Helpers	47-3013.00	$27,700	$28,400
Construction Laborers	47-2061.00	$30,500	$25,700
Industrial Machinery Mechanics	49-9041.00	$47,900	$46,600
Pipe Fitters	47-2152.01	$50,200	$46,500
Administrative Assistants	43-6014.00	$32,800	$30,400

Cost estimators help determine the correct prices of products and services related to commercial construction sites, and may specialize in building CNG and LNG station sites. The duties of a cost estimator may include reading over site blueprints to estimate specific costs of station components and determining the effects of station modifications in real time. They manage the monitoring of construction costs and reporting of information to management.

Construction managers direct activities related to the construction of CNG and LNG stations and structures, usually through the management of subordinate supervisory personnel. They oversee the organization, scheduling, and budgeting of the project, and help monitor

compliance with environmental regulations. They also investigate damage, accidents, or delays that might occur at the construction site.

Construction equipment operators use different types of power construction equipment to move earth, grade, excavate, and erect structures for natural gas stations. They are proficient at operating specific tools such as the back hoes, motor graders, bulldozers, scrapers, shovels, or front end loaders.

Construction foremen supervise the activities of construction workers on natural gas station sites. They assign work to construction laborers and inspect work for quality. Foremen on sites monitor supplies and order or requisition supplies as needed.

Purchasing agents purchase a variety of equipment, components, and services for the construction and operation of natural gas fueling stations. They prepare purchase orders and review bid proposals to complete their duties. They also research and review different suppliers and vendors in order to evaluate the quality, service, and price of goods.

Architectural drafters assist architects by preparing designs and plans for stations. Drafters use computer aided drafting (CAD) and other software to graphically present these designs. They also may analyze building codes and bylaws to determine their effect on the designs of stations. They may also represent architects on the site to ensure plans are being carried out on time.

Mechanical engineers oversee the installation of mechanical equipment such as natural gas compressors and storage tanks at natural gas fueling stations. They test and investigate equipment failures and recommend modifications to designs to ensure that all equipment operates according to specification. Mechanical engineers also interpret blueprints and technical drawings to understand how mechanical systems and process function.

Construction carpenters use an array of carpenter's hand tools and power tools to construct and install structures made of wood, plywood, and wallboard. The practice of carpenters involves studying blueprints and plans to create dimensions for materials, measuring and cutting wood to create correct lengths, and using a plumb bob and level to verify trueness. *Carpenter helpers* assist construction carpenters by completing duties that require less skill such as cutting, fastening, and positioning timber.

Electricians install electrical wiring, equipment and fixtures at natural gas fueling stations. They inspect and test electrical systems to ensure safety and conformance to codes. *Electrician helpers* assist electricians by measuring, cutting, and being wire and conduit.

Pipe fitters assemble and install pipe systems for transporting CNG and LNG in natural gas fuel stations. Pipe fitters select the correct pipe sizes, and test systems using pressure gauges, hydrostatic testing, and observation. Pipes may be hammered, cut, or thread to specifications.

2013 Vehicle Fleet Workforce Median Salaries

Natural gas vehicles use combustion engines whose production, assembly, and maintenance and components are very similar across combustion types.

Table 51: Fleet Workforce Median Salary; Source: Department of Labor

Job	Codes	Average Salary in the U.S	Average Salary in Texas
Electromechanical equipment assemblers	51-2023.00	$31,800	$30,100
Engine and other machine assemblers	51-2031.00	$37,300	$38,400
Team assemblers	51-2092.00	$28,200	$24,100
Machinists	51-4041.00	$39,600	$38,700
Industrial production managers	11-3051.00	$90,800	$94,000
Automotive Master Mechanics	49-3023.01	$36,700	$35,200
Transportation Vehicle, Equipment and Systems Inspectors, Except Aviation (CNG/ LNG Fuel System Inspector)	53-6051.07	$66,000	$51,100

Electromechanical equipment assemblers is in charge of assembling or modifying electromechanical equipment such as servomechanisms, gyros, dynamometers, magnetic drums, tape drives, brakes, control linkage, or actuators in the manufacturing aspect of the fleets. One of their main duties is to inspect and adjust completed units to ensure that units meet specifications, tolerances, and customer order requirements. They use a variety of electromechanical tools and components to assemble the fleets.

Engine and other machine assemblers direct activities relate to constructing and assembling engines and turbines for the fleet's manufacture. They are responsible for any assembling procedures within the fleet manufacturing process.

Team assemblers work together for assembling the entire production of the fleets. Team assemblers can perform all tasks conducted by the team in the assembly process and rotate through all or most of them rather than being assigned to a specific task on a permanent basis, also known as the lean manufacturing system. The workers are usually on a team to complete the exterior components of the CNG or LNG vehicles such as the body or frames.

Machinists' duties consist of setting up and operating a variety of machine tools to produce precision parts and instruments. Machinists are responsible for monitoring the machines and the quality of the output from the produced product. They are also in charge of fabricating,

modifying, or repairing mechanical instruments from the vehicles. Fleet machinist must acquire and apply knowledge of mechanics, mathematics, metal properties, layout, and machining procedures for fleet conversion.

Industrial production managers plan, direct, or coordinate the work activities and resources necessary for manufacturing products in accordance with cost, quality, and quantity specifications that are required to manufacture vehicles and vehicles components. They are responsible for creating clear and attainable objectives, building the requirements, and managing the constraints of the production for the fleets.

Occupation vehicle maintenance technicians are also known as the automotive service technicians or mechanics. Their duties consist of diagnosing and repairing the CNG or LNG vehicles. Due to the fact that they are running on a different source of gas from gasoline, they will need a specialist that knows about specific CNG or LNG fleet. They will perform basic car maintenance and vehicle repairs.

CNG fuel system inspectors manage the inspection of the containers, valves, pressure relief devices and other fuel system components of CNG-fueled vehicles. Certified inspectors will have demonstrated proficiency in inspecting CNG vehicle cylinders and fuel systems, identifying and documenting defects, and the safe handling of cylinders and fuel system components.

Analysis of Workforce Required for Natural Gas Vehicles and Stations

Gladstein, Neandross and Associates (GNA) released a report in April 2011 that provides valuable information on how to estimate the workforce needed to construct and operate natural gas vehicles and fueling stations[29] GNA surveyed two large natural gas vehicle manufacturers to create the total labor hours necessary per truck relating to production, training, service, parts manufacturing, delivery, and truck operation. These two manufacturers represent a large share of the natural gas vehicle production market. The total labor hours per truck were then multiplied by the number of trucks to find the total workforce hours. To create the full time equivalent jobs, the total workforce was then divided by 2,000, or the amount of hours an employee is estimated to work in a year.

Table 52: Summary for the Pennsylvania Clean Transportation Corridor; Source: GNA Associates[30]

	Foundation	Developed
Jobs (Trucks)	516	1,096
Jobs (Stations)	50	107
Jobs (Facilities)	20	43
Jobs (E&P)	53	113
Jobs (TOTAL)	**639**	**1,359**

[29] "NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air", *Marcellus Shale* Coalition, April 2011
[30] "NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air", *Marcellus Shale* Coalition, April 2011. 36

The development of natural gas vehicles and stations has impacts on employment in Texas industries including the vehicle production, training, vehicle service, parts manufacturing, delivery, and truck operation companies. Jobs supporting natural gas vehicles are created and special training is needed for maintenance and service of vehicle tanks, fuel lines, and engines. Under a scenario where 400 trucks are built and operated, it is assumed that 516 full-time jobs will be created, or an equivalent of 1.29 jobs per vehicle.

Construction of natural gas fueling stations creates an array of jobs from industries that include the mechanical engineering, construction, and management fields. The GNA report assumes that 5.3 full-time equivalent jobs will be needed to perform the construction duties of the station. Each station also requires one full-time equivalent job to support the maintenance and operations of the fueling station. Under the "foundation" scenario, eight natural gas stations will be constructed creating a total of 50 jobs, or 6.25 full-time equivalent jobs per station. Fleet conversion will also result in the creation of jobs related to the modification of vehicle bays and other buildings required by fire code.

Conclusion

The program supporting natural gas vehicle conversions or replacement, as well as facility construction, has made an impact on the availability of the natural gas options for transportation. According to David Porter, Texas Railroad Commissioner, availability of facilities has supported purchase and use of vehicles that use this fuel, which in turn spurs additional facility construction. State monies provided by these incentive grants contributed approximately 25 percent of the total of private sector investment in facilities spending, and provided a highly beneficial and positive economic impact for Texas related to jobs, environmental sustainability, energy independence, and the strength of Texas industry and its citizens.

In the past, the adoption of NG vehicles has been delayed because of a “chicken or egg” problem: fleet owners did not want to invest in new NG trucks because of the absence of natural gas stations; and station owners did not want to invest in NG facilities because of the absence of trucks using these facilities. The grants help in reducing the costs to build the stations and, at the same time, allow station and fleet owners to develop partnerships that are mutually beneficial. Several station grantees show the commitments from fleets as the basis for their future success.

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APPENDICES

Appendix A: Grantee Company Highlights

Green Buffalo Fuel (GBF)
720 Riverview Rd
Tonawanda, NY 14150
P: 716.768.0600
greenbuffalofuel.com

Green Buffalo Fuel offers Well to Wheels® LNG solution for the heavy duty truck market. Well to Wheels® is a turnkey solution, covering all aspects of the supply chain from natural gas, equipment, and mobile LNG dispensing systems with fill rates up to 50GPM. Green Buffalo Fuel specializes in engineering and designing LNG vehicle tanks, LNG fuel stations, as well as dispensing and metering systems. Their technical expertise areas also include engineering, design, fabrication, installation and operation of LNG fueling facilities, dispenser metering systems, cryogenic vehicular fuel tanks, and fuel system integration with both dual fuel and dedicated natural gas spark ignited engines. These services are provided with no up-front costs to customers. GBF also offers LNG vehicle fuel tanks that were designed specifically for truck applications and these tanks are the only tank systems that meet SAE J2343 insulation requirement standards. In August 2014, GBF announced they were partnering with American Power Group, a fuel conversion company, to market GBF's LNG converters in Canada[31].

Clean Energy Fuels Corp.
Corporate Headquarters
4675 MacArthur Court, Suite 800
Newport Beach, CA 92660
P: 949.437.1000
cleanenergyfuels.com

Co-founded in 1997 by T. Boone Pickens, Clean Energy is the leading provider of natural gas (CNG and LNG) in North America with the largest network of stations. The company designs, builds, operates, and maintains fueling stations as well as manufacture CNG and LNG technologies and equipment. They are also in the business of developing renewable natural gas (RNG) facilities, facility modification services, and vehicle conversions. The company has committed to building a nationwide network of natural gas fueling stations, America's Natural Gas Highway[32]. As of July 2014, the Texas Commission on Environmental Quality (TCEQ) awarded Clean Energy $3.6 million for the expansion of natural gas fueling infrastructure and the company has also opened the Interstate 10 corridor, linking Los Angeles to Houston, for heavy duty LNG trucks with its El Paso, Texas station[33],[34]. A subsidiary of Clean Energy Fuels Corp. is Transtar Energy Company, L.P., a Clean Energy Company which has been awarded four grants from the Clean Transportation Triangle (CTT) Program with plans to build stations in the Dallas-Fort Worth and San Antonio/I35 corridor.

[31]Power Engineering. (July 30, 2014). *American Power Group Partners With Green Buffalo Fuel, LLC to Open Up Canadian LNG Markets for APG's Turbocharged Natural Gas® Dual Fuel Vehicular Solution.* Power-eng.com
[32] Chamberlin, Alex. (July 31, 2014). *Overview: Clean Energy Fuels Corp's operations and financials.* Marketrealist.com
[33]Business Wire. (July 16, 2014). *Clean Energy Opens "Gateway to the West" for Seaboard Heavy-duty CNG Truck Fleet; Opens First –of-its-Kind CNG Station with NG Advantage in Pembroke, N.H.* Marketwatch.com
[34] Business Wire. (June 17, 2014). *Clean Energy Opens Interstate 10 Highway Between Los Angeles and Houston to LNG Fueling; Signs Multiple Fueling and Construction Agreements.* Investors.cleanenergyfuels.com

Zeit Energy
1717 McKinney Ave, #700
Dallas, Texas 75202
P: 817.223.1401
zeitenergy.com

Zeit Energy was founded in 2009 and became one of the fastest growing companies offering compressed natural gas (CNG) fueling services in Dallas, Texas. Zeit Energy was created to help municipalities and private fleet owners gather information and make decisions about whether or not compressed natural gas powered vehicles are right for their organization. They offer turnkey solutions for implementations of CNG Stations, CNG station feasibility consulting, station construction management, turn-key station construction, maintenance contracts, and also offer $0 investment CNG operation and fueling contracts. Zeit Energy's management team has the ability to offer sound design, engineering, equipment procurement, construction, and ongoing maintenance to a wide range of customers including, municipalities, school districts, utilities and private fleets. The company's customer base is over 50 percent natural gas utilities such as Atmos, Centerpoint, Oneok and exploration and production companies like EnCana, Apache, and Southwestern Energy (SWN)[35]. Recently, Atmos Energy Corporation teamed up with ZeitEnergy to introduce its newest Ford F-150 and Ford F-250 natural gas fleet along with celebrating the groundbreaking of a new public compressed natural gas (CNG) fueling station on April 30, 2014 at the Atmos Energy service center located at the Tech Center Parkway in Arlington, TX[36]. This collaboration will introduce 67 new natural gas vehicles to Atmos Energy's NGV fleet which will also benefit ZeitEnergy's new CNG station in Arlington.

Questar Fueling Company
Utah
P: 801.324.2861
questarfueling.com

Questar Fueling grew out of Utah-based Questar Corporation, which also includes several affiliate companies such as Questar Gas, a natural gas utility. With several years of experience with natural gas through Questar Gas beginning in 1981, Questar Fueling has grown to offer consultations, design work, packaging, and installation of fueling stations[37]. Questar Fueling strategic focus is on meeting the fueling requirements for medium and heavy duty fleet operators in high traffic corridors. The company has begun constructing fueling stations in Dallas and Desoto, with additional locations in various stages of development in Texas[38]. In 2013, Questar Fueling completed what is lauded as the nation's largest CNG station with five high-speed fueling land and 120 time-fill spaces[39]. The station was constructed for Central Freights in Houston, Texas. As of 2014, the company announced the construction of a station in San Antonio which will be publicly accessible and offer high-speed and time fill fueling[40]. The station will have 60 private time-fill spaces designated for Central Freight Lines with a 6 lane high speed fueling station designated for public access.

[35] Business Wire. (April 30, 2014). *Atmos Energy & ZeitEnergy Celebrate Booming CNG Business in North Texas.* WSJ.com
[36] ibid
[37] Questar Fueling. (2014). *Questar Fueling Home.* Questarfueling.com
[38] Seeking Alpha. (August 2, 2014). *Questar's (STR) CEO Ronald W. Jibson On Q2 2014 results – Earnings Transcript.* Seekingalpha.com
[39] Questar Corporation. (2014). *Questar Fueling Starts Construction on CNG-Fueling in DeSoto, Texas.* Investor.shareholder.com/questarcorp
[40] Ibid. *Questar Fueling Plans Second Texas CNG Fueling Station for Central Freight Lines and the Public.*

Trillium CNG
Corporate Headquarters
200 East Randolph Street
Chicago, IL 60601
trilliumcng.com

Trillium CNG is a subsidiary of Integrys Energy Group, a diverse holding company with several subsidiaries related to natural gas. It is a leading provider of compressed natural gas (CNG) fueling services as well as a single-source provider of CNG fueling facility design, construction, operation and maintenance for over 20 years[41]. Trillium CNG provides exceptional CNG fueling solutions and equipment including the proprietary Pinnacle line of hydraulic intensifier compressors. They specialize in fueling fleets that require high-performance solutions. Trillium's has completed projects in Texas cities such as Austin, Beaumont, Midland, San Antonio, San Marcos, and Sterling City[42]. In March 2014, Trillium CNG along with EVO CNG started construction on a new CNG fueling station in Fort Worth, Texas. The station would be the third station Trillium has constructed in Texas and would be publicly accessible. The station design designed to accommodate both large vehicles such as Class 8 tractors and trailers, and smaller vehicles[43].

AMP Trillium LLC
1130 West Monroe Avenue
Chicago, IL 60607
ampcng.com
312.300.6700
AMP Trillium, LLC is a joint venture of AMPCNG and Trillium offering end-to-end services, from supplying fuel, building stations, leasing trucks to sourcing renewable forms of natural gas.[44] As of July 2014, the company has opened two of eight public fueling stations as part of a joint venture with Dairy Farmers of America and Select Milk Producers.[45] The joint venture will construct six additional stations in Texas. These stations are located in Amarillo and Waco, with future stations in Harrold, Rosenberg, Sweetwater, Brock, Kerrville and Midland.

Independence Fuel System (IFS)
Corporate Office
515 North Fredonia
Longview, Texas, 75601
Tel.9037530242
ifsfuel.com

Independence Fuel Systems, is a Longview, Texas based company that focuses building CNG refueling stations, as well as consulting and assisting with fleet vehicle conversions. IFS opened Longview's first CNG fueling station in 2013 with plans to build more stations throughout East Texas.[46]

[41] Trillium CNG. (2014). *Trillium CNG Home*. Trilliumcng.com/
[42] Project Portfolio. (2014). *Trillium CNG Home*. Trilliumcng.com/company/portfolio.aspx
[43] EVO Trillium, LLC breaks ground on new CNG fueling station at Central Freight Lines terminal in Fort Worth, Texas. (2014). *Integrys Transportation Fuels*. Integrysgroup.com/news/view_article.cfm?reckey=02537&companyID=ITF
[44] Fuel Provider. (2014). *Cummins Westport Fuel Providers*. Cumminswestport.com/links/fuel-providers
[45] Texas City Gets First Public-Access CNG Station. (July 30, 2014). *NGT News Next-Gen Transportation*. Ngtnews.com/e107_plugins/content/content.php?content.9941#.U-4CHPldWSo
[46] Company cuts ribbon on CNG station near Gregg County's busiest interchange. (July 28, 2013). Independence Fuel Systems. Thiessen, Brad. Ifsfuel.com/latest-news-information/

Alpha Terra Engineering, Inc.
8626 Tesoro Drive, Suite 810
San Antonio, TX 78217
P: 210.930.2834
alphaterraengineering.com

Alpha Terra is an engineering firm based in San Antonio, Texas. The company has worked nationally and abroad on wide range of environmental and infrastructure projects for the commercial sector, federal government, as well as state and local governments.[47] In 2013, Alpha Terra was awarded grants from CTT with plans to build two CNG and LNG stations in the San Antonio-Austin area.[48]

ET Environmental Corp., LLC
P: (602) 920-7852
etenv.com

Founded in 1993, ET Environmental is offers a variety of environmental services and construction management. The Energy Division specializes in building fueling facilities from general contracting, project management, and station designing. In 2004, ET Environmental completed its first CNG project and since then have worked on numerous energy-related projects that span from facility evaluations, feasibility studies to multi-million dollar new construction installations and CNG conversions. The company now considers itself to be a leading design/builder of CNG fueling infrastructure, fueling facilities and CNG vehicle maintenance facilities. Current ongoing projects in Texas are CNG fueling and facility modifications in Fort Worth and Grapevine.[49]

American Fueling Systems (AFS)
121 Perimeter Center West, Suite 250
Atlanta, GA 30346
P: 770.399.7800
americanfuelingsystems.com

American Fueling Systems (AFS) services range from providing CNG and LNG to operating fueling stations. The company's services also include designing, building, equipment sales, and offers consulting on the costs and benefits of using alternative fuels. AFS's turnkey solution services are inclusive of site selection, construction management, budget management, permitting process, and after sales maintenance. AFS also offers feasibility studies. There is a Houston, Texas, CNG station currently under construction.[50]

Advance Fuel Systems, Corp.(AFSC)
1145 South Route 31, Unit I-90
Crystal Lake, IL 60014
P: 866.725.0801
advancefuelsystems.com

Advance Fuel Systems Corp. (AFSC) offers designing, manufacturing, packaging, distribution, installations and maintenance of their Vehicle Refueling Stations (VRS) and accessories. Although much of their work is outside of Texas, they have built CNG stations in various other states such as Illinois, Indiana, Michigan, Wisconsin, California, Oklahoma and Ohio. The company's focus is on being a small turnkey solution provider with an emphasis on meeting the needs of smaller fleets. However, they are capable of and have supplied, serviced and maintained a variety of station sizes.[51]

[47] Alpha Terra Engineering About Us. (2014). *Alpha Engineering Home*. Alphaterraengineering.com/aboutus.html
[48] TERP, TCEQ, CTT Projects. (2014). *Texas Commission on Environmental Quality*. Tceq.texas.gov/assets/public/implementation/air/terp/reports/ctt_all_projects_funded.pdf
[49] ET Environmental. (2014). *ET Environmental*. Etenv.com/news/
[50] Building for the Future of Alternative Fuels Projects. (2014). *American Fueling Systems CNG Stations*. Americanfuelingsystems.com/projects.html
[51] AFSC Competed Projects. (2014). *Advance Fuel Systems Corp. CNG Refueling Stations*. Advancefuelsystems.com/AFSCProjects.html

Weaver Inc.
4210 E. La Palma Ave.
Anaheim, CA 92807
P: 714.917.1165
weaverinc.net

Weaver Inc., California construction industry, has the ability to handle any type of construction project requirement in today's market. The company has 54 years of hands-on experience coupled with the essential business acumen, professional and technical expertise. Customers are provided a lump-sum bid or a complete time and materials breakdown for a proposed project. The company maintain competent performance and technical expertise for operations related to the electrical utility, petro-chemical, refinery, specializing in engineering/design/build infrastructure for the alternative fuel, and heavy-duty industries. Weaver Inc. has successfully provided the expertise as either the primary general contractor or a qualified subcontractor, on many projects in the electrical utility, petro-chemical, refinery and heavy-duty industries, involving varying degrees of complexity and technical considerations. Currently, Weaver Inc. is involved in the field of CNG, LNG, and H2 fueling facilities turnkey design and development. Weaver Inc. has a record of accomplishment, completing a wide range of multi-trade turnkey projects. [52]Some of their recent projects consist of constructing a CNG tube trailer for the City of Barstow General and building a CNG maintenance training for the Camp Pendleton Training Consultant. One of their current ongoing project is building a CNG fueling facility for the City of Los Angeles General. [53]

Pivotal LNG
Two Allen Center
1200 Smith Street
Houston, TX 77002
http://www.pivotalenergydev.com/About-Us.aspx

Pivotal Energy Development also known as Pivotal is a part of the Corporate segment of AGL Resources (NYSE: GAS), which is the nation's largest natural gas-only distributor based on customer count. They are currently serving approximately 4.5 million utility customers through its regulated distribution of liquefied natural gas subsidiaries in seven states. Pivotal LNG is supported by more than four decades of experience in LNG production, delivery and transportation. Pivotal's mission is to acquire, improve and operate natural gas assets. Pivotal takes a long-term view of acquisitions and works to improve those facilities to provide long-term value to its customer, the communities in which AGL Resources operates and the shareholders of AGL Resources. Through Pivotal, AGL Resources supports its core business of delivering natural gas by investing in related companies ranging from pipeline operators to salt cavern storage facilities to retail services. With their experience, they are able to build a history of service, reliability and knowledge by delivering unparalleled value to its customers in the form of clean, low-cost LNG. [54]A few of Pivotal Energy Development's projects consist of the Golden Triangle Storage and the Jefferson Island Storage and Hub. Golden Triangle Storage, a wholly-owned subsidiary of AGL Resources, through support and management provided by Pivotal, is in the process of building a natural gas storage facility in the Spindletop salt dome in Jefferson County and Beaumont, Texas approximately a half-mile to a mile below ground, by hollowing out the salt to create caverns. Virtually impermeable and protected deep underground, salt dome caverns are considered to be the safest means of storing natural gas, according to the U.S. Department of Energy. The Golden Triangle Storage project will increase Jefferson County's storage capacity by 80 percent, enhancing the area's position as a national energy hub and increasing the functionality of both its existing and planned energy infrastructure.[55] As for the Jefferson Island Storage and Hub, salt domes supply 8 percent of natural gas storage in the U.S. To meet the increased demand for natural gas storage, AGL Resources, through Pivotal, plans to expand its storage facility at JISH, a natural gas salt-dome storage

[52] Partial List of Projects. (2014). *Weaver Inc. General and Electrical Contractor*. Weaverinc.net/projects.asp
[53] Ibid.

[54] Pivotal Energy Development About Me. (2014). *Pivotal Energy Development*. Pivotalenergydev.com/About-Us.aspx
[55] Project Development Golden Triangle Storage. (2014). *Pivotal Energy Development*. Pivotalenergydev.com/Project-Development/Golden-Triangle-Storage.aspx

facility located near the Henry Hub at Erath, Louisiana in Vermillion and Iberia Parishes.[56]

Appendix B: Alternative and Renewable Fuel in California

The United States has developed dependencies on dependent on foreign oil without developing mainstream use of the reserves of natural gas available in in the country. This gap has led to the development of different grants across the nation in an attempt to incentivize using cleaner and more inexpensive fuels for U.S. vehicle transportation systems. Among the states participating in these grants, California has been one of the most active states in the Alternative fuel vehicle movement[571].

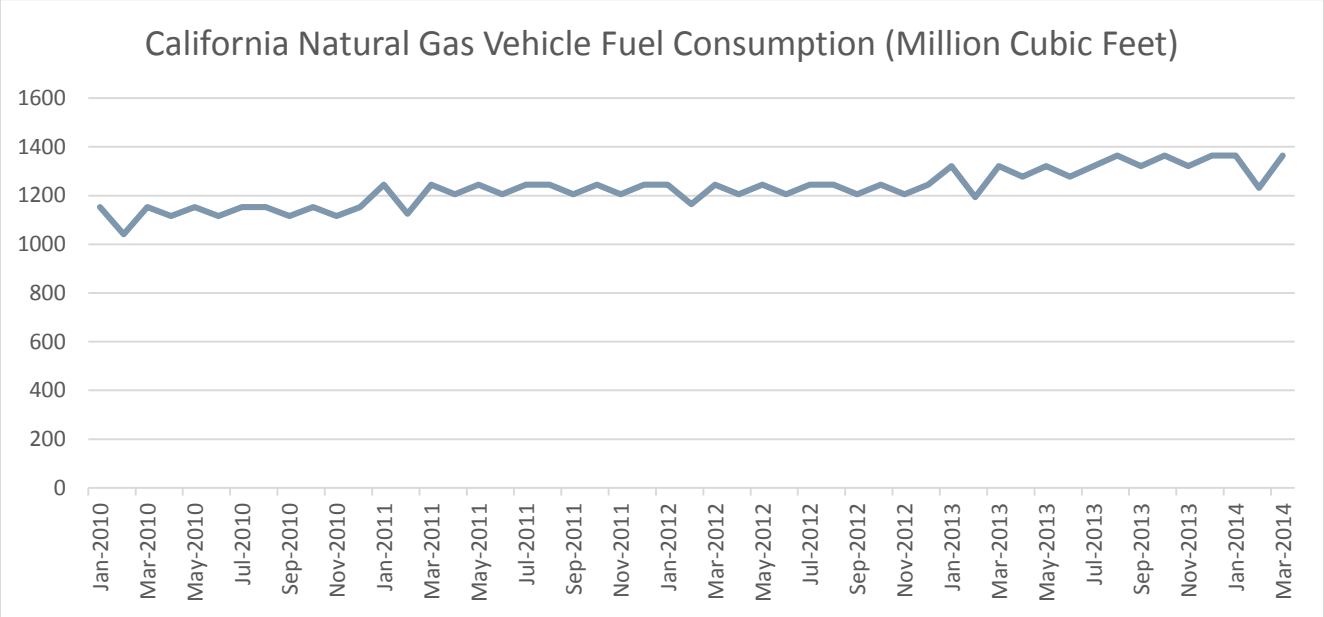


Figure 7: California Natural Gas Vehicle Fuel Consumption in Million Cubic Feet ; Source: EIA

California's natural gas consumption has been on a constant rise since 2010. The Energy Commission is proving funding of up to $100 million annually, leveraging public and private investment to develop and deploy clean, efficient, and low-carbon alternative fuels and technologies[58]. This program also provides a foundation for sustainable development and use of transportation energy as an economic stimulus creating California jobs and businesses.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	1,153	1,041	1,153	1,116	1,153	1,116	1,153	1,153	1,116	1,153	1,116	1,153
2011	1,245	1,125	1,245	1,205	1,245	1,205	1,245	1,245	1,205	1,245	1,205	1,245

[56] Project Development Jefferson Island Storage Hub. (2014). *Pivotal Energy Development*. Pivotalenergydev.com/Project-Development/Jefferson-Island-Storage-Hub.aspx

[57] California Natural Gas Vehicle Fuel Consumption (Million Cubic Feet). (n.d.).*California Natural Gas Vehicle Fuel Consumption (Million Cubic Feet)*. Retrieved June 11, 2014, from http://www.eia.gov/dnav/ng/hist/na1570_s

[58] Smith, Charles, Jim McKinney. 2012. 2012-2013 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program Commission Report. California Energy Commission, Fuels and Transportation Division. Publication Number: CEC-600-2012-001-CMF

2012	1,245	1,165	1,245	1,205	1,245	1,205	1,245	1,245	1,205	1,245	1,205	1,245
2013	1,321	1,193	1,321	1,278	1,321	1,278	1,321	1,365	1,321	1,365	1,321	1,365
2014	1,365	1,232	1,365									

Figure 8: California Consumption; Source: EIA

California's Energy Commission has provided to date more than $420 million in program funding toward more than 250 projects. Among the standout items for fiscal 2014-2015 are $20 million for biofuel production and supply and for hydrogen fueling infrastructure, $15 million each for electric charging infrastructure and medium and heavy duty advanced technology demos, and $9 million for natural gas vehicle incentives[59].

Table 53: California Energy Commission Summary of Previous, Upcoming, and Proposed Funding (In Millions); Source: CEC

Category	Funded Activity	2012-2013*	2013-2014	2014-2015 (Proposed)
Alternative Fuel Production	Biofuel Production and Supply	$18.0	$23	$20
Alternative Fuel Infrastructure	Electric Charging Infrastructure	$6.75	$7	$15
	Hydrogen Fueling Infrastructure	$9.9	$20	$20
	E85 Fueling Infrastructure	$1.35	-	-
	Natural Gas Fueling Infrastructure	$1.35	$1.5	$1.5
Alternative Fuel and Advanced Technology Vehicles	Natural Gas Vehicle Incentives	$10.8	$12	$9
	Propane Vehicle Incentives	$0.8	-	-
	Light-Duty Electric Vehicle Deployment	$12.5	$5	$5
	Medium- and Heavy-Duty Advanced Vehicle Technology Demonstration	$5.4	$15	$15
Related Needs and Opportunities	Emerging Opportunities	$2.5	$4	$7
	Manufacturing	$14.66	$5	$5
	Workforce Training and Development Agreements	$1.19	$2	$2.5
	Regional Alternative Fuel Readiness and Planning	$2.1	$3.5	-
	Centers for Alternative Fuels and Advanced Vehicle Technology	$2.7	$2	-
Total		**$90**	**$100**	**$100**

Source: California Energy Commission. * All funding allocations in FY 2012-2013 were evenly reduced due to insufficient program funds. Certain funding allocations for FY 2012-2013 were modified at a subsequent business meeting to reflect the listed amounts.

According to the 2013-2014 ARFVT plan, an approximate of $12 million dollars will be invested in natural gas vehicle incentives[3]. These incentives will be used to pay the difference between the cost of alternative-fuel vehicles and conventional vehicles in the market. In order to be eligible to receive any of these incentives, buyers must agree to register and operate the vehicles in California at least 90 percent of the time for three years[60]. CEC will also invest $1.5 million for natural gas fueling infrastructure to support growing use of these alternative fuel vehicles by many entities including school districts[2].

Table 54: Alternative Fuel Infrastructure Funding Allocation; Source: CEC

Charging Infrastructure	$7.5 Million
Hydrogen Fueling Infrastructure	$11 Million

[59] Another $100 Million from California. (n.d.). *Fleets and Fuelscom*. Retrieved June 11, 2014, from http://www.fleetsandfuels.com/fuels/cng/2013/05/another-100-million-from-california/

[60] Another $100 Million from California. (n.d.). *Fleets and Fuelscom*. Retrieved June 11, 2014, from http://www.fleetsandfuels.com/fuels/cng/2013/05/another-100-million-from-california/

E85 Fueling Infrastructure	$1.5 Million
Natural Gas Fueling Infrastructure	$1.5 Million

Fueling infrastructure for natural gas vehicles in California is made up of a combination of public or private accessibility and compressed natural gas (CNG) or liquefied natural gas (LNG) dispensing. A few public stations serve light-duty natural gas passenger vehicles; however, most natural gas is dispensed for private fleet at private fleet at private stations[61]. The size of these stations vary according to the stations' size and ability to dispense CNG or LNG.

Table 55: Natural Gas Fueling Stations; Source: California Natural Gas Vehicle Coalition, U.S. DOE Alternative Fuels and Advanced Vehicles Data Center

	Publicly Accessible Stations	Private Access Stations
CNG	140	424
LNG	13	19

Currently, California is looking at an approximate of 27 laws and incentives for natural gas projects. Funded projects include:

- Commercial alternative fuel vehicle (AFV) demonstrations and deployment
- Alternative and renewable fuel production
- Research and development of alternative and renewable fuels and innovative technologies
- AFV manufacturing
- Workforce training
- Public education, outreach and promotion

Some of these projects have already been approved and grants have been awarded, others are currently being analyzed. Through these incentives, California's commitment to curb greenhouse gas emissions, reduce petroleum use, improve air quality, and stimulate the sustainable production and use of biofuels[2] will be accomplished faster than expected.

Figure 9: Facility infrastructure for LCNG Station; Source: CCBR

[61] Smith, Charles, Jim McKinney. 2012. 2012-2013 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program Commission Report. California Energy Commission, Fuels and Transportation Division. Publication Number: CEC-600-2012-001-CMF

Appendix C: CNG and LNG Fueling Station Infrastructure

This Appendix describes compressed natural gas (CNG), liquid natural gas (LNG) and liquid to compressed natural gas (LCNG) fueling station infrastructure in detail by first describing the components that make up the station and then how those components can make up different configurations. CNG fueling station infrastructure is discussed first and followed by LNG and LCNG. (*Graphics source: CCBR GIS, Mari Wells*)

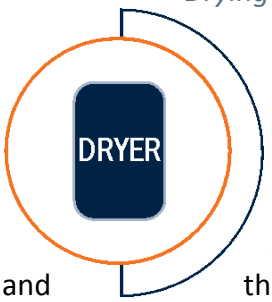
CNG Station Components

The different components of a CNG station vary according to a station's fuel demand and fueling patterns.

Inlet Gas Connection

The inlet is a connection that supplies natural gas to a CNG station and is usually metered by a local utility. The natural gas inlet must have adequate pressure and flow rate for the station design. The higher the pressure, the easier is it to get the required volume necessary to meet a fast-fill rate. An inlet pressure of 35 psi is suitable for a public station that serves light- or medium-duty vehicles. A station that serves heavy-duty vehicles would need a much higher pressure. In fact, one fueling station company only uses 100 psi or above. In addition, it may be necessary to filter pipe scale or other foreign matter that has accumulated in the gas line. Dryers and compressors can be equipped with filters that remove the particulates.

Drying

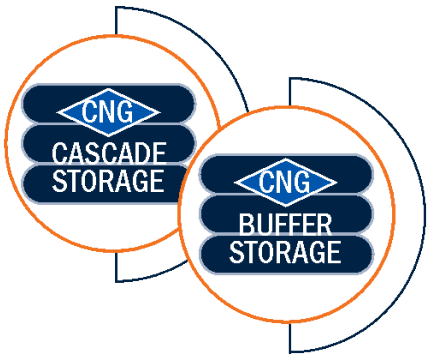


In addition to particulates, natural gas from the inlet line may have high moisture content. Since compressed natural gas loses its ability to hold moisture, it may be necessary to separate the moisture content from the natural gas prior to compressing it. If the moisture content was not separated, it could condensate out in the station or vehicle storage tanks, and this could lead to operational or other issues. "Drying" removes the moisture content from natural gas using a desiccant material such as molecular sieve. Although industry practice has proven that dryers are most effective following the inlet using a low pressure inlet dryer, drying can also be completed after the gas is compressed using a high pressure dryer. Unlike high pressure dryers that use replaceable desiccant cartridges, low pressure dryers require that the desiccant material be replaced periodically or have the ability to regenerate it. In addition, low pressure dryers can come in single or twin tower configurations for small or large stations, and high pressure dryers can be combined to filter out any oil that may have come from the compressor's lubricated moving parts.

Compression

A compressor compresses natural gas to approximately 1/290th of its original volume. Once the natural gas goes through the compression process, it is considered compressed natural gas (CNG). If already dried, the CNG goes from the compressor to storage tanks or directly to a fuel dispenser and into a vehicle. A station must have a compressor that is appropriate for the fueling pattern of its customers - it must be able to replenish the storage supply in a timely manner. Installing two compressors is a way to create "redundancy" to provide consistent pressure and flow to the customer. A second compressor also acts as a back-up in case one of the compressors fails. A portable compressor can also act as a back-up or be used temporarily pending the construction of a permanent facility. A portable compressor would require a natural gas line (at 10 PSI) and (110V) electrical. There are a broad range of configurations on the market, sized to fit the needs of the station. For example, compressors can be compact for light-duty applications, suitable for different inlet pressures, cooled using water or air, and fitted with different engine capacities. The motor can use either electric or natural gas, and its power can range between 7.5 to 300+ horsepower. Compressors can also be "oil-free" (in the crank case and cylinders), which eliminates any concern for oil in the compressed gas and the need for a coalescing filter system to remove oil after compression.

Storage, Priority and Sequencing



Storage systems must be sized to match the output of the compressor, and if at a public station, there must be enough storage to accommodate peak fuel demand. There are two common types of storage configurations, cascade and buffer, both of which are used for fast-fill applications. Fast-fill applications use high pressure as a driving force to fill vehicle tanks more quickly. A cascade storage system is configured in three banks at high, medium, and low pressures. Priority and sequencing valves are used with cascade storage systems to route the CNG from the compressor(s) to the appropriate bank and then from the bank to the vehicle tank. This method maximizes the usable gas volume in a vehicle's tank. A bank is one or more tanks at the same storage pressure. A buffer storage system uses a single bank that is made up of one or more vessels. Because CNG is stored at high pressures, it must be stored in American Society of Mechanical Engineers (ASME) certified vessels. The storage vessels, by law, must be stored above ground and can be cylinder or sphere shaped. Both shapes have the same PSI pressure capability, SCF capacity, and safety ratings. Cylinders can be stored horizontal or vertical, and they are generally cheaper to purchase than spheres.

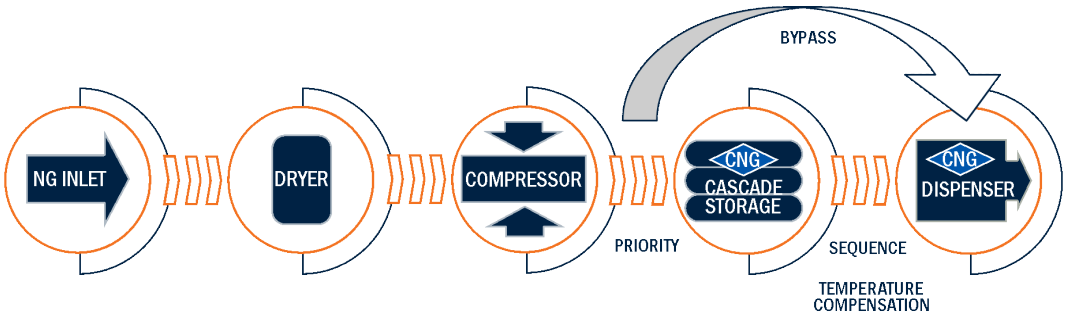
Dispenser and Temperature Compensation System

CNG dispensers can include metering and charging capabilities similar to conventional fuel dispensers, and most come with a temperature compensation system. A temperature compensation system uses an algorithm to adjust a fill for the ambient temperature. Fast-fill dispensers measure the volume available in the vehicle tank before rapidly dispensing to the given volume. A time-fill dispenser typically uses a fixed pressure regulator and bases the fill on the fuel flow rate. The dispensing stops once the fuel flow reaches a minimum rate. A dispenser can be single or dual hosed. Single hoses are typically used to fuel heavy-duty vehicles, while dual hosed dispensers are typically used for light- or medium-duty vehicles. There are two standards for CNG vehicle fill pressures in the U.S. – 3,000 psi and the most typical 3,600 psi. The fill pressures are based on a 70˚F ambient air temperature. Dispensing pumps are equipped to deliver CNG at 3,000 or 3,600 psi. The dispensers typically display a gasoline gallon equivalent (GGE) unit of measure.

CNG Station Configurations

Four of the most common CNG fueling station configurations are discussed in the following sections.

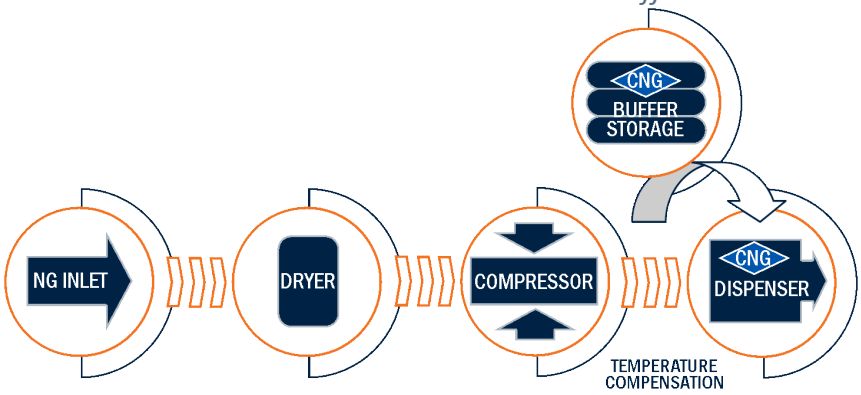
Cascade Fast-Fill



This application is typically used for random filling like in retail (public) stations. Cascade fast-fill stations include a dryer, a compressor, priority valves, storage vessels, storage bypass sequence valves, a temperature compensation system, and a dispenser. Vehicles are primarily filled from storage tanks. The vehicle fill process uses a cascade technique, where the flow from high, medium, or low pressured storage tanks to the vehicle tank represents a systematic sequence to compensate for the changes in gas pressure. If the pressure in the vehicle tank equalizes to that of the highest pressure tank, then the tanks are bypassed and filled directly through the compressor. Cascade fast-fill stations are designed according to the fueling patterns, including peak demand, of customers. These stations can accommodate light- to heavy-duty vehicles. A total fill cycle takes approximately 3-10 minutes per vehicle.

⇒ MOSTLY RETAIL (PUBLIC) STATION
⇒ SIZED FOR PEAK DEMAND AND RANDOM FILLING
⇒ LIGHT- TO HEAVY-DUTY VEHICLES
⇒ 3-10 MINUTE FILL PER VEHICLE

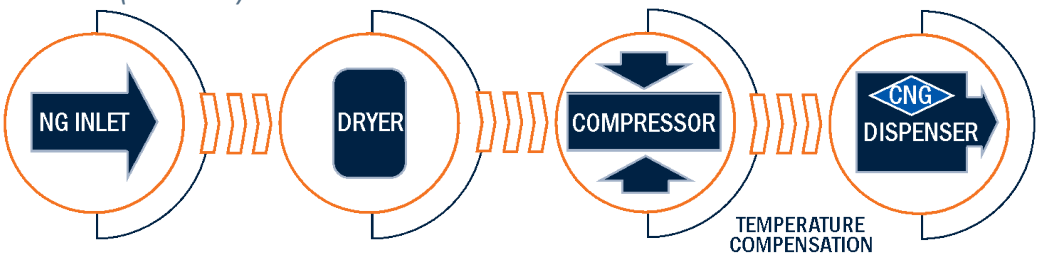
Buffered Fast-Fill



Buffered fast-fill stations are used for refueling high-fuel use vehicles on a continuous basis. Similar to the cascade fast-fill stations, the buffered fast-fill stations use dryers and compressors. Two to five compressors is typical, where one is used as a redundant backup. However, vehicles are primarily filled directly through the compressor instead of from the storage tanks. The storage tanks act as a temporary storage, or buffer, to keep the compressors running loaded between refilling vehicles. If the compressors completely fill the buffer storage between vehicle refills, then the compressor operates unloaded, or "idles." An idling compressor means that it is operating without the flow of natural gas. The compressor will return to a loaded status once the next vehicle is connected. The vehicle will then be filled both from the buffer storage (until the pressure from the storage equalizes with the pressure in the vehicle tank) and through the compressors. These stations are typically designed to accommodate a specific fleet, such as taxis and buses. A total fill cycle takes approximately 4-10 minutes per vehicle.

⇒ MOSTLY PRIVATE USE
⇒ SIZED FOR SPECIFIC FLEETS WITH HIGH FUEL-USE THAT ARE FILLED ON A CONTINUOUS BASIS
⇒ TAXIS OR TRANSPORT BUSES
⇒ 4-10 MINUTE FILL PER VEHICLE

Time-Fill (Slow-Fill)



Time-fill stations, also known as slow-fill stations, are primarily used for private fleets such as refuse trucks and school or transport buses that return to their yard for an extended period of time. However, time-fill is also used on a much smaller scale. It is used for residential refueling appliances. Time-fill method of refueling requires a dryer, compressor and a dispenser. Because time-fill stations do not require storage, priority or sequential refueling components, they have significantly lower equipment and installation costs. The vehicle is filled directly from the compressor, so complicated dispensers are not required. This station is easily modified for a fast-fill configuration. A total fill cycle typically requires 8 or more hours.

⇒ PRIVATE USE
⇒ SIZED FOR SPECIFIC FLEETS THAT ARE CENTRALLY LOCATED FOR EXTENDED PERIOD OF TIME
⇒ REFUSE TRUCKS, SCHOOL OR TRANSPORT BUSES
⇒ 8+ HOURS FILL PER VEHICLE

Combination

A combination station combines two of the three aforementioned configurations. It offers maximum flexibility for fleets that may have requirements for both fast-fill and time-fill applications.

⇒ PRIVATE USE
⇒ SIZED FOR SPECIFIC FLEET
⇒ TWO CONFIGURATIONS

LNG and LCNG Station Components

Unlike CNG fueling stations, where the compression of the natural gas is completed onsite, the liquefaction of natural gas for LNG and LCNG fueling stations is usually performed upstream. However, other technologies do provide for a small scaled LNG production facility to be located onsite. For example, cryogenic nitrogen can be used to liquefy natural gas from a standard utility natural gas line. Onsite LNG production does not seem to be a common configuration for public fueling stations.

LNG is a cryogenic fuel, which means it maintains its liquid state at very low temperatures. When LNG temperatures increase, it regasifies and is usually vented from its storage unit into the atmosphere through a pressure relief valve. The venting of boil-off gas must be managed to minimize the loss of fuel. Some LNG stations may include components that reliquefy, sell, or use the boil-off gas.

There are two types of LNG gas to support two types of technologies. Currently, most vehicles use green LNG for spark-ignited engines. Blue LNG supports the compression ignition engines. Blue LNG is saturated[62] at approximately -220˚F and green at -200˚F. The lower the temperature of LNG, the lower the vapor pressure is and the denser the fuel is. Lower vapor pressures decrease the likelihood of venting, and denser fuel increases the range of travel for a vehicle. Consequently, a fueling system was recently developed that allows spark-ignited engines to use blue LNG. The two types of fuel influence the station components and their configurations.

Bulk Delivery

Similar to conventional fuels, most LNG or LCNG stations receive bulk delivery via tanker truck to an onsite storage tank. The tanker truck offloads the LNG using a hose and couplings. Some stations have an offloading pump, which helps to minimize venting.

Vaporizer

A vaporizer acts as a heat exchanger to perform a process called "conditioning." It uses ambient air temperatures or other sources to heat the fuel. It is designed to ensure the fuel is saturated at the appropriate pressure before being delivered to a vehicle tank. Conditioning can be completed for bulk storage, for separate smaller storage tanks, or when delivering to vehicles (on-the-fly conditioning).

[62] A saturated liquid contains as much thermal energy as it can without boiling. http://en.wikipedia.org/wiki/Boiling_point (retrieved July 23, 2014)

Storage

LNG must be stored in insulated, double-walled pressurized tanks to keep it at its cryogenic state. Storage temperatures must be kept between -260˚F and -117˚F, depending on the pressure, to remain a liquid. The storage vessels can be configured horizontally or vertically, are either above or below ground, and typically have a capacity of 15,000 to 30,000 gallons. Above ground tanks require a below grade containment wall in case of a major spill from the LNG bulk storage tank.

Dispenser

Each of the two fuels types, blue and green, would need their own dispensers. The dispensing hoses are insulated, and the nozzles must be compatible with the receptacles on the vehicle fuel tanks. There are three primary types of nozzles, but research is being conducted to create a standard. LNG dispensers can also include metering and charging capabilities similar to conventional fuel dispensers. The dispensers typically display a diesel gallon equivalent (DGE) unit of measure.

LNG and LCNG Station Configurations

LNG can be used to make compressed natural gas. It is referred to as liquid to compressed natural gas or LCNG. LCNG technology offers flexibility for the location of a CNG fueling station because adequate pipeline access is not required. A station can be built to dispense both LNG and LCNG. The following two sections illustrate the two most common configurations.

LNG

The LNG fueling station receives bulk delivery from a liquefaction plant via tanker truck. The LNG goes through a pump to an ambient air vaporizer and into a storage vessel. The LNG is dispensed from the storage vessel as a liquid into cryogenic tanks aboard a vehicle. The vehicle

is refueled through a dispenser using a hose and nozzle. Handlers should wear gear while handling the cryogenic fuel including face shield, gloves, apron, and boots.

- ⇒ PUBLIC OR PRIVATE USE
- ⇒ SIZED FOR SPECIFIC FLEET
- ⇒ HEAVY-DUTY VEHICLES
- ⇒ 3-10 MINUTE FILL PER VEHICLE

LCNG

From the LNG storage tank, the LNG is pumped into the ambient air vaporizer. The LNG is warmed to approximately 40˚F and becomes a gas again. The technology to odorize LNG does not exist, so it is odorized after it becomes a gas. LCNG can be dispensed through cascade fast-fill, buffer fast-fill or time-fill dispensing systems.

- ⇒ PUBLIC OR PRIVATE USE
- ⇒ LIGHT- TO HEAVY-DUTY VEHICLES
- ⇒ 3-10 MINUTE FILL PER VEHICLE

Appendix D: CNG Fast-Fill Fueling Station Component Costs

The cost to build a CNG or LNG fueling station varies according to the equipment needed for the station's design and the services needed to build it. Primary and secondary research was attempted to retrieve the equipment and building costs of both CNG and LNG fueling stations. However, the attempts for collecting the LNG fueling station costs were inconclusive.

A CNG fast-fill station is relevant to this study because it is suitable for a public facility. In addition, 37 out of the 54 grants issued for natural gas fueling stations are for CNG fueling stations. It is reasonable to expect that the grantees have or will assume costs similar to the examples provided.

Primary Research: Interviews

Interviews were garnered by CCBR staff from grant recipients for information about the grant funding process, their participation in the program, and the natural gas fuels industry.

The estimates for the station equipment came from an interview with a CNG station builder account manager.[63] The account manager said a dryer would cost between $70,000 and $140,000, depending on if it regenerates the desiccant material and if it has dual power. A compressor with a 150 to 300 horsepower engine would cost between $200,000 and $300,000. At that price, the compressor is the expense driver of the equipment, especially since best practice is to have at least two to provide redundancy. A 12,000 cubic foot storage vessel would cost between $35,000 and $40,000, and a typical three-pack storage configuration is approximately $115,000. A dual-hose dispenser would cost approximately $100,000, and stations typically have one to two dispensers. Finally, the account manager said that the hoses cost about $1,000 while nozzles cost between $4,000 and $5,000. All together, the station equipment can be estimated to cost between $685,000 and $1,084,000.

Another cost that the account manager mentioned was for the extension of natural gas pipeline, which would cost approximately $100 per foot. This cost can add up quickly and sway the bottom line significantly if there is a substantial distance from the pipeline to the station site. The account manager also mentioned that in some cases, the pressure from the inlet is too high for the compressor, so there would be additional costs to add a fitting to reduce the pressure.

[63] Interview with Ted Skierski, National Accounts Manager, TruStar Energy, (May 2014)

Construction costs such as these can be estimated between 22[64] and 35[65] percent of the total capital costs. Given the estimated equipment costs, construction and other service costs can be estimated between $193,000 and $584,000, for a total capital cost between $878,000 and $1,668,000. Table A.1 summarizes the discussed CNG fueling station components and their costs.

The table below is a summary of reported costs and other information gained from interviews.

Table 56: CNG Fast-Fill Fueling Station Component Costs; Source: CCBR Grantee Interviews

Component	Estimated Costs, $	Other Information
Extend Natural Gas Line	100 per foot	
Dryer	70,000 – 140,000	
Compressor	200,000 – 300,000	150 to 300 hp engine
Storage	35,000 – 40,000	12,000 cu ft vessel
Dispenser	100,000	Dual hose
Hose	1,000	
Nozzle	4,000 0 5,000	
Construction	193,000 – 584,000	22 to 35 percent
Estimated Total	878,000 – 1,668,000	

Secondary Research: Industry Sources

The primary research findings align with secondary research. The CNG Infrastructure Guide: For the Prospective CNG Developer, prepared by the Drive Natural Gas Initiative, includes a table summarizing CNG fueling station component costs. See table A.2.

[64] Estimate of 22% is based on interview with Dennis Foose, Senior Vice President, Nat G Solutions (June 2014). Mr. Foose estimates a station with a dryer, 2 compressors, 2 heavy-duty single hose dispensers, and 1 light-duty dual hose to cost approximately $1.15 million, $900,000 for equipment and $250,000 for construction expenses.

[65] Estimate of 35% is based on interview with Ryan Erickson, Senior Project Director, Gladstein, Neandross & Associates (June 2014), who is one of the authors of "NGV Roadmap for Pennsylvania Jobs, Energy Security and Clean Air" (2011). The study uses $2.6 million for the cost of an LNG/LCNG station. Mr. Erickson estimated $1 million of the $2.6 million was other-than-equipment costs.

Table 57: CNG Fast-Fill Fueling Station Component cCosts; Source: CCBR Secondary Research

Component	Estimated Costs, $	Other Information
Gas Supply Line	20,000 – 150,000	
Compressor Package	200,000 – 400,000	
Noise Abatement	0 – 40,000	
Gas Dryer	50,000 – 80,000	
Storage	100,000 – 200,000	3 or 6 ASME
Dispenser	60,000 – 120,000	1 or 2 00M-hose
Card Reader Interface	20,000 – 30,000	
Engineering	25,000 – 75,000	3 to 4 percent
Construction	300,000 – 600,000	37 to 33 percent
Contingencies	10 – 150,000	
Estimated Total	805,000 – 1,845,000	

Comparatively, the Idaho National Laboratory estimates mechanical systems for LNG stations to range between $350,000 and $1,000,000 and a conventional fuel station to range between $50,000 and $150,000.[66]

Government Programs

Federal Incentive for Alternative Fuel Infrastructure

The Energy Policy Act (EPAct) of 2005 affords an income tax credit equal to 30 percent of the cost of installing new natural gas refueling equipment. This credit can be of up to $30,000 for business property and $1,000 for home refueling appliances. This grant exists to expand the availability of natural gas refueling stations, increase use of natural gas as a motor vehicle fuel, and reduce demand for petroleum motor fuels. To qualify for this incentive, generally the equipment is required to be new and the first owner of equipment should be the one applying for and claiming this available credit. This tax credit replaces a tax deduction that had been previously allotted by the EPAct since 1992. Other requisites to qualify for this grant include: the fueling equipment must be used to refuel motor vehicles such as primary use vehicles for public streets, roads, and highways, and that the converted or retrofitted equipment will qualify only if it previously was not used to refuel alternative fuel motor vehicles.[67]

[66] Idaho National Laboratory, "Natural Gas Technologies – Research Projects: Low-Cost Refueling Station," https://inlportal.inl.gov/portal/server.pt/community/natural_gas_technologies/437/low-cost_refueling_station/4370 (retrieved July 22, 2014)
[67] "Federal Incentive for Alternative Fuel Infrastructure." Natural Gas Vehicle for America. http://www.ngvc.org/pdfs/Alternative_Fuel_Infrastructure_Tax_Credit.pdf (accessed June 2014)

The Texas Commission on Environmental Quality Grant

The TCEQ is investing up to $4.5 million in grants where individuals, businesses, and governmental entities can apply. This grant will support the development of a network of natural gas vehicle fueling stations toward reaching a self-sustainable market for natural gas vehicles in Texas. This grant also advocates especially for grant receivers that plan to build public natural gas fueling stations right along the interstate highways specifically connecting Houston, San Antonio, Dallas, and Fort Worth. This important grant ensures that natural gas vehicles as they are purchased, commercially financed, or repowered under the Texas Natural Gas Vehicle Grant Program have access to fuel, and become more and more readily available for the new consumers. [68]

Funding Opportunities for Alternative Fuel Vehicles in Texas

Additional grants available include these two projects: Drayage Truck Incentive and the Diesel Emission Reduction Incentive. The Drayage Truck Incentive program is being given out this year from September thru November 2014 for funds up to 80 percent of purchase price of pre-2007 M.Y. trucks. These vehicles must transport loads to or from seaports or rail yards in a non-attainment area in Texas. The Diesel Emission Reduction Incentive program is for $34,261,891 and it is available also from September thru November 2014. For this grant, there is a rebate subprogram open as well, from January thru May of 2015. [69]

U.S. Department of Energy Efficiency & Renewable Energy

The Natural Gas Fuel Rates and Alternative Fuel Promotion grant is available thru the Public Customer Gas program. Here, the Texas General Land Office (GLO) affords competitively priced natural gas available to school districts and other state and local public entities for use in natural gas vehicles. This program has also founded alternate fuel programs to swiftly promote the use of other energy sources, putting an accent on fuels abundant in Texas.

Natural Gas Vehicle (NGV) and Fueling Infrastructure Rebates

The Texas Gas Service Conservation program offers rebates of $2,000 for the purchase of a qualified Natural Gas Vehicle or $3,000 for the conversion of a gasoline powered vehicle to operate on natural gas. Within this program, a rebate of $1,000 is also available for the purchase of a natural gas forklift. In addition, qualified residential and commercial NGV fueling infrastructure may be eligible for a rebate of $2,000. These incentives are offered to commercial and residential customers within the city limits of Austin, amongst other cities, but not directly in San Antonio.

Utility/Private Incentives

The Electric Vehicle Supply Equipment (EVSE) Incentive in Austin Energy is granting plug-in electric vehicle owners in the Austin Energy service area the eligibility to receive a rebate of 50

[68] "Grant Programs." University of Houston: Greater Houston Natural Gas Vehicle Alliance. http://etuo.uh.edu/ngva/?page_id=239 (accessed July 2014).
[69] "Upcoming Funding Opportunities for Alt. Fuel Vehicles in Texas." Lone Star Clean Fuels Alliance |. http://www.lonestarcfa.org/content/upcoming-funding-opportunities-alt-fuel-vehicles-texas (accessed July 2014).

percent of the cost to purchase and install a qualified level 2 EVSE. The maximum an individual can receive from this grant is $1,000. [70]

All of these incentivized funding opportunities are available to various users and consumers in search of new and innovative ideas for conversion opportunities in Texas. These are available in various levels to various clients and are approaching a higher level of publicity amongst the educated community willing to learn and take advantage of these various programs and grant options.

Figure 10: LNG Fueling: 3 hoses- fuel, pressure relief, and electrical ground; Source: CCBR

[70] "Alternative Fuels Data Center." Alternative Fuels Data Center. http://www.afdc.energy.gov/laws/all?state=TX (accessed July 30, 2014)

Appendix E: Costs of Vehicle Conversions

Natural Gas Vehicles

According to the Texas Comptroller of Public Accounts and the Texas Railroad Commission, with 7,000 in operation, natural gas vehicles (NGVs) are the most popular alternative fuel vehicles in the state.[71] This is also reflected with the sale CNG (compressed natural gas) and LNG (liquefied natural gas) which has sold over 11.4 million gallon equivalences within the first nine months of fiscal 2014, surpassing previous estimations by 72%.[72] According to the Comptroller, these sales represent $1.70 million in natural gas motor-fuel tax collections thus far in fiscal 2014.

Natural gas is considered the cleanest burning alternative fuel, producing 30% less greenhouse gases than gasoline or diesel.[73] This resource is also found in abundance in the United States, ranking first in natural gas production in 2012.[74] In addition to traditional and hydraulic means of extraction, natural gas can be produced as a renewable resource using bio-methane or biogas from sewage and animal and crop waste.[75]

Figure 1 illustrates the financial incentive provided by natural gas. According to an April 2014 report by U.S. Department of Energy, CNG fuel prices cost $1.50, or 41%, less than traditional gasoline and 50% and 35% less than diesel and E85 alternatives, respectively (Figure 1).[76] Additionally, unlike gasoline and diesel whose prices have fluctuated greatly and in particularly during the Great Recession, natural gas prices have remained stable (Figure 2).[77] These economic characteristics in savings and price stability provides CNG an advantage in alternative fuels market, in addition to its benefits in reducing carbon emissions.[78]

[71] Heather Ball, Texas Railroad Commission, July 31, 2014.
[72] Doug Freer, Comptroller of Public Accounts, July 31, 2014.
[73] About Natural Gas. (n.d.). Clean Energy Fuels. Retrieved June 18, 2014, from http://www.cleanenergyfuels.com/about-clean-energy-natural-gas-fueling/aboutng.html
[74] International Energy Statistics. United States Energy Information Administration. Retrieved July 24, from http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=3&pid=3&aid=1
[75] Clean Energy Fuels. (n.d.). *Clean Energy Fuels*. Retrieved June 18, 2014, from http://www.cleanenergyfuels.com/
[76] Clean Cities Alternative Fuel Price Report. January 2014. Retrieved from http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2014.pdf
[77] Economics of Natural Gas. (n.d.).*Westport » Natural Gas for Transportation »*. Retrieved June 18, 2014, from http://www.westport.com/is/natural-gas/economics
[78] Daimler introduces new Freightliner natural gas truck. (n.d.). *AutoblogGreen*. Retrieved June 18, 2014, from http://green.autoblog.com/2009/07/21/daimler-introduces-new-freightliner-natural-gas-truck/

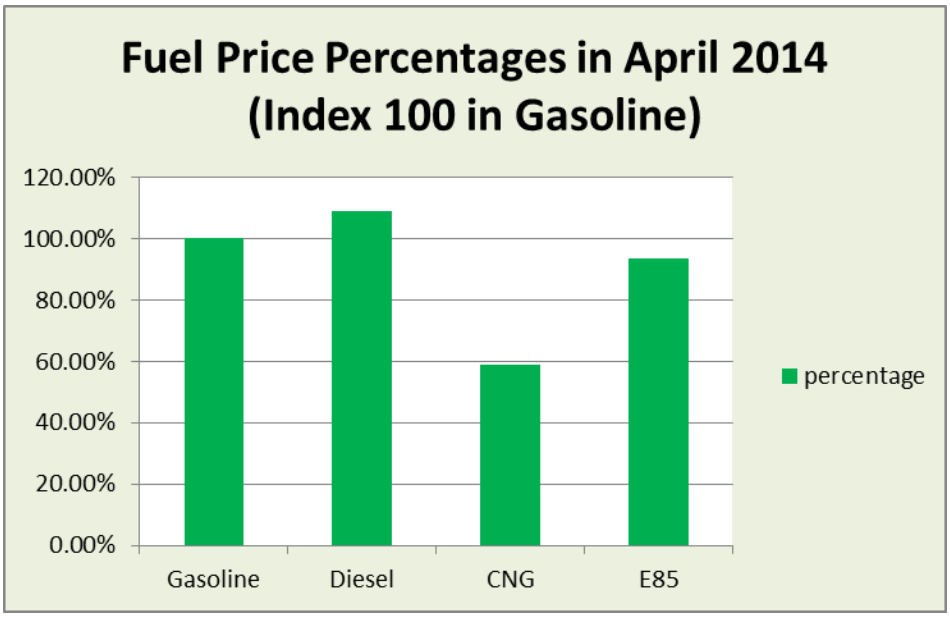


Figure 11: Alternative Fuel Average Prices in the United States, April 2014 ; Source: AFDC[79]

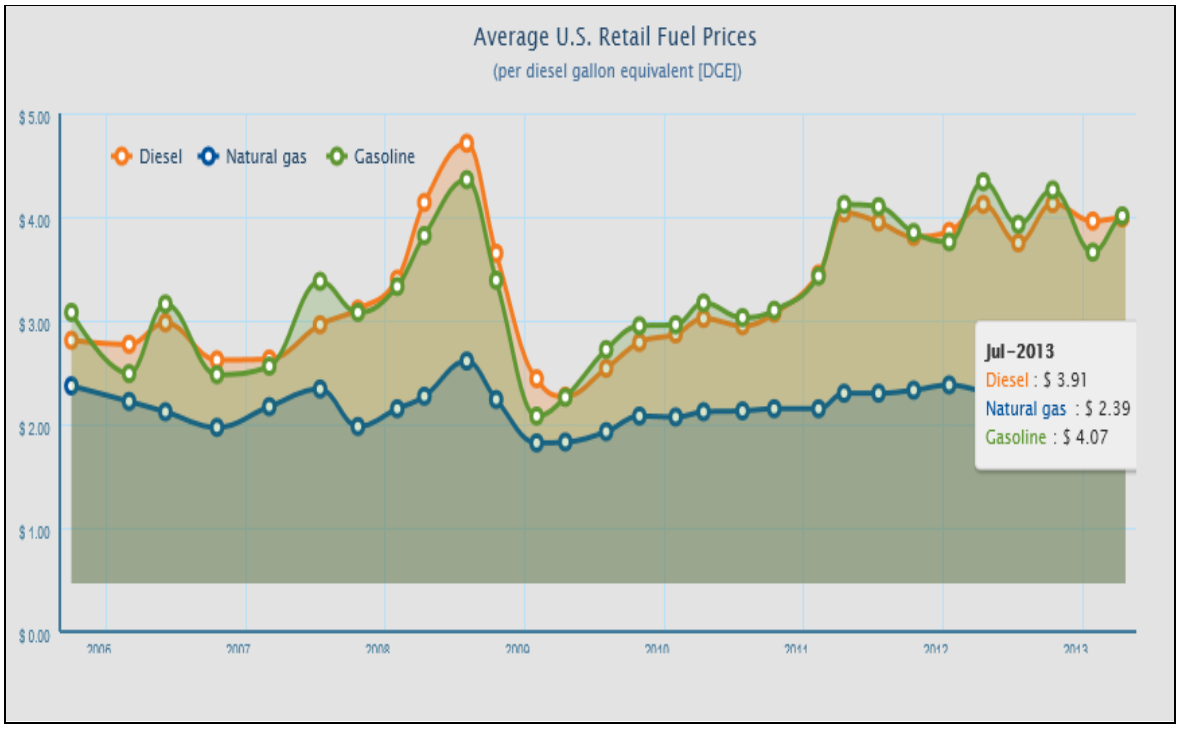


Figure 12: Average U.S. Retail Fuel Prices ; Source: Westport.com[80]

[79]Clean Cities Alternative Fuel Price Report. January 2014. Retrieved from http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_april_2014.pdf

[80] Economics of Natural Gas. (n.d.).*Westport » Natural Gas for Transportation »*. Retrieved June 18, 2014, from http://www.westport.com/is/natural-gas/economics

Natural Gas Vehicle Engines

Natural gas engines have similar construction to their diesel counterparts but differ in the combustion mechanism, air-fuel ratio, and compression ratio. These designs enable natural gas engines to perform comparable to diesel but with lower emissions.[81] Table 1 compares the performance and the schematics of the ISX 15 diesel engine with two natural gas engines, the ISL G and the C Gas Plus; all produced by Cummins, Inc. By comparison, the natural gas engines are both lighter with a faster governed speed, but provide less torque.

Table 58: Comparison of Natural Gas Vehicle Engines (ISL G and C GAS Plus) and ISX 15 Diesel Engine ; Source: AFDC[82]

	ISL G	C GAS Plus	ISX 15
Fuel Type	CNG/LNG/RNG	CNG/LNG	Diesel
Weight (Dry)	1,625 lbs.	1,330 lbs.	2,964 lbs.
Governed Speed	2,200 rpm	2400 rpm	1800-2000 rpm
Torque	550 lb-ft	410 lb-ft	1450 - 2050 lb-ft
Oil and Filter change	15,000mi	500 hours (6 months)	20,000mi

Types of Natural Gas-Auto Fuels

Because the fuel exists in a gaseous state under atmospheric conditions, it requires more space to store natural gas than any other fuel. As a result, there are two types of options available in the market for motor fuel consumption: Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG).

CNG

Compressed Natural Gas (CNG) is one of the options available for our Natural Gas Vehicles (NGV). Owners of NGV have preference for CNG because the fuel can be stored in cylinders at a pressure of 3,000 to 3,600 pounds per square inch.[83] This requires less storage space than their LNG counterpart. This natural gas option also has the versatility to be used with any type of vehicle, either light, medium or heavy duty vehicles. CNG is often, however, recommended for drivers that operate within a limited area and have high-fuel consumption needs.

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[81] NGVA. (n.d.). *NGVA*. Retrieved June 18, 2014, from http://ngvc.org/about_ngv/for_consumers.

[82] C Gas Plus. (n.d.). *Cummins Westport*. Retrieved June 18, 2014, from http://cumminswestport.com/models/c-gas-plus

[83] Natural Gas Fuel Basics. (n.d.).*Alternative Fuels Data Center:*. Retrieved June 18, 2014, from http://afdc.energy.gov/fuels/natural_gas_basics.html

LNG

Liquefied Natural Gas (LNG) is produced by purifying natural gas and super-cooling into a liquid form at -260° F.[84] To maintain these low temperatures, LNG has to be stored in double-walled, vacuum-insulated pressure vessels, requiring more storage requirements. Unlike CNG, LNG is recommended for drivers who travel long routes on a daily basis and are considered the best option for fleet owners.

Conversion of Engines into Natural Gas Engines

Through different grants, interested investors have the option to either purchase a new vehicle or convert the engines of conventional-fuel models. Conversion costs for natural gas vehicles range between $12,000 to $18,000; which covers the replacement and installation of fuel tanks, tubes and brackets, and retrofitting.[85] Conversion pricing vary brand, model year, tank size, and GGE capacity. One of the participating dealerships for Texas Natural Gas Vehicle Grant Program in 2012 reported that the CNG conversion cost approximately $15,000.

After the initial investment, the purchase of a new or a conversion to natural gas vehicles is more cost efficient than traditional gasoline and diesel systems by reducing overall transportation and operational costs through the lifetime of the vehicle. For example, CNG systems have longer operational lifetimes than conventional fuel systems and retain 50% of its residual value at resale.[86] Additionally, as the cost of gasoline continue to rise, natural gas prices have been reported as remaining constant, representing savings of up to $2 dollars for the vehicle owners.[87]

LNG and CNG Truck Simple Payback

Table 1 illustrates the payback of a natural gas vehicle, the timeframe required to recover the incremental or initial cost of investment. The total cost of a natural gas truck is $140,000. In comparison to the $106,400 for a diesel truck, this results in an incremental cost of $33,600 for an LNG truck. However, in comparison to diesel trucks, there is a savings of $0.15 per mile in operational costs for natural gas vehicles. As a result, natural gas vehicles under heavy usage (>150,000 miles per year) have a payback period of 18 months (1.5 years), and NGV with an operational usage of 100,000 annual miles possess a payback period of 28 months (2.3 years). Under these scenarios, an investor in a fleet of 20 CNG trucks would expect to recover their incremental cost in 36 months (Table 1).

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[84] Natural Gas Fuel Basics. (n.d.).*Alternative Fuels Data Center:*. Retrieved June 18, 2014, from http://afdc.energy.gov/fuels/natural_gas_basics.html

[85] CNG Frequently Asked Questions - OEM Systems. (n.d.). *CNG Frequently Asked Questions - OEM Systems*. Retrieved June 18, 2014, from http://www.oemsystems.net/faqs

[86] Economics of Natural Gas. (n.d.).*Westport » Natural Gas for Transportation »*. Retrieved June 18, 2014, from http://www.westport.com/is/natural-gas/economics

[87] CNG Frequently Asked Questions - OEM Systems. (n.d.). *CNG Frequently Asked Questions - OEM Systems*. Retrieved June 18, 2014, from http://www.oemsystems.net/faqs

Table 59: Vehicle Cost Tables; Source: Clean Energy Fuels. (n.d.). Clean Energy Fuels. Retrieved June 26, 2014, from http://www.cleanenergyfuels.com/

Diesel Truck Cost	$ 85,000	**LNG Truck Cost**	$ 125,000
Diesel 2010 Emissions System	$ 10,000		
FET @ 12%	$ 11,400	FET @ 12%	$ 15,000
Total Diesel Truck Cost	$ 106,400	Total Natural Gas Truck Cost	$ 140,000
Incremental Cost			**$ 33,600**

Diesel Truck Operating Costs		**NG Truck Operating Cost**	
Fule Economy (MPG)	6.5	Fuel Economy (MPG)	5.8
Diesel Fuel Cost ($/Gallon)	$ 3.75	NG Fuel Cost ($/Gallon)	$ 2.50
Fuel Cost per mile	$ 0.58	Fuel Cost per Mile	$ 0.43
NG Truck Savings per Mile			$ 0.15

Annual Mileage	150000	125000	100000
Annual Fuel(DGE)	25862	21552	17241
Annual Savings	$ 21,883	$ 18,236	$ 14,589
Simple Payback (Years)	1.5	1.8	2.3
Simple Payback (Months)	**18**	**22**	**28**

Table 60: Example Business Case Analysis- Four Scenarios; Source: Case study – Compressed Natural Gas Refuse Fleets. U.S. Department of Energy Energy Efficiency & Renewable Energy

CNG Fleet Size	20
CNG Price ($/DGE)	$ 2.22
Diesel Price ($/gal)	$ 4.01
Total vehicle incremental cost	$ 760,000.00
Incremental Cost (each)	**$ 38,000.00**
Simple Payback (Months)	**36**

Incremental Cost	$57,218[88]	
	Diesel Truck	Natural Gas Truck
Fuel Economy (MPG)	6.5	5.8
Fuel Cost ($/Gallon)	$3.83	$2.50
Fuel Cost per mile	$0.58	$0.43
Natural Gas Truck Savings per Mile	$.15	

Annual Mileage	150,000	125,000	100,000
Annual Fuel (DGE)	25,862	21,552	17,241
Annual Savings	$39,764	$33,137	$26,509
Simple Payback (Years)	1.4	1.7	2.2
Simple Payback (Months)	17	21	26

Table 61 - Incremental Truck cost based on grantee information

[88] Incremental Cost based on grant average. Other studies have a less conservative estimate for such cost. See "Natural Gas Basics Webinar" *Wisconsin Clean cities*. Retrieved June 26, 2014. http://www.slideshare.net/WiCleanCities/natural-gas-basics-webinar.

Appendix F: Freight Flows and Vehicle Usage

Alternative fuel vehicles (AFVs) are taking an increased share of the vehicle market in the United States. Figure 7 shows the types of vehicles used in the ten states with the most AFV usage. California and Texas, among these states, exceed the number of AFVs in use over the next eight states by over 100,000 vehicles.[89] The most widely used AFVs in these ten states use Ethanol, 85 percent (E85), accounting for 63.6 percent of all AFVs in use. The second and third most used vehicles use liquefied petroleum gas at 13.8 percent and compressed natural gas at 13.4 percent of the total share of AFV use in these ten states. Only 8.7 percent of vehicles run on electricity. Looking to the future, rising petroleum prices will likely increase the popularity of AFV use in the United States making alternative fuel vehicles an important source of transportation fuel and economic savings in the future.

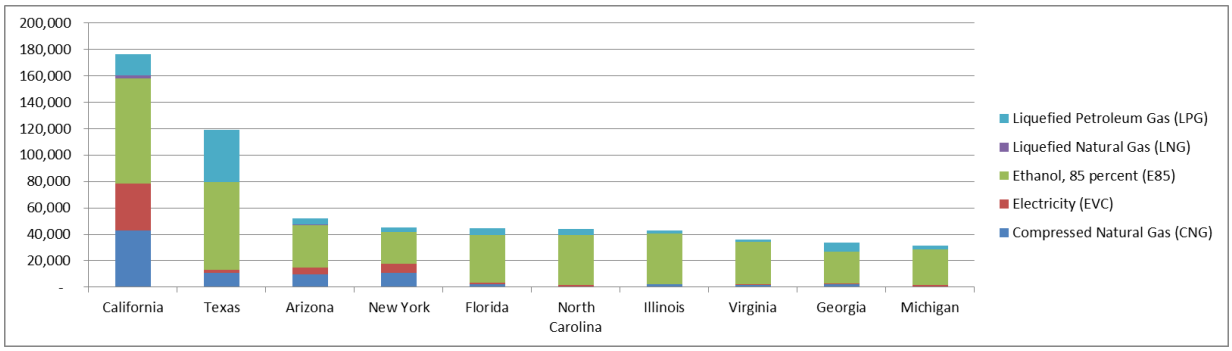


Figure 13: Alternative Fuel Vehicles in Use by State Rank, 2011, Source: EIA

The use of natural gas as an alternative fuel source has grown at a slower rate nationally than the use of all AFVs despite increased production of natural gas, lower prices, and lower environmental impacts. There was an average of 7.2 percent more alternative fuel vehicles on the road per year between 2003 and 2011. Natural gas vehicle use over the same period grew at a slower rate of 5.0 percent. Interest in natural gas as an alternative fuel source continues to grow as increases in tight oil production serve to keep prices below gasoline for many years in the future.[90] There are currently 83,971 compressed natural gas (CNG) and 2,976 liquefied natural gas (LNG) vehicles operating in the United States as of 2011. A gasoline gallon equivalent (GGE) of natural gas in comparison to a gallon of regular gasoline is $1.25 less as of January, 2014.[91] Using natural gas as a fuel source may also have a positive effect on the environment as the burning of natural gas releases an average of 28.7 percent less CO_2 than petroleum products.[92]

[89] For more information on California natural gas use in vehicles read "Alternative and Renewable Fuel in California" in Appendix.

[90] See Eagleford Shale report

[91] "Clean Cities Alternative Fuel Price Report" *U.S. Department of Energy* January, 2014 http://www.afdc.energy.gov/uploads/publication/alternative_fuel_price_report_january_2014.pdf

[92] "Natural Gas and the Environment" *EIA* 1998: http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/natural_gas_1998_issues_trends/pdf/chapter2.pdf

Table 62: Alternative Fuel Vehicles by State; Source: DoE

Alternative Fuel Vehicles in Use by State Rank Detail						
2011	**Compressed Natural Gas (CNG)**	**Electricity (EVC)**	**Ethanol, 85 percent (E85)**	**Liquefied Natural Gas (LNG)**	**Liquefied Petroleum Gas (LPG)**	**Grand Total**
California	43,044	35,458	79,392	2,203	16,134	176,231
Texas	10,845	2,071	66,475	340	39,182	118,913
Arizona	9,796	4,896	32,372	428	4,831	52,323
New York	10,607	6,852	24,384	-	3,260	45,103
Florida	2,518	770	36,032	-	5,211	44,531
North Carolina	648	1,292	37,322	-	4,651	43,913
Illinois	2,143	260	38,439	5	2,018	42,865
Virginia	1,695	790	32,057	-	1,632	36,174
Georgia	2,071	665	24,183	-	6,590	33,509
Michigan	604	1,161	26,803	-	2,980	31,548

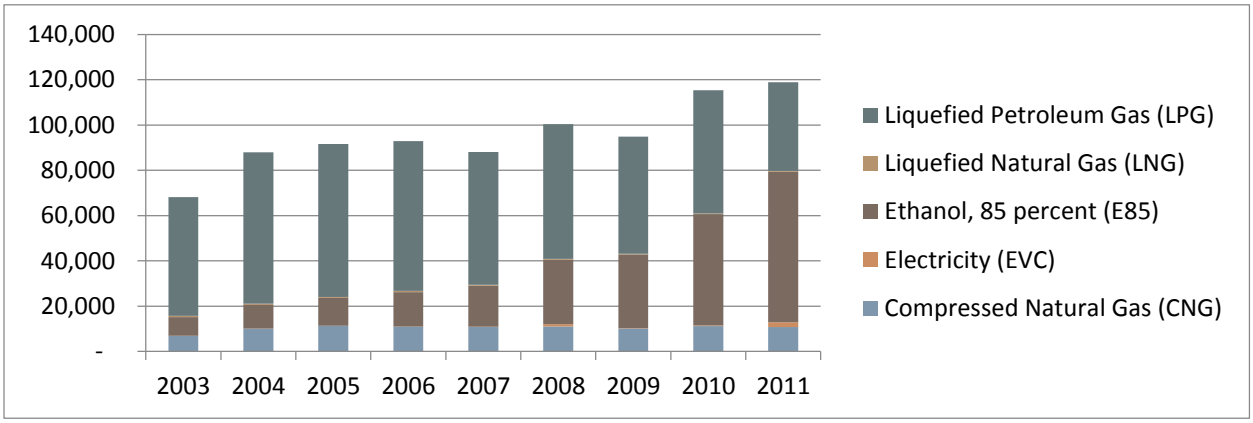


Figure 14: Alternative Fuel Vehicle Use, Texas; Source: DoE

Popularity of alternative fuel vehicles is very high in the state of Texas, ranking only behind California in total vehicles. California (43,044), Texas (10,845), and New York (10,607) have the highest amounts of licensed CNG vehicles according to the U.S Energy Information Administration. These three states also have the highest rate of CNG fuel stations per vehicle with 6.3, 7.5, and 10.3 stations per thousand vehicles.

Table 63: Alternative Fuel Vehicle Use, Texas; Source: DoE

Alternative Fuel Vehicles in Use Texas Detail									
	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Compressed Natural Gas (CNG)	6,927	10,160	11,376	11,026	10,827	11,032	10,125	11,275	10,845
Electricity (EVC)	40	28	-	108	173	1,096	35	289	2,071
Ethanol, 85 percent (E85)	8,194	10,325	12,257	15,042	18,009	28,405	32,755	49,158	66,475
Liquefied Natural Gas (LNG)	604	558	501	550	411	422	315	319	340
Liquefied Petroleum Gas (LPG)	52,369	66,955	67,456	66,242	58,715	59,438	51,699	54,333	39,182
Total	68,134	88,026	91,590	92,968	88,135	100,393	94,929	115,374	118,913

The state of Texas is a major corridor for freight flows with a total of 10.2 million trucks operating in the state according to the Federal Highway Administration's 2010 data. The 2007 Commodity Flow Survey reported that 57.2 percent of the freight flow in Texas is delivered by trucks for a total of 109,052.4 ton-miles travelled per year (See Figure 1). These freight flows are projected to increase significantly over the next 30 years. Under the assumption that the average truck consumes between 1,814 and 4,180 gallons of fuel per year depending on its size, and the average savings of natural gas is $1.25 per GGE, the potential net cost savings in Texas alone could range between $23.1 billion and $53.3 billion dollars.[93]

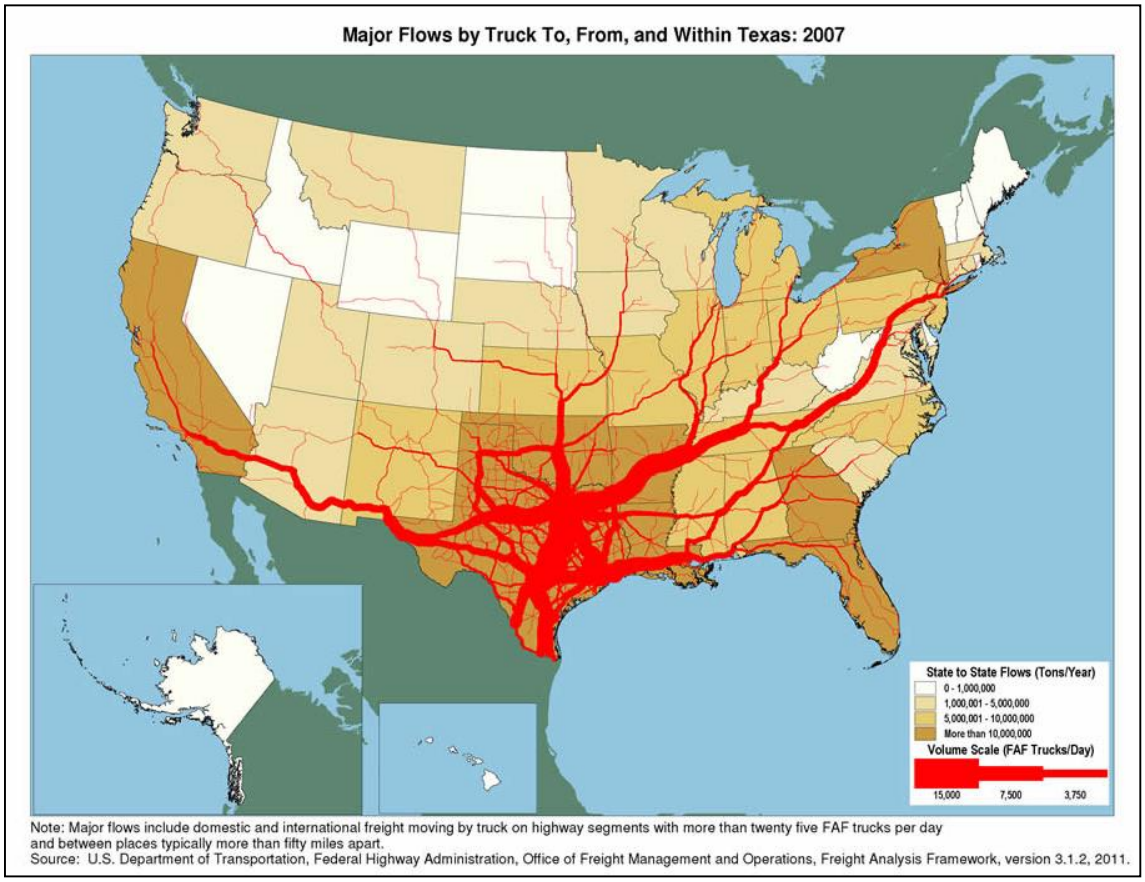
The benefits of natural gas vehicles reflect the direct and induced benefits of building natural gas vehicle and fueling infrastructure and the induced benefits of cost savings based on the price spread of natural gas and gasoline. Direct economic effects related to the construction costs of new fueling stations and the conversion of vehicles would also become a source of jobs in the state. The multiplier effect of cost savings could also be expected to have a positive effect on job creation and the state's economy.

With these economic effects in mind, there exists many federal and state government incentives and tools to increase and promote the long term use of CNG and LNG vehicles. The federal government's $.50 excise tax was a significant in promoting the alternative fuel. Other statewide incentive programs can help create CNG and LNG infrastructure. The Clean Texas Transportation Triangle initiative is a good example of a statewide incentive, providing more than $150 million in grants for compressed natural gas infrastructure with the goal of alternative fuel mobility between the Dallas Fort-Worth, Houston, and San Antonio metropolitan areas. Another example of statewide efforts in promoting CNG and LNG infrastructure is California's Liquefied Natural Gas Interagency Permitting Working Group which helps to address issues related to zoning, permitting, and coordination of state agencies in the permitting process of LNG facilities. Efforts to increase commercial use of natural gas as a

[93] "Highway Statistics 2011" FHA: Office of Highway Policy Information Mar. 1, 2013, http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm1.cfm.

vehicle fuel source should continue and remain a top priority, the construction of new fuel stations solve the problems connected to fuel supply and future demand.

Figure 15 Truck Freight Flows Texas, 2007



Map 9: Truck Freight Flows Texas, 2007; Source: Federal Highway Administration; 2007 is the most current year, with an update due in 2015

The benefits of natural gas vehicles reflect the direct and induced impacts of building natural gas vehicle and fueling infrastructure and the cost savings based on the price spread of natural gas and gasoline. The state of Texas is a major corridor for freight flows that is projected to grow by a large amount over the next 30 years. The 2007 Commodity Flow Survey reports that 57.2 percent of the freight flow in Texas is delivered by trucks for a total of 109,052.4 ton-miles travelled per year (See Figure 1). [94] [95] According to the Federal Highway Administration, a total of 10.2 million trucks were in operation in Texas as of 2010. Under the assumption that the average truck consumes between 1,814 and 4,180 gallons of fuel per year depending on its size, and the average savings of natural gas is $1.25 per gasoline gallon equivalent, the possible net cost savings in Texas alone could range between $23.1 billion and $53.3 billion dollars. [96] Direct economic effects related to the construction costs of new fueling stations and the conversion of

[94] "2007 Commodity Flow Survey State Summary: Texas" *U.S. DOT Bureau of Transportation Statistics* Mar. 1, 2010, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/commodity_flow_survey/2007/state_summaries/html/texas.html
[95] "Texas- Freight Management and Operations" *Federal Highway Administration*
[96] "Highway Statistics 2011" *FHA: Office of Highway Policy Information* Mar. 1, 2013, http://www.fhwa.dot.gov/policyinformation/statistics/2011/vm1.cfm

vehicles would also become a source of jobs in the state. The multiplier effect of cost savings could also be expected to have a positive effect on job creation and the state's economy. With these economic effects in mind, the state has many tools to increase CNG and LNG vehicle use over the long term. Another example of statewide efforts in promoting CNG and LNG infrastructure is California's Liquefied Natural Gas Interagency Permitting Working Group which helps to address issues related to zoning, permitting, and coordination of state agencies in the permitting process of LNG facilities. Efforts to increase commercial use of natural gas as a vehicle fuel source should continue and remain a top priority, the construction of new fuel stations solve the problems connected to fuel supply and future demand.

The federal government's $.50 excise tax was a significant to promoting the alternative fuel. Other statewide incentive programs can help to create CNG and LNG infrastructure. The Clean Texas Transportation Triangle initiative is a good first step, providing more than $150 million in grants for compressed natural gas infrastructure with the goal of alternative fuel mobility between the Dallas Fort-Worth, Houston, and San Antonio metropolitan areas.

Another example of statewide efforts in promoting CNG and LNG infrastructure is California's Liquefied Natural Gas Interagency Permitting Working Group which helps to address issues related to zoning, permitting, and coordination of state agencies in the permitting process of LNG facilities. Efforts to increase commercial use of natural gas as a vehicle fuel source should remain the largest priority, as the construction of new fuel stations solve the problems connected to fuel supply and future demand.

Figure 16: Natural Gas powered heavy-duty truck; Source: CCBR

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