FINAL REPORT

MAY 5, 2011

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OVERVIEW

Mission Statement

Our mission is to provide our partners with innovative solutions that fit their needs both practically and economically by creating a product that will advance the use of natural gas as an alternative fuel.

PROBLEM STATEMENT

The team needs to create a high-end, commercial natural gas conversion kit for use on large golf course greens mowers. The conversion kit must be economically viable for golf courses to convert their mowing fleets to CNG.

The product created must be effective enough to encourage golf courses to invest in the CNG refueling skid or Phil systems necessary to make a CNG riding mower a reasonable alternative. The product must also be cheaper (or produce more profit) in the long run than traditional gasoline powered mowers. It should also take advantage of CNG's marketability as a clean fuel produced domestically.

OBJECTIVES

The team needs to create a high-end, commercial riding lawn mower conversion kit that will allow the mower to run on compressed natural gas. To develop the kit, a natural gas pressure regulator will need to be developed to lower the fuel pressure within the engine to a functional level. The team will conduct research to determine the economic viability and safety repercussions of both removable and permanent-mounted CNG fuel tanks. The kit will also include high-pressure fuel lines made from 316 stainless steel and an intake manifold adapter to facilitate safe fuel flow into the mower engine. The kit must make it economically viable for golf course turf managers and landscaping businesses that service businesses, municipalities and other large clients to convert to and operate their equipment to run on compressed natural gas.

BACKGROUND

Tulsa Gas Technologies is a compressed natural gas service company that has become the largest manufacturer of CNG dispensers in North America. TGT has been a leader in CNG technology for over 18 years.

For 18 years, Tulsa Gas Technologies has become a leader in the compressed natural gas service industry. They are the largest manufacturer of CNG dispensers in North America. Owner Tom Sewell is a pioneer in the CNG industry. He is an opinion leader and innovator in the natural gas fueling service industry. TGT is an aggressive and open-minded company researching new types of equipment and their uses and blending new technologies in existing equipment, according to the company's website[1].

A niche market for CNG equipment arose when California passed a law mandating cleaner emissions engines. This law, which heavily impacts golf courses and landscaping businesses, is projected to be copied across the country in locations such as New York, Florida, and Chicago. TGT would be able to successfully market a CNG powered riding mowers to large landscaping operations that have to operate within the new environmental restrictions.

SCOPE OF WORK

Blue Innovations will turn in a final report on April 28, 2011 that contains:

a) Problem statement, statement of work, work breakdown structure and task lists
b) Revised competitive analysis that includes market research, patent searches, and any research conducted during the project
c) Customer requirements
d) Development of engineering specifications
e) Media and communications plan
f) Business plan and financial analysis
g) Design concepts
h) Project schedule and budget

Blue Innovations will present a final presentation on Thursday, April 28, 201l to peers, professors, and clients that will include all the material presented in the final report. A website has been developed to showcase the Blue Innovations team and the work completed on this project.

LOCATION OF WORK

The Blue Innovations team will conduct research and develop reports on the campus of Oklahoma State University utilizing the Biosystems and Agricultural Engineering laboratories and computer system. The team will also conduct research at the Helmerich Advanced

Technology Research Center and work in conjunction with TGT research and development facilities in Tulsa, Okla. to develop final design plans and create a prototype of a CNG conversion kit.

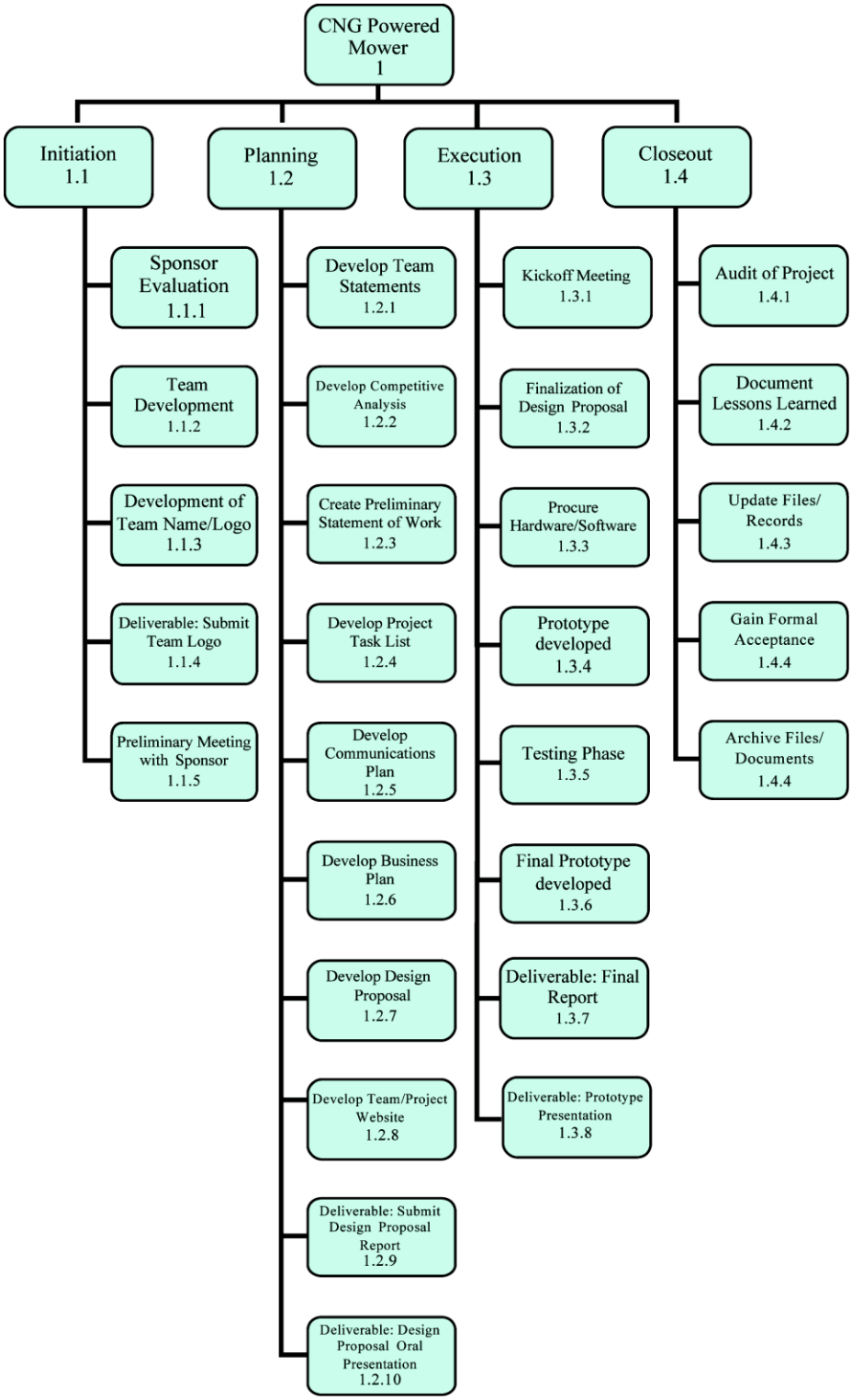
Period of Performance

Between August 2010 and May 2011 Blue Innovations will work towards the completion of the project.

Delivery Requirements

Weekly activity plans will be provided every Monday to professors and team members. Weekly summaries will be compiled every Friday. They will include a summary of the week's accomplishments and any weekend projects. Blue Innovations team will meet weekly on Tuesday nights at 5:30 p.m. to accomplish weekly goals.

WORK BREAKDOWN STRUCTURE



Level	WBS Code	Element Name	Definition
1	1	CNG Powered Riding Mower	All work to develop a Compressed Natural Gas Powered Riding Lawn Mower.
2	**1.1**	**Initiation**	**The work to initiate the project.**
3	1.1.1	Sponsor Evaluation	Instructors evaluate potential projects and sponsors for class.
3	1.1.2	Team Development	Instructors develop five member team to design innovative product for Tulsa Gas Technologies, Inc. Team determines team leader.
3	1.1.3	Development of Team Name/Logo	Team members develop team name and design team logo.
3	1.1.4	Deliverable: Submit Team Logo	Approved team logo is delivered to instructors.
3	1.1.5	Preliminary Meeting with Sponsor	The team members meet with representatives of TGT to determine the product that will be developed then move to the Planning Process.
2	**1.2**	**Planning**	**The work for the planning process for the project.**
3	1.2.1	Develop Team Statements	Team develops a problem and mission statement for project.
3	1.2.2	Develop Competitive Analysis	Team conducts market research and develops a competitive analysis of TGT that includes patent searches that are relevant to CNG powered mowers.
3	1.2.3	Create Preliminary Statement of Work	Team develops a concise definition of project and defines what team plans to deliver to sponsor.

3	1.2.4	Develop Project Task List	Under the direction of the team leader the team develops a task list for deliverables.
3	1.2.5	Develop Communications Plan	Communication team members develop a marketing campaign for CNG powered riding mower
3	1.2.6	Develop Business Plan	Business team member develops a financial analysis/business plan for the project
3	1.2.7	Develop Design Proposal	Engineers develop possible designs for a natural gas powered riding mower to present to sponsor.
3	1.2.8	Develop Team/Project Website	Develop a simple website that showcases team members and project. It will also contain all final reports and presentations developed by the team.
3	1.2.9	Deliverable: Submit Design Proposal Report	Team will compile Competitive Analysis, SOW, and task list and develop a design concept to present to sponsor.
3	1.2.10	Deliverable: Design Proposal Oral Presentation	The team will present an oral presentation to sponsor, instructors, and classmates at the end of Fall semester that shows the development process of the CNG mower.
2	**1.3**	**Execution**	**Work involved to execute the project.**
3	1.3.1	Kickoff Meeting	Team conducts a formal kick off meeting with the project sponsor TGT to gain approval to move ahead with development.
3	1.3.2	Finalization of Design Proposal	Team works with sponsor to make final adjustments to proposed mower design.

3	1.3.3	Procure Hardware/Software	The gathering of all hardware, software and facility needs for the project.
3	1.3.4	Prototype developed	Team develops prototype of CNG powered mower for testing.
3	1.3.5	Testing Phase	The mower is evaluated with a select set of users.
3	1.3.6	Final Prototype developed	Final improvements are added to mower.
3	1.3.7	Deliverable: Final Report	Revised Fall report with added design information along with communication and business plan for project.
3	1.3.8	Deliverable: Prototype presentation	Final design is presented to sponsor along with its financial analysis and marketing campaign.
2	**1.4**	**Closeout**	**The work to close-out the project.**
3	1.4.1	Audit of Project	Team conducts self, peer and class evaluations. An audit of all hardware used for the project is conducted to ensure that all purchased products are accounted for and a review of the project budget is conducted to determine how well it was followed.
3	1.4.2	Document Lessons Learned	Team performs a lessons learned meeting and documents the lessons learned for the project.
3	1.4.3	Update Files/Records	Files and records are updated to reflect the completion of project.
3	1.4.4	Archive Files/Documents	All project related files and documents are collected and archived.

TASK LIST

- Market Research
  - Phone survey of landscaping businesses
  - Develop list of similar alternative fueled landscape equipment
- Communication Campaign
  - Develop Website
    - Select color scheme
    - Develop basic page dimensions/Layout
    - Develop file tree
    - Go live
    - Upload content
  - Image Development
    - Create:
      - Logo
      - Letterhead
      - Brochure
      - Team Polos
- Research DOT and EPA safety regulations
  - Develop list of regulations/requirements mower must meet
- Test an available generator conversion kit
- Decide mower design to develop based on:
  - Lawnmower deck size
  - Price
  - Horsepower
  - Safety requirements
  - Permanent or removable fuel tank
  - Refueling coupler placement
  - Efficiency calculations
  - "Idiot" proofing
- Fall Report
  - Revise statement of work
  - Compile and expand market research into market analysis
  - Write sections individually
  - Revise
  - Cite sources in an appendix
- Fall Presentation
  - Create PowerPoint presentation
  - Develop basic script for the presentation
  - Individual and group practice
  - Present to client

- Spring Engineering tasks
    - Determine which design to build a prototype of
    - Select components to use for mower prototype construction
    - Order and make components for mower construction
    - Construct prototype
    - Test prototype
    - Make revisions, improvements, and fix malfunctioning parts of prototype
    - Retest Prototype
    - Finalize prototype
- Spring Final Report
    - Revise, Revise, Revise fall report
    - Expand testing section with results from spring semester testing
        - Include graphs, tables, and illustrations of development process
    - Cite any additional sources use in appendix
- Spring Final Presentation
    - Expand fall PowerPoint to include work completed during spring semester
    - Include solid works designs
    - Develop updated script for presentation
    - Individual and group practice

COMPETITIVE ANALYSIS, RESEARCH AND INVESTIGATIONS

BACKGROUND

Blue Energy Fuels is a new company formed by a partnership between Tulsa Gas Technologies and Wilco Machine and Fabrication. Although Blue Energy Fuels is less than one year old, TGT and Wilco Machine and Fabrication have a combined 65 years of experience in the natural gas industry. TGT converts automobiles to run on compressed natural gas. The owner of TGT, Tom Sewell, also was involved in creating the CNG-powered Dixie Chopper riding lawnmower. Wilco Machine and Fabrication produces and tests CNG storage vessels.

Blue Energy Fuels builds and runs CNG refueling stations. The company offers a full service maintenance package with every station it builds. The company has also developed a credit card system that allows fleet owners to control and monitor access to their private refueling stations.

PROBLEM

Blue Energy Fuels and Tulsa Gas Technologies have expressed interest in furthering their involvement in the natural gas industry. The clean air laws passed in California that are expected to eventually become standard nation-wide have created a niche market for low emissions, compressed natural gas mowers.

The company needs a converter kit to allow a high-end golf course greens mower (or other commercial riding mower) to run on compressed natural gas. The conversion kit and CNG tank needs to exceed all safety standards while maintaining a reasonable overhead cost for the customer.

Blue Innovations will create a conversion kit that will allow a high-end commercial riding mower to run on compressed natural gas and allow Blue Energy Fuels to fill an expanding niche market and capitalize on the business value of being "green."

SWOT ANALYSIS

STRENGTHS

A compressed natural gas mower would be cheaper to fuel and maintain than a traditional gas powered mower. In natural gas equipment you do not have to change the oil half as much as the gasoline powered equipment. Compressed natural gas equipment has a low air pollution foot print on the environment. This low footprint allows it to comply with California clean air admissions.

WEAKNESSES

This mower with the present price of a bottle makes the price about 27 percent of the cost of the mowers. The cost of repairing the mower will go up if it ever breaks. Finding someone who will work on the mower and know what they are doing is a lot higher. The transpiration of the mower becomes harder because you cannot put it in the bake of you truck. You want have to secure it down in your pick up or in or tailor. The refueling of the mover is a weakness because you ether need to have more than one bottle if it is removable. If it is a fixed bottle there is a problem with

find a station at has compressed natural gas or has a slid in cascade refueling system for your vehicle.

OPPORTUNITIES

There is a good niche markets in California and Florida for alternative fueled riding mowers. This market was form so that commercial mowers can still mow on clean air emission days. On low emission days at these areas you cannot operate a gas mower or blowers. This will always people who use these thing on any everyday basis for the living to continue to make a living on those days.

THREATS

Threats include other alternative fueled mowers fueled by propane or electricity. These mowers are generally cheaper then what are mower will cost they are in the $200 to $500 range. They also have the lower emissions and are cheaper to operate then gasoline mowers. These mowers allow the people who make their living operating mower to operate on low emissions day. Gasoline mowers are also a threat because they are proven in the market place and people know what they are getting. With the gasoline mowers transportation and refueling are not problem ether. You can throw them in your truck with relatively no consequences. The refueling issue is solved because you can refuel them in most every town in multiple places or the gas can in the back of your truck.

INDUSTRY ANALYSIS

ECONOMIC CONDITIONS AFFECTING THE INDUSTRY

Until 2015, federal and state tax credits will be given for converting personal and fleet vehicles to compressed natural gas[1]. The cost of converting a vehicle is approximately $13,500[2]. Tax incentives do not extend to converting small engines to CNG, but fleets that have already converted to CNG would be able to refill tanks on small equipment like lawn mowers using their fleet tanks. The high prices of oil-based fuels also affect the decision to convert to CNG. CNG is roughly half the price of gasoline, although it must be obtained at specialized filling stations[3].

There is also a high overhead associated with converting to CNG when installing on-site refueling stations or purchasing a refueling trailer. However, businesses who run equipment on CNG can market themselves as “green.” CNG also allows for longer engine life than gasoline.

[1] Oklahoma State Tax Code Title 68, Article 23, 2357.22

[2] Tulsa Gas Technologies. (2010). Retrieved Nov. 14, 2010, from http://www.tulsagastech.com/conversion.html

[3] CNGPrices.com. (2010). *CNG Stations and Prices for the US, Canada, and Europe*. Retrieved Nov. 14, 2010, from http://www.cngprices.com

INDUSTRY SIZE AND GROWTH

The CNG industry has been growing at a rate of 30.6 percent since 2000[4]. Globally, CNG has become a standard in taxis, buses and other forms of public transportation. Figures 1.1-1.2 shows the growth of natural gas vehicles around the world. As the world looks for alternatives to petroleum-based fuels, natural gas has gained ground.

Large natural gas reserves in the United States mean that many politicians and businessmen are looking to natural gas to solve U.S. dependence on foreign oil. Natural gas entered the political arena as a cleaner-burning alternative fuel but is now being championed by those hoping to eliminate reliance on OPEC for fuel. The Pickens Plan, proposed by oil tycoon T. Boone Pickens, seeks to use natural gas as the main fuel in America. The Bush Institute on Economic Growth, sponsored by former U.S. President George W. Bush, devoted its first conference to natural gas. "Natural Gas Nation" sought to promote the replacement of oil-based fuels with domestic natural gas[5]

GOVERNMENT REGULATIONS

Government regulations affect this industry from two sides. Clean air and emissions regulations create the tax incentives that entice businesses into switching to CNG. The Environmental Protection Agency regulates greenhouse gases, vehicle emissions and the labeling of CNG-capable vehicles. These regulations restrict the amount of carbon gas a vehicle is permitted to put in the atmosphere. Since CNG is cleaner-burning than fossil fuels like gasoline, these regulations help to promote CNG usage.

California has adopted regulations dictating the amount of pollution small engines like those found on landscaping equipment and lawn mowers can emit[6]. This increased regulation has created a market for cleaner lawn mowers and lawn equipment in California. Since California is such a large market, this also overlaps into manufacturing decision across the country.

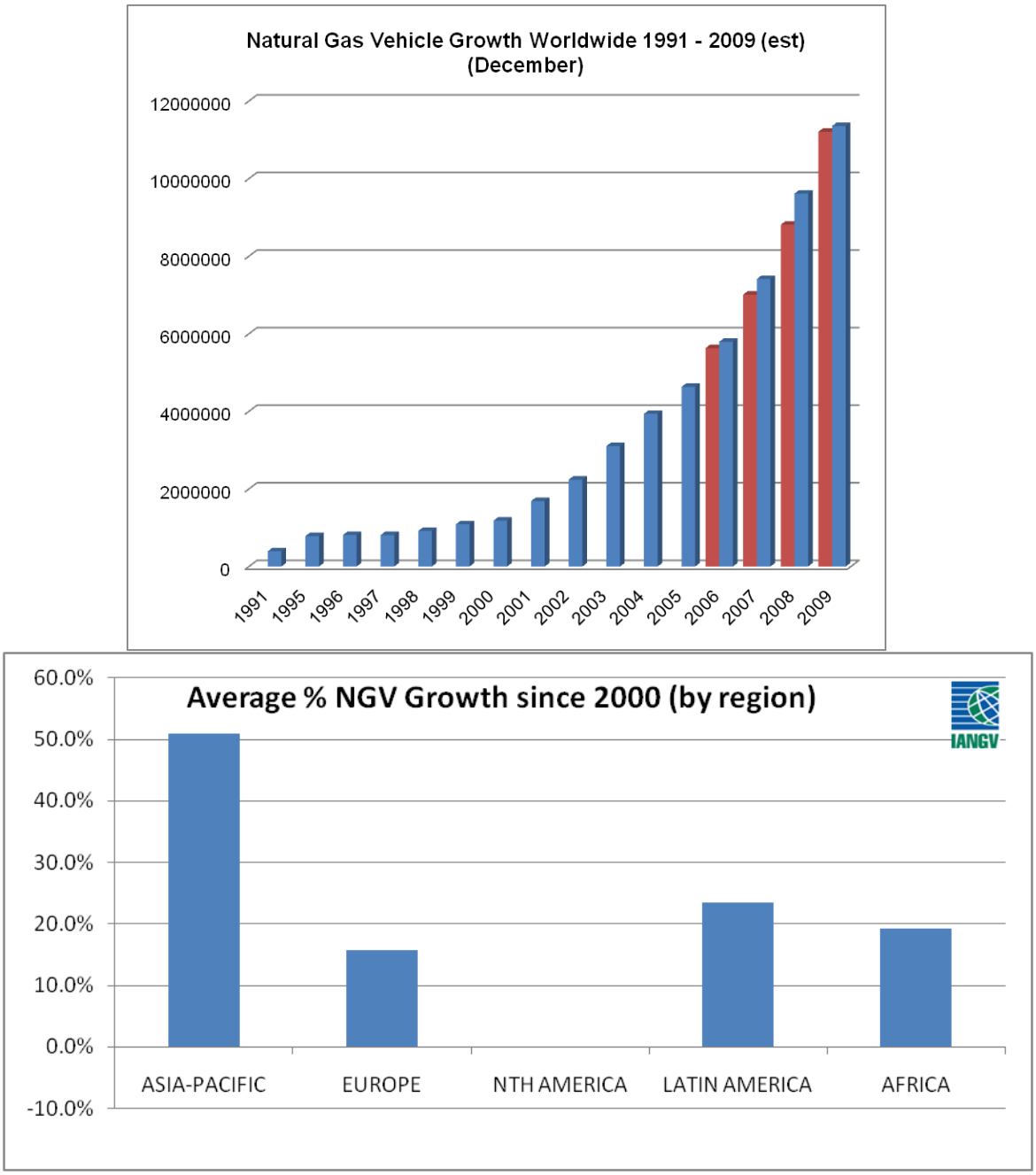
Regulations also affect the testing and transport of CNG vessels. Because CNG is held at high pressure inside the tanks, safety is a big concern. The Department of Transportation regulates the transport of all CNG containers, vehicles and other refueling equipment like a CNG trailer. Blue Innovations will have to create a tank that complies with DOT and other safety regulations to allow it to be sold and transported to and by customers

[4] CNG Now. (2010). *What is CNG?*. Retrieved Nov. 14, 2010, from http://www.cngnow.com/EN-US/WhatIsCNG/pages/default.aspx

[5] George W. Bush Presidential Center. (2010). *Natural Gas Nation Highlights*. Retrieved Nov. 14, 2010, from http://www.georgewbushcenter.com/articles/natural-gas-nation-highlights

[6] California Exhaust and Emission Regulation Order, Article 1, Chapter 9, Division 3, Title 13

FIGURE 1.1: CNG VEHICLE GROWTH WORLD WIDE[7]



[7] International Association for Natural Gas Vehicles. (2010). *Natural Gas Vehicle Statistics.* Retrieved Nov. 14, 2010, from http://www.iangv.org/tools-resources/statistics.html

[8]International Association for Natural Gas Vehicles. (2010). *Natural Gas Vehicle Statistics.* Retrieved Nov. 14, 2010, from http://www.iangv.org/tools-resources/statistics.html

KEY RESOURCES

The key resource for the natural gas industry is the abundant supply of domestic natural gas in the United States. The U.S. has an estimated 2,587 trillion cubic feet of recoverable natural gas[9]. Natural gas is an alternative fuel that is typically endorsed by people hoping to lower carbon emissions and those whose primary goal is to reduce dependence on foreign oil. U.S. natural gas has made CNG powered vehicles a political talking point and lead to tax incentives and regulations promoting cleaner fuels and natural gas. Natural gas also is a resource for a marketing campaign as it is cheaper and greener than traditional fuels.

The manufactured resources available to Blue Innovations are compression technology, refueling stations, drilling technology and equipment, and engine conversion technology. The group also has testing facilities available through Blue Energy Fuels and Wilco Machine and Fabrication. The Helmerich Advanced Technology and Research Center at Oklahoma State University-Tulsa is available also for testing and for production of a composite tank.

CUSTOMERS/BUYERS

MARKET SIZE

The target customer of a CNG powered commercial mower is golf courses and landscaping businesses who must comply with EPA and California Air Emissions standards. Golf courses have to mow every day, regardless of daily air quality standards. They would also have a better faster on investment because golf courses require extensive mowing and the course would be able to recoup the initial cost of the conversion with cheaper CNG fuel.

Landscaping businesses serving municipalities are another potential customer. Cities are under pressure to operate within a budget, keep the city looking nice, and avoid mowing on ozone action days. Despite an initial overhead, running CNG equipment is cheaper over time. Cities could also mow on ozone action days because CNG lawn mowers do not release as much carbon gas as traditional gasoline mowers. Being able to mow on ozone action days would allow cities to better maintain their landscaping. Private companies also would benefit from having more days when they could mow and by catering to the niche market of "green" consumers.

There is also a potential niche market of "prosumer" buyers who want to privately operate high-end equipment to maintain their property to a high standard. This market would be extended by also considering consumers who wish to lessen their environmental impact or who are interested in alternative fuels and being green.

[9] NaturalGas.org. (2010). *NaturalGas.org*. Retrieved Nov. 14, 2010, from http://www.naturalgas.org/overview/resources.asp

Although there currently is a riding lawn mower powered by CNG available on the market, there are none readily available or specific to golf courses[10]. Golf courses invest in high-end greens and fairway mowers and would benefit from being able to convert an existing fleet.

ECONOMIC STATUS AND DEMOGRAPHICS

This product would be targeted to golf courses and companies serving governmental agencies and municipalities. Cities and golf courses spend a substantial amount of money mowing and therefore could benefit more quickly from the long term cost benefits of running CNG equipment. For example, the city of Tulsa spends $35,000 each mowing cycle, and so could benefit from longer engine life and reduced fueling costs[11].

Many of the individual courses or companies would be independently or family owned and operated. Most of the companies would operate in one area only. Although their clients might be concerned with being green, the companies themselves would be more concerned with being profitable. High overhead investments would need to be backed up with solid evidence of future profitability. These companies would also be concerned with meeting environmental regulations and with worker safety. Ease of operation is also a concern with this product because of the potential decreased ease of refueling.

[10] Dixie Chopper. (2010). *Eco-Eagle*. Retrieved Nov. 14, 2010, from http://www.dixiechopper.com/mowers/view-mowers/eco-eagle

[11] News on 6. (2010). *City of Tulsa Begins Mowing City Parks*. Retrieved Nov. 14, 2010, from http://www.newson6.com/Global/story.asp?S=12333101

FINANCIAL ANALYSIS

The selling price of the conversion system is $2,811.95. The cost of production is $2,343.29. The selling price is the cost of production plus a 20 percent markup. Court Newkirk of Blue Energy Fuels provided the 20 percent markup.

	Cost of Goods Sold		
Item	Quantity	Price	Cost of Good
5/8 refuel coupler	1	$50.00	$50.00
Pressure gauge to 1000 psi	1	$95.00	$95.00
5/8 Male/female adapter	1 pack (30 per pack)	$3.00	$3.00
316 stainless steel pip	25 in	$4.22/ft	$8.80
18 gauge steel sheet	18 square ft	$3.25/square ft	$58.50
7.2 GGE type 4 tank	1	$1,800.00	$1,800.00
¼ angle	2 ft	$0.75/ft	$1.40
¼ 1.5 inch galvanized bolt	10	$0.11	$1.10
¼ galvanized nuts	10	$0.03	$0.30
¼ galvanized washers	10	$0.04	$0.40

5/8 ball valve	1	$58.80	$58.80
Regulator	1	$70.00	$70.00
Carburetor plate	1	$100.00	$100.00
Studs	2	$2.00	$4.00
Rubber hose	4 ft	$1.00/ft	$4.00
Air line extender	1	$10	$10
Labor for assembly	2	$19.00	$38.00
Low pressure regulator	1	$39.99	$39.99
Total			**$2343.29**

In the table below are the assumptions made in this financial analysis, including the 20 percent markup as provided by Blue Energy Fuels, plus an 8 percent estimated sales growth.

Table of Financial Assumptions	
Marketing Expenses	$8,000
Sales Commissions	10%
Delivery cost per unit	$25
Expense Inflation Rate	1.50%
Discount for NPV calculation	6%
Markup	20%
Sales Growth	8%

CONVERSION FEASIBILITY ASSESSMENT TOOL

Pay Back = (conversion and refueling cost)/ (B1+B2+B3+B4)

This is an assessment tool to assist in the marketing and promotion of a compressed natural gas lawn mower conversion kit. It will help show the benefits of making the decision to convert to CNG. There are many different shapes and sizes of golf courses in the country. These golf courses all have different ways of running their business and so would convert to CNG in different ways. This situation shows how a golf course with 10 greens mowers would switch to CNGThe first benefit is calculated price of gas minus the price of compressed natural gas times the amount of CNG bought. This will tell you how much you will save in gas for a year by switching to natural gas. The price of regular gas is averaging $3.50 a gallon in Oklahoma according to http://www.oklahomagasprices.com, as of April 6, 2011. The price of CNG $1.99 a gallon gas equivalent, according to http://www.cngprices.com, which is the price is at the OSU fleet station as of April 6, 2011. By using compressed natural gas, operators save a $1.51 per gallon of gas equivalent. This assessment will use a hypothetical golf club that would convert 10 greens mowers to CNG. “CNG Club” uses 7,665.9 gallons of gas a year. CNG Club has ten gasoline mowers, and so could have ten conversions. That would be a saving of $11,575.50 a year for using the cheaper fuel. The savings in fuel costs would enable CNG Club to pay off the conversions in two and half years. ($ 28,119.50/ 11575.50 = 2.43 years)

Benefit 1 = (Gal used) (P Gas – P CNG)

The additional expense of converting to CNG is refueling. CNG Club could use a slow fill refueling station to do that. Toxie Dearman from NGV Fleet Partners quoted an installed slow fill system that refills half gallon an hour for $10,000. CNG Club would need five slow fill systems, adding up to a $50,000 cost. They would need five refueling stations because each station has two hoses, and CNG Club has ten mowers to refuel.

If CNG Club does not have a big truck to haul mowers and they can complete their mowing without refueling more than once a day, a slow fill system is the practical option. If they had a three quarter ton pickup or better, or planned to buy one, they could buy a TGT refueling trailer. They would need a three quarter ton pickup to pull, because the weight of the trailer is too much to be pulled by a half ton or smaller truck. With this trailer, they could refuel off of it several times before they would have to refuel the trailer. They could also load all of their mowers up and pull them to a CNG station and refill them. Because of the expense of acquiring a truck to do this; a refueling station at the golf course would be the best option, requiring a $50,000 investment for the five refilling pumps. They will make $ 11,575.50 a year from converting to CNG because of savings in fuel costs. CNG Club will break even on its investment in the fueling station in about four years ($50,000/$11,575.50 = 4.32 years). That means that their total investment, including purchasing the conversion kits, is $78,119.50 and they would pay back all their investment in 6.70 years. This is based entirely on saving money on cost the fuel.

Benefit 2 = (Decrease in Maintenance Costs)

CNG Club spends $15,000 dollars a year on maintenance of their mowers. Only 10 out of the 13 mowers they have are conversion compatible. That would leave $11,550 or 77% of their maintenance cost. Most of this is spent on things like tires, belts and blades. Compressed Natural Gas mowers do not need as much maintenance as conventional gasoline powered mowers because they run cleaner and more efficiently. That means that the mowers do not need to have the oil changed as much and the engines last longer. On average it costs $15 to change the oil and filters in a mower. At CNG Club they change their oil twice a year at a cost of $300; for 10 mowers with CNG you could cut that cost in half to $150. With the extra saving they would see a return on their investment in just over six years ($78,119.50/ $11,725.50 = 6.66 years).

Benefit 3 = (Value of extra mowing)

The value of being allowed to mow on Ozone Alert Days is a great advantage for mowers with CNG, because keeping the greens smooth and neat is a primary concern to the golf course, no matter the weather. Not being able to mow on Ozone alert days can cut into the CNG Club's bottom line in lost green fees due to fewer golfers on the course. No golfer wants to play on a scraggly or rough course. With CNG mowers; employees will be able to maintain productivity and increase the profitability of the club.

Benefit 4 = (Value of going eco-friendly)

The last point of the benefits is the value of going eco-friendly. This benefit deals with people's perception of the value of being "green." To some people lessening the damage they put on the environment means a lot. They are willing to invest more money to help out the environment. Golf course managers may recognize a positive benefit from their ability to market their course as a course that is lessening its carbon footprint. Only management can determine the value of this

"greener" status, which can vary from nothing to a large competitive advantage, depending on the type of customers served.

$$NPV = 0 = \$\ 78{,}119.50 - (11{,}725.50/(1+R)^1) - (11{,}725.50/(1+R)^2) - (11{,}725.50/(1+R)^3) - (11{,}725.50/(1+R)^4) - (11{,}725.50/(1+R)^5) - (11{,}725.50/(1+R)^6) - (11{,}725.50/1+R)^7) - (11{,}725.50/(1+R)^8) - (11{,}725.50/(1+R)^9) - (11{,}725.50/(1+R)^{10})$$

$$ROI = 6\ \%$$

COMPANY AND ITS RESOURCES

MANAGEMENT TEAM

Court Newkirk is the general manager of Blue Energy Fuels, LLC. He is responsible for the marketing side of the business. Tom Sewell is the president of Tulsa Gas Technologies. He is responsible for the sales and operations of TGT. Charles Sewell is the vice president of TGT and is responsible for research and development.

PRODUCT LINE

Tulsa Gas Technologies, Inc. manufactures CNG dispensing equipment and related control systems that refuel alternative fueled vehicles, a Lighting Management System (LMS), which controls exterior lights of more than 500 gasoline stations and convenience stores across the country, and is a PHILL FuelMaker and Oasis valve distributor.

MANUFACTURING EXPERTISE AND CAPACITY

Owner Tom Sewell is an expert in the compressed natural gas field. He began working in the industry in the late 1980s.

INPUT SUPPLIERS

Tulsa Gas Technologies, Inc. fabricates almost all of the parts required for the products they sell. TGT is also a distributor of PHILL FuelMaker home fueling systems and Oasis valves.

PRODUCTS

Blue Innovations will need to contact TGT for pricing, financing, and maintenance costs of their products, their financial condition, income statements and cash flow. We will also have to contact TGT for a list of current distribution of their products and key current customers.

PROMOTION PROGRAMS AND CURRENT CAMPAIGNS

Blue Energy Fuels (BEF) is a joint venture of two of Oklahoma's leading manufacturers in the oil and gas industry[12]. These two companies combined their manufacturing experience to design and build the most modern and efficient compressed natural gas (CNG) fueling stations available.

[12] Blue Energy Fuels. (2010). *Blue Energy Fuels*. Retrieved Nov. 14, 2010, from http://www.blueenergyfuels.com/blueenergyfuelsb.html

BRAND/REPUTATION/TRADEMARKS

Both Blue Energy Fuels and Tulsa Gas Technologies use the color blue in their logos and marketing campaigns. Blue Energy Fuels also uses green to emphasize the environmental friendliness of compressed natural gas. Tulsa Gas Technologies also uses the slogan "service with the sale" to emphasize the company's role in follow-up services such as refueling and maintenance[13].

FIGURE 2.1: TULSA GAS TECHNOLOGIES LOGO

FIGURE 2.2: BLUE ENERGY FUELS LOGO

[13] Tulsa Gas Technologies. (2010) *Tulsa Gas Technologies.* Retrieved Nov. 14, 2010, from http://www.tulsagastech.com/index.html

COMPETITORS

COMPETING COMPANIES

Although no other company currently produces a conversion kit for large commercial mowers, there are products that compete on several levels. The largest competitor is the traditional gasoline powered mower because it has familiarity, comfort and can be refueled at any traditional gas station. A variety of alternative fuels also compete with natural gas. Propane and battery powered lawn mowers capitalize on environmental responsibility. Many golf courses that have already converted to alternative fuel use electric or propane mowers.

The Dixie Chopper Eco-Eagle is a main direct competitor in the landscape market, although it is not designed to mow golf courses. It also would require the company to purchase an entirely new piece of equipment, whereas with the TGT conversion kit companies could use existing mowers.

TECHNICAL ANALYSIS

SCIENTIFIC LITERATURE

There is currently only one CNG riding mower and no walk behind mowers available on the market today.

PATENTS

Blue Innovations found four patents that have some relevance to CNG fueling systems. Patent 5,676,117 is dated October 14, 1997. It is titled "Lawnmower powered by alternative fuels," and focuses mostly on fuel injection. Patent 5,878,730 is dated March 9, 1999. It is titled "Lawn Mower Powered by Alternative Fuels Using a Fuel Injector Adapted for Gaseous Fuels," and focuses mostly on LPG fuel injection. Patent 5,941,210 is dated August 24, 1999. It is titled "Gaseous Fuel Direct Injection System for Internal Combustion Engines," and focuses on injection method. Patent 5,411,058 is dated May 2, 1995. It is titled "Method and Apparatus for Utilizing Gaseous and Liquid Fuels in an Internal Combustion Device," and focuses on the combination of gaseous and liquid fuels. These patents are relevant because they discuss using gaseous fluids as a replacement for conventional liquid fuels.

PHYSICAL TESTING AND DATA COLLECTION

Blue Innovations conducted one experiment on an 8 horsepower engine running on gasoline using a dyno to measure power and torque. The power and torque was measured across the entire rpm range of the engine. Another test will be conducted using CNG to power the engine. The resulting power, torque, and rpm readings will be compared to the gasoline data.

SIMULATION AND MODELING

Blue Innovations are going to make a 3D CAD model of a kit that would be mounted on a greens mower. The model will contain a tank, regulators, and the piping required to run the engine off of CNG.

DESIGN PROPOSAL

MOWER SIZE

Based on the calculations and expense of the composite tank, a kit for a golf course riding greens mower is more feasible than a standard push or riding lawnmower. Because of the vast price difference in the mowers, and the small price difference between the CNG systems that would apply to each, a greens mower will provide for a better return on investment. If customers would only spend 10% to 20% more for a lawnmower that ran on CNG, it is more reasonable to design our system for a greens mower due to the price it will cost. Furthermore, since the CNG system will cost relatively the same for both size mowers, it allows for a greater profit if applied to the more expensive greens mower.

REMOVABLE VS. NON-REMOVABLE TANK

Due to the large amount of regulations, and uncertainty in the CNG market, a permanent tank is more feasible and economical to use in the design of the CNG lawnmower. From a safety standpoint, there is no substitute for the extra sense of security that would come with knowing the tank is permanently mounted to the lawnmower. Since a permanent tank will require very little user interaction, it is a safer option all around. Figure 4.2 shows the specifications and design concerns associated with permanent and removable tanks.

REGULATIONS

A removable tank will have to be regulated more strictly not only when on the mower, but also when being transported alone.

When the tank is on the mower, there will have to be adequate shielding to prevent anything from striking the tank. Since it is able to be removed, extra care will be needed to make sure that the tank is not allowed to vibrate.

There are numerous DOT regulations dealing with transport of pressurized vessels that all must be followed when dealing with a CNG tank.

A secure rack will have to be on the trailer/truck to prevent any movement or vibration while the tanks are transported.

COST

A removable tank itself could be made more cheaply than a permanent tank because it can be inspected and fixed upon removal, where a permanent tank will need to be built stronger in order to last longer on the mower before needing attention.

The extra safety measures, because of the ability to exchange (shielding, rack for transport, etc.), will increase the cost.

Efficiency/Functionality

The efficiency will be the same on paper, but since the tank is able to be removed, it will allow for a much smoother refill and allow the operator to simply switch tanks rather than stopping and loading the mower to take it to a CNG refueling station

Hours per refill

The hours per refill will be the same since the tanks are the same, but as mentioned before, the refueling process will be eliminated since you can simple remove the empty tank and replace it with a full one.

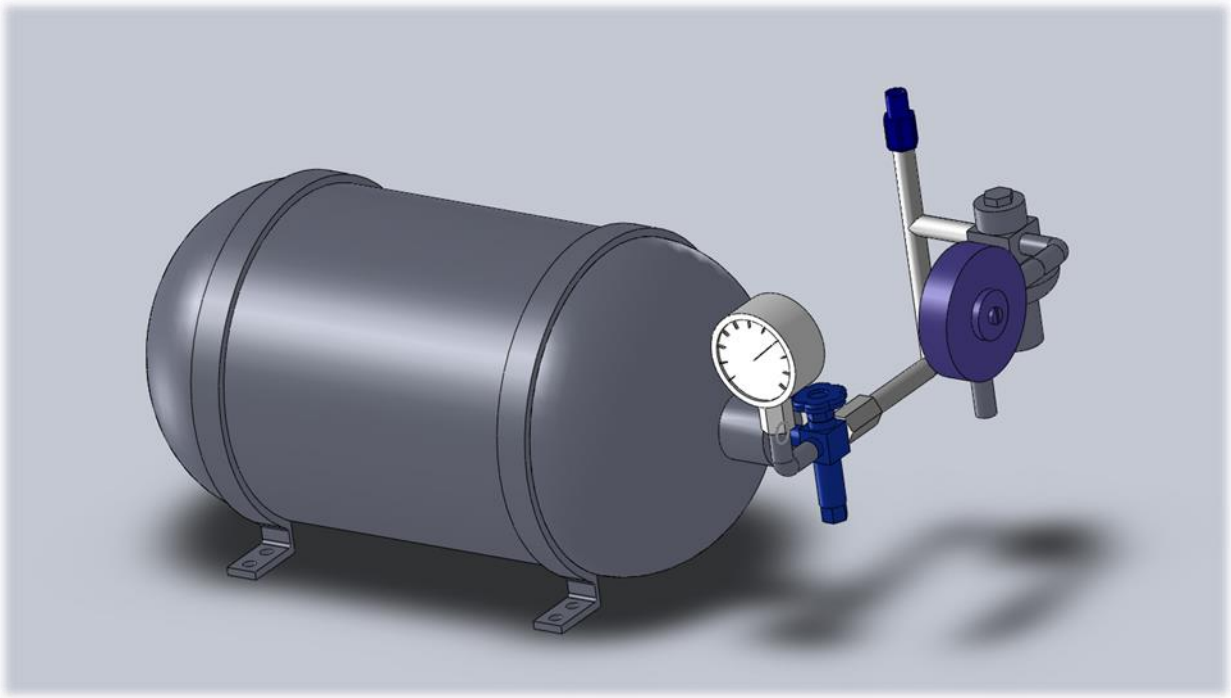
Convenience

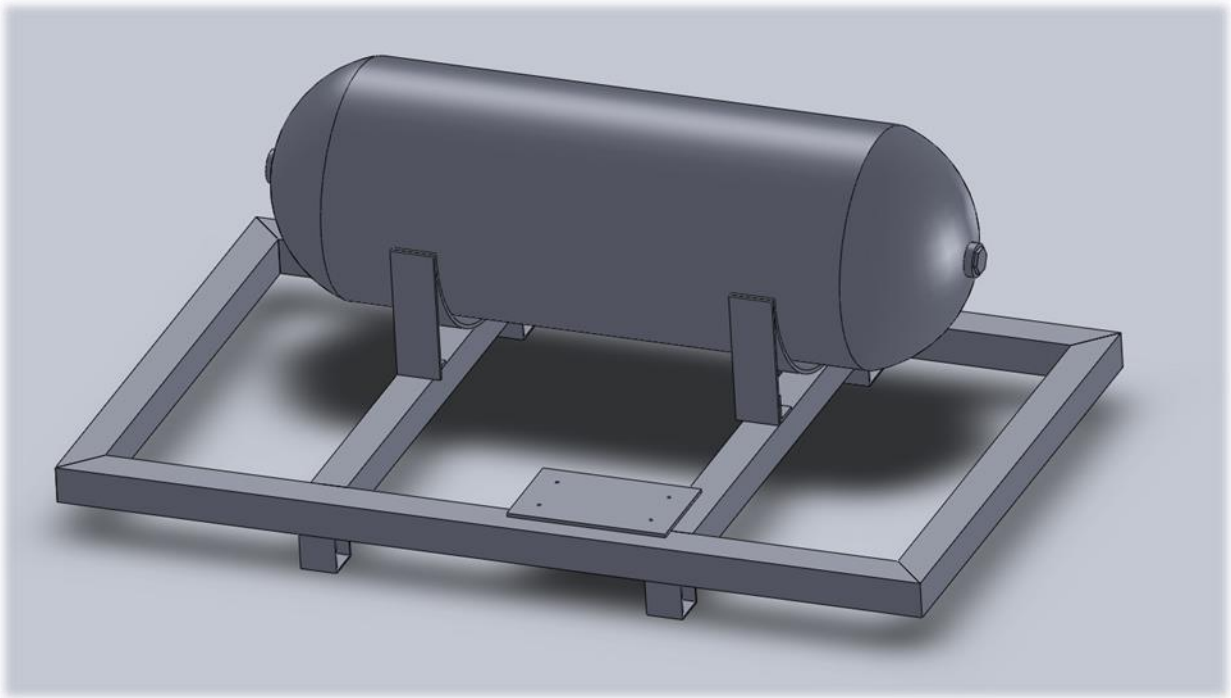
The removable tank will be more convenient from an operational standpoint due to the ease of refuel, but it does pose an inconvenience dealing with the extra safety measures and transport regulations**.**

Safety

While the removable tank poses a greater safety issue due to the requirement for more precautions, in the long run a removable tank can be safer because the user can take their empty tanks in to CNG tank company/refueling station and simply exchange them for full tanks, where the refueling company can inspect the empty tanks before sending them back out, ensuring safe use in the future.

CNG TANK MODEL

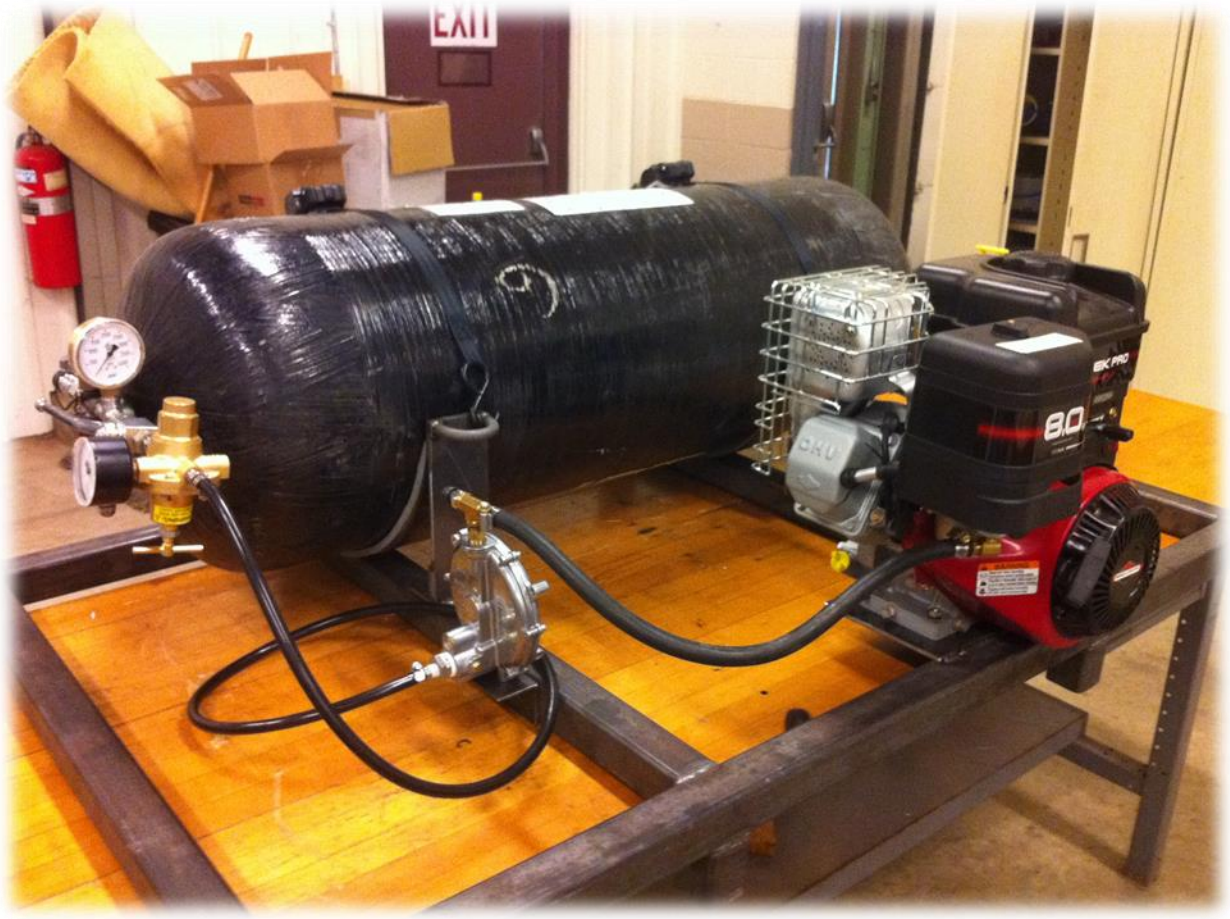




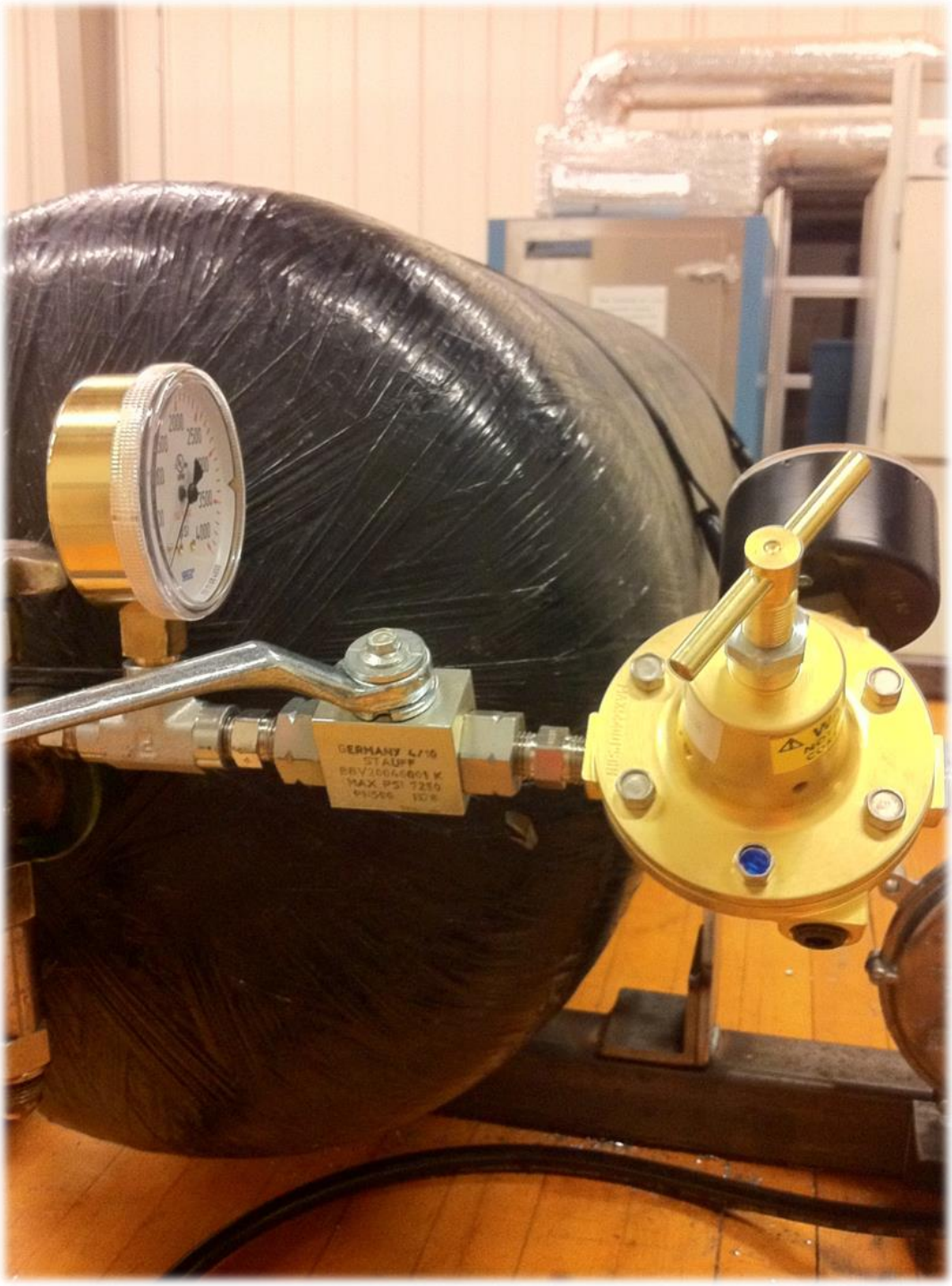
TESTING

TEST SET UP

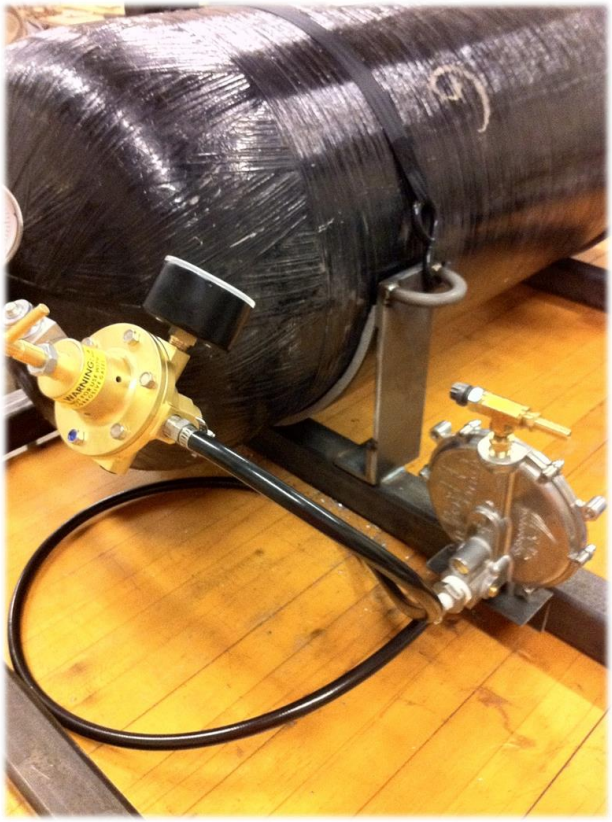
The CNG conversion kit was tested by being hooked up to a Briggs and Stratton engine and tested on a Dyno. The pictures below show the test set up.



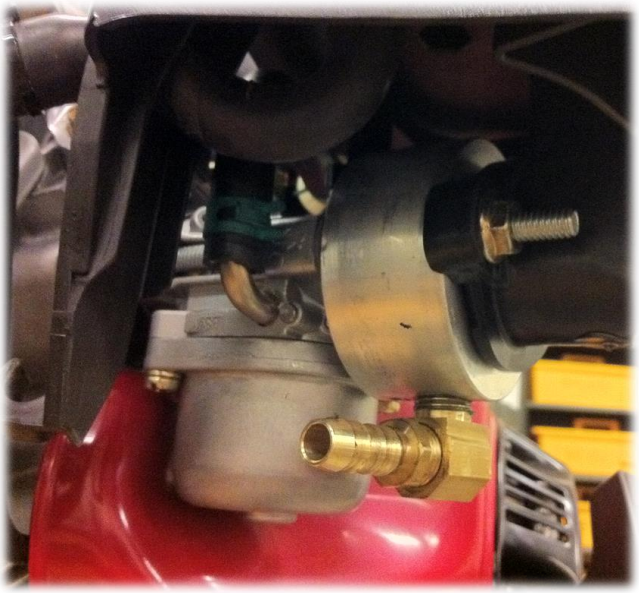
The picture above shows the complete kit with the engine and CNG tank.



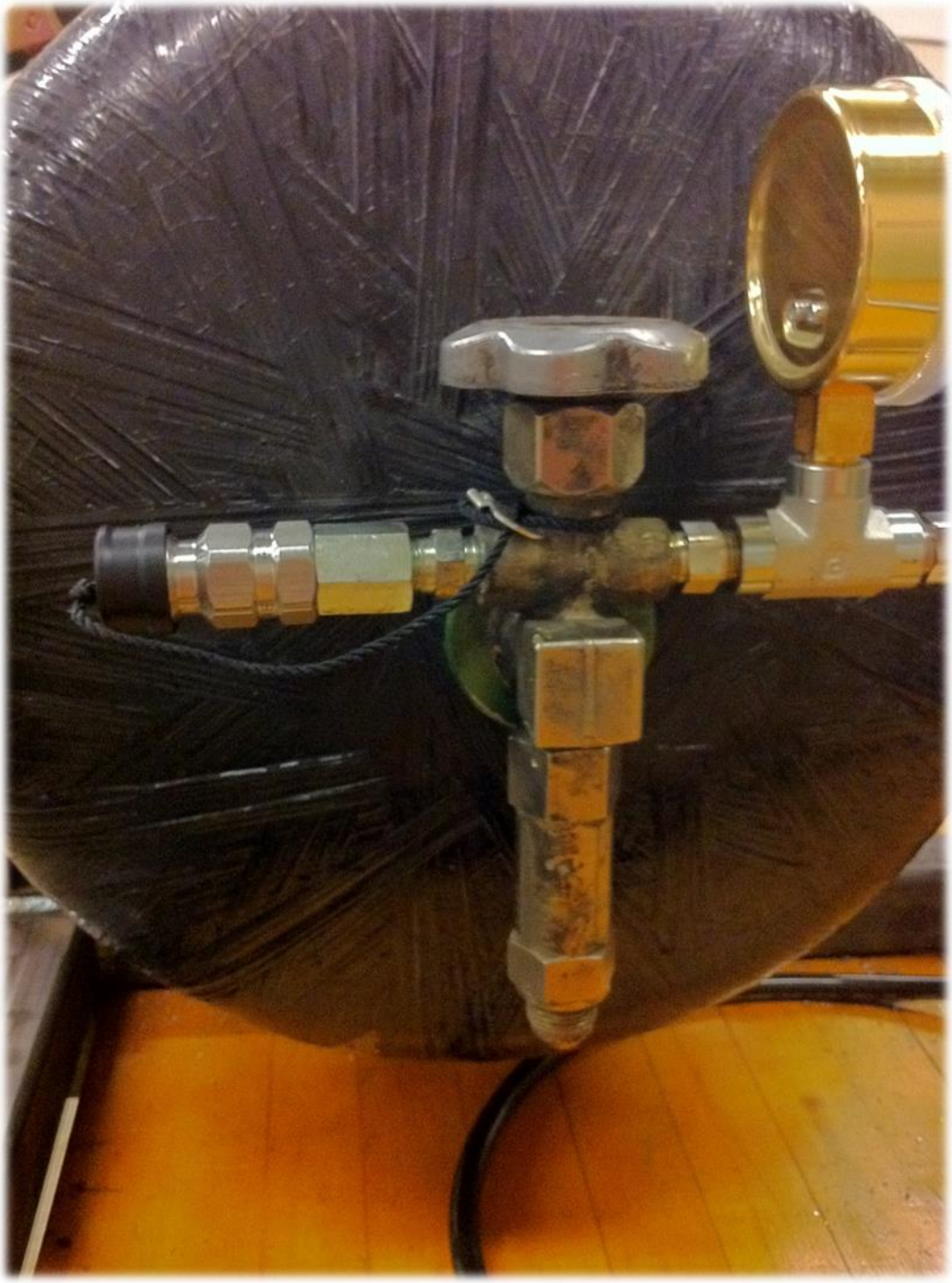
Pictured above is the high pressure gauge, the shut off valve and the high pressure regulator.



This photo shows the connection between the high-pressure regulator and the low-pressure regulator.



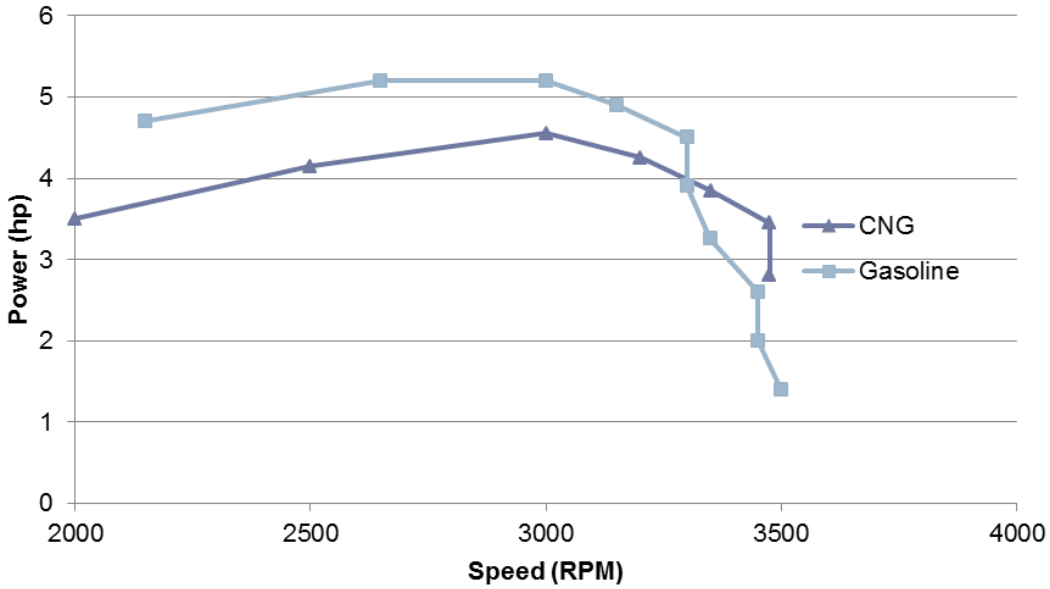
Above is the carburetor adapter plate.

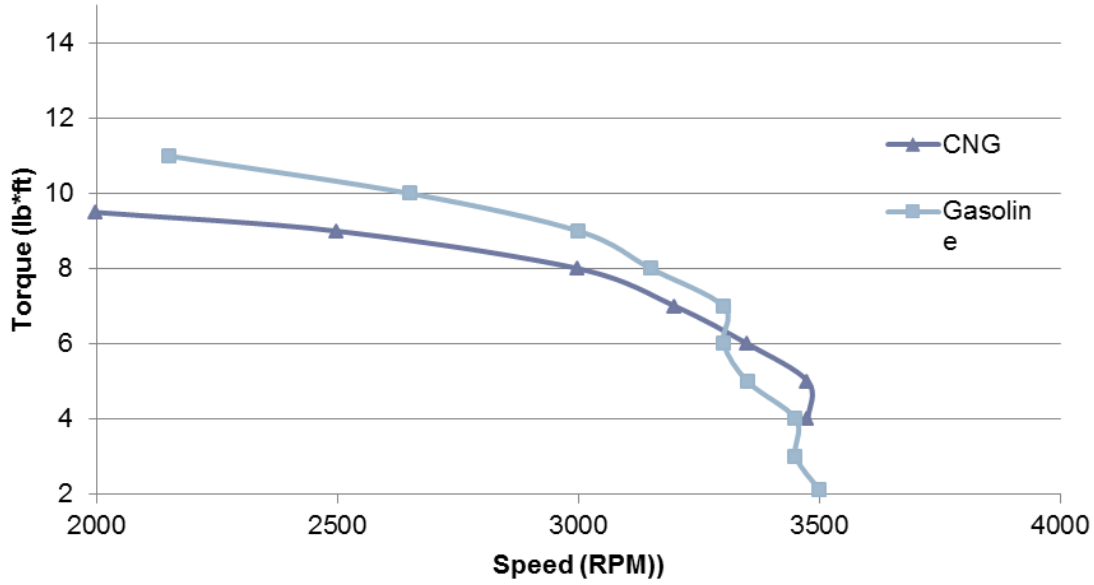


This shows the refuel nozzle, the tank shut off valve and the thermal relief valve.

TESTING RESULTS

The graphs below show the results of running the engine on CNG and on traditional gasoline. The engine was tested on the Dyno for horsepower and torque at different revolutions per minute.





PROPOSED MARKETING CAMPAIGN

CURRENT MARKETING RESOURCES

Tulsa Gas Technologies, Inc. (TGT) and Blue Energy Fuels both currently have websites, company logos, and promotional brochures. TGT's website contains a large amount of information about the company's products and services as well as the natural gas industry. However, the way the links and the news blurbs are displayed is not intuitive or user-friendly. This makes it difficult for the customer to easily find what they need. Blue Energy Fuels' website is eye appealing and well organized, but is somewhat vague on the company's services, perhaps because, as a new company, Blue Energy is still defining what it will do. Some pages also have no text on them, the text is actually an imported as a graphic. This would make the site more difficult to edit and restrict the content search engines can use to find the site. Blue Energy also has nothing in its home page title about CNG or CNG dispensers, again limiting the likelihood of getting search engine referrals. TGT is the first search result for "CNG dispensers Oklahoma" and "CNG fueling stations Tulsa" but Blue Energy doesn't show up in the first three pages[14], probably because of the page title.

OVERVIEW OF PROPOSED CAMPAIGN

This product needs a modern, simple, and cohesive designed campaign. We plan to create a campaign theme based on the environmentally friendly aspect of alternative fuels combined with the high price of traditional gasoline. This will include the designing of brochures, print ads, web based ads, and a product website. All of these elements will have a blue color scheme with green acting as an accent color. The continued public perception of CNG as a clean alternative fuel is essential to the continuation of tax credits and government regulations that encourages conversion.

A secondary marketing plan to specifically target our customer base will focus on being EPA- and other regulation-compliant. The main incentive to business owners for converting to CNG gas will be national and state emissions regulations that make gasoline-powered small engines economically not viable. The campaign will also focus on the long-term savings of converting to CNG. Although the initial investment in CNG conversions can be high, CNG's low cost compared to gas creates long-term savings, especially when an entire fleet is converted.

To promote the CNG mower conversion kit, we will use print advertising, brochures, and a product website. Additionally, the team is open to using web-based advertising, YouTube, and social networking sites to promote the product. We could also use trade shows such as lawn and garden expos and alternative fuel shows to promote the conversion kit.

[14] Using www.google.com as a search engine, no quotes in search terms

TRADE PUBLICATIONS

Blue Innovations would use golf course trade publications to promote converting to CNG. The figure below shows four potential trade publications and their advantages.

Club Manager magazine
Published by Club Manager's Association of America
Full color and black and white ads
Also has online edition with potential for flash ads and hyperlinks
Online directory
Golf Course Management magazine
Published by Golf Course Superintendent's Association of America
Claims to reach 95% of golf course superintendents
Also has online advertising opportunity with a blog
Created in 1927
Superintendent magazine
Online edition available for free
Spanish-language version
Digital edition
Professional audience
Golf Course Industry magazine
Digital edition
Professional audience

SAMPLE ADVERTISEMENT

This is a sample advertisement to run in a trade publication targeted towards golf course professionals.

Blue Innovations

CNG Conversion Kit

Katy Sokolosky
Jackie Barber
JJ Stoeckl
Thomas Hyde
Braden Warcup

Client Company

- Blue Energy Fuels
  - New company
  - Cooperative effort
  - Fueling stations
- Tulsa Gas Technologies
  - Over 19 years of experience
  - Pioneer in industry
  - CNG dispenser manufacturer
  - Vehicle conversions

Blue Energy Fuels CNG

TGT Tulsa Gas Technologies, Inc. www.tgtcng.com

Tulsa Gas Technologies, Inc.
4809 S. 101st E. Ave., Tulsa, OK 74146
Phone: 918-665-2641 Fax: 918-665-2657

Blue Innovations

Mission/Problem Statement

- Our mission is to provide our partners with innovative solutions that fit their needs both practically and economically by creating a product that will advance the use of natural gas as an alternative fuel.

- Develop an innovative way to encourage the use of natural gas as an economically viable alternative fuel

Blue Innovations

Objectives

- Create a conversion kit that will allow commercial riding lawn mowers and golf course mowers to run on compressed natural gas
  - Help Blue Energy Fuels/TGT fill an expanding niche market
  - Give businesses and municipalities opportunity to decrease their impact on the environment

Blue Innovations

Industry Analysis

- Oklahoma
  - Oklahoma is the 3rd largest producer of natural gas, providing 1,643.3 billion cubic feet in 2007.
  - Oklahoma is ranked 5th in the amount of natural gas reserves yet to be explored and produced.
  - Eight percent of America's natural gas liquid reserves are located in Oklahoma.
  - Eight of the 50 greatest energy fields in America are located in Oklahoma.

Source: www.oerb.com

Blue Innovations

Industry Analysis

- National
  - Slightly more than half of the homes in the U.S. use natural gas as their main heating fuel.
  - 62.5% of home appliances – kitchen stoves, water heaters and clothes dryers – operate on natural gas.
  - There are about 130,000 vehicles that run on CNG on American roadways now, and about 7 million worldwide.
  - Natural gas is the raw material for many common products, such as: paints, fertilizer, plastics, antifreeze, dyes, photographic film and medicines.

Source: www.oerb.com

Blue Innovations

CNG vs. Gasoline

- According to the Environmental Protection Agency, the potential reductions of CNG relative to conventional gasoline include*
  - 90-97% reduction carbon monoxide emissions
  - 25% reduction in carbon dioxide emissions
  - 35-60% reduction in nitrogen oxide emissions
  - 50-75% potential reduction in nonmethane hydrocarbon emission
  - Reduction in toxic and carcinogenic pollutants
  - Little to no particulate matter produced
  - No evaporative emissions in engines dedicated to CNG

*Estimates based on CNG's inherently "cleaner" chemical properties with an engine that takes full advantage of these properties

Clean Alternative Fuels: Compressed Natural Gas. Environmental Protection Agency Fact Sheet: EPA420-F-00-033. March 2002. www.epa.gov

Blue Innovations

CNG vs. Gasoline

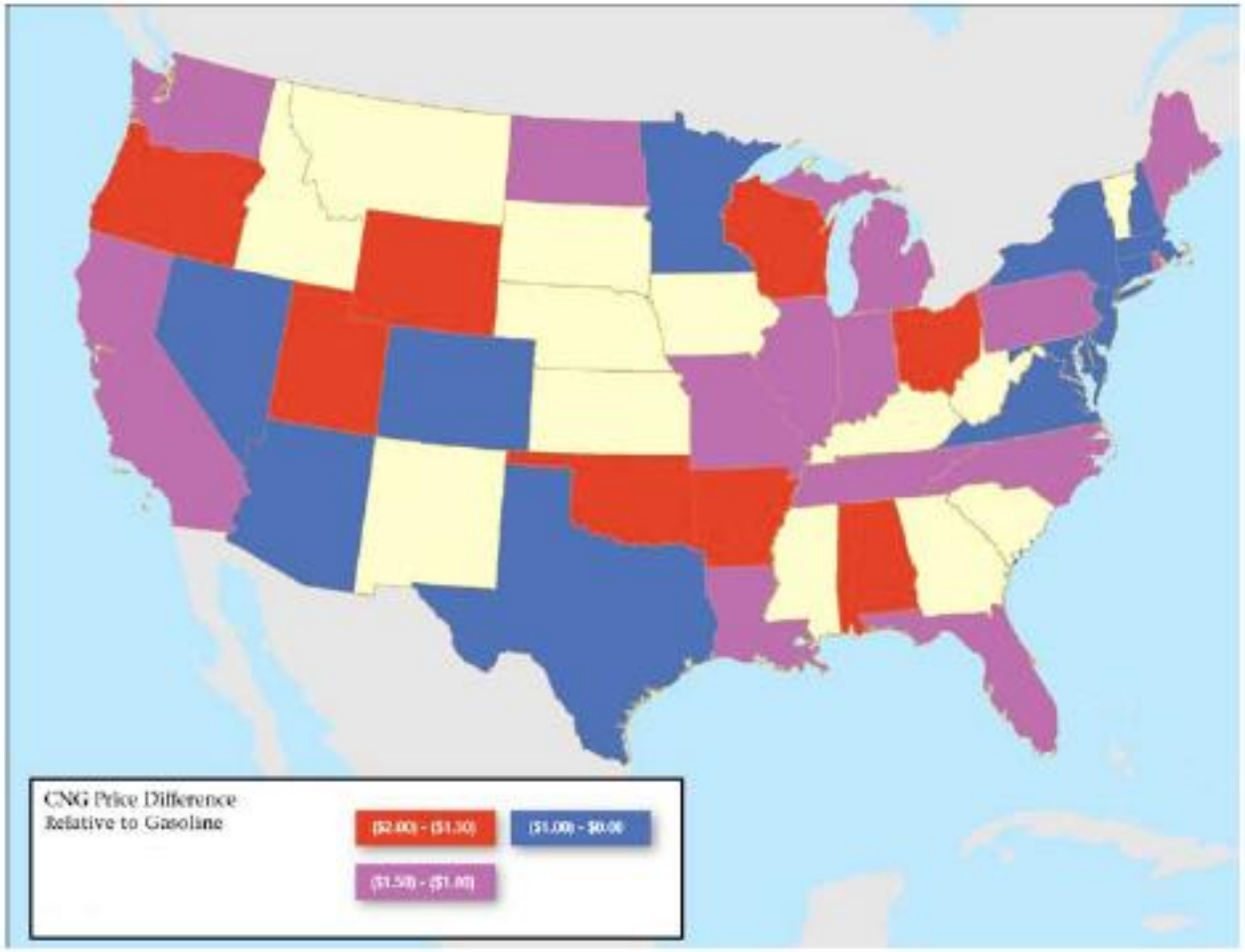
Table 5. Compressed Natural Gas Average Prices by Region from Clean Cities Sources

	Natural Gas (CNG) Information Reported by Clean Cities ($/GGE)		*Regular Gasoline Information Reported by Clean Cities ($/gal)*	
	Average Price/ Standard Deviation of Price	*Number of Data Points*	*Average Price/ Standard Deviation of Price*	*Number of Data Points*
New England	$2.36 / 0.74	11	$3.26 / 0.15	45
Central Atlantic	$2.27 / 0.54	75	$3.19 / 0.19	32
Lower Atlantic	$1.82 / 0.53	7	$3.00 / 0.22	51
Midwest	$1.70 / 0.40	27	$3.08 / 0.14	152
Gulf Coast	$1.79 / 0.43	6	$2.95 / 0.05	38
Rocky Mountain	$1.37 / 0.27	82	$2.89 / 0.10	71
West Coast	$2.21 / 0.50	90	$3.28 / 0.23	49
NATIONAL AVERAGE	$1.93 / 0.60	298	$3.08 / 0.20	438

*U.S. Department of Energy Clean Cities Alternative Fuel Price Report January 2011

Blue Innovations

CNG vs. Gasoline



*U.S. Department of Energy Clean Cities Alternative Fuel Price Report January 2011

Blue Innovations

Aftermarket AFV Conversions

- Alternative Fuel Vehicle (AFV) aftermarket conversions are classified as original manufacturer vehicles altered to operate on propane, natural gas, methane gas, ethanol, or electricity.
- All vehicle conversions, except those that are completed for a vehicle to run on electricity, must meet current applicable U.S. Environmental Protection Agency standards.

*U.S. Department of Energy – Energy Efficiency and Renewable Energy Alternative Fuels and Advanced Vehicles Data Center

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Aftermarket AFV Conversions

- Certificate of Conformity
  - Cover a “test group” of specific engine models to operate on an alternative fuel
  - Certificate holders must complete an application and submit emissions test data to EPA for a test group of vehicles equipped with the retrofit system.

Blue Innovations

Riding Greens Mowers

- Jacobsen Greens King IV Plus
- 18 HP Briggs & Stratton Vanguard
- 8 gal Fuel capacity
- 1239 lbs.

Source: http://www.globalturfequipment.com/?page=details&tag=3068

Riding Greens Mowers

- Toro Greens Master 3050
- 18 HP Briggs & Stratton Vanguard
- 7 gal Fuel Capacity
- 970 lbs

Source: ://www.globalturfequipment.com/?page=details&tag=2768

Riding Greens Mowers

- John Deere 2500A
- 18.7 hp Kawasaki FD620D
- 8.5 gal Fuel Capacity
- 1270 lbs.

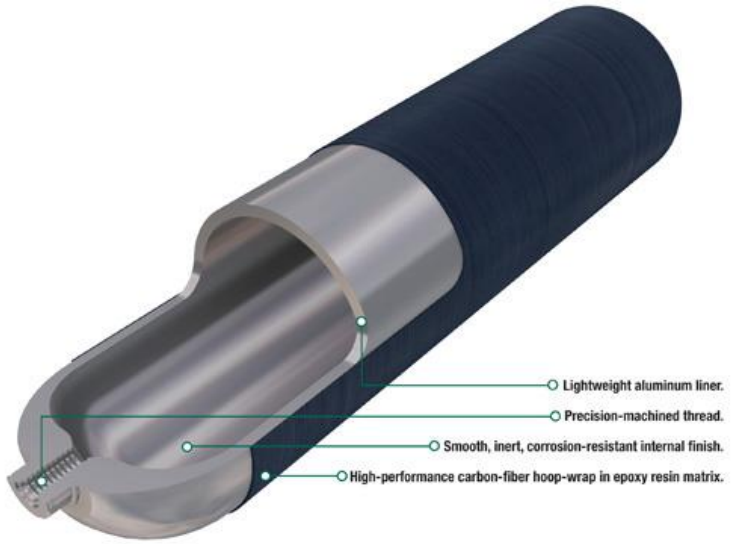
Source: http://www.globalturfequipment.com/?page=details&tag=2346

Tank Comparison

- Type I
  - 100% Steel Tank

Source: www.sailnet.com

- Type II
  - Lightweight Aluminum Liner with Carbon-fiber Hoop wrap



Source: www.luxfercylinders.com

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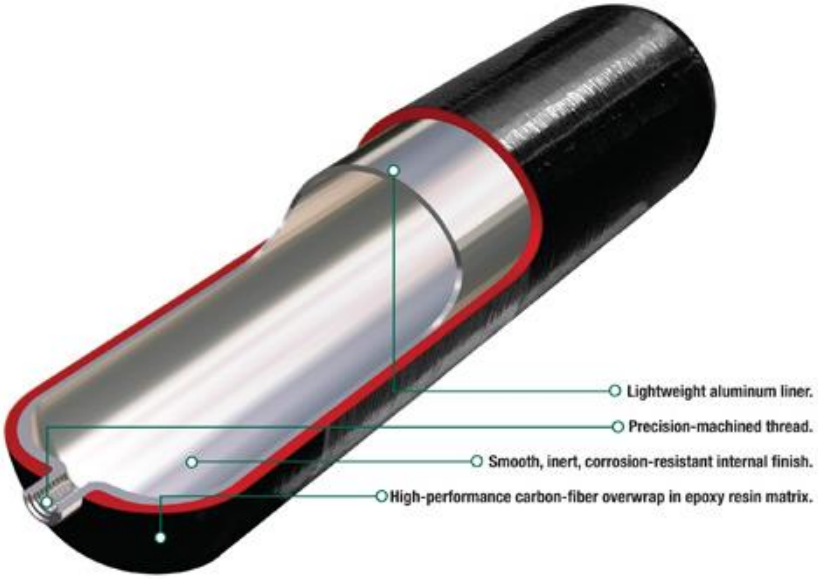
Tank Comparison

- Type III
  - Lightweight Aluminum Liner with Carbon-fiber Overwrap



Source: www.luxfercylinders.com

- Type IV
  - 100% Composite Material

Source: lincolncomposites.com

Blue Innovations

Tank Comparison

	Capacity (GGE)	Empty Weight (lb)	Price
Type I	5.5	196	$432
Type II	5.5	137	$512
Type III	5.5	62	$1017
Type IV	5.4	74	$1600

Type I, II, II values quoted from metal-mate.com

Type IV values based on quotes obtained from Lincoln Composites

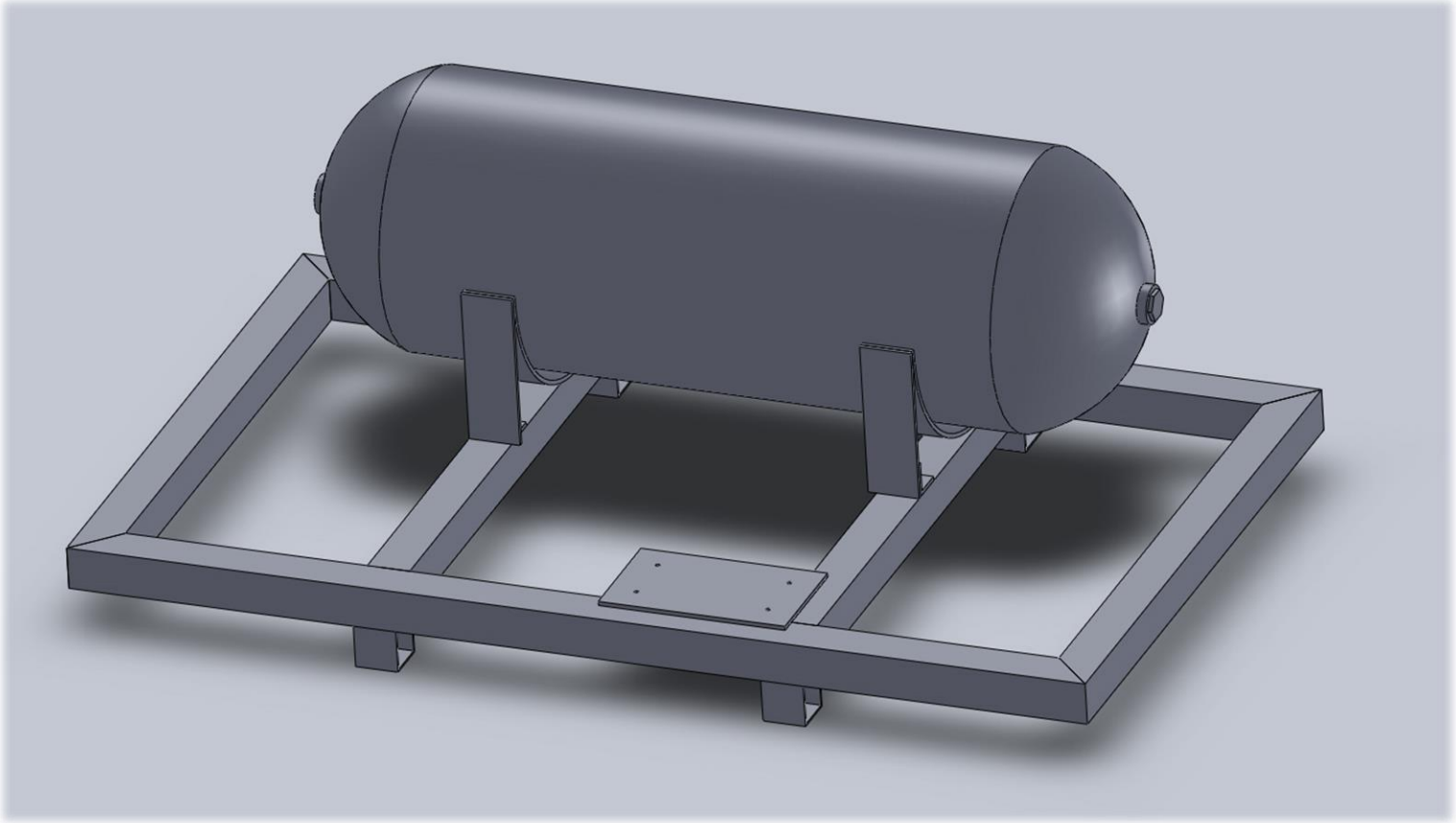
Blue Innovations

Tank Comparison

Permanent	
Pros	**Cons**
•Very Secure •No interaction with tank removal •Hidden and inaccessible to user •Can use Type I, II, or III	•Must transport the mower to refuel at station or refuel using a tank trailer •More planning and time •Requires professional replacement
Removable	
Pros	**Cons**
•Refuel by a quick tank switch on-site •Damaged tank can be replaced quickly •Fewer fuel station visits	•Less secure •More costly tank investment •Fittings must be more resistant to wear •Limited to Type III, or IV

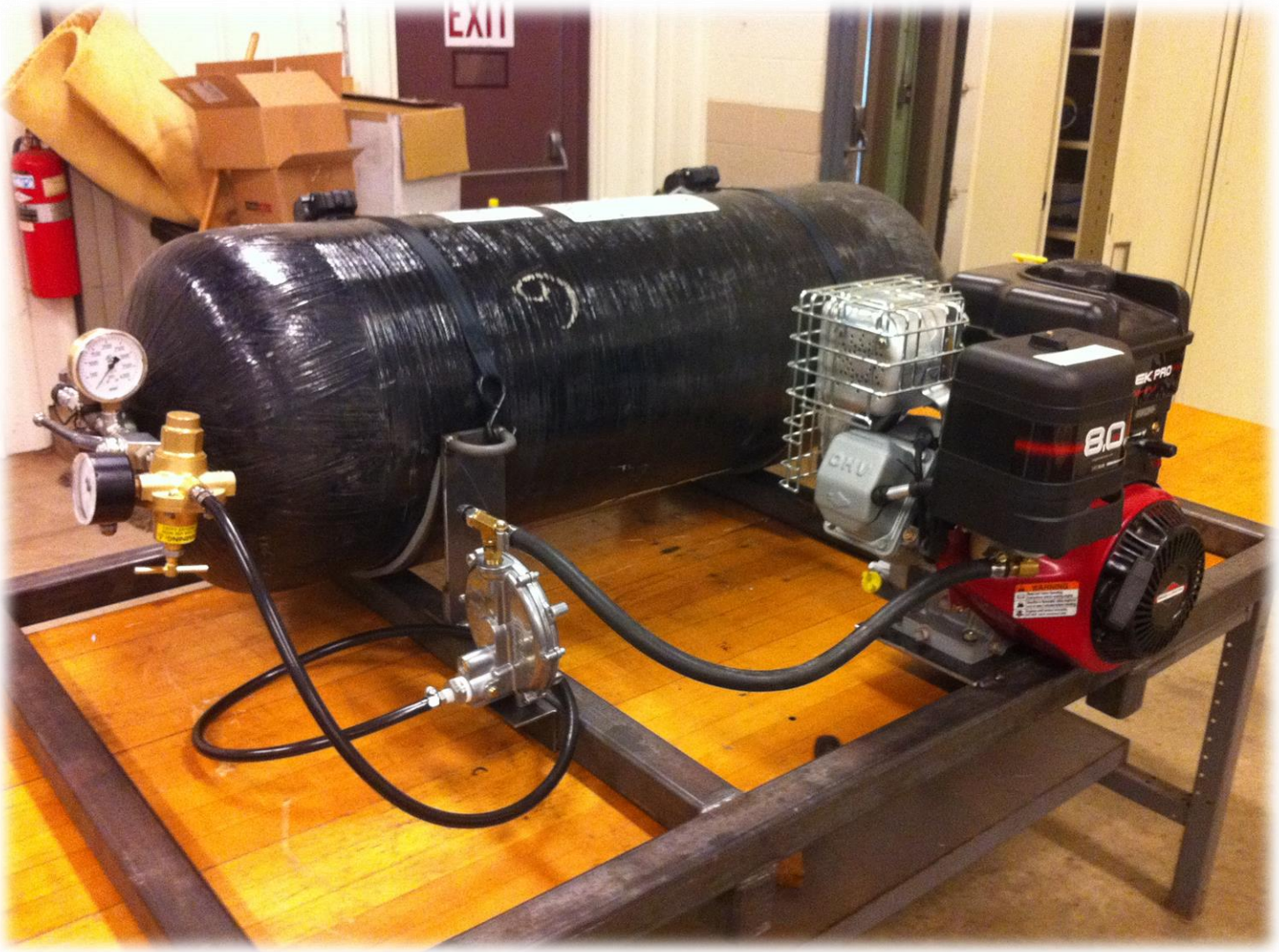
Blue Innovations

Tank/Engine Frame



Blue Innovations

Test Setup



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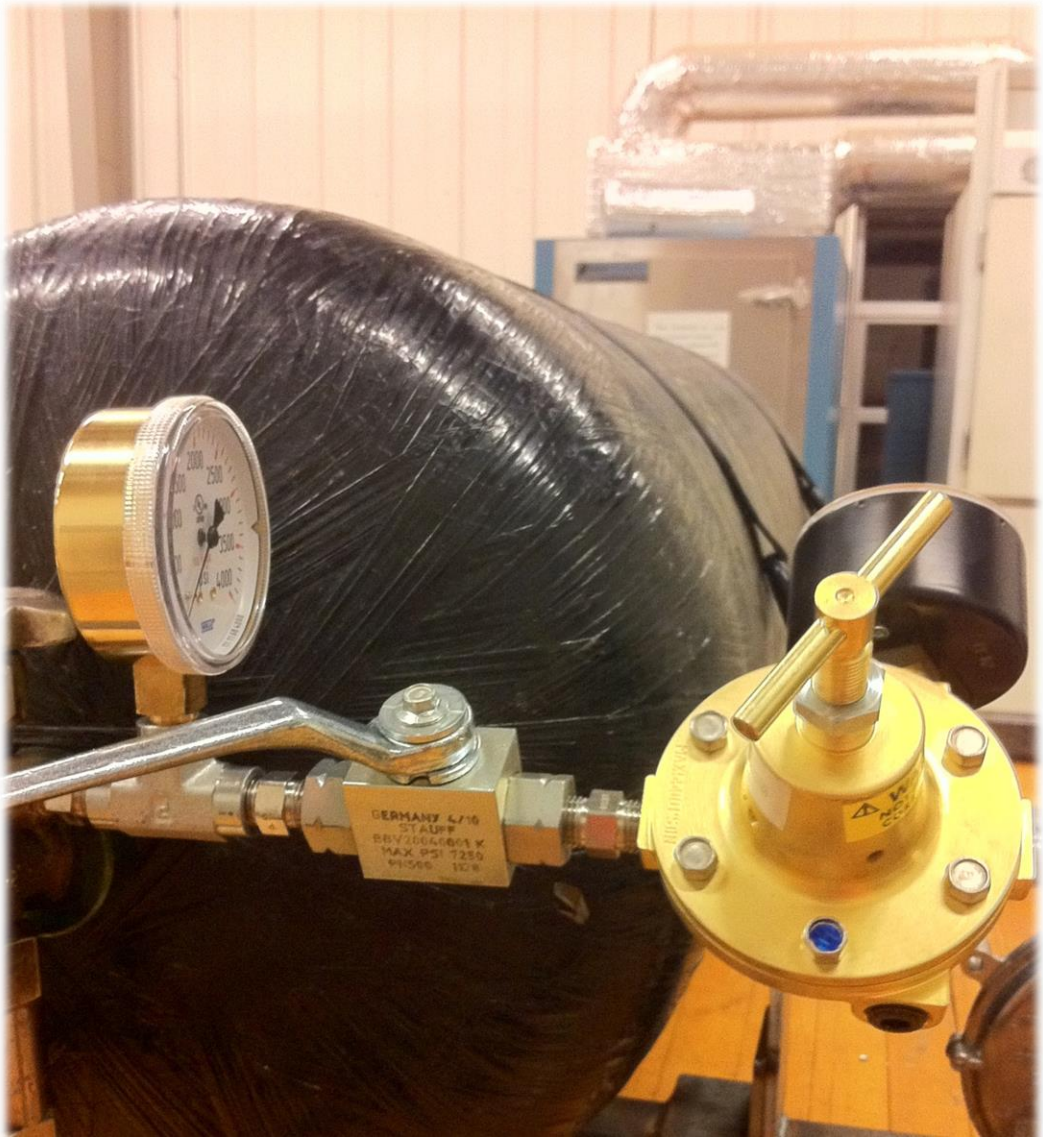
Test Setup

- Refuel Nozzle
- Tank Shutoff Valve
- Thermal Relief Valve

Blue Innovations

Test Setup



- High Pressure Gauge
- System Shutoff Valve
- High Pressure Regulator with Gauge

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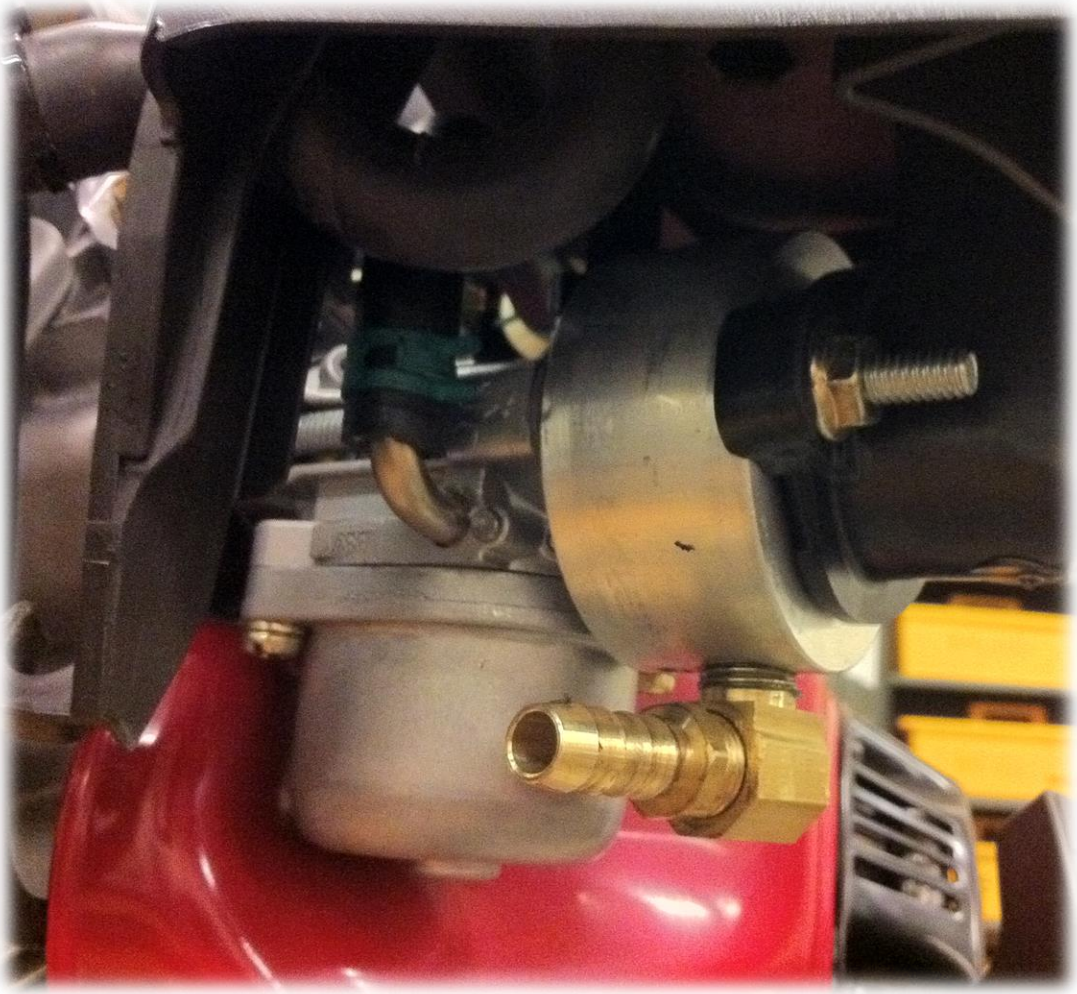
Test Setup

- Connection from High Pressure Regulator to Low Pressure Regulator

Blue Innovations

Test Setup



- Carburetor adaptor plate

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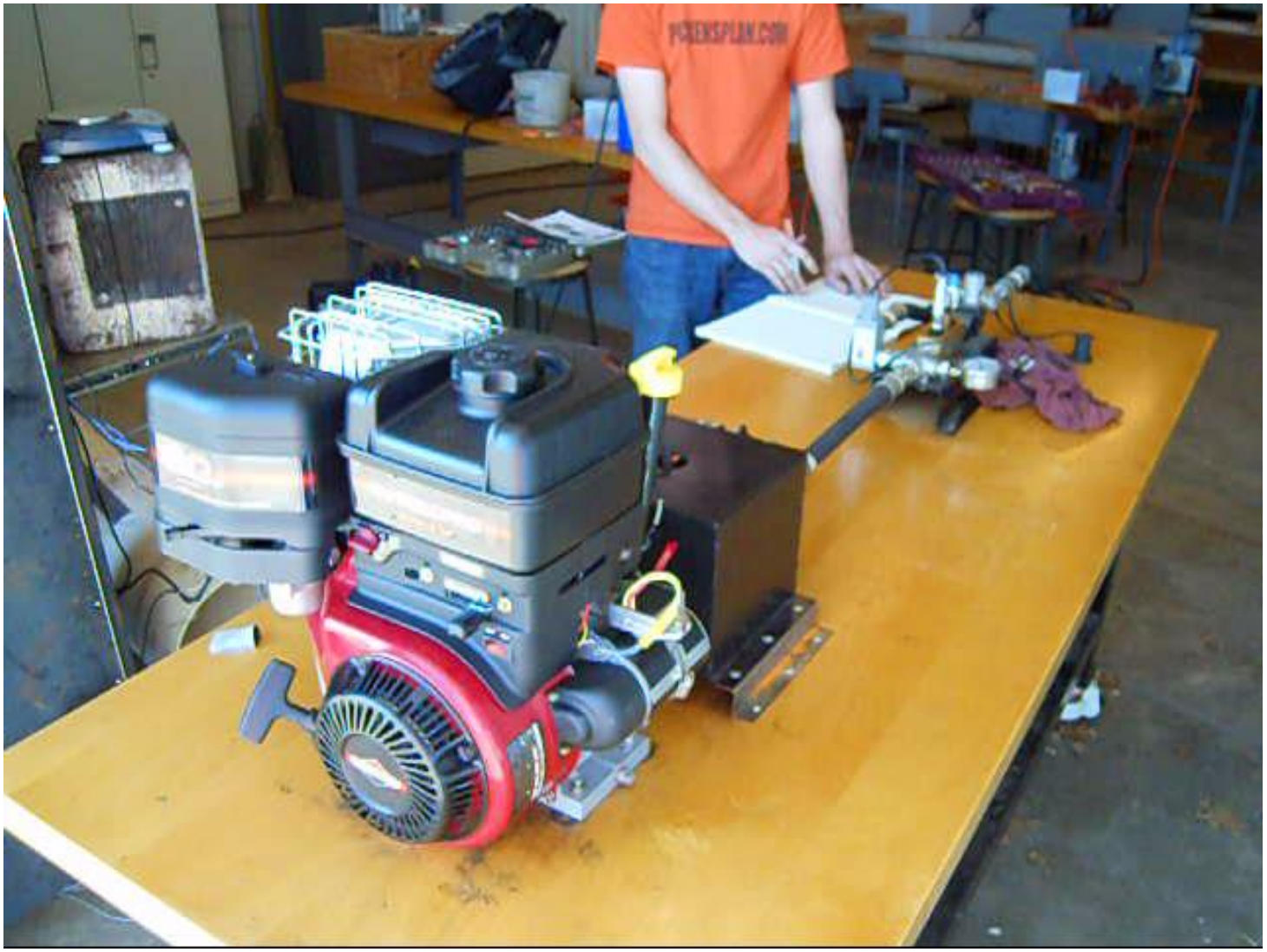
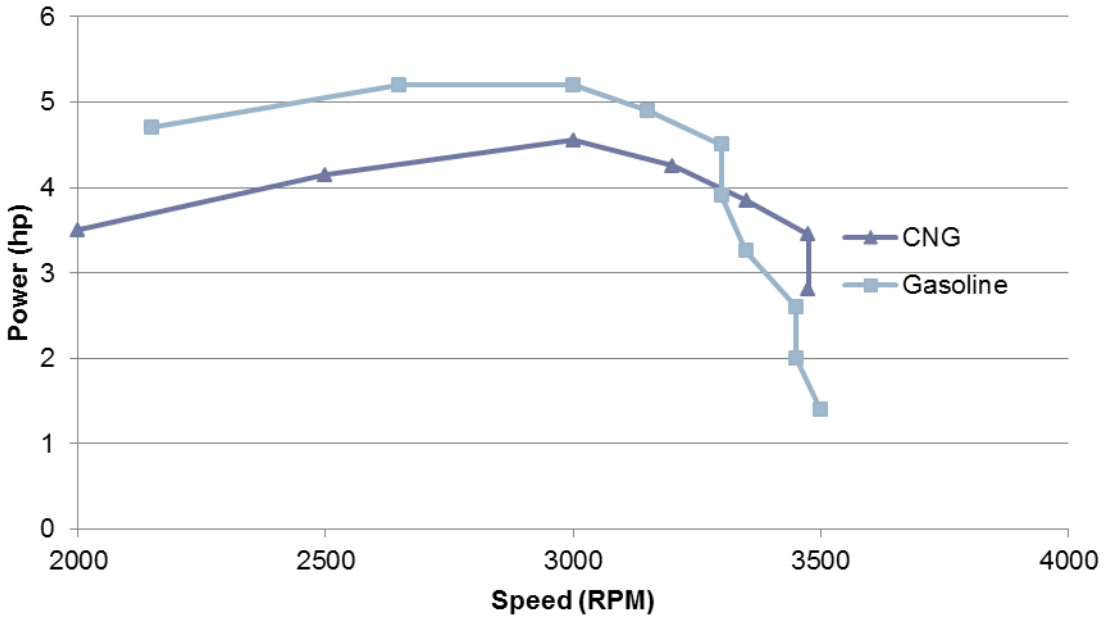
Dyno Testing



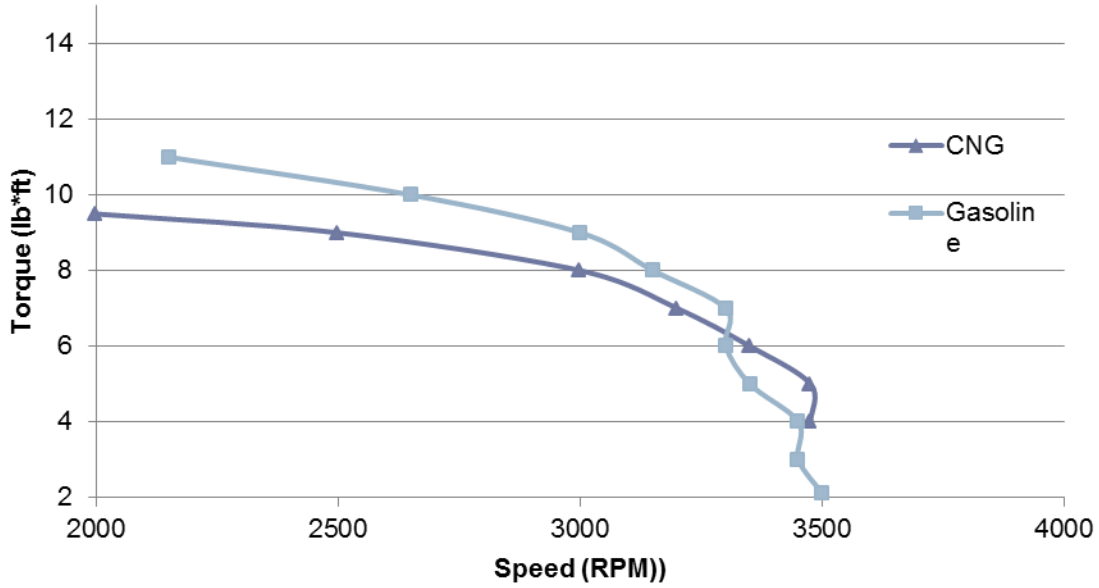
Blue Innovations

Dyno Testing



Blue Innovations

Dyno Testing



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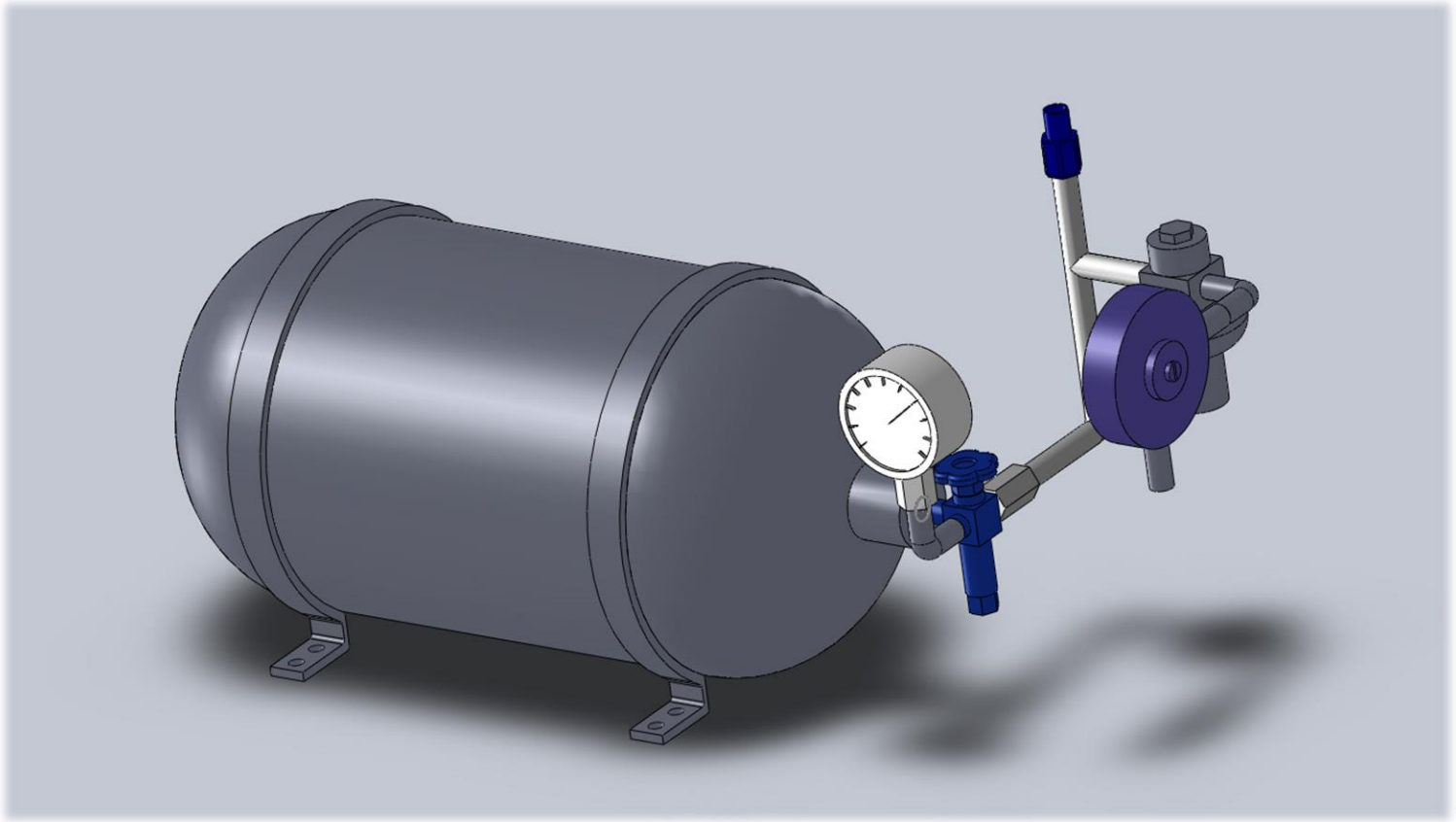
Assembled Kit



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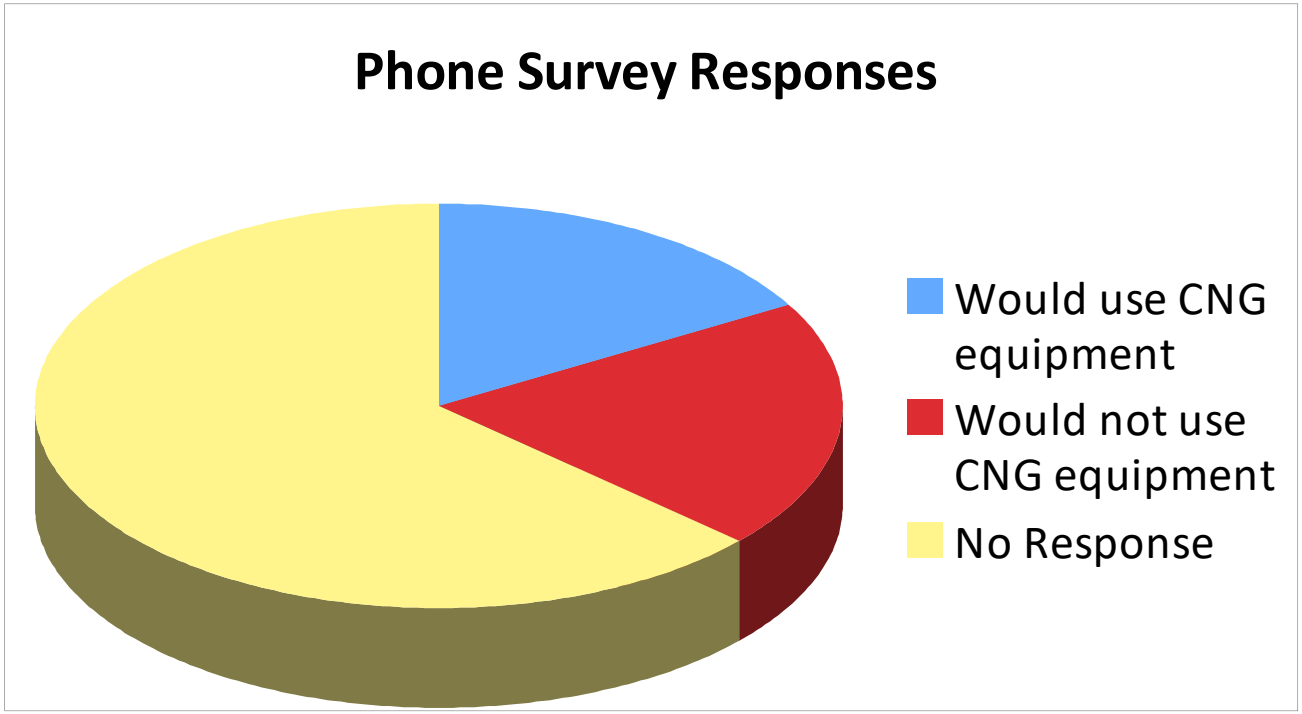
Market Research



- Contacted 31 lawn care companies
- 12 gave responses

Blue Innovations

Alternative Fuel Competitors

- CNG
  - Dixie Chopper Eco-Eagle

Source: www.dixiechopper.com

Source: www.ferrisindustries.com

- Propane
  - FERRIS IS® 3100ZP
  - Zipper Front Mount STS -28 LP

Source: www.zippermowers.com

- Electric
  - Solar Inc. Recharge Mower™

Source: www.rechargemower.com

Blue Innovations

Business Analysis

Golf course with converted fleet

↓

Slow fill system ($10,000/system)

↓

One tank of CNG per day

↓

Money saved

Golf course with converted fleet

↓

Hauling mowers to CNG station

↓

Uses more than one tank per day

↓

Paying gas and labor to drive and fill up

↓

Less cost in conversion

Golf course with converted fleet

↓

TGT refuel trailer

↓

Heavy duty truck to pull refuel trailer

↓

Can refuel mowers on site

↓

Cost of maintaining truck and trailer

Blue Innovations

Cost of Goods Sold

Item	Quantity	Price	Cost of good
5/8 refuel coupler	1	50.00	$50.00
pressure gauge 10000 psi	1	95.00	$95.00
5/8 male/female adapter	1	30/pack	$3.00
5/8 316 stainless steel pipe	25 inch	4.22/ft	$8.80
18 gauge steel sheet	18 sq ft	3.25/sq ft	$58.50
7.2 GGE type 4 tank	1	1,800.00	$1,800.00
1/4 Angle	2 ft	.75/ft	$1.40
1/4 1.5 inch galvanized bolt	10	0.11	$1.10
1/4 galvanized nuts	10	0.03	$0.30
1/4 galvanized washers	10	0.04	$0.40
5/8 ball valve	1	58.80	$58.80
Regulator	1	70.00	$70.00
carb plate	1	100.00	$100.00
studs	2	2.00	$4.00
rubber hose	4	1.00 ft	$4.00
air line extender	1	10.00	$10.00
low pressure regulator	1	39.99	$39.99
Cost of Conversion Kit			$2,305.29

Blue Innovations

Financial Analysis Assumptions

- Marketing budget
  - $8,000
- Sales Commission
  - 10%
- Delivery cost/unit
  - $25.00
- Inflation rate
  - 1.5%
- Discount rate
  - 6%
- Markup
  - 20%
- Sales growth
  - 8%

Net present value = $(21,217)

Blue Innovations

Marketing

- Objectives
  - to sell 20 units in the first year
  - to promote CNG to course managers as a more efficient fuel
  - to promote CNG to golfers as green
- Audience
  - Golf courses managers
  - Large landscaping companies, city contracts, parks and recreation
  - Golfers, voters, eco-conscious people
- Plan
  - Ads in trade magazines
  - Ads at Blue Energy Fuels CNG stations
  - Brochures for mechanic shops
  - Promotional materials (golf tees, etc)
  - Trade shows

Blue Innovations

Industry Trade Shows

- Central Oklahoma Clean Cities Alternative Fuel Vehicle Fair
  - April 2012
  - Oklahoma City, Okla.
  - Open to the public, business owners, fleet operations, automotive techs and students, and advanced technology vehicle enthusiasts
- Golf Industry Show
  - Feb. 29-March 1, 2012
  - Las Vegas, Nev.
  - An innovative trade show designed for owners and operators of golf facilities and golf course management professionals

Blue Innovations

Trade Magazines

- Club Manager's Association of America
  - Club Manager magazine
  - Full color and black and white ads
  - Also has online edition with potential for flash ads and hyperlinks
  - Online directory
- Golf Course Superintendent's Association of America
  - Golf Course Management magazine
  - Claims to reach 95% of golf course superintendents
  - Also has online advertising opportunity with a blog
  - Created in 1927

Blue Innovations

Trade Magazines

- Superintendent magazine
  - Online digital edition available for free
  - Spanish-language version
  - Digital edition
  - Professional audience
- Golf Course Industry magazine
  - Digital edition
  - Professional audience

http://www.cmaa.org/template.aspx?id=298
http://www.gcsaa.org/news/publications.aspx

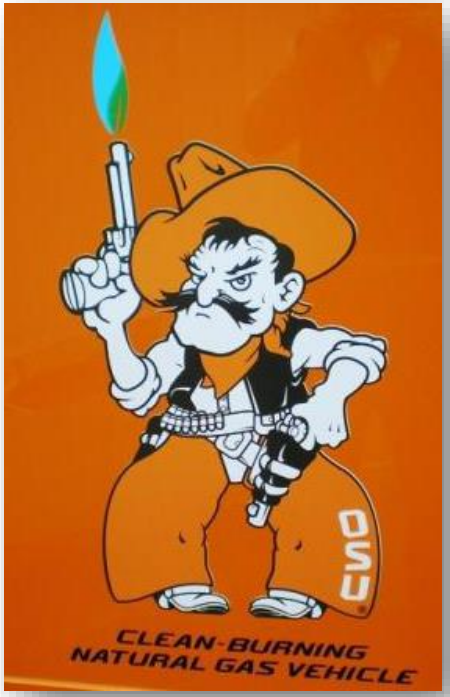
Blue Innovations

Sample Advertisement

Blue Innovations

Thank you

- Court Newkirk – Blue Energy Fuels
- Tom Sewell – Tulsa Gas Technologies
- Innovations Faculty
  - Dr. Weckler
  - Dr. Tilley
  - Dr. Blackwell
  - Dr. Holcomb



Blue Innovations

FALL REPORT

DECEMBER 10, 2010

JACKIE BARBER

KATY SOKOLOSKY

JJ STOECKL

BRADEN WARCUP

THOMAS HYDE

TABLE OF CONTENTS

OVERVIEW

MISSION STATEMENT

Our mission is to provide our partners with innovative solutions that fit their needs both practically and economically by creating a product that will advance the use of natural gas as an alternative fuel.

PROBLEM STATEMENT

The team needs to create a high-end, commercial push mower natural gas conversion kit. The conversion kit must be economically viable for large landscaping businesses that service areas such as golf courses, businesses, and municipalities.

Creating a conversion kit that will allow mowers to legally be used on ozone action days is especially critical for city and town contractors, as they legally cannot use traditional gasoline-powered mowers on those days. Ozone action days occur most frequently during the summer when landscaping crews are likely to be mowing. Action days also occur most frequently in urban areas that would employ large amounts of contractors to mow the cityscape.

The product created must be effective enough to encourage landscape businesses to invest in the CNG refueling skid necessary to make a CNG push mower a reasonable alternative. The product must also be cheaper (or produce more profit) in the long run than traditional gasoline powered mowers. It should also take advantage of CNG's marketability as a clean fuel produced domestically.

OBJECTIVES

The team needs to create a high-end, commercial push lawn mower conversion kit that will allow the mower to run on compressed natural gas. To develop the kit a natural gas pressure regulator will need to be developed to lower the fuel pressure within the engine to a functional level. The team will conduct research to determine the economic viability and safety repercussions of both removable and permanent-mounted CNG fuel tanks. The kit will also include high-pressure fuel lines made from 316 stainless steal and an intake manifold adapter to facilitate safe fuel flow into the mower engine. The kit must make it economically viable for large landscaping businesses that service areas such as golf courses, businesses, and municipalities to convert to and operate their equipment to run on compressed natural gas.

BACKGROUND

Tulsa Gas Technologies is a compressed natural gas service company that has become the largest manufacturer of CNG dispensers in North America. TGT has been a leader in CNG technology for over 18 years.

For 18 years Tulsa Gas Technologies has become a leader in the compressed natural gas service industry. They are the largest manufacturer of CNG dispensers in North America. Owner Tom Sewell is a pioneer in the CNG industry. He is an opinion leader and innovator in the natural gas fueling service industry. TGT is an aggressive and open-minded company researching new types of equipment and their uses and blending new technologies in existing equipment, according to the company's website[1].

A niche market for CNG equipment arose when California passed a law mandating cleaner emissions engines. This law, which heavily impacts the landscaping business, is projected to be copied across the country in locations such as New York, Florida, and Chicago. TGT would be able to successfully market a CNG powered push mowers to large landscaping operations that have to operate within the new environmental restrictions.

SCOPE OF WORK

Blue Innovations will turn in a fall report on Dec. 6, 2010 that contains:

a) Problem statement, statement of work, work breakdown structure and task lists
b) Revised competitive analysis that includes market research, patent searches, and any research conducted during the project
c) Customer requirements
d) Development of engineering specifications
e) Media and communications plan
f) Business plan and financial analysis
g) Design concepts
h) Project schedule and proposed budget

Blue Innovations will present a design proposal on Thursday, Dec. 9, 2010 to peers, professors, and clients that will include all the material presented in the fall report. A website will be developed to showcase the Blue Innovations team and the work completed on this project.

LOCATION OF WORK

The Blue Innovations team will conduct research and develop reports on the campus of Oklahoma State University utilizing the Biosystems and Agricultural Engineering laboratories and computer system. The team will also conduct research at the Helmerich Advanced Technology Research Center and work in conjunction with TGT research and development facilities in Tulsa, Okla. to develop final design plans and create a prototype of a CNG conversion kit.

PERIOD OF PERFORMANCE

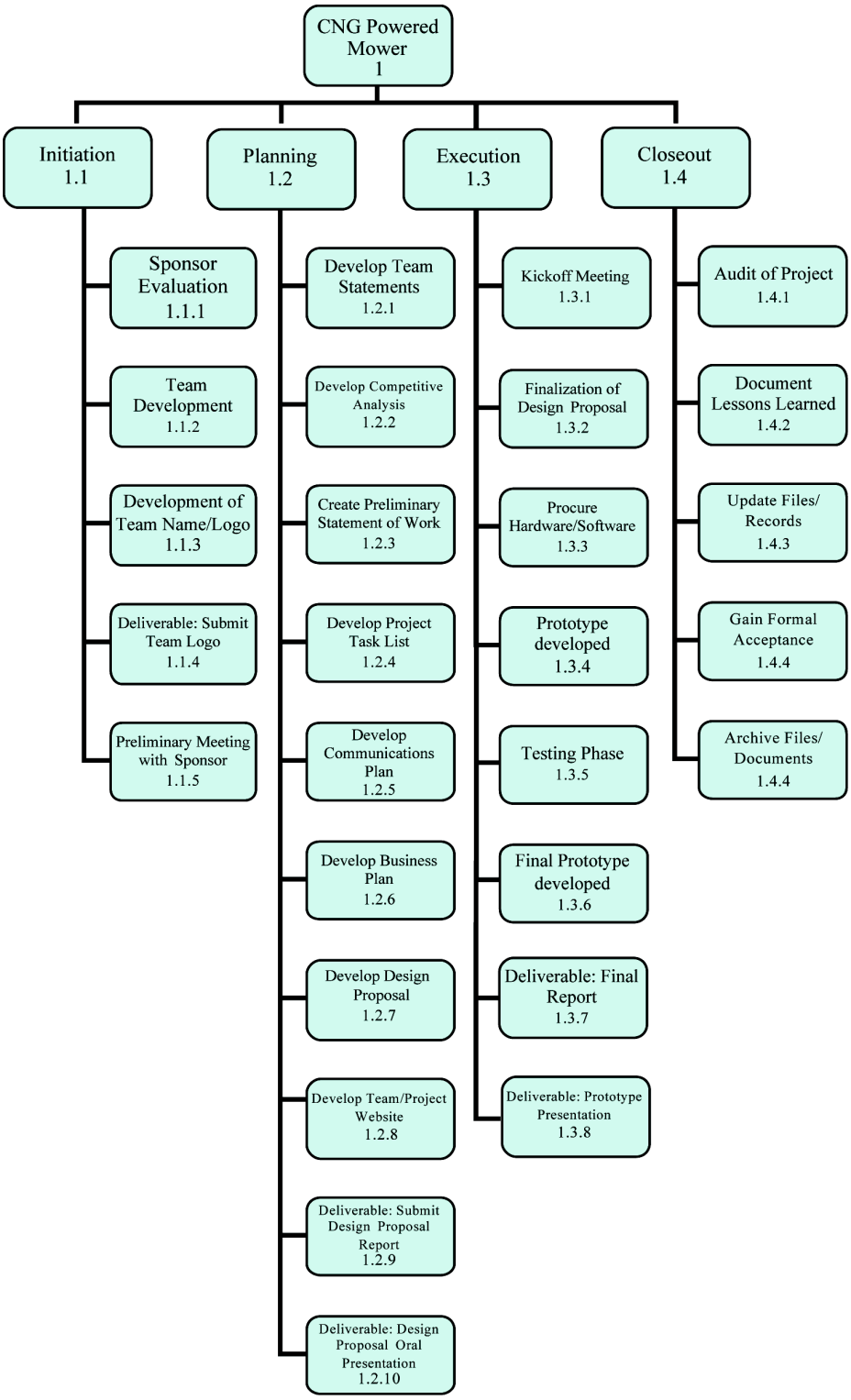
Between August 2010 and May 2011 Blue Innovations will work towards the completion of the project.

DELIVERY REQUIREMENTS

Item	Delivery date
Statement of Work	Oct. 29, 2010
Work breakdown structure	Nov. 5, 2010
Task list	Nov. 8, 2010
First draft	Nov. 15, 2010
Fall report	Dec. 6, 2010
Final presentation	Dec. 9-10, 2010
Web page	Dec. 13, 2010
Evaluations	Dec. 13, 2010

Weekly activity plans will be provided every Monday to professors and team members. Weekly summaries will be compiled every Friday. They will include a summary of the week's accomplishments and any weekend projects. Blue Innovations team will meet weekly on Monday nights at 8 p.m. to accomplish weekly goals.

WORK BREAKDOWN STRUCTURE



Level	WBS Code	Element Name	Definition
1	1	CNG Powered Push Mower	All work to develop a Compressed Natural Gas Powered Push Lawn Mower.
2	**1.1**	**Initiation**	**The work to initiate the project.**
3	1.1.1	Sponsor Evaluation	Instructors evaluate potential projects and sponsors for class.
3	1.1.2	Team Development	Instructors develop five member team to design innovative product for Tulsa Gas Technologies, Inc. Team determines team leader.
3	1.1.3	Development of Team Name/Logo	Team members develop team name and design team logo.
3	1.1.4	Deliverable: Submit Team Logo	Approved team logo is delivered to instructors.
3	1.1.5	Preliminary Meeting with Sponsor	The team members meet with representatives of TGT to determine the product that will be developed then move to the Planning Process.
2	**1.2**	**Planning**	**The work for the planning process for the project.**
3	1.2.1	Develop Team Statements	Team develops a problem and mission statement for project.
3	1.2.2	Develop Competitive Analysis	Team conducts market research and develops a competitive analysis of TGT that includes patent searches that are relevant to CNG powered mowers.
3	1.2.3	Create Preliminary Statement of Work	Team develops a concise definition of project and defines what team plans to deliver to sponsor.
3	1.2.4	Develop Project Task List	Under the direction of the team leader the team develops a task list for deliverables.

3	1.2.5	Develop Communications Plan	Communication team members develop a marketing campaign for CNG powered push mower
3	1.2.6	Develop Business Plan	Business team member develops a financial analysis/business plan for the project
3	1.2.7	Develop Design Proposal	Engineers develop possible designs for a natural gas powered push mower to present to sponsor.
3	1.2.8	Develop Team/Project Website	Develop a simple website that showcases team members and project. It will also contain all final reports and presentations developed by the team.
3	1.2.9	Deliverable: Submit Design Proposal Report	Team will compile Competitive Analysis, SOW, and task list and develop a design concept to present to sponsor.
3	1.2.10	Deliverable: Design Proposal Oral Presentation	The team will present an oral presentation to sponsor, instructors, and classmates at the end of Fall semester that shows the development process of the CNG mower.
2	**1.3**	**Execution**	**Work involved to execute the project.**
3	1.3.1	Kickoff Meeting	Team conducts a formal kick off meeting with the project sponsor TGT to gain approval to move ahead with development.
3	1.3.2	Finalization of Design Proposal	Team works with sponsor to make final adjustments to proposed mower design.
3	1.3.3	Procure Hardware/Software	The gathering of all hardware, software and facility needs for the project.

3	1.3.4	Prototype developed	Team develops prototype of CNG powered mower for testing.
3	1.3.5	Testing Phase	The mower is evaluated with a select set of users.
3	1.3.6	Final Prototype developed	Final improvements are added to mower.
3	1.3.7	Deliverable: Final Report	Revised Fall report with added design information along with communication and business plan for project.
3	1.3.8	Deliverable: Prototype presentation	Final design is presented to sponsor along with its financial analysis and marketing campaign.
2	**1.4**	**Closeout**	**The work to close-out the project.**
3	1.4.1	Audit of Project	Team conducts self, peer and class evaluations. An audit of all hardware used for the project is conducted to ensure that all purchased products are accounted for and a review of the project budget is conducted to determine how well it was followed.
3	1.4.2	Document Lessons Learned	Team performs a lessons learned meeting and documents the lessons learned for the project.
3	1.4.3	Update Files/Records	Files and records are updated to reflect the completion of project.
3	1.4.4	Archive Files/Documents	All project related files and documents are collected and archived.

TASK LIST

- Market Research
  - Phone survey of landscaping businesses
  - Develop list of similar alternative fueled landscape equipment
- Communication Campaign
  - Develop Website
    - Select color scheme
    - Develop basic page dimensions/Layout
    - Develop file tree
    - Go live
    - Upload content
  - Image Development
    - Create:
      - Logo
      - Letterhead
      - Brochure
      - Team Polos
- Research DOT and EPA safety regulations
  - Develop list of regulations/requirements mower must meet
- Test an available generator conversion kit
- Decide mower design to develop based on:
  - Lawnmower deck size
  - Price
  - Horsepower
  - Safety requirements
  - Permanent or removable fuel tank
  - Refueling coupler placement
  - Efficiency calculations
  - "Idiot" proofing
- Fall Report
  - Revise statement of work
  - Compile and expand market research into market analysis
  - Write sections individually
  - Revise
  - Cite sources in an appendix
- Fall Presentation
  - Create PowerPoint presentation
  - Develop basic script for the presentation
  - Individual and group practice
  - Present to client

- Spring Engineering tasks
    - Determine which design to build a prototype of
    - Select components to use for mower prototype construction
    - Order and make components for mower construction
    - Construct mower prototype
    - Test mower prototype
    - Make revisions, improvements, and fix malfunctioning parts of prototype
    - Retest Prototype
    - Finalize mower prototype
- Spring Final Report
    - Revise, Revise, Revise fall report
    - Expand testing section with results from spring semester testing
        - Include graphs, tables, and illustrations of development process
    - Cite any additional sources use in appendix
- Spring Final Presentation
    - Expand fall PowerPoint to include work completed during spring semester
    - Include solid works designs
    - Develop updated script for presentation
    - Individual and group practice

COMPETITIVE ANALYSIS, RESEARCH AND INVESTIGATIONS

BACKGROUND

Blue Energy Fuels is a new company formed by a partnership between Tulsa Gas Technologies and Wilco Machine and Fabrication. Although Blue Energy Fuels is less than one year old, TGT and Wilco Machine and Fabrication have a combined 65 years of experience in the natural gas industry. TGT converts automobiles to run on compressed natural gas. The owner of TGT, Tom Sewell, also was involved in creating the CNG-powered Dixie Chopper riding lawnmower. Wilco Machine and Fabrication produces and tests CNG storage vessels.

Blue Energy Fuels builds and runs CNG refueling stations. The company offers a full service maintenance package with every station it builds. The company has also developed a credit card system that allows fleet owners to control and monitor access to their private refueling stations.

PROBLEM

Blue Energy Fuels and Tulsa Gas Technologies have expressed interest in furthering their involvement in the natural gas industry. The clean air laws passed in California that are expected to eventually become standard nation-wide have created a niche market for low emissions, compressed natural gas lawn mowers.

The company needs a converter kit to allow a standard, high-end commercial mower with a 21 inch-33 inch mowing deck to run on compressed natural gas. The conversion kit and CNG tank need to exceed all safety standards while maintaining a reasonable overhead cost for the customer.

Blue Innovations will create a conversion kit that will allow a high-end commercial self propelled walk behind mower to run on compressed natural gas and allow Blue Energy Fuels to fill an expanding niche market and capitalize on the business value of being “green.”

SWOT Analysis

Strengths

A compressed natural gas mower would be cheaper to fuel and maintain than a traditional gas powered mower. In natural gas equipment you do not have to change the oil half as much as the gasoline powered equipment. Compressed natural gas equipment has a low air pollution foot print on the environment. This low foot print allows it to comply with California clean air admissions.

Weaknesses

This mower with the present price of a bottle makes the price about 27 percent of the cost of the mowers. The cost of repairing the mower will go up if it ever breaks. Finding someone who will work on the mower and know what they are doing is a lot higher. The transpiration of the mower becomes harder because you cannot put it in the bake of you truck. You want have to secure it down in your pick up or in or tailor. The refueling of the mover is a weakness because you ether need to have more than one bottle if it is removable. If it is a fixed bottle there is a problem with find a station at has compressed natural gas or has a slid in cascade refueling system for your vehicle.

Opportunities

There is a good niche markets in California and Florida for alternative fueled push mowers. This market was form so that commercial mowers can still mow on clean air emission days. On low emission days at these areas you cannot operate a gas mower or blowers. This will always people who use these thing on any everyday basis for the living to continue to make a living on those days.

Threats

Threats include other alternative fueled mowers fueled by propane or electricity. These mowers are generally cheaper then what are mower will cost they are in the $200 to $500 range. They also have the lower emissions and are cheaper to operate then gasoline mowers. These mowers allow the people who make their living operating mower to operate on low emissions day. Gasoline mowers are also a threat because they are proven in the market place and people know what they are getting. With the gasoline mowers transportation and refueling are not problem ether. You can throw them in your truck with relatively no consequences. The refueling issue is solved because you can refuel them in most every town in multiple places or the gas can in the back of your truck.

INDUSTRY ANALYSIS

ECONOMIC CONDITIONS AFFECTING THE INDUSTRY

Until 2015, federal and state tax credits will be given for converting personal and fleet vehicles to compressed natural gas[1]. The cost of converting a vehicle is approximately $13,500[2]. Tax incentives do not extend to converting small engines to CNG, but fleets that have already converted to CNG would be able to refill tanks on small equipment like lawn mowers using their fleet tanks. The high prices of oil-based fuels also affect the decision to convert to CNG. CNG is roughly half the price of gasoline, although it must be obtained at specialized filling stations[3].

There is also a high overhead associated with converting to CNG when installing on-site refueling stations or purchasing a refueling trailer. However, businesses who run equipment on CNG can market themselves as "green." CNG also allows for longer engine life than gasoline.

INDUSTRY SIZE AND GROWTH

The CNG industry has been growing at a rate of 30.6 percent since 2000[4]. Globally, CNG has become a standard in taxis, buses and other forms of public transportation. Figures 1.1-1.2 shows the growth of natural gas vehicles around the world. As the world looks for alternatives to petroleum-based fuels, natural gas has gained ground.

Large natural gas reserves in the United States mean that many politicians and businessmen are looking to natural gas to solve U.S. dependence on foreign oil. Natural gas entered the political arena as a cleaner-burning alternative fuel but is now being championed by those hoping to eliminate reliance on OPEC for fuel. The Pickens Plan, proposed by oil tycoon T. Boone Pickens, seeks to use natural gas as the main fuel in America. The Bush Institute on Economic Growth, sponsored by former U.S. President George W. Bush, devoted its first conference to natural gas. "Natural Gas Nation" sought to promote the replacement of oil-based fuels with domestic natural gas[5]

GOVERNMENT REGULATIONS

Government regulations affect this industry from two sides. Clean air and emissions regulations create the tax incentives that entice businesses into switching to CNG. The Environmental Protection Agency regulates greenhouse gases, vehicle emissions and the labeling of CNG-

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[1] Oklahoma State Tax Code Title 68, Article 23, 2357.22

[2] Tulsa Gas Technologies. (2010). Retrieved Nov. 14, 2010, from http://www.tulsagastech.com/conversion.html

[3] CNGPrices.com. (2010). *CNG Stations and Prices for the US, Canada, and Europe*. Retrieved Nov. 14, 2010, from http://www.cngprices.com

[4] CNG Now. (2010). *What is CNG?*. Retrieved Nov. 14, 2010, from http://www.cngnow.com/EN-US/WhatIsCNG/pages/default.aspx

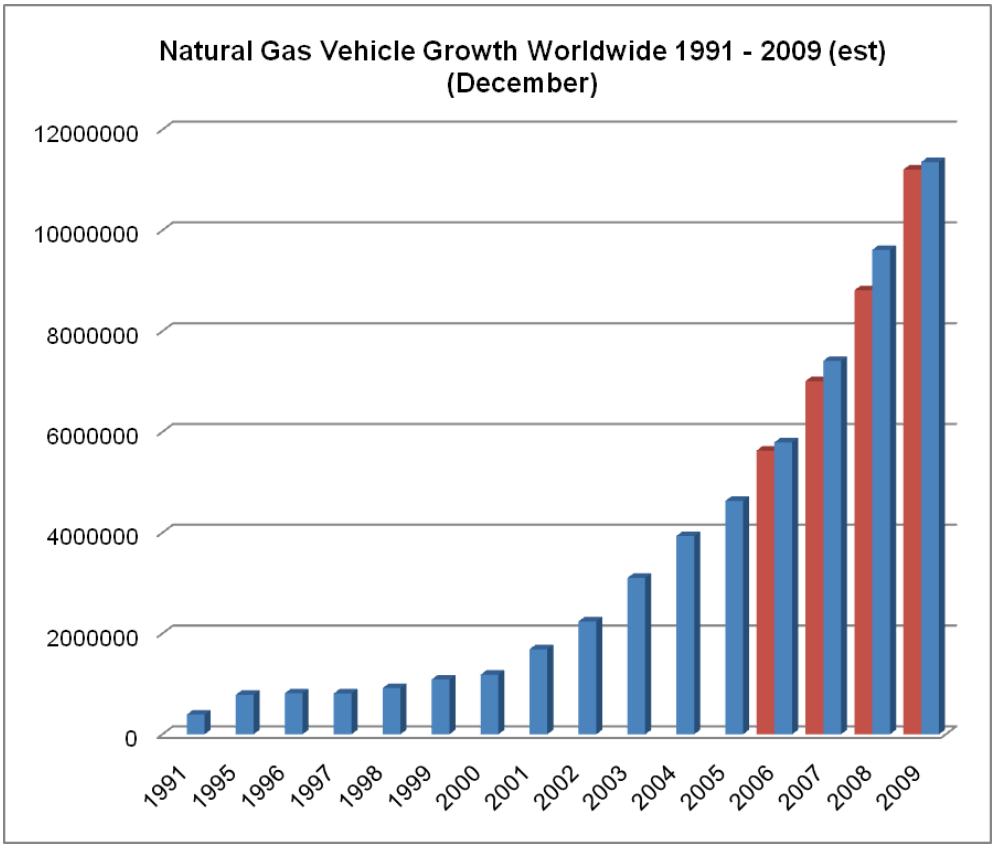
[5] George W. Bush Presidential Center. (2010). *Natural Gas Nation Highlights*. Retrieved Nov. 14, 2010, from http://www.georgewbushcenter.com/articles/natural-gas-nation-highlights

capable vehicles. These regulations restrict the amount of carbon gas a vehicle is permitted to put in the atmosphere. Since CNG is cleaner-burning than fossil fuels like gasoline, these regulations help to promote CNG usage.

California has adopted regulations dictating the amount of pollution small engines like those found on landscaping equipment and lawn mowers can emit[6]. This increased regulation has created a market for cleaner lawn mowers and lawn equipment in California. Since California is such a large market, this also overlaps into manufacturing decision across the country.

Regulations also affect the testing and transport of CNG vessels. Because CNG is held at high pressure inside the tanks, safety is a big concern. The Department of Transportation regulates the transport of all CNG containers, vehicles and other refueling equipment like a CNG trailer. Blue Innovations will have to create a tank that complies with DOT and other safety regulations to allow it to be sold and transported to and by customers

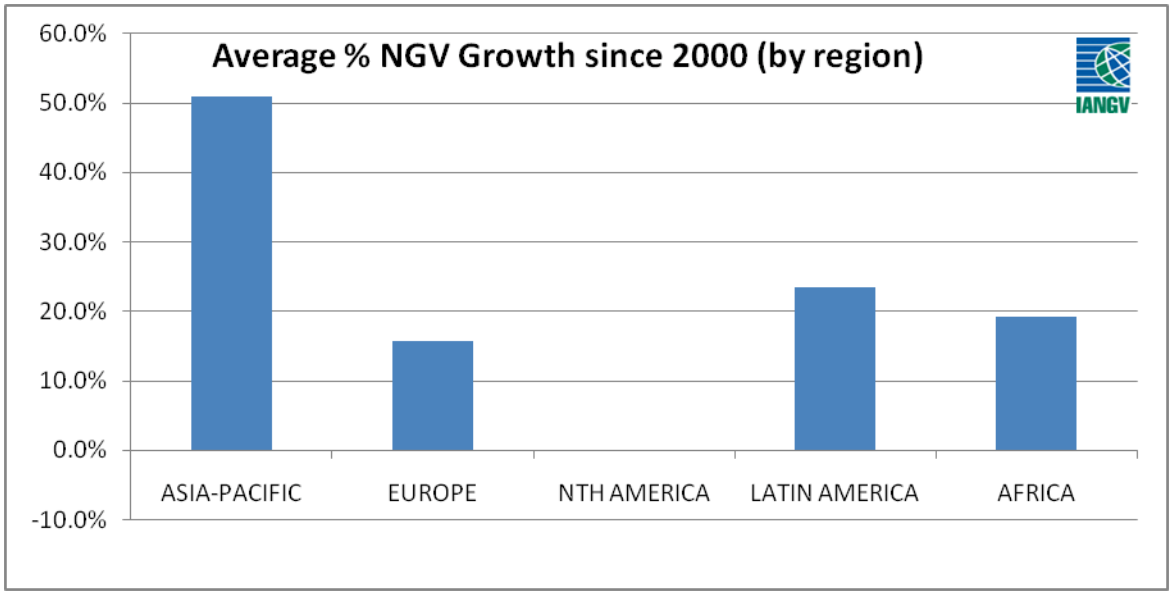
FIGURE 1.1: CNG VEHICLE GROWTH WORLD WIDE[7]



[6] California Exhaust and Emission Regulation Order, Article 1, Chapter 9, Division 3, Title 13

[7] International Association for Natural Gas Vehicles. (2010). *Natural Gas Vehicle Statistics.* Retrieved Nov. 14, 2010, from http://www.iangv.org/tools-resources/statistics.html

FIGURE 1.2: CNG VEHICLE GROWTH BY REGION[8]



KEY RESOURCES

The key resource for the natural gas industry is the abundant supply of domestic natural gas in the United States. The U.S. has an estimated 2,587 trillion cubic feet of recoverable natural gas[9]. Natural gas is an alternative fuel that is typically endorsed by people hoping to lower carbon emissions and those whose primary goal is to reduce dependence on foreign oil. U.S. natural gas has made CNG powered vehicles a political talking point and lead to tax incentives and regulations promoting cleaner fuels and natural gas. Natural gas also is a resource for a marketing campaign as it is cheaper and greener than traditional fuels.

The manufactured resources available to Blue Innovations are compression technology, refueling stations, drilling technology and equipment, and engine conversion technology. The group also has testing facilities available through Blue Energy Fuels and Wilco Machine and Fabrication. The Helmerich Advanced Technology and Research Center at Oklahoma State University-Tulsa is available also for testing and for production of a composite tank.

[8] International Association for Natural Gas Vehicles. (2010). *Natural Gas Vehicle Statistics.* Retrieved Nov. 14, 2010, from http://www.iangv.org/tools-resources/statistics.html

[9] NaturalGas.org. (2010). *NaturalGas.org*. Retrieved Nov. 14, 2010, from http://www.naturalgas.org/overview/resources.asp

CUSTOMERS/BUYERS

MARKET SIZE

The target customer of a CNG powered commercial push mower is landscaping businesses who must comply with EPA and California Air Emissions standards. These businesses would serve municipalities and areas such as golf courses and airports. The customers could be independent businesses or the in-house grounds crews employed by cities, airports or golf courses. The product would be used primarily to trim around obstacles and mow spaces to small for larger riding lawn mowers.

Cities are under pressure to operate within a budget, keep the city looking nice, and avoid mowing on ozone action days. Despite an initial overhead, running CNG equipment is cheaper over time. Cities could also mow on ozone action days because CNG lawn mowers do not release as much carbon gas as traditional gasoline mowers. Being able to mow on ozone action days would allow cities to better maintain their landscaping. Private companies also would benefit from having more days when they could mow and by catering to the niche market of "green" consumers.

There is also a potential niche market of "prosumer" buyers who want to privately operate high-end equipment to maintain their property to a high standard. This market would be extended by also considering consumers who wish to lessen their environmental impact or who are interested in alternative fuels and being green. CNG push mowers could also be easily refueled by customers who already drive a CNG vehicle and have a home slow-fill overnight refueling station.

Although there currently is a riding lawn mower powered by CNG available on the market, there is no corresponding push mower[10]. Landscaping companies that have switched their fleet over to CNG and are operating a CNG riding mower like the Dixie Chopper Eco-Eagle would still have to use gasoline to power small equipment like push mowers, leaf blowers and trimmers.

ECONOMIC STATUS AND DEMOGRAPHICS

This product would be targeted to companies serving governmental agencies and municipalities. Cities spend a substantial amount of money mowing and therefore could benefit more quickly from the long term cost benefits of running CNG equipment. For example, the city of Tulsa spends $35,000 each mowing cycle, and so could benefit from longer engine life and reduced fueling costs[11].

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[10] Dixie Chopper. (2010). *Eco-Eagle*. Retrieved Nov. 14, 2010, from http://www.dixiechopper.com/mowers/view-mowers/eco-eagle

[11] News on 6. (2010). *City of Tulsa Begins Mowing City Parks*. Retrieved Nov. 14, 2010, from http://www.newson6.com/Global/story.asp?S=12333101

Many of the individual landscaping companies would be independently or family owned and operated. Most of the companies would operate in one area only. Although their clients might be concerned with being green, the companies themselves would be more concerned with being profitable. High overhead investments would need to be backed up with solid evidence of future profitability. These companies would also be concerned with meeting environmental regulations and with worker safety. Ease of operation is also a concern with this product because of the potential decreased ease of refueling.

COMPANY AND ITS RESOURCES

MANAGEMENT TEAM

Court Newkirk is the general manager of Blue Energy Fuels, LLC. He is responsible for the marketing side of the business. Tom Sewell is the president of Tulsa Gas Technologies. He is responsible for the sales and operations of TGT. Charles Sewell is the vice president of TGT and is responsible for research and development.

PRODUCT LINE

Tulsa Gas Technologies, Inc. manufactures CNG dispensing equipment and related control systems that refuel alternative fueled vehicles, a Lighting Management System (LMS), which controls exterior lights of more than 500 gasoline stations and convenience stores across the country, and is a PHILL FuelMaker and Oasis valve distributor.

MANUFACTURING EXPERTISE AND CAPACITY

Owner Tom Sewell is an expert in the compressed natural gas field. He began working in the industry in the late 1980s.

INPUT SUPPLIERS

Tulsa Gas Technologies, Inc. fabricates almost all of the parts required for the products they sell. TGT is also a distributor of PHILL FuelMaker home fueling systems and Oasis valves.

PRODUCTS

Blue Innovations will need to contact TGT for pricing, financing, and maintenance costs of their products, their financial condition, income statements and cash flow. We will also have to contact TGT for a list of current distribution of their products and key current customers.

PROMOTION PROGRAMS AND CURRENT CAMPAIGNS

Blue Energy Fuels (BEF) is a joint venture of two of Oklahoma's leading manufacturers in the oil and gas industry[12]. These two companies combined their manufacturing experience to design and build the most modern and efficient compressed natural gas (CNG) fueling stations available.

[12] Blue Energy Fuels. (2010). *Blue Energy Fuels*. Retrieved Nov. 14, 2010, from http://www.blueenergyfuels.com/blueenergyfuelsb.html

BRAND/REPUTATION/TRADEMARKS

Both Blue Energy Fuels and Tulsa Gas Technologies use the color blue in their logos and marketing campaigns. Blue Energy Fuels also uses green to emphasize the environmental friendliness of compressed natural gas. Tulsa Gas Technologies also uses the slogan "service with the sale" to emphasize the company's role in follow-up services such as refueling and maintenance[13].

FIGURE 2.1: TULSA GAS TECHNOLOGIES LOGO

FIGURE 2.2: BLUE ENERGY FUELS LOGO

[13] Tulsa Gas Technologies. (2010) *Tulsa Gas Technologies.* Retrieved Nov. 14, 2010, from http://www.tulsagastech.com/index.html

COMPETITORS

COMPETING COMPANIES

Although no other company currently produces a conversion kit for a push mower or a push mower powered by CNG, there are products that compete on several levels. The largest competitor is the traditional gasoline powered mower because it has familiarity, comfort and can be refueled at any traditional gas station. A variety of alternative fuels also compete with natural gas. Propane and battery powered lawn mowers capitalize on environmental responsibility. Figure 2.1 shows a breakdown of competitors and their products.

FIGURE 3.1: COMPETITORS AND PRODUCT DESCRIPTIONS

Company	***Product***	***Price***	***Website***
	CNG Conversion Kits		
Alternative Fuel Technologies, Inc. 1-877-425-8383	3 different systems for converting small engines to CNG systems • Spud-in conversion: lowest cost method, can be difficult to install • Adapter conversion: mid-range in cost and installation time, can run duel fuel, easy to switch back to gasoline, sometimes requires an idle plate to be installed • Carburetor replacement: easiest to install, replaces entire carburetor on engine, only compatible with Kohler, Onan and Tecumseh engines	$130-230	www.propanecarbs.com/small_engines.html
Hendrix Industrial and Gastrux 847-526-1700	CNG and propane conversion kits for small engines using a non-removable bottle. Hendrix makes conversion kits for all kinds of engines ranging from automobiles to small generators.		www.hendrixsystems.com
	Alternative Fuel Mowers		
Dixie Chopper	The Eco-Eagle is the first CNG fueled riding lawn mower. It has a		http://www.dixiechopper.com/mowers/view-

	990 cc engine. The mowing deck is 66 inches and the mower weighs 1,686 lbs. It has two tanks designed to run for four hours each and can cut 6.13 acres per hour.		mowers/eco-eagle
LEHR Lawn Equipment	LEHR makes a push and a self-propelled propane mower. The mowers both have a running time of one hour and weigh 70 lbs. The mowing decks are 20 inches wide. The push mower has a 2-in-1 bagging and mulching system. The self-propelled mower has a 3-in-1 bagging, mulching and side discharge system.	$219 to $285	http://www.golehr.com/products.shtml#8
Cub Cadet	Cub Cadet has a corded mower and a battery powered mower. They both have a 19 inch cutting deck. The mowers have a 2 year limited warranty and a 3-in-1 mulching, bagging, and side discharge system. The battery powered mower has an LED charge indicator.	$249 - 399	http://www.cubcadet.com/webapp/wcs/stores/servlet/gallery_10051_14101_43271_33830_600000_-1_image
Black & Decker	Black & Decker makes a corded electric mower. The 19 inch deck has a lifetime warranty and the mower has a two year warranty. It has a 3-in-1 rear bagging, mulching, and side discharge system. It produces no emissions.	$199 - 239	http://www.homedepot.com/webapp/wcs/stores/servlet/ProductDisplay?storeId=10051&productId=100045379&langId=-1&catalogId=10053&PID=500871&cm_mmc=CJ-_-500871-_-10368321&cpncode=21-85076103-2&AID=10368321&cj=true&srccode=cii_9324560&locStoreNum=3907&marketID=58

Craftsman	Craftsman makes a 19 inch corded electric mower. The mower has a 3-in-1 mulching option and a single lever height adjustment.	$216	http://www.sears.com/shc/s/p_10153_12605_07137016000P?vName=Gifts&cName=Father%27sDay&sName=Backyard%20King&sid=IDx20070921x00003j&srccode=cii_9324560&cpncode=20-63586752-2
Craftsman	Craftsman also makes a 19 inch battery powered mower. It has a 48 volt rechargeable battery and a 3-in-1 deck.	$334 - 374	http://www.searsoutlet.com/d/product_details.jsp?pid=1632&mode=buyUsedOnly&source=googleps
Neuton	Neuton's battery powered mower has a 14 inch deck and a 24 volt battery. It is powered by Duracell and can mow up to a quarter of an acre on one charge. It has a 2-in-1 bagging and mulching function. It is 48 lbs. and produces no emissions.	$399	http://www.sears.com/shc/s/p_10153_12605_07160034000P?vName=Lawn%20&%20Garden&cName=Walk-BehindLawnMowers&sName=Cordless%20Rechargeable%20Mowers&sid=IDx20070921x00003j&srccode=cii_9324560&cpncode=18-71858483-2
	33in Gasoline Powered Mowers		
Club Cadet	G1332 has 13 hp Kawasaki V-Twin OHV engine with a 5 gallon gas tank and 32" steel deck	$2500	www.clubcadet.com
Club Cadet	CC760E 344cc Briggs and Stratton engine with a 33" steel deck	$1499	www.clubcadet.com
Craftsman	Craftsman Professional 88998 has a 12.5 hp Briggs and Stratton Powerbuilt OVH engine with a 33" commercial cut mowing system	$1699	www.craftsman.com

TECHNICAL ANALYSIS

SCIENTIFIC LITERATURE

There is currently only one CNG riding mower and no walk behind mowers available on the market today.

PATENTS

Blue Innovations found four patents that have some relevance to CNG fueling systems. Patent 5,676,117 is dated October 14, 1997. It is titled "Lawnmower powered by alternative fuels," and focuses mostly on fuel injection. Patent 5,878,730 is dated March 9, 1999. It is titled "Lawn Mower Powered by Alternative Fuels Using a Fuel Injector Adapted for Gaseous Fuels," and focuses mostly on LPG fuel injection. Patent 5,941,210 is dated August 24, 1999. It is titled "Gaseous Fuel Direct Injection System for Internal Combustion Engines," and focuses on injection method. Patent 5,411,058 is dated May 2, 1995. It is titled "Method and Apparatus for Utilizing Gaseous and Liquid Fuels in an Internal Combustion Device," and focuses on the combination of gaseous and liquid fuels. These patents are relevant because they discuss using gaseous fluids as a replacement for conventional liquid fuels.

EXPERIMENTS

Blue Innovations will conduct experiments both on the tank and on the lawnmower itself to determine the compatibility of the gas with the engine and also to determine the energy output that can be gained by various volumes. Experiments to determine satisfaction of safety regulations will be conducted by a second party such as Wilco Machine and Fabrication or the Helmerich Center at OSU-Tulsa.

PHYSICAL TEXTING AND DATA COLLECTION

Blue Innovations will need to obtain a 5hp to 6hp engine similar to one on a commercial lawnmower and convert it to CNG so that we may test its limits and power. The group will compare the mower's capabilities with those already on the market and determine its fuel economy. The group will use the fuel economy of the mower to market it as it will save users money on fuel in the long run.

SIMULATION AND MODELING

Blue Innovations are going to make a 3D model of a prototype and mount it in various positions on a lawnmower in order to determine the correct weight distribution in order to maintain the best cut possible.

Blue Innovations would like to have access to some type of design software that has the capability of pressure vessel design so that we can determine the pressure distribution and necessary strength requirements in order to select appropriate materials along with the required diameter and length for the tank.

DESIGN PROPOSAL

MOWER SIZE

Based on the calculations, and the input received from the landscaping companies contacted, a larger commercial walk-behind lawnmower is more feasible. Because of the vast price difference in the mowers, and the small price difference between the CNG systems that would apply to each, a larger mower will provide for a better return on investment. If customers would only spend 10% to 20% more for a lawnmower that ran on CNG, it is more reasonable to design our system for a larger mower due to the price it will cost. Furthermore, since the CNG system will cost relatively the same for both size mowers, it allows for a greater profit if applied to the larger mower. Figure 4.1 shows the design specifications and concerns raised by each tank and mower size proposal.

FIGURE 4.1: SIZE OF MOWER DECK AND SIZE OF TANK

Commercial Lawn Mower Size	**Engine**	**Horsepower (bhp)**	**Fuel Consumption (gal/hour)**	**Tank Size (GGE)***
Walk Behind w/ 21" Deck	Honda GXV160	5.5	0.370	1.48
Wide Area Walk Behind w/ 33" Deck	Honda GXV340	11	0.673	2.69
Wide Area Walk Behind w/ 33" Deck	Honda GXV390	13	0.796	3.18

*Based on a four hour continuous run time

$$BHP(hp) \times Fuel\ Consumption\left(\frac{lb}{hp * h}\right) \times gpm\ conversion(.0020003) \times 60m = Fuel\ Consumption\ (gph)$$

REMOVABLE VS. NON-REMOVABLE TANK

Due to the large amount of regulations, and uncertainty in the CNG market, a permanent tank is more feasible and economical to use in the design of the CNG lawnmower. From a safety standpoint, there is no substitute for the extra sense of security that would come with knowing the tank is permanently mounted to the lawnmower. Also, since a permanent tank will require very little user interaction, it is a safer option all around. Figure 4.2 shows the specifications and design concerns associated with permanent and removable tanks.

REGULATIONS

A removable tank will have to be regulated more strictly not only when on the mower, but also when being transported alone. When the tank is on the mower, there will have to be adequate shielding to prevent anything from striking the tank. Also since it is able to be removed, extra care will be needed to make sure that the tank is not allowed to vibrate. There are numerous DOT regulations dealing with transport of pressurized vessels… all must be followed when dealing with a CNG tank. A secure rack will have to be on the trailer/truck to prevent any movement or vibration while the tanks are being transported.

COST

A removable tank itself could be made cheaper than a permanent tank because it can be inspected and fixed upon removable, where a permanent tank will need to be built stronger in order to last longer on the mower before needing attention.
The extra safety measures, because of the ability to exchange (shielding, rack for transport, etc.), will increase the cost.

EFFICIENCY/FUNCTIONALITY

The efficiency will be the same on paper, but since the tank is able to be removed, it will allow for a much smoother refill and allow the operator to simple switch tanks rather than stopping and loading the mower to take it to a CNG refueling station

HOURS PER REFILL

The hours per refill will be the same since the tanks are the same, but as mentioned before, the refueling process will be eliminated since you can simple remove the empty tank and replace it with a full one

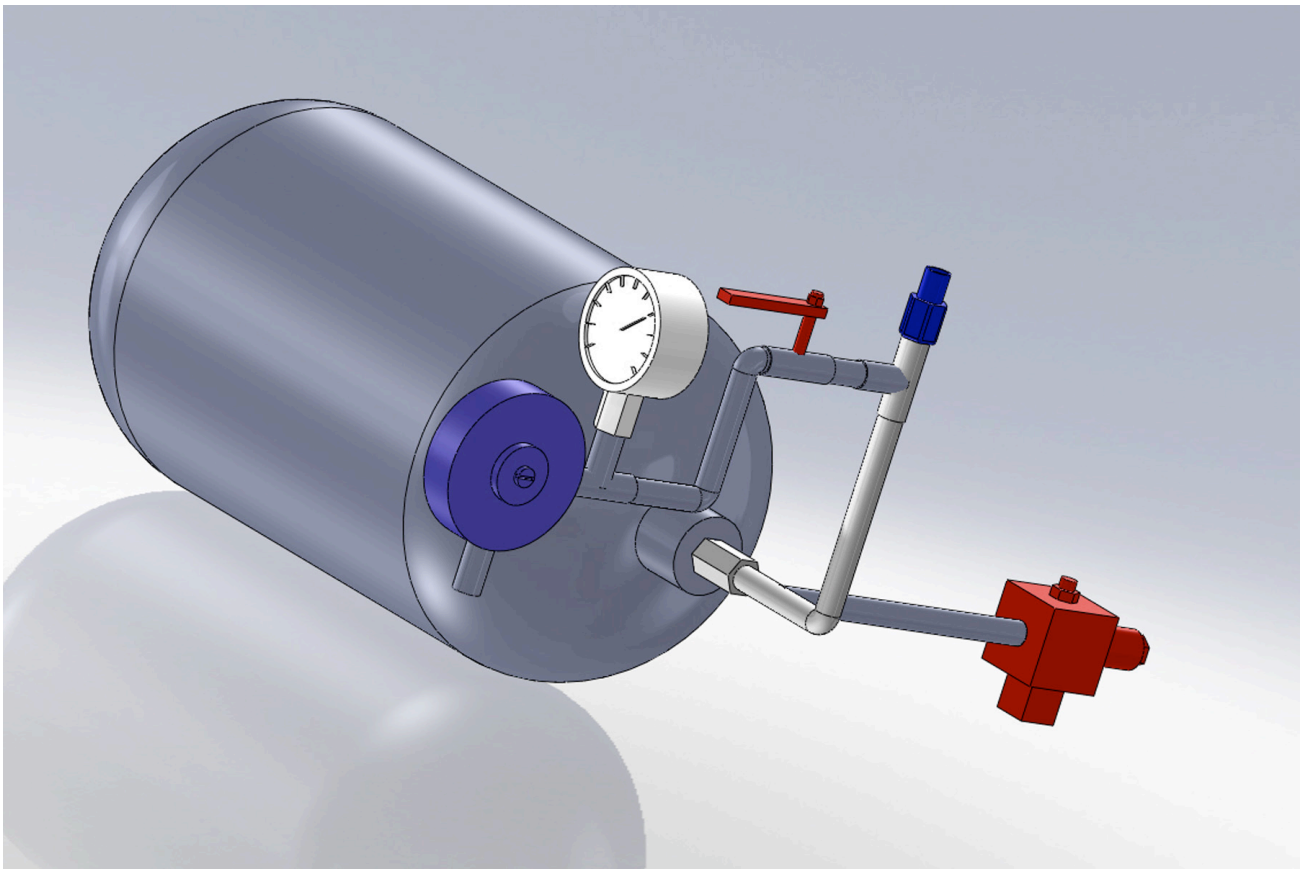
CONVENIENCE

The removable tank will be more convenient in a operational standpoint do to the ease of refuel, but it does pose an inconvenience dealing with the extra safety measures and transport regulations

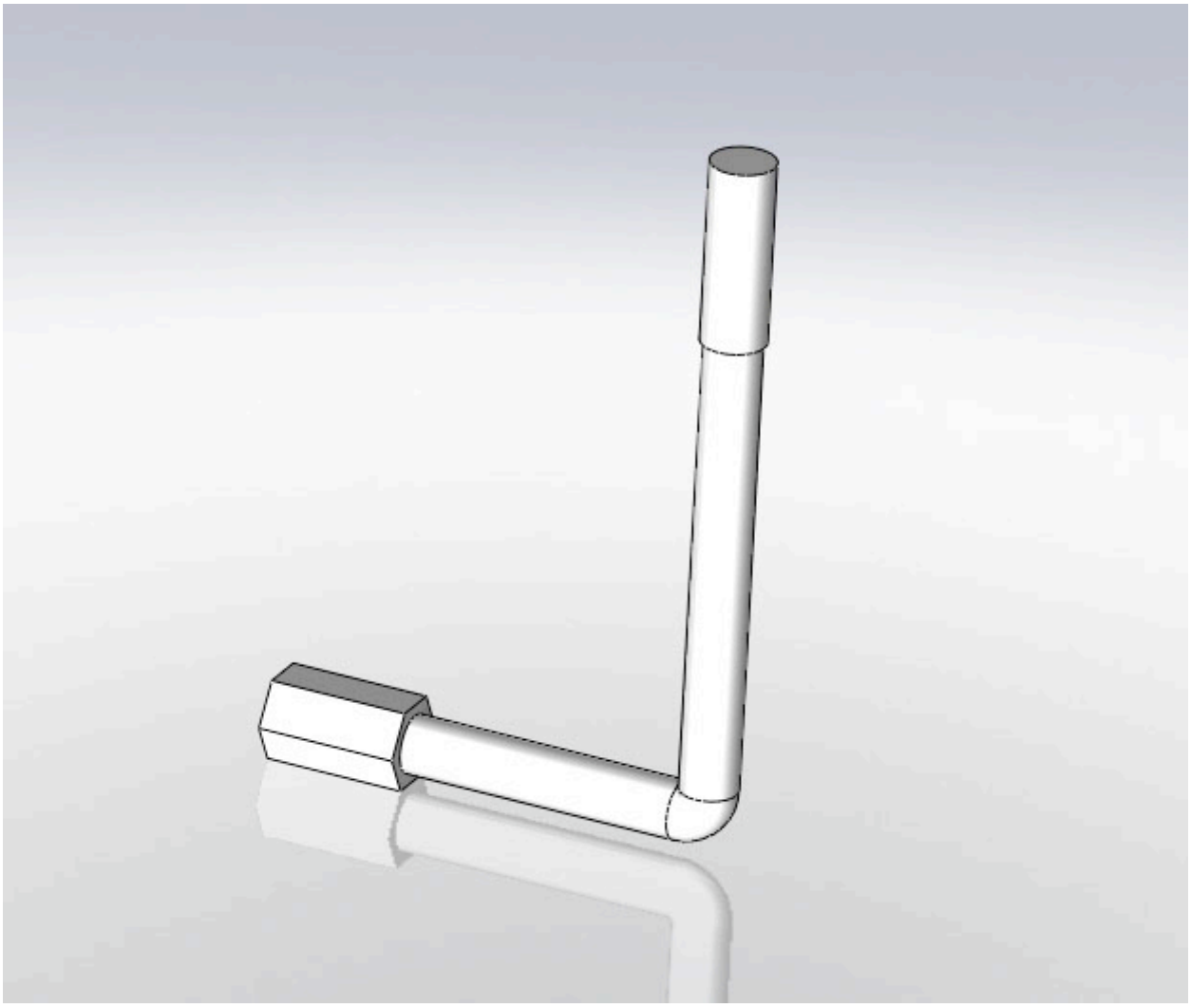
SAFETY

While the removable tank poses a greater safety issue due to the requirement for more precautions, in the long run a removable tank can be safer because the user can take their empty tanks in to CNG tank company/refueling station and simply exchange them for full tanks, where the refueling company can inspect the empty tanks before sending them back out, ensuring safe use in the future.

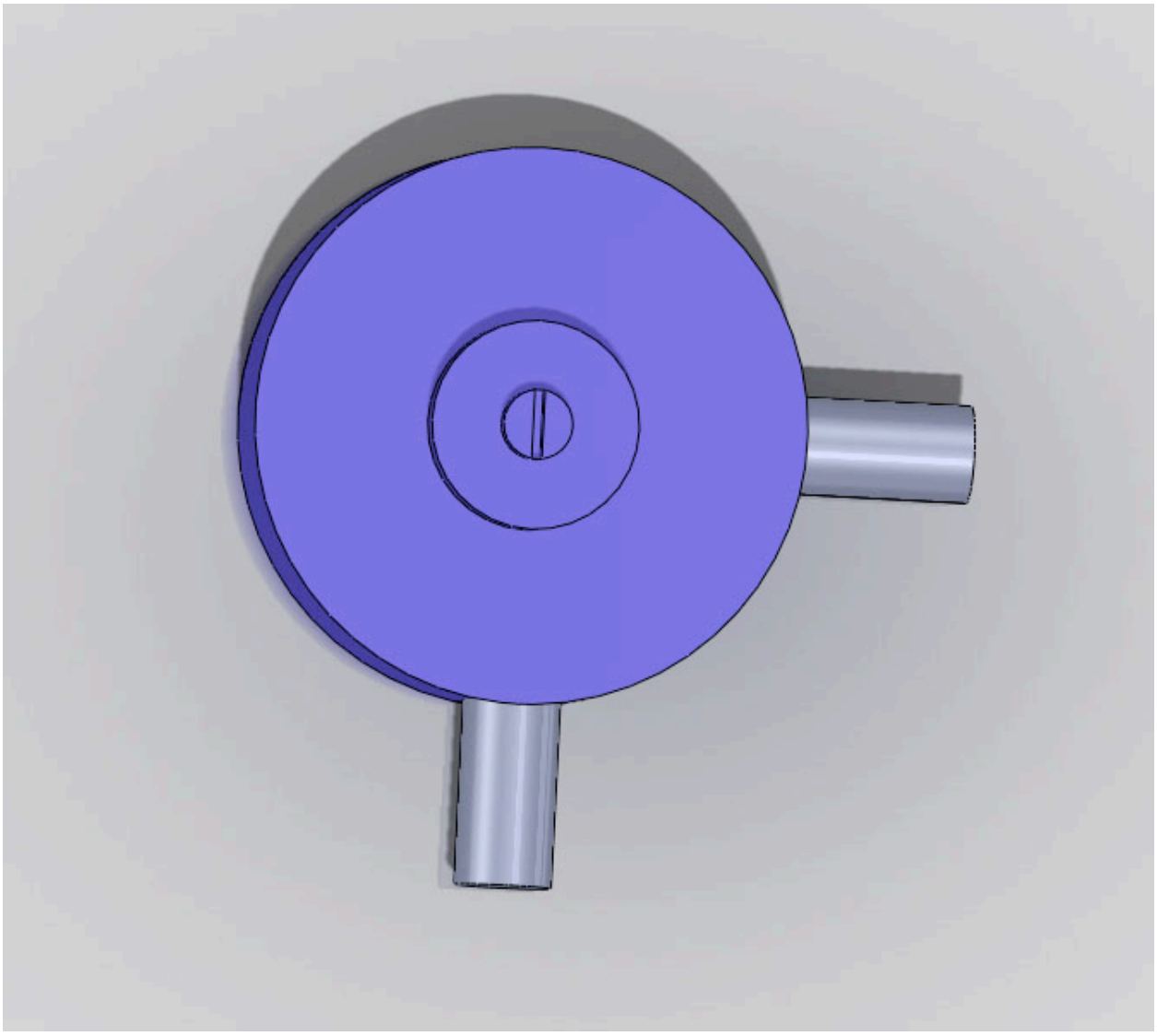
ASSEMBLED KIT



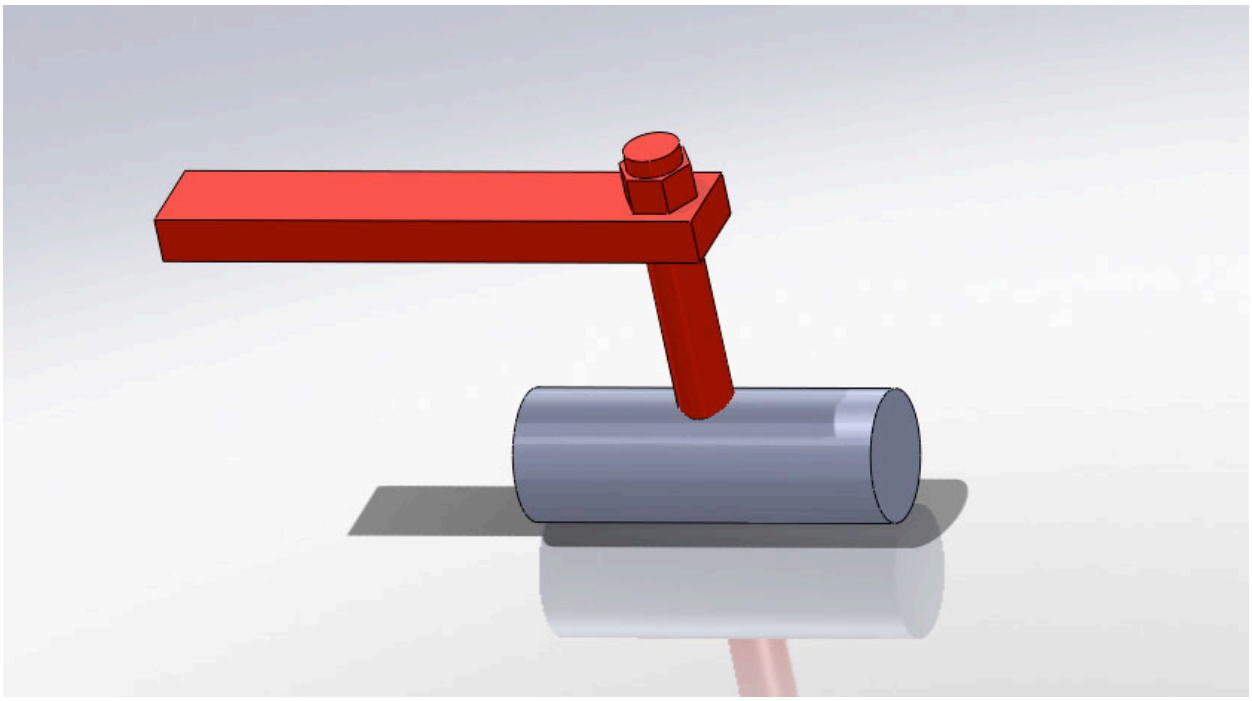
FUEL LINE



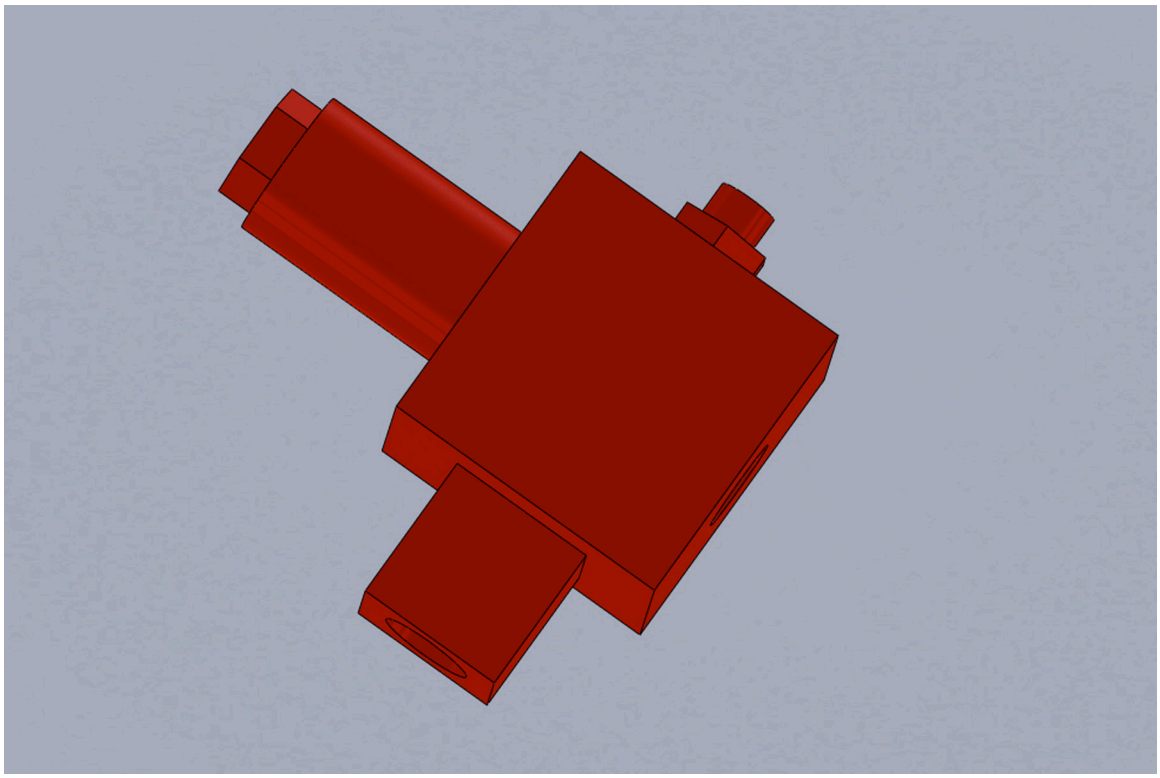
REGULATOR



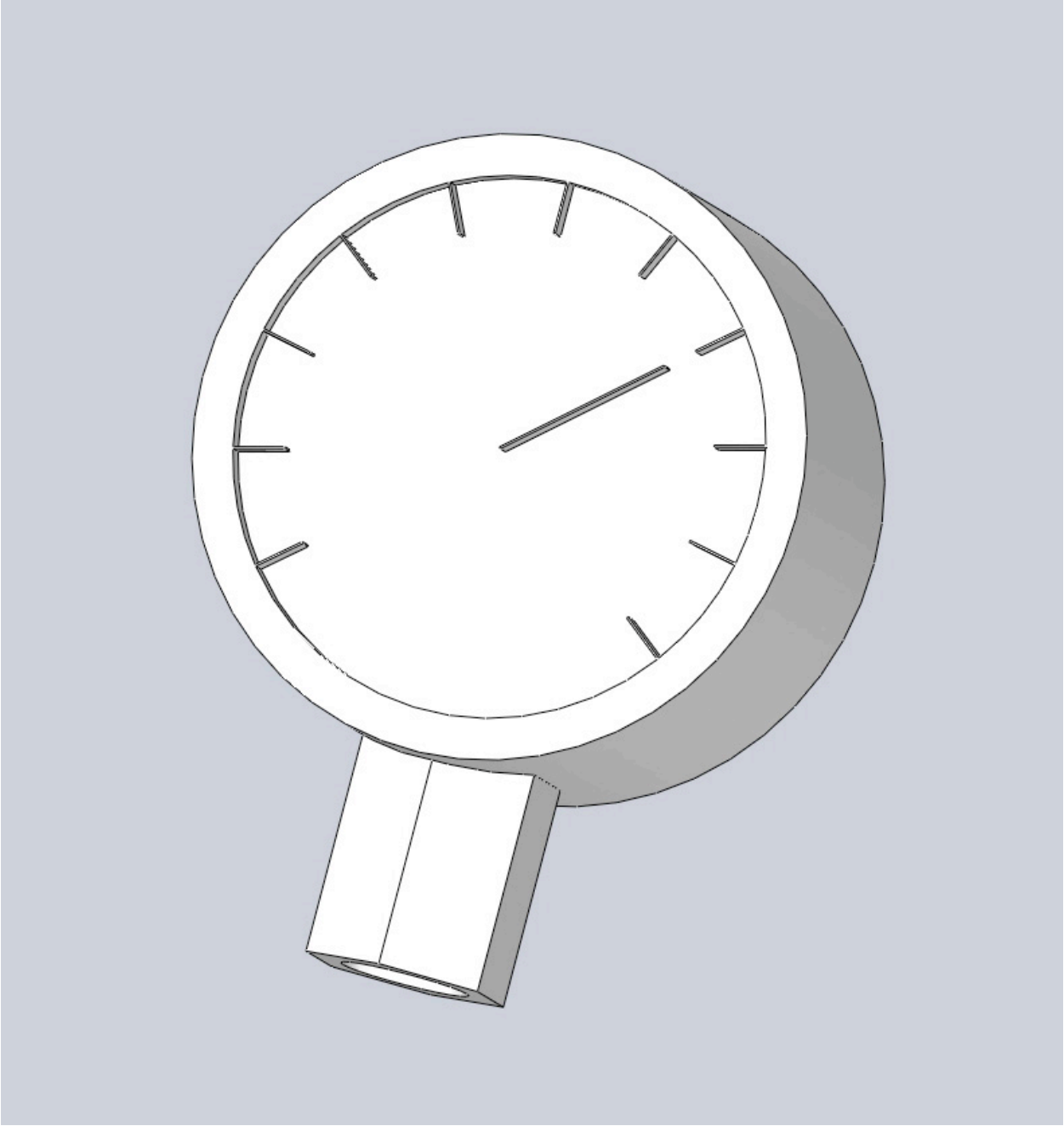
VALVE



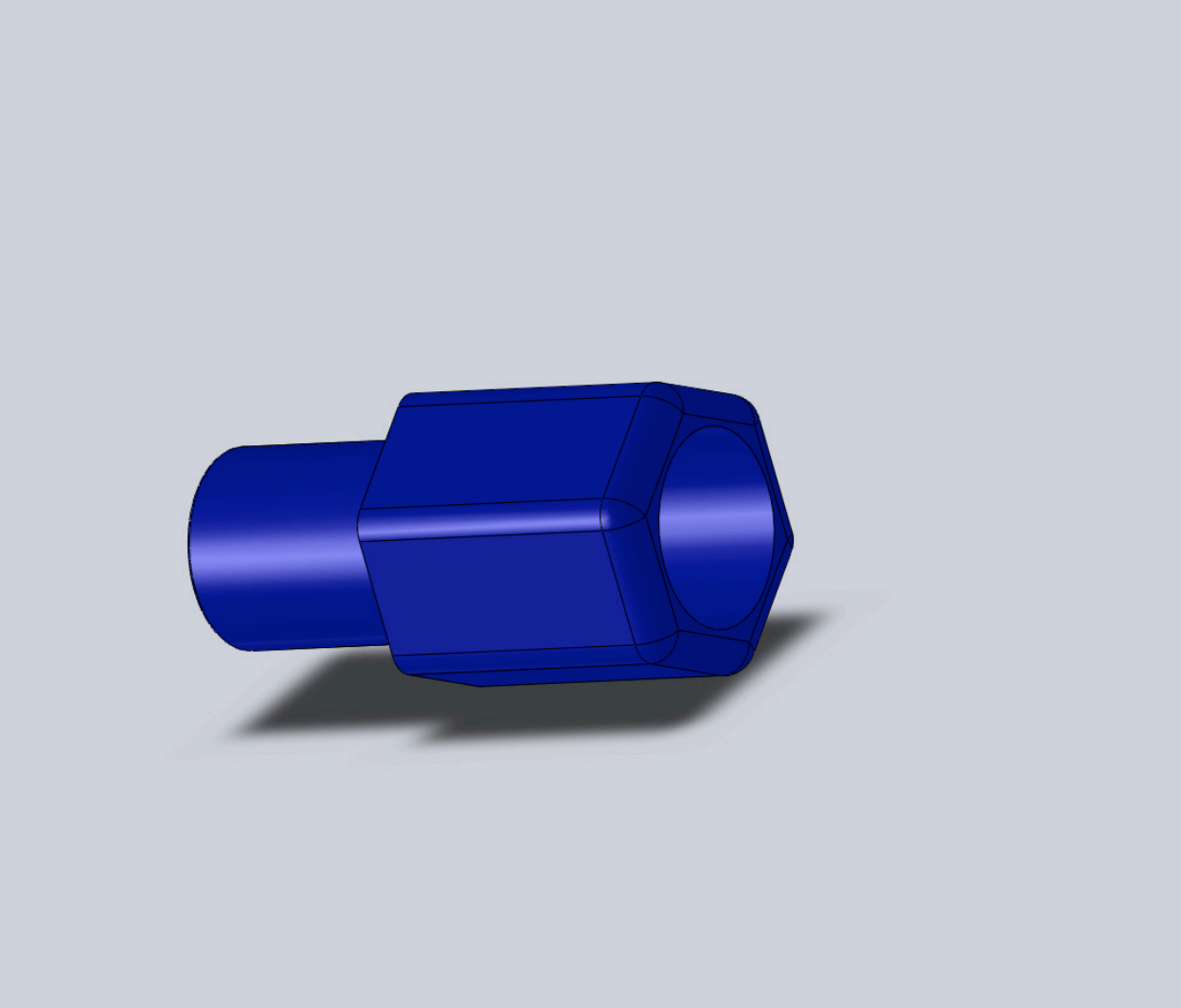
RELIEF VALVE



GAUGE



FUEL COUPLER



PROPOSED MARKETING CAMPAIGN

CURRENT MARKETING RESOURCES

Tulsa Gas Technologies, Inc. (TGT) and Blue Energy Fuels both currently have websites, company logos, and promotional brochures. TGT's website contains a large amount of information about the company's products and services as well as the natural gas industry. However, the way the links and the news blurbs are displayed is not intuitive or user-friendly. This makes it difficult for the customer to easily find what they need. Blue Energy Fuels' website is eye appealing and well organized, but is somewhat vague on the company's services, perhaps because, as a new company, Blue Energy is still defining what it will do. Some pages also have no text on them, the text is actually an imported as a graphic. This would make the site more difficult to edit and restrict the content search engines can use to find the site. Blue Energy also has nothing in its home page title about CNG or CNG dispensers, again limiting the likelihood of getting search engine referrals. TGT is the first search result for "CNG dispensers Oklahoma" and "CNG fueling stations Tulsa" but Blue Energy doesn't show up in the first three pages[14], probably because of the page title.

PROPOSED CAMPAIGN FOR CNG CONVERSION KIT

This product needs a modern, simple, and cohesive designed campaign. We plan to create a campaign theme based on the environmentally friendly aspect of alternative fuels. This will include the designing of brochures, print ads, web based ads, and a product website. All of these elements will have a blue color scheme with green acting as an accent color. The continued public perception of CNG as a clean alternative fuel is essential to the continuation of tax credits and government regulations that encourages conversion.

A secondary marketing plan to specifically target our customer base will focus on being EPA- and other regulation-compliant. The main incentive to business owners for converting to CNG gas will be national and state emissions regulations that make gasoline-powered small engines economically not viable. The campaign will also focus on the long-term savings of converting to CNG. Although the initial investment in CNG conversions can be high, CNG's low cost compared to gas creates long-term savings, especially when an entire fleet is converted.

To promote the CNG mower conversion kit, we will use print advertising, brochures, and a product website. Additionally, the team is open to using web-based advertising, YouTube, and social networking sites to promote the product. We could also use trade shows such as lawn and garden expos and alternative fuel shows to promote the conversion kit.

[14] Using www.google.com as a search engine, no quotes in search terms

TENTATIVE BUDGET

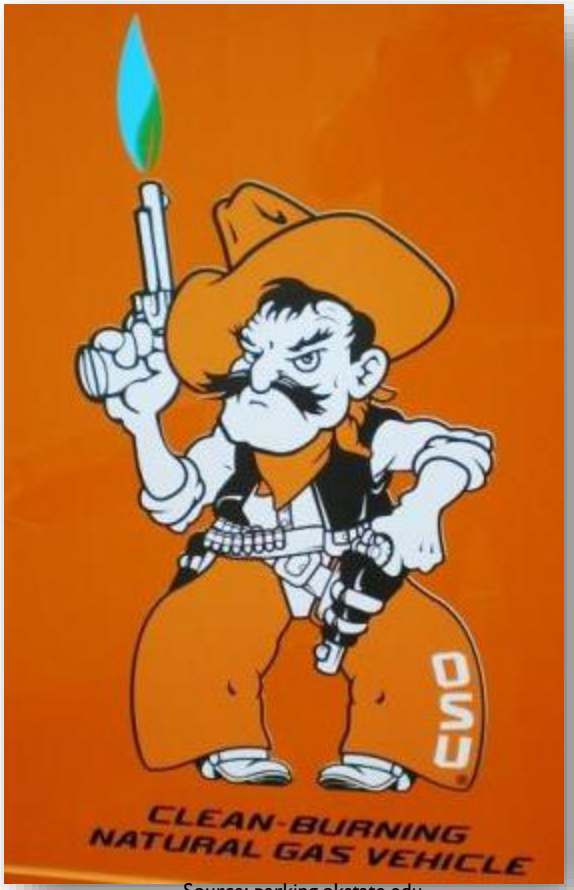
Item	Quantity	Price per ft	Price per Sq foot	Unit Price	Cost of good
refuel coupler	1	x	x	x	$69.00
pressure gauge 10000 psi	1	x	x	$95.00	$95.00
pressure relief valve	1	x	x	$250.00	$250.00
90 degree 4-way elbow	1	x	x	$20.00	$20.00
316 stainless steel pipe	25 in	$4.22	x	x	$8.80
18 gauge steel sheet	18 sq ft	x	$3.25	x	$58.50
5.4 GGE type 4 tank	1	x	X	$1,600.00	$1,600.00
CNG regulator	1	x	x	$60.00	$60.00
ball valve	1	x	x	$150.00	$150.00
Miscellaneous	1	x	x	$6.20	$6.20
Total					**$2,317.50**

*Components shown used to make CNG conversion kit. Cost of the tank is an estimate based on a 5.4 GGE type 4 bottle found at American CNG.com.


Blue
Innovations

Blue Innovations

- Katy Sokolosky, Communications & Team Leader
- JJ Stoekl, Business
- Thomas Hyde, Engineering
- Braden Warcup, Engineering
- Jackie Barber, Communications



Source: parking.okstate.edu

Mission Statement

- Our mission is to provide our partners with innovative solutions that fit their needs both practically and economically by creating a product that will advance the use of natural gas as an alternative fuel.

Problem

- To take advantage of EPA regulations and green energy initiatives
- Advance the use of natural gas as an economically viable alternative fuel

Objective

- Create a conversion kit that will allow high-end commercial, self-propelled mowers to run on CNG
  - Help Blue Energy Fuels/TGT to fill an expanding niche market
  - Give businesses and municipalities opportunity to decrease their impact on the environment

Client Company

- Blue Energy Fuels
  - New company
  - Cooperative effort
  - Fueling stations
- Tulsa Gas Technologies
  - 18 years experience
  - Pioneer in industry
  - Vehicle conversion kits

Natural Gas Industry

- Natural gas is big business in Oklahoma
- Many companies based in Oklahoma
  - Chesapeake Energy, Devon Energy

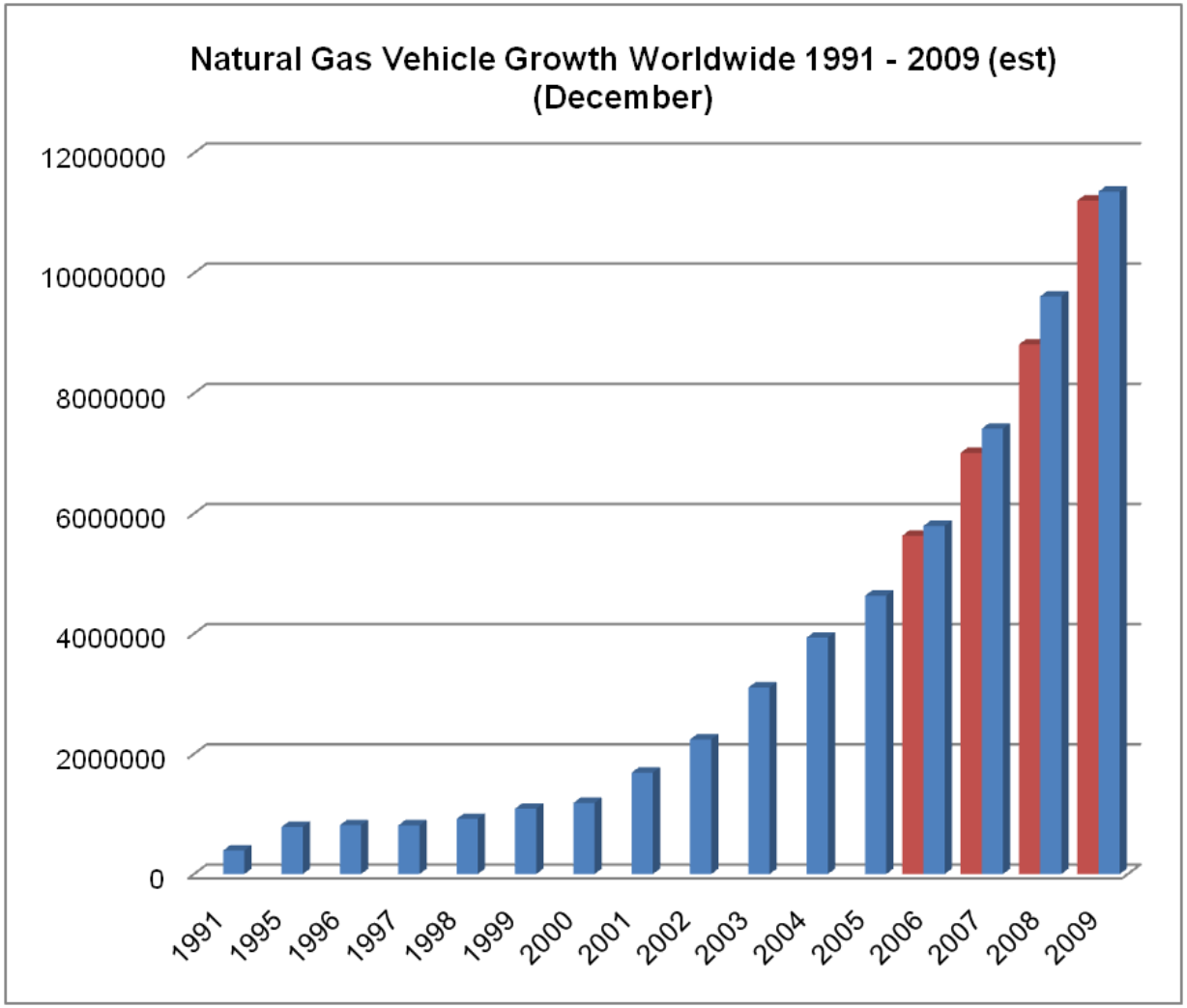
Source: www.okcimages.blogspot.com

Source: www.files.sharenator.com

Economic Conditions

- Tax incentives for vehicle conversions
- CNG is roughly half the price of gasoline
- Globally, CNG is becoming more popular
- 30.6% growth since 2000
- Political support

Economic Conditions



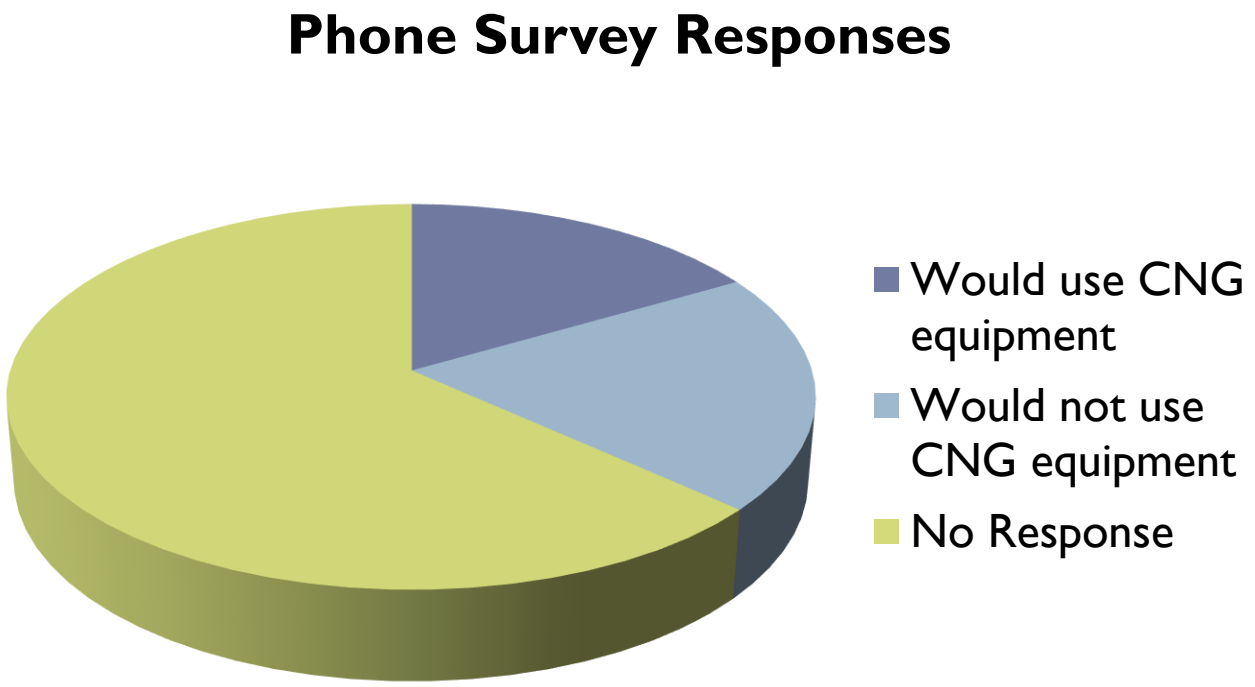
Regulations

- DOT regulations
  - Federal Motor Vehicle Safety Standard 304
- EPA Regulations
- California Air Board Regulations
  - Exhaust Emission Regulation Order (adopted 2004, amended 2010)

Customers

- Municipalities, golf courses, airports, large landscaping contractors
- California lawn mowing companies
- “Prosumers” and green consumers

Market Research



- Contacted 31 lawn care companies
- Only 12 gave responses

Alternative Fuel Competitors

- Dixie Chopper Eco-Eagle
- LEHR LM139NP, LM139SP
- Cub Cadet CC500EL
- Black & Decker MM875
- Craftsman 148-V
- Neuton CE5 Duracell

Source: www.dixiechopper.com

Source: www.mysears.com

Source: www.blowerleaf.net

Same-size competitors

- Craftsman Professional
  - $1699
- Cub Cadet CC760ES
  - $1499
- Cub Cadet G1332
  - $2500

Source: home-and-garden.become.com

Source: www.cubcadet.com

Fuel Comparison

	State	Pressure (psi)	Energy Output (BTU/gallon)	Gallon of Gas Equivalent (GGE)
Gasoline	Liquid		109,000-125,000	1 US Gallon
Propane (LPG)	Liquid	~200	84,000	1.35 US Gallons
Compressed Natural Gas (CNG)	Compressed Gas	~3600	38,000-44,000	3.82 US Gallons

* Energy Output and GGE values for LPG and CNG are at the pressures given

Design Comparison

Commercial Lawn Mower Size	Engine & Horsepower (bhp)	Energy Req'd (6 hrs)*	Volume of Gas Needed**	Volume of CNG Needed**
Honda 21" Commercial	Honda -5.5	83,985	0.77 gallons	2.21 GGE
Cub Cadet 33" Wide Area	Briggs & Stratton -12.5	190,875	1.75 gallons	5.02 GGE
Cub Cadet 33" Commercial	Kawasaki -13	198,510	1.82 gallons	5.22 GGE

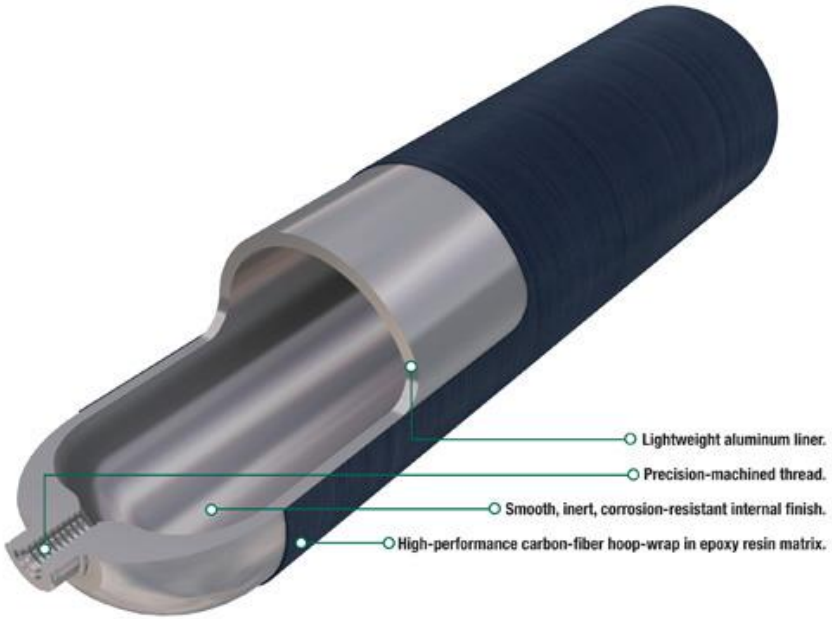
* $Energy\ Req'd = BHP * 2545 \frac{BTU}{hr} * 6hr$

** Volumes based on lowest Energy Output Value

Tank Comparison

- Type I
  - 100% Steel tank
- Type II
  - Lightweight Aluminum Liner w/ Carbon-fiber Hoop wrap

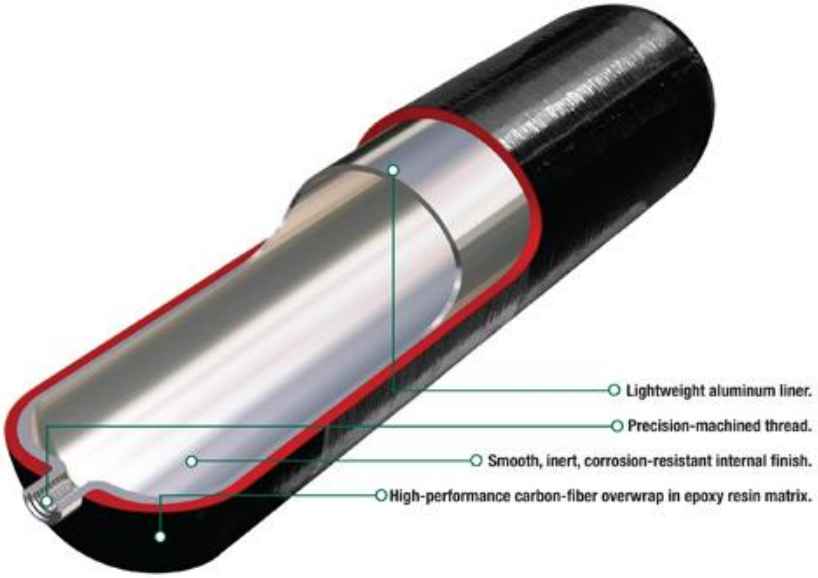
Source: www.sailnet.com



Source: www.luxfercylinders.com

Tank Comparison

- Type III
  - Lightweight Aluminum Liner w/ Carbon-fiber Overwrap



Source: www.luxfercylinders.com

- Type IV
  - 100% Composite Material

Source: lincolncomposites.com

Tank Comparison

	Capacity (GGE)	Empty Weight (lb)	Price
Type I	5.5	196	$432
Type II	5.5	137	$512
Type III	5.5	62	$1017
Type IV	5.4	74	$1600

Type I, II, III values from: metal-mate.com

Type IV values based on quotes obtained from Lincoln Composites

Tank Design

Permanent	
Pros	**Cons**
•Very Secure •No interaction with tank removal •Hidden and inaccessible to user •Can use Type I, II, or III	•Must transport the mower to refuel at station or refuel using a tank trailer •More planning and time •Requires professional replacement
Removable	
Pros	**Cons**
•Refuel by a quick tank switch on-site •Damaged tank can be replaced quickly •Fewer fuel station visits	•Less secure •More costly tank investment •Fittings must be more resistant to wear •Limited to Type III, or IV

Tank Design

	Permanent Tank	Removable Tank
Regulations	X	
Cost	X	
Efficiency/ Functionality		X
Hours per refill		X
Convenience		X
Simplicity	X	
Safety	X	

Permanent Tank Fueling Options

- Phill Slow-Fill At Home Fuel System
  - Allows for overnight filling
  - Can travel over 100 miles on a single overnight fill
  - All you need is an existing natural gas line and an electrical outlet

Source: www.tulsagastech.com

Source: www.tulsagastech.com

Permanent Tank Fueling Options

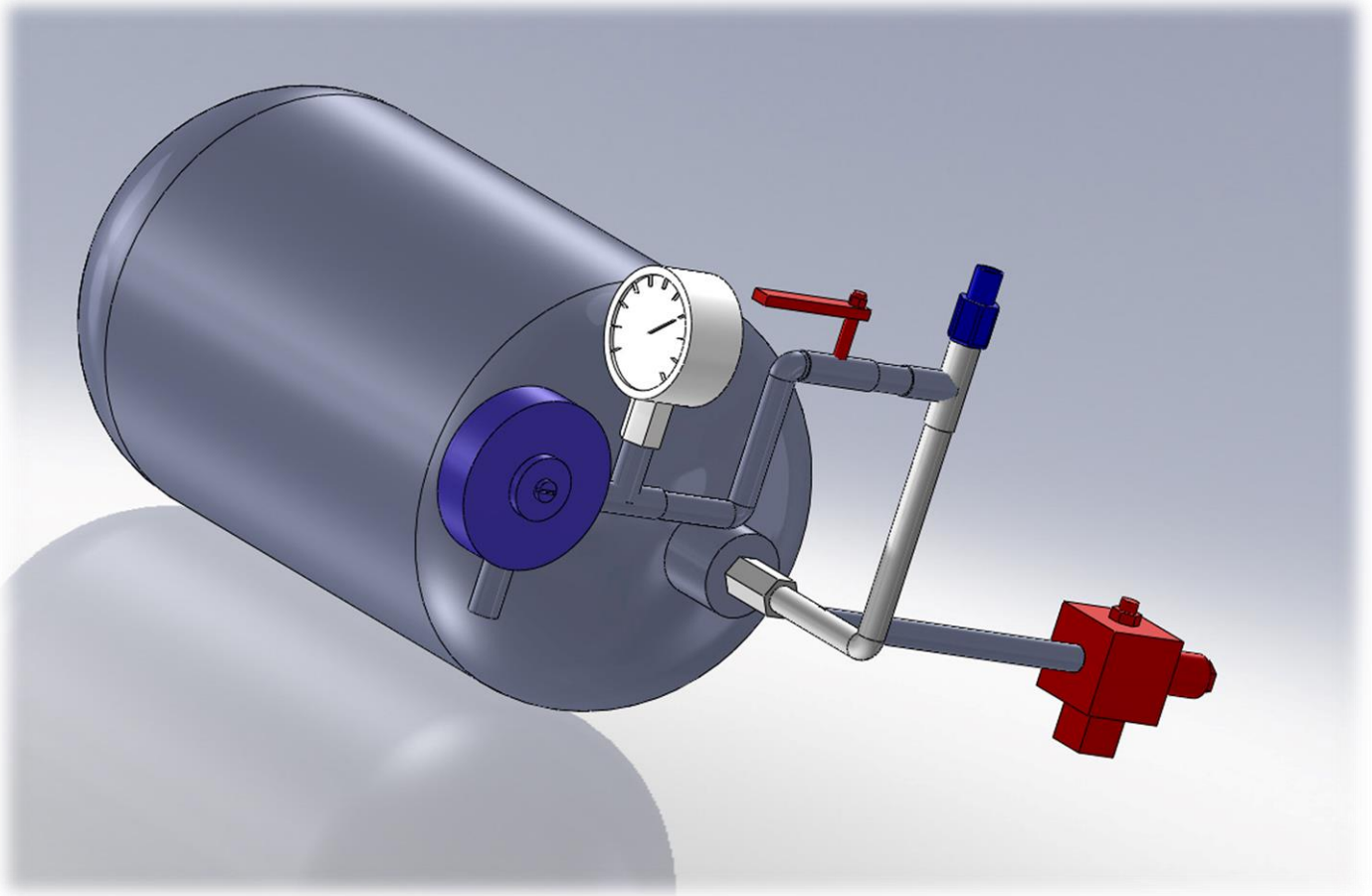
- Take Mower to CNG Fuel Station
  - Northstar CNG Station- El Paso, TX
  - TGT Dispenser at TGT- Tulsa, OK
- TGT CNG Tank Trailer

Source: www.tulsagastech.com

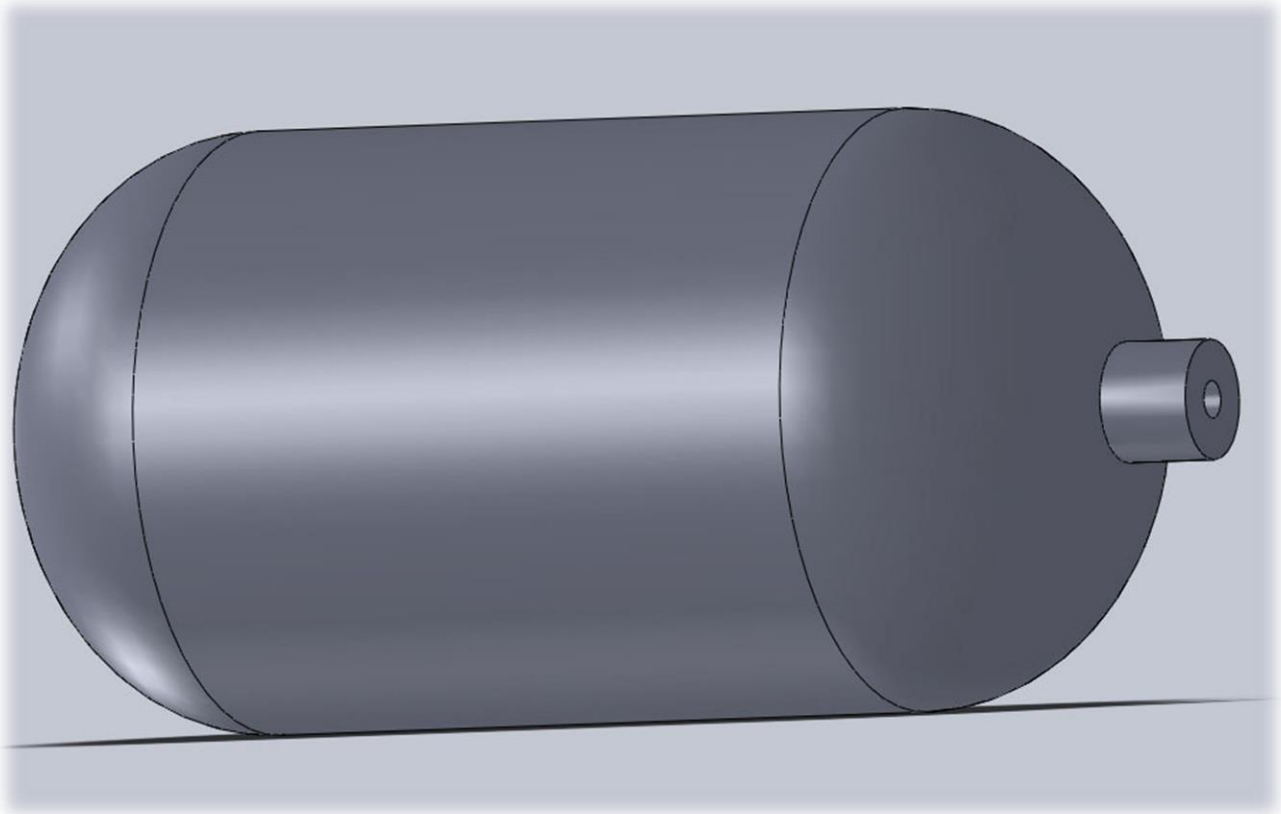
Source: www.tulsagastech.com

Source: www.tulsagastech.com

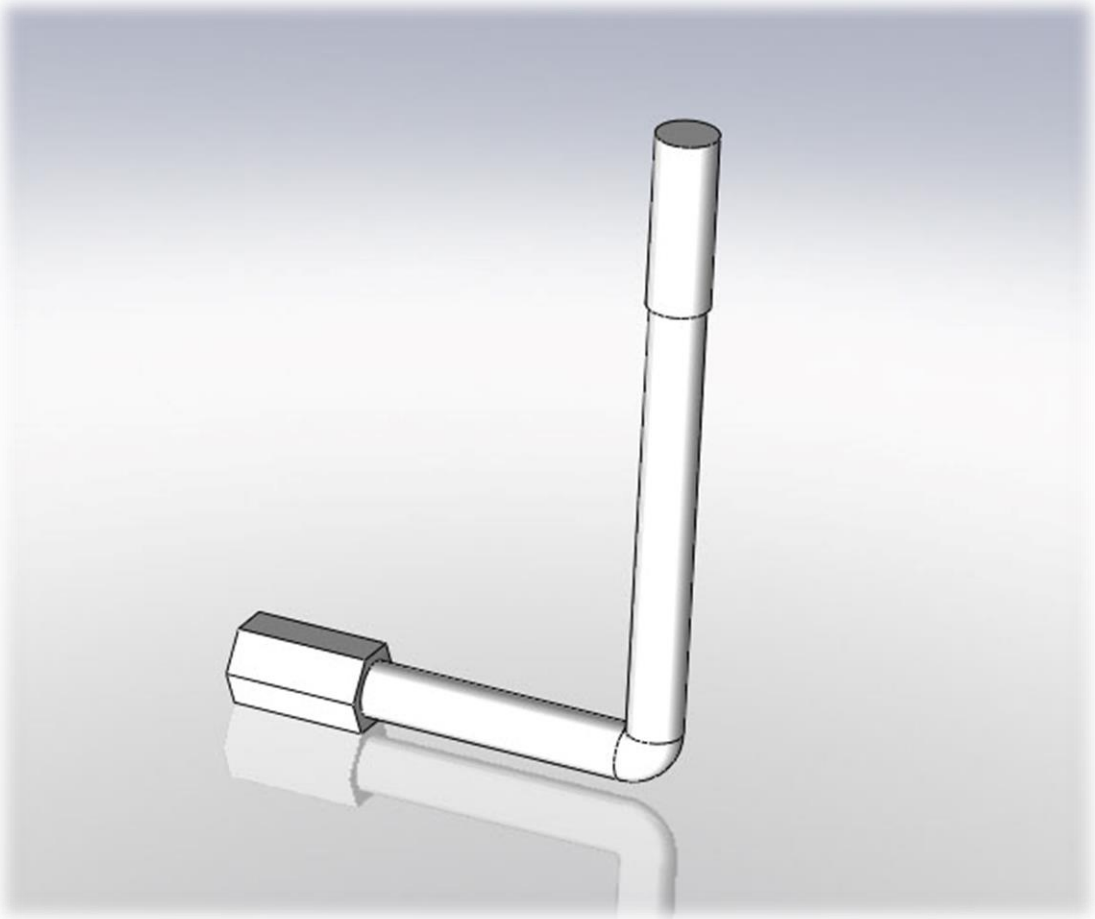
Assembled Kit



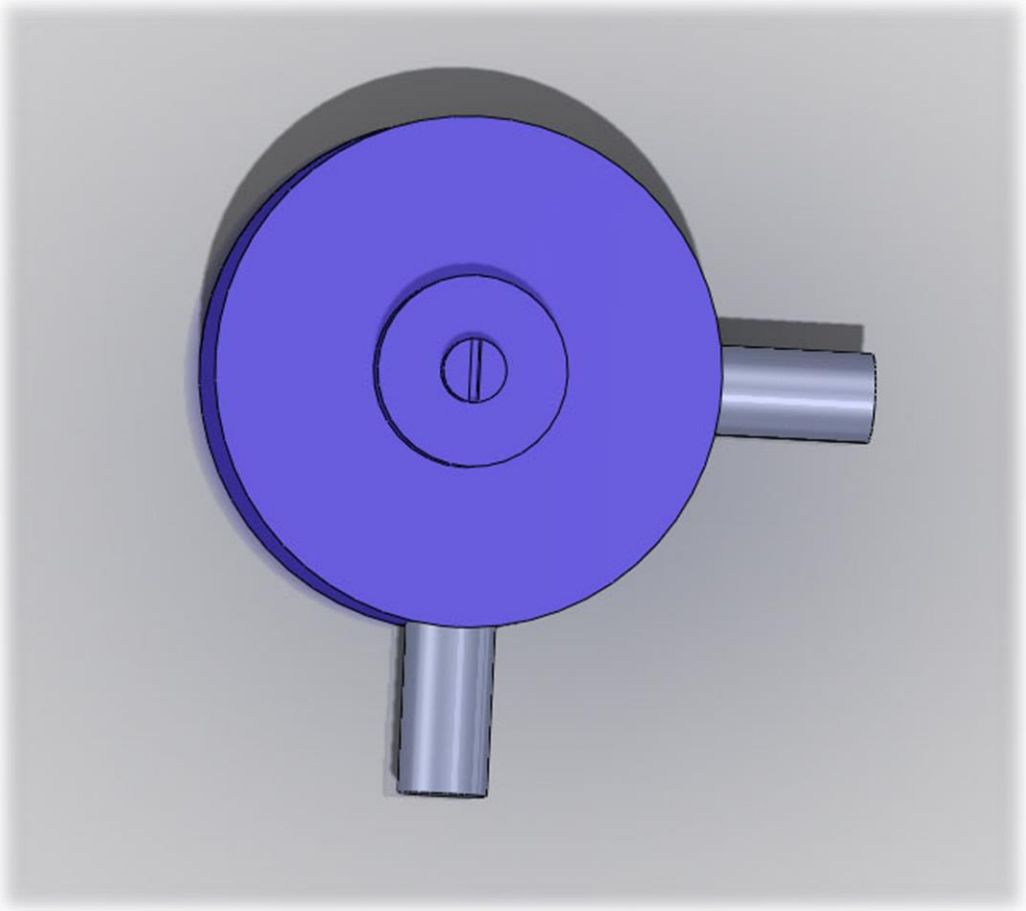
Tank



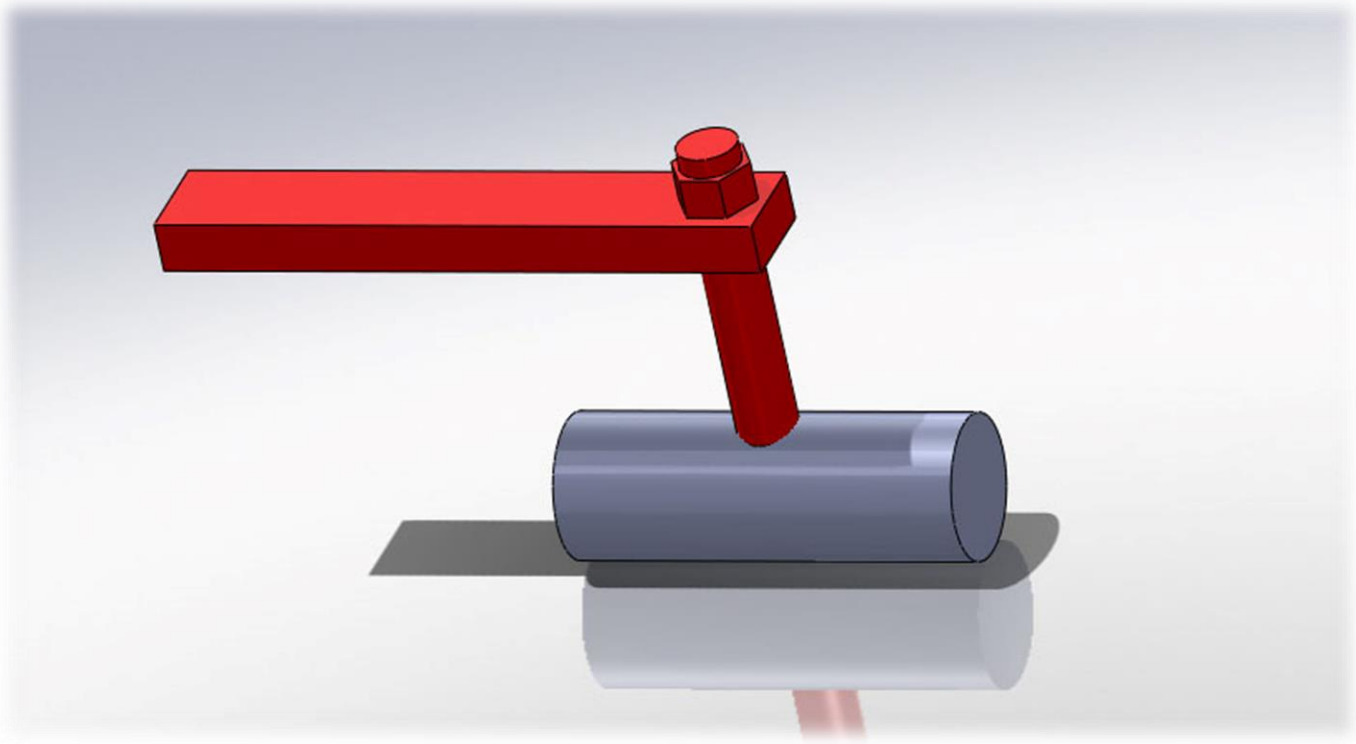
Tubing



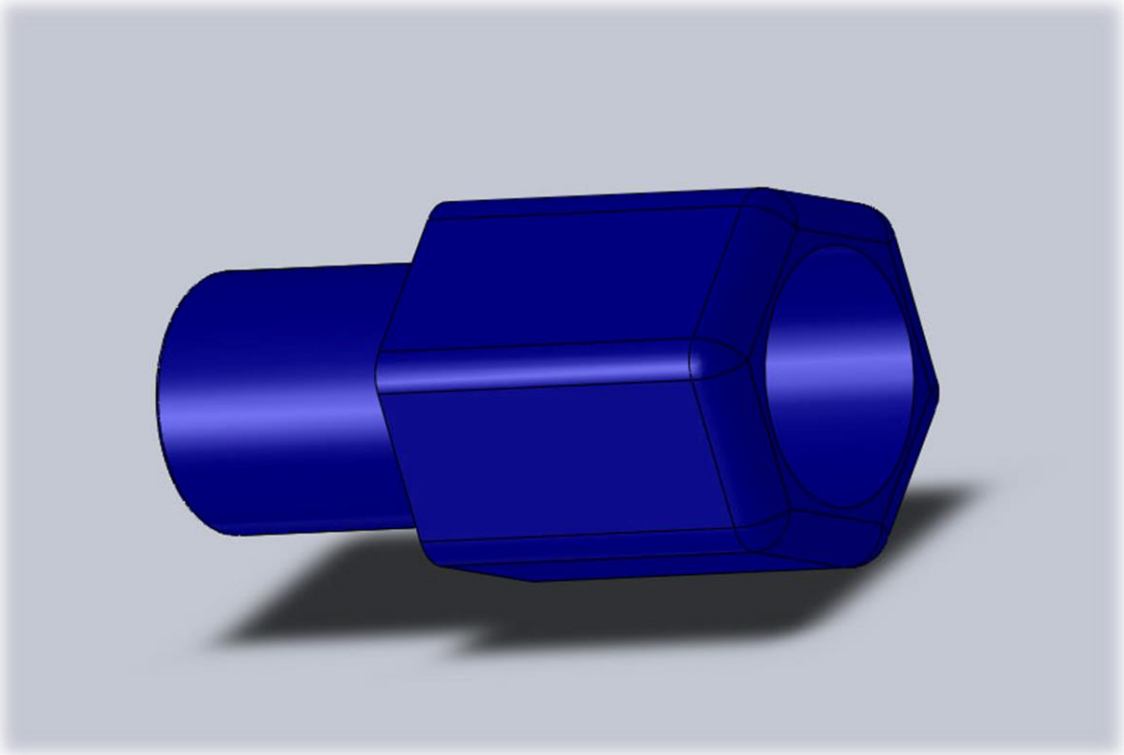
Regulator



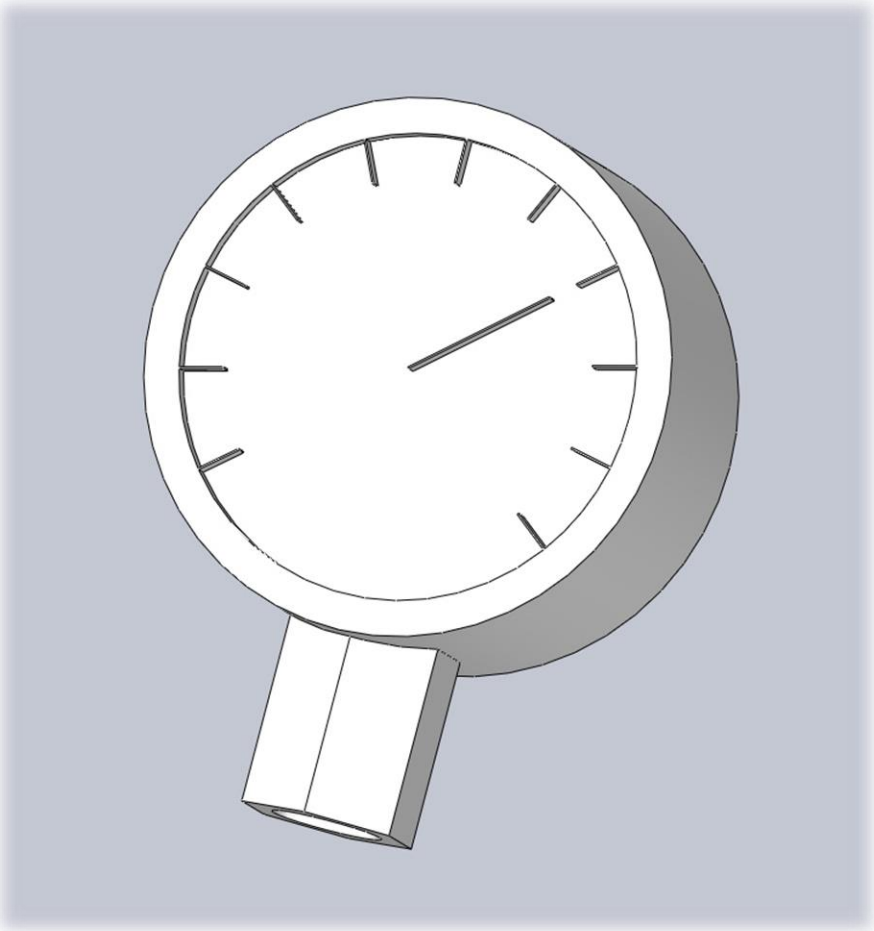
Valve



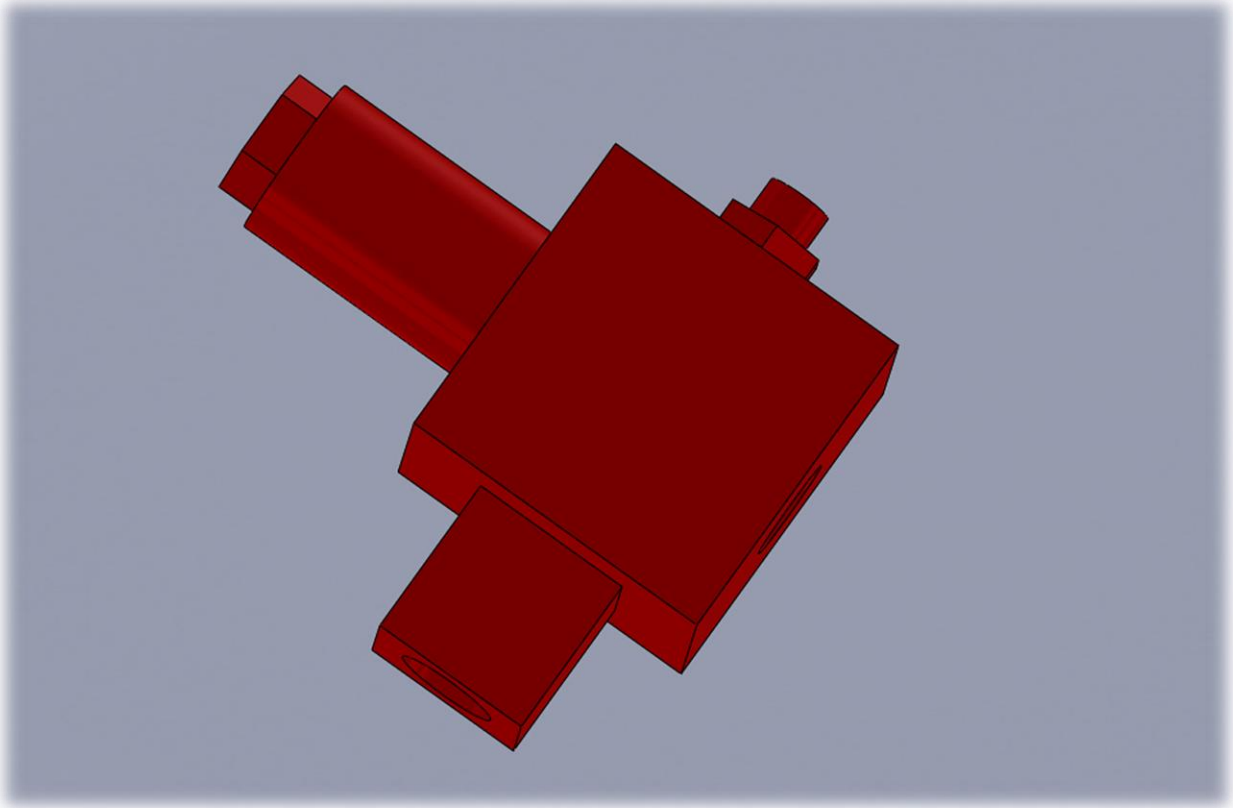
Fitting



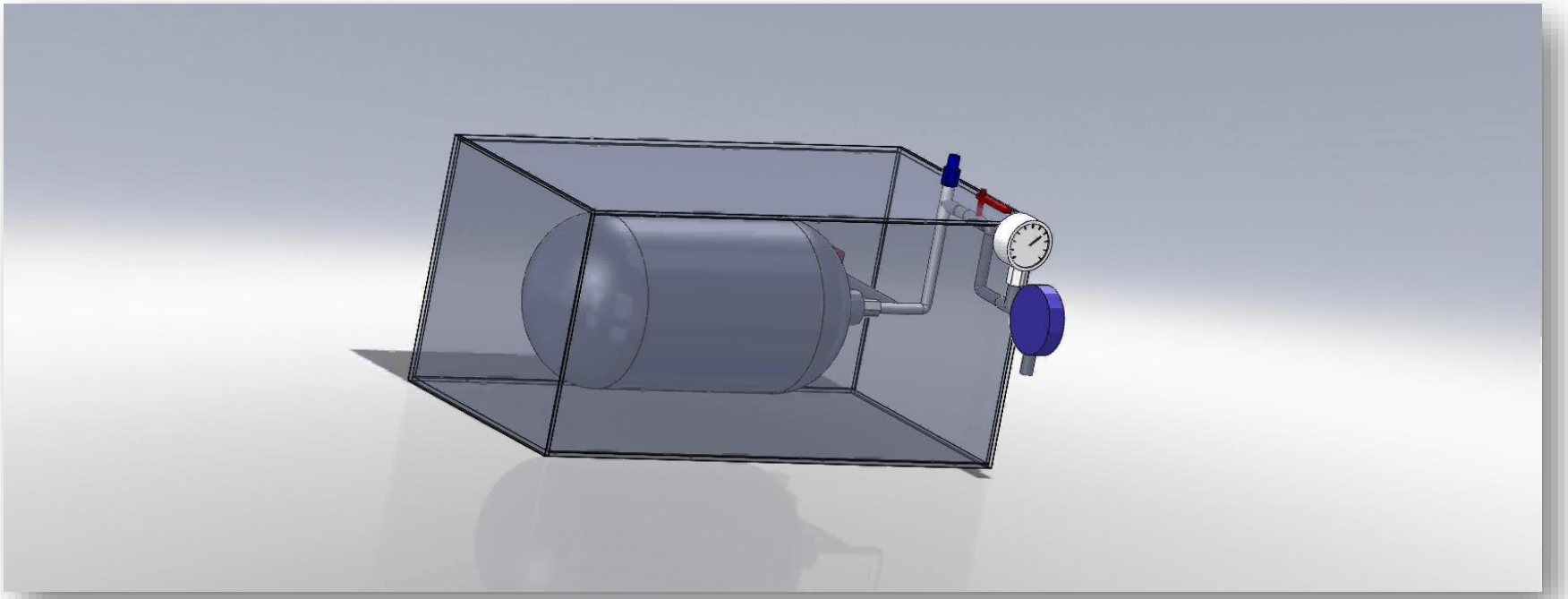
Pressure Gauge



Relief Valve



Assembled Kit with Shield



Tentative Budget

Item	Quantity	Price per ft	Price per Sq foot	Unit Price	Cost of good
refuel coupler	1	x	x	x	$69.00
pressure gauge 10000 psi	1	x	x	$95.00	$95.00
pressure relief valve	1	x	x	$250.00	$250.00
90 degree 4-way elbow	1	x	x	$20.00	$20.00
316 stainless steel pipe	25 in	$4.22	x	x	$8.80
18 gauge steel sheet	18 sq ft	x	$3.25	x	$58.50
2 GGE type 4 tank	1	x	X	$1,200.00	$1,200.00
CNG regulator	1	x	x	$60.00	$60.00
ball valve	1	x	x	$150.00	$150.00
Miscellaneous	1	x	x	$6.20	$6.20
Total					**$1,917.50**

Marketing Plan

- Green, alternative fuel
- Long term savings
- Eco-Eagle complement
- Campaign
  - Web
  - Print
  - Tradeshows

Target Cities

- EPA's most polluted cities
  - Los Angeles (Long Beach and Riverside, Calif.)
  - Bakersfield, Calif.
  - Fresno-Madera, Calif.
  - Visalia-Porterville, Calif.
  - Merced, Calif.
  - Houston (Baytown and Huntsville, Texas)
  - Sacramento, Calif.
  - Dallas/Fort Worth
  - New York (Newark, N.J. and Bridgeport, Conn.)
  - Philadelphia (Camden and Vineland, N.J.)

Issues and Concerns

- High cost of tank
  - Weight
  - Tank source
- Safety

Spring Semester

- Where do we go from here?
  - Build prototype
  - Finalize marketing campaign
  - Finalize business model

Questions?