Multi-Alternative Fueling Station: Scenario Building

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Multi-Alternative Fueling Station: Scenario Building

As local governments and organizations continue to plan for the future with sustainable growth in mind, diversification of public fleet vehicle fueling options are imperative and represent a significant strategy for ensuring transportation fuel availability.
Scenario building for government organizations and policy makers is crucial to develop sound long term decisions. In order to control costs, it is necessary to research the financial and technological feasibility of multiple fuels options before making the investment in infrastructure. This guide explains the financial considerations that are key to understanding prior to adopting renewable energy policy.

"CONNECT Our Future" is a process in which communities, counties, businesses, educators, non-profits and other organizations work together to grow jobs and the economy, improve quality of life and control the cost of government. This project will create a regional growth framework developed through extensive community engagement and built on what communities identify as existing conditions, future plans and needs, and potential strategies.

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Executive Summary

This guidebook is designed to inform readers by providing a thorough knowledge of alternative fuel filling station economics and technical best practices, and possibly to inspire. By building the scenario for a station at a replicable location, the guidebook illustrates how a facility fits not only the financial criterion, but also provides a billboard of sorts for potential users of alternative fuels. The intention of the guidebook is not to promote the building of a station; it is to deliver financial modeling and key considerations in a useful format to reach a 'yes or no' decision, as well as to provide a realistic assessment of what the economics, infrastructure and design of such a station.

The first half of this study is written for a station developer or champion inside a public organization who has specific questions about one or more types of fuels. This information is vital for the incremental approach of adding an alternative fuel to an existing station, or a mix of them to a station of their own.

First, the most relevant hard facts are presented: what market considerations must be reached in order to justify the building of a multi alternative fueling station. As necessary as a transition to alternative fuel is for many reasons, the simple fact is that *capital does not follow the maxim*: "if you build it, they will come." Governments have strained budgets and small appetites for mismanaged spending.

Rather, paradigm-shifting fueling stations will only be built if a simple and very compelling economic case can be made that an appropriate return on investment is possible from such a project. This book begins with an analysis of traffic thresholds and market requirements for an alternative fueling station, e.g., what types of vehicles must be located within certain proximity to the station. At present, it is necessary to begin with fleet vehicle traffic. Private individuals utilizing the station are such a small fraction of volume of fuel sold on-site that they should be considered a bonus to any economic model; fleets remain for the foreseeable future the backbone of any alternative fuel station.

The next chapters are devoted to a very specific discussion of the five fuels specified in the Energy Policy Act of 1992 (EPAct). This law was the foundation of a series of laws since, under administrations of both parties, which have established the regime of introducing alternative fuels into the market place. Because the EPAct fuels are very specific, they provide the most relevant list of fuels to model for this study. Each of these chapters focuses on one fuel in particular, with an analysis of market, logistical and infrastructure and other special considerations which govern its use and sale.

The Energy Policy Act (EPAct) of 1992 directed the U.S. Department of Energy to manage transportation regulatory activities which aim to reduce U.S. petroleum consumption through the use of alternative fuels. Later statutes passed in 1992, 1998, 2005 and 2007 established the renewable fuel standard and sharpened the focus of these goals. The EPAct fuels are:

- **Compressed Natural Gas (CNG)**
- **Liquid Propane Gas (LPG)**
- **Biodiesel**
- **Electric Vehicles**
- **Ethanol**

Part two of this book focuses on design considerations of a full alternative fueling station. Designing a station for multiple types of fuels requires extra thought and care to avoid unforeseen mistakes. In order to facilitate a robust design analysis, a specific site in west Charlotte (Mecklenburg County), North Carolina was chosen and a design team – Flux Design – was engaged. This team organized and ran a charrette composed of site owner representatives, fuel suppliers, building contractors with experience building stations,

and fuel infrastructure specialists. The results of this charrette – described in the Design section of the book – were integrated by the design team into the renderings included throughout this guidebook and in the appendices.

Flux Design took these practical considerations, such as lane sizes, traffic flow, etc. – and added the creative touch of a visitor center built from used shipping containers. The result, which is renewable and affordable, includes space for an attendant's office and a visitor's lounge. Although certainly not required for an alternative fueling station, it represents one method of radically rethinking how such a station might look with the added benefit of lower capital costs.

Additionally, a landscape design firm, Graceful Roots, was included on the team to assess how such a station might be situated onto a site and engage with the environment around it in a different manner than traditional fueling stations. This led to suggestions such as pervious roadway capable of shedding water but rated for large vehicles, native plants and educational garden beds, more interesting ways to showcase the fueling infrastructure rather than hide it, and a Living Wall composed of plants to welcome station users and vividly illustrate that the station is not business as usual. The complete pre-design packages are included in the appendices of the book in addition to mention in the design section.

Finally, the last section of the book is a more general discussion of factors important to implementation of this type of infrastructure: station costs, supply variability, future outlooks, funding sources, public vs. private ownership and public use vs. fleet specific access to this type of station. These factors are all important to understanding the economics, expectations and realities for an alternative fueling station.

Acknowledgements

The three most obvious acknowledgements would be to the organizations which funded this study: The Department of Housing and Urban Development (HUD), through their Sustainable Communities program, the Centralina Council of Governments (CCOG), which applied for and organized the project, and the CONNECT program, which is primarily housed at the CCOG but is a larger, bi-state effort with a wide variety of private and public sector stakeholders (http://connectourfuture.org/) This larger effort included multiple Forums in which these stakeholders were able give the writing and editing team ample feedback and direction.

At a bit closer level of cooperation and input, within the CONNECT program the Energy Working Group, under the leadership of Lisa Lee Morgan (Chair) and Jason Wager (CCOG Liaison), provided regular and thorough engagement in this process. Multiple regional organizations related to transportation, like the AFIT (Advanced Fuel Implementation Team) and Centralina Clean Fuels Coalition (a DOE Clean Cities program) provided invaluable advice under the leadership of Sean Flaherty, CCFC coordinator.

Two vendors played an excellent role in providing a unique, interesting and visually exciting counter-point to what could have easily have been a somewhat vanilla analysis of infrastructure:

Flux Design (www.Fluxwurx.com), with the excellent architectural team of Bryan and Jen Shields, led a design charrette with a room full of equipment providers, fuel experts, and fuel station construction companies and then produced visually stunning documents with serious consideration of the logistics as well as the theory of such an undertaking.

Graceful Roots (www.gracefulroots.com) principal Jennifer Coots undertook a unique effort connecting the natural and historical flora of the site to a specific landscape design, designing educational garden beds that tie that flora to concepts of biofuels, visualizing a "living wall" billboard and building an early prototype at ReVenture Park, and of solid design research underlying aesthetically-pleasing creativity, such as finding a driveway material capable of withstanding heavy truck traffic while allowing grass to grow within it.

After some study—a large airport and academic campus were also considered – the teams chose to focus this study on a potential new alternative fuel station at ReVenture Park (www.reventurepark.com). The owner of that site, Tom McKittrick, should be commended for his vision in desiring a multi-alternative fueling station even before being approached about the use of his site, and for his support, hopefully, in utilizing this guidebook as a tool to make that vision a reality.

This book was researched, written and edited by the team of Rich Deming and Justin Sharp, both of whom have a longstanding relationship and history of direct work with the CCOG, the Centralina Clean Fuels Coalition, and many others of the stakeholders acknowledged above, and who owe a debt of gratitude to these individuals and groups and to multiple other alternative fuel vendors, industry experts, alternative fuel station owners in other states, and many, many other individuals.

Introduction

As petroleum prices remain high, apparently permanently, the concept of using alternative fuel for public and private fleets has become increasingly popular. The dawn of plentiful natural gas supply and continual maturation of other alternative fuels have led to a tipping point of sorts for their use. This paradigm shift will lead to extreme advantages across multiple facets:

- improved budgets and bottom lines
- transportation fuel independence
- environmental benefits

There is, however, a major chicken-and-egg conundrum in the growth of these fuels: it is difficult to build an alternative fuel filling station without guarantee of an adequate base of vehicles using the fuels, but it is additionally problematic to make the commitment to change a vehicles' fuel to alternative fuels without the security of a strong network of filling stations. Typically these stations – whether for one fuel or several – are only built by a government or large corporations with an existing base of users.

This approach is sound, but it does not lead to the proliferation of fueling sites which would support a true transformation of the U.S. transportation sector. After billions of dollars of investment in this sector since 2010, there are still relatively few alternative fueling stations. The planning, design and building of such a station is very much a niche sector, and questions about how to start such a process, or even if such a facility is justifiable to any particular organization or business, is still shrouded in some mystery to potential advocates and investors.

The purpose of this report is to demystify where and how an alternative fueling station should be built, including market, logistics and infrastructure, and finance considerations. In other words, what type of market is necessary, what financial variables need to be in place in order to justify building a station for one or more alternative fuels, and how to proceed if the answer is "yes."

This report to provide information and facilitate consideration of such a station regardless of the type of organization (public or private) or the location. This conversation should be, and is, happening across the United States.

Incremental change vs. a larger leap forward

The addition of alternative fuels may be as simple as adding another pump to an existing station, and hopefully the financial modeling included in the fuel chapters here can assist that clearly positive development. An alternative fuel filling station can, however, represent a complete reassessment of the way things are currently done.

Toward that goal, this guidebook goes further than a general discussion of alternative fuel finance or market variables; it also seeks to show how such a station could be built on a specific site and even with a particular design concept. The goal of this exercise is not so much to provide a feasibility study for a specific alternative fuel filling station as to illustrate a scenario for such a station that could be utilized across many regions.

It is to illustrate that such a station might rethink not merely the chemical composition and origin of fuels but also how such a station can represent a sea change in fueling supply and economics, and even in how a fuel station may be a part of the natural environment around it and the lives of its users. A century of petroleum use was facilitated by fueling stations that gave no indication of the source of the fuel and the indirect costs of using it. An alternative fuel filling station may tell a different story, and strive to be more a part of the environment, while telling the story of how the fuels being dispensed are derived from the natural world. To this end, a site with a focus on renewable energy was selected and efforts were expended to include some components – alternative station and landscape design, for example – that a standard feasibility study would likely omit.

It is hoped that the study will engage some readers on an intellectual level – the economics of alternative fueling have reached a tipping point – and others on a more intuitive level. A psychological tipping point is also necessary: the development of a full understanding of the viability and superiority of alternative fuels in the vehicles' owners, fleet managers, and site developers who are essential to replicate this type of station.

The Alternative Fuel Standard, passed, expanded and extended under both Republican and Democratic administrations, mandates that the United States market utilize 36 billion gallons of alternative fuels by 2022. In order to get remotely close to that goal, public and private organizations and individual drivers will have to embrace the concepts of alternative fuels. Fueling stations such as the one envisioned in this study, and a firm grasp of the economics and logistics behind them, are essential to that process.

Market Considerations

Public Travel Routes

In order to maximize the adoption and growth of multi-alternative fuel stations (MAFS), a key consideration is siting close to or on existing transportation infrastructure.

Although a "captive" fleet onsite or agreement with a nearby fleet to use the facility is crucial to economic success—and is discussed below—choosing a site with high traffic provides additional security that the station will be viable.

The location that was chosen for this study is a regionally well-known eco-industrial park with many logistical efficiencies stemming from its proximity to heavily traveled public road ways.

- Located on Highway 27; 14,000 average daily traffic
- Interstate 485: 2.9 miles; 55,000 average daily traffic
- Interstate 85: 4.2 miles; 128,000 average daily traffic

Source: NC DOT

While the volume of traffic may fluctuate, the high visibility aspect of the location will foster quicker acceptance of the idea and adoption of more diversified fuel sources. Education and ease of use are two of the most relevant deciding factors when it comes to embracing progressive and new model of fueling stations.

Fuel Diversity of Fleets

Due to the extreme lack of diversity of fuel options and the confluence of many transportation avenues, the Charlotte region is a prime candidate for studying the applicability of a MAFS. Those factors, combined with the many public and private fleets that are operated here, make the decision to build this scenario that much more relevant.

For reasons such as the footprint of areas served, quantity of fuel consumed, and deeper knowledge of alternative technologies, it was determined by the Energy Working Group that the optimal starting point is studying the applicability of a MAFS for local fleet vehicles.

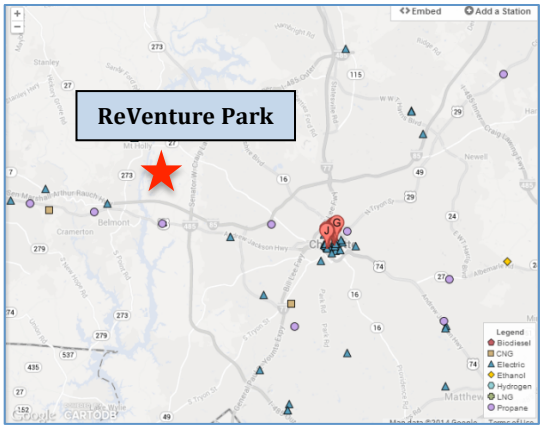
In coordination with local stakeholders such vendors of alternative fuel and infrastructure equipment, many fleets, both public and private, taking steps to diversify their vehicle fuels began to emerge.

Acceptable Radius

In collaborating with the equipment and fuel vendors of the five fuels studied, a common theme that emerged was the importance of co-located infrastructure and distance considerations for drivers. Proximity to heavily traveled roads turned out to be a major decision tree factor.

There are varying opinions about distances that drivers of alternative fuel vehicles will travel out of their way to refuel depending on which fuel type vendor surveyed, but the most common response to distance is between three to five miles in one direction.

ReVenture Park was chosen as an ideal "test case" for this study because the site turned out to be within the five mile radius of all vendor criteria listed above. As noted in the map below, the northwest corridor market of Metropolitan Charlotte is underserved when it comes to alternative fuel availability.



Number of Stations with Alternative Fuels in the Metro Charlotte Region:

- Electric: 35+
- CNG: 1
- Biodiesel: 0
- Propane: 8
- Ethanol: 1

Source: US Department of Energy: Alternative Fuels Data Center

Strategic Siting

In addition to proximity of publicly accessed transportation infrastructure, another key determining factor in siting of a MAFS is proximity to fleet vehicles and their operations. Finding and engaging with fleet managers in a local market to identify potential users of the MAFS is a very important initial process indicator.

Examples of Fleets most likely to embrace alternative fueling station:

- Mail and Package Delivery
- Local Retail Distribution Route Vehicles
- School and City Buses
- Garbage Service Trucks
- Concrete Mixing Trucks

In order to accurately project potential sales from fuel at the site, letters of intent to purchase from local fleets is essential. Not only does this factor in accurately portraying infrastructure requirements, but cash-flow and revenue projections are vital in attaining both public and private capital to fund the building of the MAFS.

Additionally, large existing truck stops typically have the infrastructure to embrace upgrades of fuel sources and could serve as excellent sites for alternative fuels.

Anchor Fleets

Tying into the idea of strategic siting, a common theme amongst equipment and fuel vendors was the importance of contracting with an 'anchor fleet.' It is essential to establish a baseline, or minimum, of fuel use onsite while the station gains popularity and awareness in the local market. Finding a public or private fleet to anchor the station will provide revenue, site traffic, and at least some of the portfolio of usage towards projected long term growth.

Analysis of DOE EPAct Fuels

Alternative Fuel Vehicles

The 1992 Energy Police Act (EPAct) requires that a fraction of new purchases of light-duty vehicles for qualified fleets be alternative-fuel vehicles (AFVs). Qualified fleets include vehicles owned by Federal and State agencies that are capable of being fueled at central locations. Law enforcement, emergency, and military vehicles are excluded from these procurement measures. The AFV requirement is 75% for Federal and State governments.

While no government regulations require private fleets to use alternative fuel vehicles, many private fleets are nonetheless adopting them into their operations to secure fuel prices and diversify their demand. This growth is driven purely by capitalistic pursuits and sustainability goals within organizations.

Compressed Natural Gas (CNG)

Domestic natural gas production has seen game changing transformation over the past 5 years. Advanced technology known as fracking – fracturing shale rock formations to retrieve the gas trapped inside – has produced an enormous and growing amount of natural gas reserves in the United States. This immense increase in production has led to swift changes in fuel mixes as more electricity, heat and transportation fuel is generated by low cost natural gas.

The Market

In North Carolina in 2013, 35 million cubic feet of natural gas was sold for vehicular use at 36 public and private fueling stations. That number continues to grow as more fleets upgrade their fuel sources to take advantage of cheap and abundant supply.

Fueling Infrastructure Considerations

The cost of installing natural gas infrastructure varies based on size, capacity, and demand on site. It also varies in the way the gas is dispensed, e.g. fast-fill vs. time-fill. According to a 2010 report published by Pacific Northwest National Laboratory for the U.S. Department of Energy, costs for installing a CNG fueling station can range up to $2 million depending on the size and application, which was confirmed with the results from the CONNECT MAFS Design Charrette.

The local gas utility can help determine if the appropriate level of gas pressure is available at your location, the gas quality and moisture content are appropriate, and your gas service can support the gas flow your site will need. Additional investment may be necessary to address these needs.

Special Considerations

Due to the "Energy Renaissance" taking place in North America, natural gas will play a major role in both transportation and electricity production in the decades to come. Nonetheless, there are still issues surrounding implementation of CNG vehicles and special considerations to keep in mind for fleet managers:

- Lack of existing refueling infrastructure across the region. Not all fleet vehicles should be transitioned if there is a chance the vehicles will be needed for long trips. Extra planning and logistical preparation would be prudent if this situation were to arise. For example, in an interview with the fleet manager of a large utility, it was noted that they would not convert their vehicles because in an emergency, they must be able to send their service trucks anywhere in a large region without fuel supply risk.

- The driving range (mileage distance) of natural gas vehicles is shorter than traditional gasoline or diesel on a per tank basis, due to lower energy content on a BTU equivalent basis. Thus, less energy available for moving the vehicle exists in the fuel tank unless larger size tanks are installed. Compressed natural gas is dispensed in therms, which have the

equivalent to 100,000 British Thermal Units. Each gallon of diesel fuel has the equivalent of 1.37 therms, thus there is less energy in the same volume of fuel. Industry wide, the standard of reference is known as a Gallon Gas Equivalent, or GGE.

- Use of CNG fuel significantly reduces certain types of tailpipe emissions and greenhouse gases (GHGs):
    - Nitrogen Oxide (NOx)
    - Carbon Monoxide (CO)
    - Carbon Dioxide (CO2)

Therefore government agencies mandated to lower GHG levels within their fleet operations may find CNG vehicles to be a solution. This is especially true in Mecklenburg County, North Carolina and the surrounding region (site of the included case study) an EPA nonattainment area for air quality.

Liquid Petroleum Gas (LPG/Propane)

Propane – also known as liquefied petroleum gas (LPG) or autogas – is a naturally occurring energy-rich gas. It is one of the liquefied petroleum gases that are found mixed with natural gas and oil. Propane and other liquefied gases, including ethane and butane, are separated from natural gas at processing plants or from crude oil at refineries.

In nature propane exists as a gas; however, at higher pressure or lower temperatures, it becomes a liquid. Propane is 270 times more compact as a liquid than as a gas, and as such it is more efficiently transported and stored in its liquid state. Propane becomes a gas again when a valve is opened to release it from its pressurized container; i.e., when returned to normal pressure, propane becomes a usable gas.

Propane is a non-renewable fossil fuel, like the natural gas and oil it is produced from. Like natural gas (methane), propane is colorless and odorless. Although propane is nontoxic and odorless, foul-smelling mercaptan is added to it to make gas leaks easy to detect. Propane is a clean burning fossil fuel, which is why it is often chosen to fuel indoor equipment such as forklifts. Its clean burning properties and its portability also make it popular as an alternative transportation fuel. Propane-fueled engines produce much fewer emissions of carbon monoxide and hydrocarbons compared to gasoline engines. Like all fossil fuels, propane emits water vapor and carbon dioxide, a greenhouse gas.

The Market

While only a small fraction of propane is used for transportation, it is the second largest alternative transportation fuel in use today. Instead of gasoline, propane often fuels fleets of vehicles used by school districts, government agencies and has been used for decades to power light, medium and heavy-duty vehicles.

Currently there are 84 propane fueling stations in North Carolina. Significant growth of LPG in on road vehicles seems poised to continue due to the existing infrastructure and relative ease of transporting, dispensing, and implementing with other traditional and alternative fuels at stations.

Fueling Infrastructure Considerations

Many suppliers offer an inexpensive lease of the tank, pump, and dispensing equipment in return for a multi-year fuel supply contract. In these cases, the station owner or fleet is only responsible for the cost of infrastructure that cannot be removed from the site when the fuel contract is over, such as the power line or concrete pad for the storage tank. This can make the upfront cost of propane infrastructure very affordable. The cost of establishing private infrastructure includes purchasing and installing the necessary equipment for dispensing propane and typically runs from $37,000 to $175,000, but varies based on situation and need.

Special Considerations

LPG is very similar to compressed natural gas in that it exists in abundance in the United States. Additionally, the vast majority of propane consumed in the U.S. is also produced here, making the need for dependence of foreign-sourced fuels, like traditional gasoline, nearly obsolete.

The infrastructure for production and distribution of propane is very well established and secure and thus fleet managers can point to long term supply, availability and pricing in planning.

For fleet applications, propane fuel costs less than traditional fuels, creating a favorable return on investment. However, it has less energy content (BTU rating) than gasoline (though a higher octane rating), therefore producing fewer miles per gallon equivalent and distance between fill-ups, as is the case with natural gas.

LPG's minimal maintenance costs are often cited to justify its popularity for high mileage vehicles.

Biodiesel

Rudolph Diesel originally invented his engine with the vision of fueling it with a variety of vegetable oils – a way for agricultural users to be able to produce their own fuel. As the global community evolved into a petroleum-based economy, this vision was forgotten. Biodiesel, which utilizes a wide variety of fat-based (vegetable and animal) feedstock to create an organic-based fuel, represents a potential to return to this early vision.

Last year, U.S. biodiesel facilities produced 1.8 billion gallons of this biofuel. Biodiesel burns in a standard engine cleanly (80% fewer particulates) and biodegrades within 24 hours if spilled on the ground. It is a promising alternative fuel which has been available sporadically for two decades. It is unique among the EPAct Fuels for several reasons:

- It is able to be produced on a smaller scale, and with less infrastructure
  - Other fuels are typically refined and distributed by large national corporations, while biodiesel is typically created by independent producers
- It is available from local suppliers.
  - There are three 1 million gallon + per year producers within a 3 hour drive from the potential ReVenture Park fueling site. The other fuels, other than EV, are shipped from far away using large-scale delivery methods
- It is not based on the use of any carbon or petroleum.
  - All other EPAct fuels are extracted from buried carbon or created using coal power (EV)
- It is a drop-in replacement in a large existing fleet of heavy vehicles
- It is created from waste products

The Market

North Carolina has 4 large commercial scale production facilities across the state with a total capacity of 10 million gallons per year. There are many other smaller production companies that serve private clients, and increased demand from fleet operations and alternative fueling stations is certain to boost the production within those facilities.

Currently there are 24 biodiesel fueling stations in North Carolina, with the majority in the Raleigh – Durham area.

It does not appear that biodiesel can be produced in large quantities at a cost that is competitive with petroleum diesel. The largest market for biodiesel probably will be as a fuel additive because EPAct requirements are unlikely to increase significantly over the next 20 years. The ultra-low-sulfur diesel program will offer an opportunity for biodiesel as a lubricity

additive and perhaps as a cetane booster as well. Biodiesel may also be marketed for applications in which reducing emissions of particulates and hydrocarbons are paramount, such as school and transit buses. Because additives that improve diesel fuel properties can sell for a price above that of the diesel fuel, the cost disadvantage for biodiesel would not be as great in the additive market.

Quality Considerations

Because biodiesel is able to be made by smaller firms, there is some concern about quality. It is essential that any fuel contracts be made with firms which utilize the full ASTM 6751 regime of testing and standards (a certificate should accompany every delivery); alternative, the production facility itself should have a BQ9000 certification, which provides quality assurance in a manner similar to an ISO certified facility in other industries.

Fueling Infrastructure Considerations

Biodiesel is a solvent, and it cleans out the fueling infrastructure that is used to store and dispense it. This is particularly relevant when tanks or pumps are used which previously stored petroleum diesel. Diesel leaves a heavy film behind; biodiesel cleans it out and then carries it into the vehicle or filter. It is thus necessary to utilize clean or new tanks for biodiesel storage, or to push several batched of the fuel through any infrastructure before filling vehicles with it.

Biodiesel cannot be stored in very cold environments – it can be ruined in temperatures lower than 40 degrees. Tanks, then, should be insulated, depending on the climate of the region in question. In winter months, a lower mixture of the fuel should be utilized (see below)

Because biodiesel is organic, it has a shorter shelf life – it should not be stored without use for more than 6 months to be safe, though anecdotally it has been used without ill affect up to 2 years after production.

Local Production

As noted, biodiesel is produced by independent facilities in every state in the U.S., thus giving it the ability to support regional economies through local purchasing. The National Biodiesel Board can provide a list of production facilities in any given area at (www.biodiesel.org). For the ReVenture site, a vendor was selected which produces biodiesel approximately 2 hours from the facility from waste vegetable oil.

Widespread Applicability

There are millions of heavy vehicles with diesel engines which are suitable for biodiesel use. Unlike any of the other fuels, these engines require no modifications whatsoever, other than some attention to the state of the fuel filters when biodiesel is first introduced.

Because of this, large diesel fleets – from buses to large transport haulers – form a massive potential market. It is very likely that diesel fleets exist in multiple locations nearby any alternative fueling site.

Special Considerations

Biodiesel can be mixed in any percentage with regular diesel. It is usually referred to with a "B" and a number which represents the percentage of biodiesel in the mix. B20, then is 20% biodiesel and 80% diesel.

For the same reason cited above—that biodiesel is a solvent which cleans out tanks—a high mixture of the fuel will clean out the tanks and piping of vehicles as well. Proper signage must accompany the fueling station to warn customers of this possibility. When a vehicle first uses biodiesel, the fuel filters should be changed within a week or two to make sure there is no service disruption. After this change, both diesel and biodiesel may be used interchangeably.

After much analysis of the proper mixture with fueling experts, B30 has been selected for the colder months of November through March at the ReVenture fueling station. The remainder of the year, a B60 will be utilized.

Electric Vehicles

Electricity is considered an alternative fuel under the Energy Policy Act of 1992. Electricity can be produced from a variety of primary energy sources. Plug-in vehicles are capable of drawing electricity from off-board electrical power sources (most often the grid) and storing it in batteries.

In plug-in electric vehicles, onboard rechargeable batteries store energy to power electric motors. Vehicles that run only on electricity produce no tailpipe emissions. But there are emissions associated with the production of most of the country's electricity: emissions from coal plants, methane leaks from natural gas facilities, etc.

Fueling plug-in vehicles with electricity is cost effective compared to gasoline, especially if drivers take advantage of off-peak charging rates offered by many utilities. Electricity costs can vary by region, type of generation, time of use, and access point.

Many plug-in vehicle owners will do the majority of their charging at home or at fleet facilities. Some employers offer access to charging at the workplace. In many states, plug-in vehicle drivers also have access to public charging stations at libraries, shopping centers, hospitals, and businesses. Charging infrastructure is rapidly expanding, providing drivers with the convenience, range, and confidence to meet more of their transportation needs with plug-in vehicles.

The Market

Electric vehicles have undergone a major growth in adoption in the past 3 years, and the electric car industry has continued high growth as battery storage technology advances and gasoline fuel prices stay high.

Federal and state incentives for electric vehicle adoption have driven down the costs of implementation within fleets and helped the market to grow significantly.

- Federal Plug-In Electric Vehicle Credit
  - Minimum of $2,500
  - Up to $7,500
  - For vehicles using a traction battery of at least 5 kilowatt hours of capacity and an external source of power to recharge

- North Carolina State Incentives
  - Alternative Fuel and Alternative Fuel Vehicle Fund
  - EPAct Credit Sales generate funds for implementation of AF/AFV projects

Charging Infrastructure Considerations

For reasons of convenience and cost, implementation of direct current (DC) fast charge systems has been determined to be the best choice for a MAFS station. These systems can charge vehicles 60 to 80 miles of range in 20 minutes of charging, and can cost $20,000 to $50,000 prior to incentives.

Factors that affect the cost and installation time include the number of circuits and electric vehicle supply equipment units on site, indoor or outdoor location, and upgrades to electrical infrastructure.

The Department of Energy has invested significant resources to research the implications of a growing PEV infrastructure. In the appendix there is a *PEV Handbook for Fleets* which includes substantial information about the use of plug in electric vehicles for fleets.

Special Considerations

EVs are unique in that they can be charged through the traditional grid, thus supplying a more sustainable method of using traditional carbon-based fuel (from coal plants, for instance). But they are also capable of being supplied through renewable energy such as wind

or solar, thus enhancing further the application on an economic and environmental level.

At the case study site, for example, electricity is being produced by both a renewable waste-to-energy plant and a landfill gas facility – either could charge EVs and thus create transportation fuel completely independent of coal-fired resources.

In the present case study, solar is not envisioned because of extensive tree cover at the site; however, if power is supplied by the biomass or landfill gas plant, the transportation fuel could be eligible for RINs (the numbers supplied by the EPA to fulfill the Renewable Fuel Standard, explained further in the ethanol section below), or other innovative financial frameworks. This option will be vetted more thoroughly if the project reaches implementation level, as it requires a long process at the EPA for approval.

At other stations, a solar alternative could and should be investigated.

Ethanol

Ethanol is a clear, colorless alcohol made from the sugars found in grains, such as corn, sorghum, barley and yard clippings. Ethanol is a renewable fuel because it is made from plants. Ethanol can be a transportation fuel used as a partial replacement in gasoline, and 95% of gasoline now sold in the United States contains ethanol to oxygenate the fuel and reduce air pollution. About 99% of the ethanol consumed in the United States is added to gasoline in mixtures of up to 10% ethanol and 90% gasoline. Any gasoline-powered engine in the United States can use E10 (gasoline with 10% ethanol), but only specific types of vehicles can use mixtures containing more than 10% ethanol.

The Market

In 2005, Congress enacted a renewable fuel standard (RFS) that set minimum requirements for the use of renewable fuels, including ethanol. In 2007, the RFS renewable fuel use targets were set to rise steadily to a level of 36 billion gallons by 2022. In 2013, about 13 billion gallons of ethanol were added to the gasoline consumed in the United States.

E85 refers to a fuel that contains up to 85% ethanol. E85 is used mainly in the Midwest, but there are 25 active pumps in North Carolina, with the largest concentration in the Raleigh – Durham area.

Vehicles that use E85 are called flexible fuel vehicles (FFV). FFVs can run on any mixture of ethanol and gasoline up to E85. In 2012, there were about 110 million vehicles in the Unites States capable of running on E85, but only about 10% of them actually used E85.

Public Relations Considerations

For the case study site at ReVenture Park, an ethanol specific pump is not likely to be implemented though contemplated on the design. Ethanol has suffered from some public relations problems because of the view that it competes, as currently produced, with food crops. Additionally, some opponents of the fuel say that it causes damage in engines, though this has not been found to be the case in clinical studies.

Even more importantly, there is less pressing need to include ethanol in a MAFS because it has already become entrenched in the U.S. fueling system after decades of inclusion, supported by the RFS. At present, for example, over 400 million gallons of ethanol are mixed into the Charlotte metro area fuel supply at the central fuel depot known as Paw Creek (or Tank Town). At this point, the higher octane of ethanol is utilized to create the different levels of fuel octane quality (i.e., regular, premium, etc.). Thus, the fuel industry will continue to blend ethanol into the U.S. fuel supply regardless of what subsidies exist—it is logistically superior to have it.

As new methods of creating the fuel are commercialized – there is a cellulosic ethanol start-company located at ReVenture Park, for example – the food vs. fuel debate will become less important; in the

interim, a vast quantity of ethanol is already being blended into the U.S. fuel distribution system, so including a higher blend at the MAFS, with all of the additional capital requirements for safety, etc., (below) is not recommended. For potential MAFS developers who are interested in it, however, the discussion of these considerations and recommendations for others is neutral – it is useful to include it in certain scenarios.

Fueling Infrastructure Considerations

More than 95% of the gasoline sold in the United States contains low levels of ethanol. The low-level blends that saturate the market require no special fueling equipment, and they can be used in any conventional gasoline vehicle.

The equipment used to store and dispense ethanol blends above E10 (10% ethanol, 90% gasoline) is the same equipment used for traditional gasoline with modifications for safety purposes, due to the high flammability of ethanol. All equipment used in the handling, storing, and dispensing of these blends must be designed specifically for such use. Specifically, the Handbook for Storing, Handling, and Dispensing E85 and Other Ethanol-Gasoline Blends has been provided in the appendix for detailed information on compatible equipment.

Flex Fuel Vehicles (FFVs), which can operate on E85, gasoline, or any blend of the two, are available nationwide as standard equipment with no incremental costs, making them an affordable alternative fuel vehicle option. However, because most U.S. ethanol plants are concentrated in the Midwest, fueling stations offering E85 are predominately located in that region.

Safety

Ethanol is a poisonous and very flammable fuel option. Due to the extremely low flashpoint, it should be regarded as the most dangerous of the fuels being considered for implementation.

In general, the same safety measures that apply to gasoline apply to ethanol. All employees and fleet drivers using an E85 fueling system should:

- Know basic safety practices when in the presence of flammable fuels
- Understand the purpose and content of the multi-alternative fueling site's emergency action plan.
- Be familiar with signage and emergency equipment including the emergency shutdown button
- Understand what emergency actions must be taken in the event of an accident
- Cigarettes and other open ignition sources should never be allowed in fueling areas

Special Considerations

With the widespread availability of E85 fuel – there are more than 15.5 million flex fuel vehicles on the roads in the United States today – it makes sense to offer an E85 station. However, it should be noted that due to required separation distances of storage and dispensing equipment could create a challenging economic scenario and / or siting issues at facilities with limited space for the station itself.

Financial Modeling

Financial Models

Figuring out the economics of a multi alternative fuel station is an incredibly complex undertaking and likely a major reason there are not more of them in existence domestically. When a decision-maker in the private sector needs to engage with a single fuel station, the economic case is somewhat simple: Is there enough demand volume and profit margin (or savings) in the fuel to make up for the investment?

Below is a detailed discussion of the modeling for this type of station. Descriptions of such modeling can get dense, and are subject to lengthy and inconclusive results about proper metrics and baselines. Because of this, and an exchange with multiple parties involved in both public procurement and private investment, certain qualitative metric decisions were necessary to create a coherent summary. A list of bullet points describing the methodology precedes it, with more details following. The study authors welcome further investigation from interested parties.

Results

- Within the parameters of the design offered by the scenario building team, a budget for the entirety of the MAFS was generated and is within range of industry norms surveyed at the design charrette of energy leaders and other surveys.

- A low and high pricing scenario, generally accepted margins, and operating costs (OPEX) were run through the models using each fuel.

- Additionally, the capital expense of required infrastructure was benchmarked against a 5 year "payback" period. This period does not include cost of capital (interest) and several other indirect expenses. Five years is considered a benchmark for whether to invest in new technology or capital markets, and is a typical timeline for payback in the private sector.

- From these baselines, conclusions were determined about the viability of which EPAct fuels to include in a station. No fuels were excluded, but it was determined that some fuels required certain volumes and margins that made them less feasible in the parameters of this particular study. This does not mean they are not excellent candidates in another context or at another site.

Given these considerations, the following conclusions were derived at from extensive modeling. The study index includes a wide variety of models indicative of the multiple scenarios analyzed.

- This cannot be stressed enough: For reasons of investment due diligence or responsible public funding, commitments from one or more fleets to use the facility are essential to making it feasible.
    - There is not enough alternative fuel demand in the marketplace to take a "build it and they will come" approach to a MAFS.
    - In the end, a commitment from a fleet for each of the fuels will be the single largest determining factor on whether it is feasible to include that fuel. Thus, the following conclusions could easily be adjusted by the inclusion of any particular fleet.
- Because of market considerations and capital costs, it seems likely that liquid propane gas and biodiesel are the most likely "winning" fuel choices.
    - Not coincidentally, both fuels are affordable, have an easily understandable and stable supply market, and do not require large capital expense for fueling infrastructure.
- Compressed natural gas is closely in contention but, is dependent on an existing or nearby gas line and especially, due to high capital costs, purchase and use commitments from nearby fleets for required volumes.
- A MAFS of at least two or three fuels makes a lot of sense because certain costs – driveways, real estate, and station canopy, etc. – are better defrayed over several fleet users.
- Due to cost of 'time-fill' electric vehicle charging stations, they are not yet viable in any traditional fuel station business model. This may change if high voltage, fast charge models decrease in price.
- Through 25 years of subsidy and logistical efficiencies, ethanol is already wide-spread in the fuel universe. Particularly given the extra precautions required for fire, and the absence of

flex-fuel engines, it is difficult to justify ethanol as a fuel in a MAFS.

A station with several fuels is complex. This study utilizes financial modeling which accounts for the capital expense (CAPEX), operating expense (OPEX) and revenue of a full station as depicted in the designs included, and the financial case (OPEX, CAPEX, and Revenues) of each individual fuel. It is not possible within the context of a written guide to show how such modeling is applied to the incredible complexity of price and margin ranges of multiple fuels. The authors of the study are available to walk though those complexities in specific scenarios as needed.

> Of course a station built by a government entity does not have to follow the same rules of CAPEX, OPEX, Return on Investment, etc. For a government entity, there are other considerations, including public procurement, political considerations, and sustainability goals.
>
> However, for this section, the discussion and analysis centers on private sector financial metrics, which are the more easily collected and summarized, and in the end a public entity is charged with watching responsible financial management. Thus, a discussion of what is "worth" it financially is useful to both public and private decision-makers.

Rather, for the purposes of this study, ranges of fuel pricing and standard margins were collected by industry personnel for each fuel and multiple scenarios were run under each. For this exercise a general budget, within acceptable limits, for a station was reached – as determined by survey and during the design charrette with industry authorities – of $750,000 to $1.25 million dollars. The study authors were careful to make this station close to the generally-accepted average cost range; some design flourishes were included while cost savings in building materials were utilized. It is important to note that this cost does not include a CNG component, which by itself could cost as much as the rest of the station and fuels. CNG must be considered alone with the aforementioned focus on existing fleet commitments.

The methodology was to run dozens, hundreds even, of fuel pricing scenarios through this model: What does it take to carry the costs of a station from the perspective of multiple fuels? For this modeling, it was determined that the CAPEX of each fuel – the necessary infrastructure of delivering it exclusive of the remainder of the station, had to have a payback – repayment of capital expenditure from profit margins – of less than ten (10) years – and typically less than seven (7) if private funding is involved – to make it economically viable. This is a generally accepted timeframe for "pay-back" of a capital investment in new technology or markets. Beyond that the investment becomes difficult to fund.

Assumptions used for this guidebook. Values based on interactions with technology and fuel vendors.

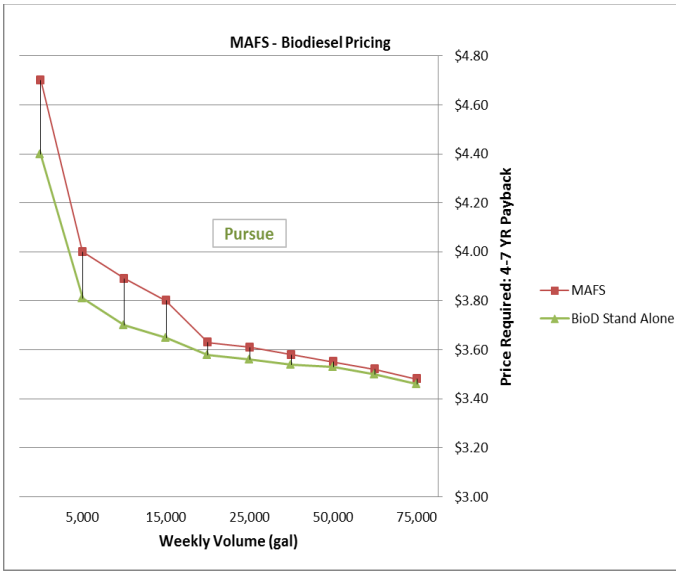
Capital Expense (CAPEX)		Budget
Design Permitting	$	26,000
Building (list below)	$	75,000
Sitework	$	58,000
Fencing	$	16,500
Landscape (list below)	$	40,000
Driveway	$	142,000
Misc. Concrete Work	$	25,000
Utility Infrastructure	$	145,000
Misc.	$	65,000
Total	**$**	**592,500**

Fuel Infrastructure		Cost
Compress Natural Gas	$	851,500
Liquid Propane Gas	$	15,300
Biodiesel	$	36,550
EV Charging Station	$	11,260
Ethanol	$	87,700
Total	$	1,002,310
Grand Total	**$**	**1,594,810**

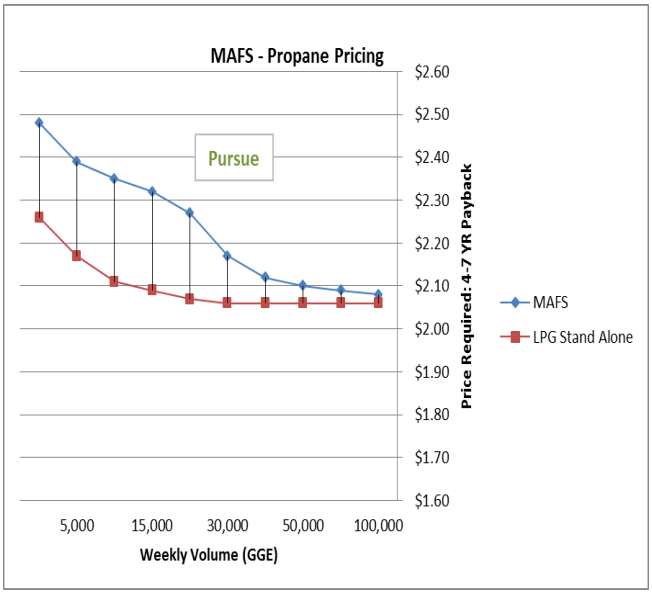
Operating Expense (OPEX)		Annual
Administration/Logistics	$	36,000
Fuel Attendant	$	41,000
Maintenance	$	35,000
Utilities	$	48,000
Misc.	$	10,000
Total	**$**	**170,000**

Several economic conclusions can be reached about each fuel from this modeling, and can assist in deciding which fuels to include:

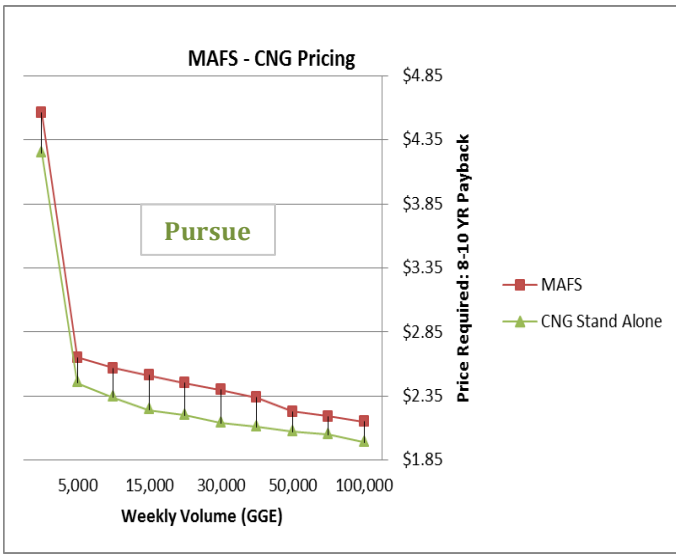
- The most economically feasible alternative fuel to offer is biodiesel:
  - Low flash point means minimal fire safety or environmental requirements
  - Fueling equipment is relatively inexpensive
  - A huge existing market already exists – no conversions or vehicle upgrades are necessary. For a captive or sole-source fleet – "behind the gate fueling" – there is particular ease of transition.
  - There are a few education challenges – percentage of biodiesel to use in cold seasons, filter issues, etc. – that would have to be addressed



- Liquid Propane Gas is likely the second most attractive fuel
  - IF a fleet is already in existence to use the fuel – essential
  - Infrastructure is available from vendors for a lease arrangement for guaranteed minimum volumes – no capital expense
  - Supply is proven and the model is transparent: commodity pricing plus transport plus profit margin

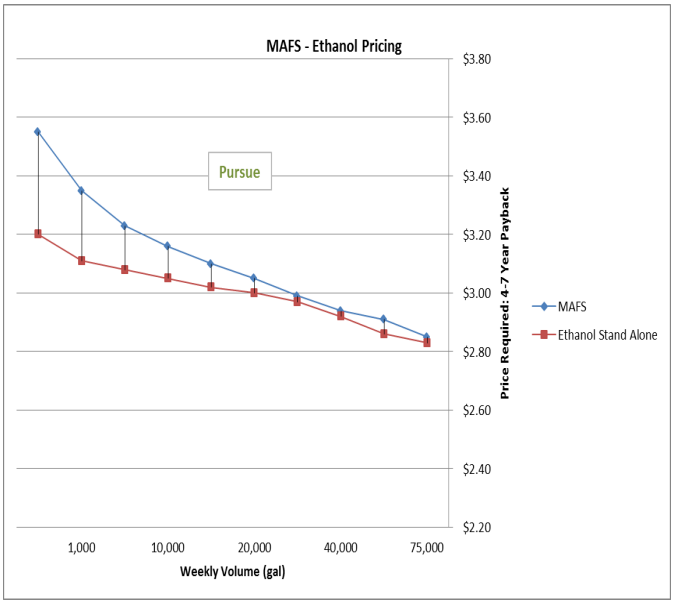


- Compressed Natural Gas is a winner – if a gas line is proximate, and a large fleet will commit to high volume
  - CNG has very expensive infrastructure >$750,000 or much more depending on pipeline on-site
  - This investment requires a substantial commitment, only feasible if a large fleet is available and there is a willingness to convert
  - Gas utility companies will assist in the calculations
  - A US Department of Energy National Labs has created a VICE (Vehicle and Infrastructure Cash-Flow Evaluation) tool that is available for free online at: afdc.energy.gov/fuels/natural_gas_infrastructure.html



- Electric Vehicle Charging Stations should be considered next
  - Look for incentive programs to help pay for the equipment
    - Several vendors are paying to help proliferate equipment
  - Long charge times are a disadvantage – is there something for the driver to do while waiting?
  - The financials are hard to model – "charge time" is necessary because electricity can only be sold by a utility
  - The model gets better every year with station technology improvements – recommendation is to leave a good space, and perhaps "pre-wire" it, for later installation when the economics and logistics are more feasible

- Ethanol would be the last consideration for a MAFS
  - There are more and more flex fuel vehicles
  - Due to lower energy content, does not provide a bargain to the customer
    - Lower cost savings means less incentive to utilize
  - Due to production concerns – i.e. energy balances – environmental benefits are not universally accepted, also cutting down on market drivers
  - Due to engine damage concerns, there is currently a backlash against the fuel in the market
- Fueling equipment is more difficult because of high flammability
- The fuel "wicks" water moisture and is more difficult to manage and handle



Note: Ethanol is already incorporated into the massive gasoline supply at a rate far higher than any other alternative fuel, so inclusion in a MAFS is irrelevant to the success or failure of the industry

Other Considerations

Permitting

Permitting is a delay point for many construction projects, and for a cutting edge type of infrastructure build-out, it can often become more problematic. Often, a new way of doing something is not initiated because it is simply easier to continue to do things the traditional way. In the case of a MAFS, for example, often the champion of the project is not the same person or group that would be in charge of a regular fueling installation, and is thus less versed in the requirements. This can be exacerbated because the technology and construction techniques may be less than well-known to permitting authorities making the process more difficult. If a permitting official is unsure of how to proceed and happens to be dealing with a project champion who is not experienced, it may dampen their enthusiasm for permitting the project in a speedy and efficient manner.

For this reason, it is an excellent idea to engage the right professionals early in the project. Whether having the Building Services Department involved in the project from the start (for a public entity), or hiring consultants and contractors with long experience in the deal process, the technology and equipment, it is well worth making sure that the learning curve for a MAFS is not overly steep.

At a macro level, for government agencies and municipalities interested in embracing alternative fuel fleet vehicles, fast track permitting should be taken into account as a strategy to promote private group interest. Often times, many progressive and economically beneficial clean energy and fuel projects are saddled with long lead cycles for permitting, siting, interconnection, etc. In order to alleviate some of the cost burden for private developers, partnerships can be created to research the pain points for both public and private entities to increase development efficiency across the implementation of multi-alternative fueling stations.

Regardless, the permitting process is often daunting, and it should be well accounted for in both the budgeting and design phase of a MAFS project; building and fire officials should be consulted early and often in the process. Issues at the permitting, inspection, and final approval milestones of the project are often the biggest reason for delays and cost over-runs.

Regulatory

Governments across the United States are taking steps to not only improve their local air quality through reduced emissions from alternative fuels, but increasing their fuel security by adding alternative fuels and alt fuel vehicle fleets to the mix of traditional fuels. Such mandates and incentive programs will increase the long term adoption of the most technologically advanced and economically sound choices for fuels and vehicles.

The following laws have been implemented within North Carolina to drive growth of local alternative fuel production, use, and increase fuel availability. Corresponding regulations for other states can be found at: http://www.dsireusa.org/

Alternative Fuel Vehicle (AFV) Acquisition Requirements

At least 75% of new or replacement state government light-duty cars and trucks with a gross vehicle weight rating of 8,500 pounds or less must be AFVs or low emission vehicles. (Reference North Carolina General Statutes 143-215.107C)

Alternative Fuel Tax Exemption

The retail sale, use, storage, and consumption of alternative fuels is exempt from the state retail sales and use tax. (Reference North Carolina General Statutes 105-164.13(11))

Alternative Fuel and Alternative Fuel Vehicle (AFV) Fund

The North Carolina State Energy Office administers the Energy Policy Act (EPAct) Credit Banking and Selling Program, which enables the state to generate funds from the sale of EPAct 1992 credits. The funds that EPAct credit sales generate are deposited into the Alternative Fuel Revolving Fund (Fund) for state agencies to offset the incremental costs of purchasing biodiesel blends of at least 20% (B20) or ethanol blends of at least 85% (E85), developing alternative fueling infrastructure, and purchasing AFVs and hybrid electric vehicles. Funds are distributed to state departments, institutions, and agencies in proportion to the number of EPAct credits generated by each. For the purposes of this program, alternative fuels include 100% biodiesel (B100), biodiesel blends of at least B20, ethanol blends of at least E85, compressed natural

gas, propane, and electricity. The Fund also covers additional projects approved by the Energy Policy Council. (Reference North Carolina General Statutes 143-58.4, 143-58.5, 143-341(8)i, and 136-28.13)

Biodiesel Requirement for School Buses
Every school bus that is capable of operating on diesel fuel must be capable of operating using blends of at least 20% biodiesel (B20). At least 2% of the total volume of fuel purchased annually by local school districts statewide for use in diesel school buses must be a minimum of B20, to the extent that biodiesel blends are available and compatible with the technology of the vehicles and the equipment used. (Reference North Carolina General Statutes 115C-240(c) and 115C-249(a))

Biodiesel Tax Exemption
An individual who produces biodiesel for use in that individual's private passenger vehicle is exempt from the state motor fuel excise tax. (Reference North Carolina General Statutes105-449.88(9))

Biodiesel Warranty Requirement
All new state government diesel vehicles must have a manufacturer's warranty that allows the use of biodiesel blends of 20% (B20) in the vehicle. This requirement does not apply if the North Carolina Department of Administration determines that there is no vehicle available that is suited for the intended use and that has a manufacturer's warranty allowing the use of B20. (Reference North Carolina General Statutes 20-351.11, 136-28.15, and 143-341(8)(i))

Fuel-Efficient Vehicle Acquisition Requirements
When purchasing new state vehicles, the North Carolina Department of Administration must give purchase preference to vehicles with fuel economy ratings that rank among the top 15% of comparable vehicles in their class. (Reference North Carolina General Statutes143-341(8)(i))

Design Considerations

Spatial Requirements

Charrette Results

During the process of pre-feasibility and design of a multi-alternative fueling station, careful consideration must be taken to enhance the usability, allow for permitted fuel storage, and take precautions for safety of both heavy and light duty vehicles during onsite interaction.

Pricing

Vendors at the charrette provided rough estimates between $1 and $1.3 million dollars for the station, including all engineering design, implementation and fuel storage.

It is imperative to locate as close to the natural gas utility pipeline as possible, as piping costs and gas pressure to the site are key variables in determining capital costs and thus project viability. For example, if a station is located miles from a pipeline, it may cost more to install the gas line than all other expenses combined.

Permitting

In order to get permitting for the station in a timely and efficient manner, the developing body should meet with local permit officials as early as possible to keep them informed of design plans. These stakeholders include, but are not limited to:

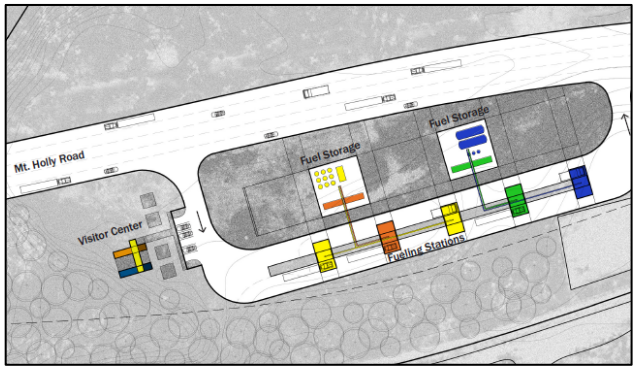
- Fire Marshall
- Air Quality
- Water Quality
- Waste Management
- Building Department

Traffic Patterns

In order to decrease potential congestion and confusion for users of the site, it is best to design the station with a dedicated entrance and exit. Designing the site with a one way traffic pattern significantly reduces the potential of safety hazards from heavy duty trucks attempting to turn around in a limited space with flammable fuels nearby.

The charrette members also suggested the use of an outside lane for truck bypass. The extra lane has the potential to cut wait time for drivers who finish fueling prior to a vehicle at a pump in front of them, or allows for fuel delivery during operating hours with no hindrances to refueling.

Finally, all parties stressed that if the station will service both passenger vehicles and heavy trucks, care should be taken to separate these traffic flows wherever possible. In the case of the ReVenture Park station, for example, this was accomplished by including a separate area for ethanol and EV charging which kept that, typically smaller, traffic clear of truck traffic.



Lane Size and Distance to Pumps

Fuel pumping stations should be far enough apart for large trucks to maintain maneuverability around other large trucks in attempting to access a fuel pump. This diminishes wait time, and in operating these large vehicles, time is money.

To begin execution of the multi-alternative fueling station, it is a good idea to start with just 1 or 2 compressed natural gas pumps, and build infrastructure based upon gradual growth in usage. In the past, projects that have been over-sold and over-built without realistic market volumes have ceased operations. This type of economic mistake causes immediate difficulty for the decision-makers involved in the station, whether in the private or public sector, and does damage to the concept of alternative fuels as a whole.

Fuel Regulations

All regulations pertaining to fueling infrastructure such as set-backs, dispensing, storage, and re-fueling are available to the public in the 2012 North Carolina Building Code: Fire Codes. It is important to note that

along with the North Carolina regulations that must be followed, all stations must be designed with specifications from the *International Building Code, International Fuel Gas Code* and the *International Mechanical Code*.

Liquid fuels are divided into Class I – III depending on their flashpoint and flammability, and as such regulations surrounding their storage are easily found in the "Minimum Separation Requirements for Above-Ground Tanks" section of the NC Building Code: Fire Codes manual.

Information found below comes directly from Chapter 22 of the NC Building Codes: Motor Fuel-Dispensing Facilities and Repair Garages.

Location of Dispensing Devices for all flammable liquid and gas based fuels:

- Minimum 10 feet from lot lines
- Minimum 10 feet from buildings with combustible exterior wall surfaces
- All portions of vehicle being fueled will be on the premises of the dispensing facility
- When hose fully extended, nozzle not within 5 feet of building openings
- Minimum 20 feet from fixed sources of ignition
- Emergency disconnect within 100 feet, but more than 20 feet, of fuel dispenser

Operational Requirements for all flammable liquid and gas based fuels:

- For delivery of liquid fuel to above ground storage tanks, vehicles shall be positioned a minimum of 25 feet from tanks receiving Class I liquids and 15 feet minimum from Class II and IIIA liquids
- Automatic emergency shutoff valves shall be checked not less than once per year by manually tripping the dispensing device
- Leak detection devices are required and shall be checked and tested at least annually in accordance with manufacturer's specifications
- Approved portable fire extinguishers shall be within 75 feet of pumps, dispensers and storage tank fill-pipe openings
- Warning signs must be conspicuously posted within sight of each fuel dispenser and state the following:
  - No Smoking
  - Shut off motor
  - Discharge static electricity before fueling by touching a metal surface away from the nozzle
  - Do not reenter your vehicle while fuel is pumping
  - If fire starts, do not remove nozzle. Back away immediately
- Minimum separation requirements for above-ground storage tanks can be found in Section 2206, page 212 of the 2012 NC Fire Code

Compressed Natural Gas (CNG)
Section 2208 of North Carolina Fire Code

Storage:

- All storage vessels and equipment used for the storage, compression or dispensing of CNG shall be approved or listed

Location of dispensing devices specific to CNG:

- Not beneath power lines
- Minimum 10 feet or more from nearest building or lot line, public street, side-walk, or source of ignition
- Minimum 25 feet or more from nearest rail of any railroad track and 50 feet from nearest main track where train power for train propulsion is provided by an outside electrical source
- Minimum 50 feet or more from the vertical plane below the nearest overhead wire of a trolley bus line
- Compression, storage or dispensing equipment shall be allowed in buildings of noncombustible construction, as set forth in the *International Building Code*, and which are unclosed for ¾ or more of the perimeter.

Emergency Shutdown Control:

- Shall be located within 75 feet, but not less than 25 feet way from dispensers and also be provided in the gas compressor area
- Shutdown system shall automatically shut off the power supply to the compressor and close valves between gas supply, compressor and storage containers

Separation distance for atmospheric venting of compressed natural gas storage:

Minimum 25 feet:
- Buildings and building openings
- CNG compressor and storage vessels
- CNG dispensers
- Other vehicles

Minimum 15 feet:
- Lot lines
- Public right of ways

Liquefied Petroleum Gas (Propane)
Section 2207 of North Carolina Fire Code

Definition: A fluid in the liquid state composed predominantly of methane which may contain minor quantities of ethane, propane, nitrogen or other components normally found in natural gas.

Storage
- All storage vessels and equipment used for the storing and dispensing of LPG shall be approved or listed, and includes containers, pressure relief devices, regulators, hoses and hose connections, pumps, and electrical equipment.
- Operations shall be conducted by qualified and properly trained attendants
- Minimum 50 feet between other fuel storage tanks

Location of dispensing devices specific to LPG:
- Dispensing devices minimum 20 feet from any other dispenser of vehicle fuels
- The point of transfer for LPG dispensing operations shall be a minimum of 25 feet from buildings having noncombustible exterior wall surfaces, and not part of a 1 hour fire resistant assembly
- At minimum 10 feet from driveways, sidewalks and buildings having noncombustible exterior wall surfaces

Emergency Shutdown Control:
- A manual shutoff valve and an excess flow-control check valve shall be located in the liquid line between pump and dispenser inlet
- An emergency shutoff valve shall be installed in or on the dispenser at the point at which the dispenser hose is connected to the liquid piping
- Self-service LPG dispensing systems shall not be open to the public
- Emergency shutoff switch shall be located within 100 feet but not less than 20 feet from dispensers

Separation distance for atmospheric venting of liquefied petroleum gas storage:
- Due to the liquid nature of liquefied gas, there are no venting issues listed in the NC Fire Codes

Biodiesel
- Class IIIB fuel due to very high flashpoint of 260 degrees Fahrenheit

Due to the lack of flammability and simple implementability of biodiesel, there are no special fire codes pertaining to the fuel being collocated at a MAFS facility. Biodiesel storage can and should be inside the same fenced pad as the other fuels, so long it follows the regulations for the other flammable liquid and gas fuels.

Electric Vehicles
Installations of electric vehicle charging stations are becoming ubiquitous across the United States. As more diverse vehicle fuel options become available in the form of electric drive motors, these charging stations will become even more prevalent. In the case of a multi-alternative fueling station, as long the minimum operational, storage, and dispensing regulations are met for liquid and gas fuels on site, there are no further laws governing the siting of an electric vehicle charger.

Ethanol
Section 2206 of North Carolina Fire Code: Flammable and Combustible Liquid Motor Fuel

Definition of Alcohol Blended Fuels: Alcohol blended fuels, including those containing 85-percent ethanol and 15-percent unleaded gasoline (E85), are flammable liquids consisting of ethanol or other alcohols blended greater than 15 percent by volume.

- Class IB Fuel due to low flashpoint of 55 degrees Fahrenheit

Storage:
- Above ground storage tanks shall be safeguarded from public access or unauthorized entry
- Guard posts shall be provided to protect above ground tanks from impact by a motor vehicle
- Openings for above ground tank shall be through the top only

Location of dispensing devices specific to ethanol:
- Class I and II liquids shall be transferred from tanks by means of fixed pumps designed and equipped to

allow control of flow and prevent leakage or accidental discharge
- Shall be mounted on a concrete island of 6 inches or more in height

Emergency Shutdown Control:
- An approved automatic emergency shutoff valve designed to close in the event of a fire or impact shall be installed in the supply line at the base of each dispenser
- Dispenser hose should be a maximum of 18 feet in length and equipped with an listed emergency breakaway device designed to retain liquid on both sides of the breakaway point

Separation distance for atmospheric venting of ethanol:
- A spill container of capacity not less than 5 gallons shall be provided for each fill connection
- Relief venting shall comply with Chapter 34 regulations and NFPA 30A

Other Considerations

In addition to these very practical considerations when designing an alternative fueling station, for the purposes of the ReVenture station, several other design considerations arose during multiple work sessions, charrette's, and other exchanges of ideas with multiple parties.

Specifically, the questions arose: *how can the language of architecture and design be used to underscore that this station represents an entirely different way to fuel the transportation necessary to our economy? How can the station, while maintaining a reasonable or comparable budget, illustrate to both users and passing traffic that using alternative fuels is a mark of the future, of progress and a re-thinking of how our needs can be met in relation to the environment around them?*

Additionally, at ReVenture, the station will serve as a gateway to a very unique eco-industrial park which also re-thinks key relationships between industrial economic infrastructure and nature around it.

Visitors Center

In keeping with the use of the fueling station at ReVenture as a gateway to the Park itself, a visitor's center has been programmed into the primary building. The building itself is conceived to be built from re-purposed shipping containers – this underscores the existence of ReVenture as a recycled industrial park, of alternative fuels as a renewable resource, and it provides an opportunity to provide a visually stunning architectural component of the station within a reasonable budget. The visitor center will be programmed by the staff of ReVenture, and will include maps, interactive videos, and historical items.

In the words of the Architects

In addition, the design team focused on several other aspects of how the station fits into the environment around it that could be considered "extra-curricular" to the basic needs of a station but which are not a large additional expense, while adding to the unique character of this type of station in comparison to a normal petroleum station. Some of the key points, here from the design summary completed by the architects, are inserted below:

Based on a design charrette led by Flux Design at the outset of this project, we determined that the primary objectives of the architectural design for the Alternative Fuel Filling Station are:

1. To act as a sign and threshold to ReVenture Park;

2. To highlight the unique nature of this Filling Station as representative of a number of alternative fuels, rather than a traditional petroleum filling station;

3. To serve a didactic purpose, educating visitors about alternative fuels and ReVenture Park.

These objectives, while derived from the specifics of ReVenture Park, could be extrapolated and adapted to other sites with a similar agenda.

Design Summary

Several strategies have been employed in order to meet the previously stated objectives. These strategies are as follows:

A. The site is planned to establish clear entry/access to the site, providing well-defined routes of circulation for vehicles and visitors. The zoning and circulation create a dialogue between the fueling infrastructure and the elements of nature that is re-introduced to the site – both of which offer unique experiences and educational opportunities for visitors.

B. A Visitor Center will be provided to establish a node on the site that is comfortably scaled and programmed for people (rather than vehicles). This Center would be constructed of repurposed shipping containers to communicate the ideal of reuse/reclamation that exists at ReVenture Park.

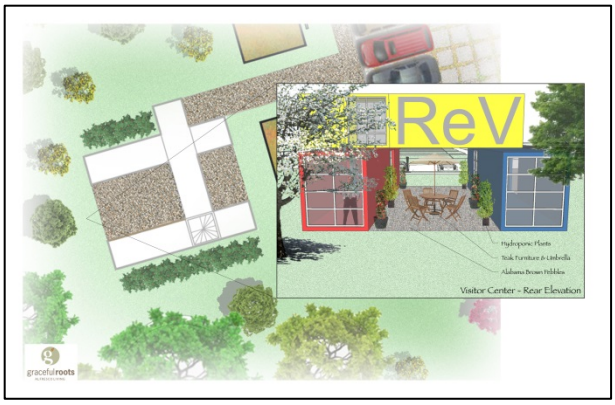
C. To differentiate this Filling Station, and use an architectural language to convey its purpose, the storage and transfer equipment will be placed near the road and minimally screened. The equipment as well as the station canopies will be color-coded by fuel to highlight the diversity of fuels and technologies that are offered – bold colors will draw attention to the site.

Landscape Design

Rethinking the Interface of Fueling

As the design considerations of an alternative fueling station took shape for this study, the recurring theme in group work sessions was this: if the concept of how we obtain and distribute our fuel is being radically changed, how can the design of the facility itself reflect and promote that basic fact. In other words, why should an alternative fuel station look and feel the same as a regular fuel station? Indeed, rethinking how a station looks and "feels" during the fill-up process can help to promote the fuels themselves.

This concept was reinforced by the selection of ReVenture Park as the example feasibility site. ReVenture is a 670 acre post-industrial site that has been re-invigorated through the robust application of principles of industrial ecology. This process has extended to creating a facility that is extremely friendly to wildlife (osprey nests and other habitats, Wildlife and Industry Together Certification) and with a particular focus on sustainable habitat creation as part of the landscape design and maintenance. With this in mind, it was decided in consultation with the project architects to include a landscape designer on the team; in this case, the concept is that landscaping – typically an afterthought for a fueling facility – could play a larger role in re-casting the image of fueling stations, promoting the use of alternative fuels by creating a more pleasant place to fill up, and integrating the station into the region around it.



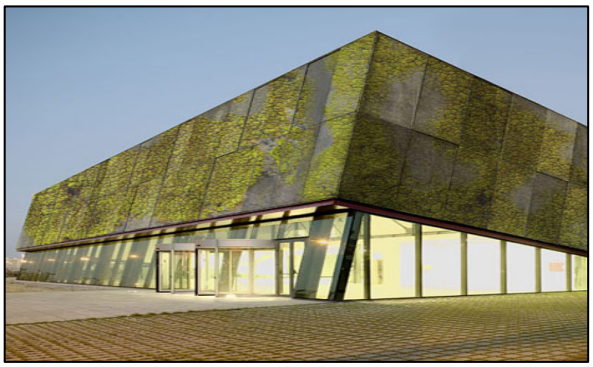
The landscape design for the ReVenture site is included on the next page. The principles which were included, derived from multiple work sessions with the design team, are copied here from the designer's summary of her work, included in the appendix:

A. A series of four educational garden beds are to be installed in front of the parking area, with plantings (indicated in the attached schematic) of regional plants which engage the growing cycle in each of the four seasons. These beds will contain educational placards to illustrate the historical, regional and/or cultural significance of the plants, and will educate and provide a unique aesthetic perspective to visitors to the station.

B. Rather than hide the compression and other equipment as is commonly done, it will be painted in a colorful manner and walkways constructed around it so that visitors waiting for their vehicle fill to complete can enjoy a walk around the facility. The pathways will be made of wood mulched from the thinning of the forest on the hill behind the facility to continue the theme of sustainability/reuse.

C. A "Living Wall" will be constructed at the front of the facility with the letters "ReV" incorporated into the plantings. The wall will be accessible from the pathways listed above and visible from the road, and will provide an avenue to start conversations about the station and the Park. The contrast between a "living" sign to the facility as opposed to the electrical signage of a traditional

station will reinforce the radical departure from business as usual.



D. The roadway of the facility will be made of a paver that allows grass to grow in every-other cell. This material, specified in the drawings, is rated for and has been tested with heavy vehicle traffic of the type expected at the station. The grass mix roadway will provide another stark counter-point to the more expanse of bare concrete at a traditional station. It will also illustrate the concept of safety and environmental cleanliness – as opposed to a service station with petroleum stains on concrete, this station will have living grass in the roadway itself.

E. The rest of the station will be populated with strong contrasts of color and size with mostly regional plants, and a 3' retaining wall behind the roadway to provide emphasis to the upward slope and existing (thinned) forest behind the station. A pathway from the station down to the Catawba River will allow for a more interesting walkway for station customers who have more time, such as those using electric vehicle charging stations.

F. Although not included in the drawings, the designer also recommends the option of including edible landscaping, in the form of garden towers placed along the front of the visitor's center, which can be utilized as a food source for natural, local soup & sandwich vending in the visitors center. This option would require the engagement of a food vendor with a non-traditional business model, which may be very difficult to find, and is thus listed as an option here rather than drawn into the design.

Other Variables

Cost

The issue of cost as it relates both to operating expenses (mostly the cost of fuels) and to capital expenditure (the cost of building a station) varies widely and dramatically affects the feasibility of a Multi Alternative Fueling Station.

Fuel Costs

Specific fuel cost considerations are discussed in the individual fuel sections but it is worth noting a few general observations.

Alternative fuels are, like traditional fuels, a commodity market and dramatically affected over both the long and short term by commodity prices. This is particularly true for alternative fuels because they will be compared to the traditional fuels they replace; long trends can make an alternative fuel less expensive at some points and more expensive others. Decision-makers must look at the economic projections of a project, but also decide if it is worthwhile to implement for fuel security or environmental reasons as well. It is the believe of the writers of this book that, in these times of tight budgets, decisions should be driven primarily by fiscal prudence; when commodity market trends invert the cost structure of alternative vs. traditional fuels, however, it is less stressful if other considerations were part of the equation.

There are two easy examples of how long range commodity markets can affect the cost of alternative fuels.

- Biodiesel is an excellent alternative fuel because it can be made regionally and used in a huge existing inventory of diesel engines. But it has faced some difficulty in widespread implementation due to commodity pricing factors. During the early years of biodiesel's wider use – from 2005-2009, it was often made from waste sources of vegetable oil, many of them high volume wastes from industrial food processes or other rendering sources. This promoted a widespread growth of regional, small- and medium-scale fuel production facilities. At the end of that time, however, the commodity market for those feedstocks, driven by animal feed mills and other industries, rose dramatically, essentially causing the feedstock to cost almost as much as the market for the fuel itself would bear. This, along with uncertainty around the related tax credits, caused a massive consolidation and price shift upward in the fuel.

- Natural gas is currently one of the least expensive alternative fuels due to the discovery of large amounts of domestic resources through new drilling techniques. This has spurred a massive investment in CNG vehicle and fueling infrastructure. However, macro market forces – particularly the opening of overseas export markets – promise to change market balances. Most experts predict that natural gas prices will rise over the next few years, though they are still expected to be very competitive with traditional fuel.

Supply Variability

The distribution system for traditional fuels has been developed over the past 100 years. It is highly efficient and disrupted typically only in severe weather-related incidents, such as the petroleum shortage experienced in the Charlotte region after several hurricanes disrupted fuel logistics in the Gulf of Mexico region in 2008.

The distribution system for alternative fuels is currently evolving and faces specific challenges, such as the limitation of natural gas pipelines or the impossibility of putting ethanol – with its wicking qualities – in the existing fuel pipelines.

Because of this, special consideration should be given to the fuel supply for a multi alternative fueling station. In each region surveyed for this study, existing fuel distributors had a steady supply of alternative fuels provided over many years without incident. A planner or champion for a MAFS should simply be aware of this issue and make key decisions early to avoid a problem with supply.

Key questions are:

- Is the goal to always save money, in which case supply variability will require more attention but discounts on the commodity market may be obtained (with additional work/effort on the part of the MAFS managers)

- Should the MAFS team work with a particular vendor for each fuel. If there is no stomach for market pricing risk or bandwidth for periodic fuel

pricing negotiations, one local vendor should be engaged from the beginning of the process. A local vendor with decades of experience, who deals in both alternative and traditional fuels (for back-up purposes) and is highly recommended and credit-worthy, will reduce operational and supply risk, if not pricing advantages.

Fuel Security

It should be noted that alternative fuels do enhance the fuel mix and thus increase fuel security. As noted above, though they have been rare, in natural emergencies it is common to experience fuel shortages. In the last decade this type of emergency has become less rare – droughts in the West, hurricanes and tsunami's globally – have become more and more common. As recently as 2 years ago massive shortages occurred in the New Jersey region after a hurricane struck there. There is a fair amount of concurrence in scientific opinion that such incidents may increase.

Also, stability in the Middle East and other oil-producing regions has been elusive; at the time of this writing, a radical group is threatening the oil producing facilities in northern Iraq.

For foreseeable decades, there will always be a large distribution system for traditional fuels. The proliferation of alternative fuel infrastructure, and inclusion of more vehicles in fleets (particularly in emergency/vital service fleets), provides an added measure of fuel security.

Future Outlook

There has been much debate about how long the supplies of traditional fuels will last – the widespread concept of Peak Oil predicted that supply would "peak" and start to decline over a decade ago, has not happened. Advancing extraction techniques have opened larger supplies than previously thought.

Still, it is undeniable that the new techniques make it more difficult and expensive to get to the remaining oil, and further that it is very likely harmful to the environment to continue to extract those sources of fuel.

At the same time, the EPAct alternative fuels have steadily become more and more available and economically sensible. New methods of extraction have made natural gas into a key part of the U.S. economic recovery, for example, and new methods of creating ethanol and biodiesel from waste resources and novel methods, such as algae, promise to bring significant change to those fuels.

While there is pressure from environmental concerns surrounding traditional fuels – private and public organizations are adopting sustainability goals, there is federal regulatory pressure on pricing and supply, etc. – it is likely that the implementation of more alternative fueling infrastructure will continue and increase for the simple reason of pricing.

Simply put, regardless of how one may perceive environmental threats, at present it is simply a good economic decision to diversify the fuel mix to include alternative. This promises to bring about a sea change in the fueling investment infrastructure which has already begun, especially in compressed natural gas.

Funding Sources

The implementation of novel technologies or infrastructure is always a challenge due to the lack of historical risk data. Put simply, the decision-makers for capital investment are charged with reducing risk, and a new model is inherently risky.

Because of this, the funding for an alternative fuel station will be fundamentally harder to come by than funding for a more traditional piece of equipment or fueling infrastructure that has been implemented nationally, repeatedly, for decades.

This list is not meant to be exhaustive – funding sources are widely varied by region and change regularly. Instead, it is meant to give the reader an idea of what sources are available at present, and to provide background or context to a search for funds for a specific site.

Private Funding

The largest numbers of alternative fuel stations to date have been funded by large utility companies – typically natural gas for CNG or electricity for charging stations – and by regional or local governments, which will be discussed below.

In the former case, the business justification is simple: these modes of transportation, if widely adopted, would provide an entirely new customer base to the utilities. The utility companies are adequately capitalized to be able to budget for stations and can justify them as both research and development and marketing expenditures. Examples of this type of

funding in the Charlotte region would be the compressed natural gas filling station off South Tryon Street installed by Piedmont Natural Gas and various electric charging stations funded by Duke Energy. A closely related effort, undertaken for the same purposes, would be the large scale effort of Nissan to fund electric charging stations to expand the customer base of its Leaf Electric Vehicle.

Often, these organizations look to work with private and public sector fleets to ensure activity at their stations. Anyone contemplating the development of a MAFS – whether a public or private entity, or of a single fuel station, should have some conversation with their local utilities and other large companies with a market incentive to participate financially or otherwise assist.

Municipal/County Regional Governments

Local government units are the second largest funding source for alternative fuel infrastructure. Including school district's bus operations, municipal public transportation, maintenance operations, and the fleet vehicles associated with government entities are fruitful areas for alternative fuel stations.

In these cases, very often the same obligations of return on investment are not required for expenditures, though public decision-makers should and typically do follow the same types of fiscal prudence as the private sector. Still, often in a public entity it is enough for one champion of an idea to be able to convince several other key people – perhaps Finance and Building Service Directors, for example, and start the process of implementing a MAFS station. In the private sector that process – including private individuals or companies with funds at risk, lending institutions and underwriters, is often more conservative.

Private Sector Developers

As noted above, this is perhaps the most difficult position for development of a MAFS because of the conservative nature of raising private sector capital. Yet, in order for wide-scale implementation of this type of fueling infrastructure, this type of development is essential. Consider the tens of thousands of fueling stations nationally devoted to traditional fuels, and that only the smallest fraction are owned by the public sector. The fact is that in order for wide-scale implementation of alternative fuels to occur, the private sector must see the infrastructure as a safe investment for which adequate returns on investment are available.

During the transition stage – from novel concept to historically proven investment – funding for a MAFS by the private sector will likely involve a high degree of innovative financing coupled with funding back-stopped with adequate balance sheets rather than simple reliance on the business model.

Innovative private sector funding mechanisms:

The Self-Help Credit Union in North Carolina has a New Markets loan fund which could be used for MAFS construction. The fund, which takes advantage of the tax credits of associated with underdeveloped areas, allows a private sector developer to tap low interest funding (currently +/- 4%) without the documentation burden of the New Market Tax Credit regime. This loan program can be accompanied, in rural zones, with a USDA loan guarantee. Between the two programs, private capital is leveraged, and de-risked, sufficiently to allow investment in an innovative infrastructure project like an alternative fueling station.

There are a wide variety of public funding sources for a MAFS station, whether constructed by the private or public sector. The descriptions below will give the reader an idea of what is available.

Federal and State level incentives, subsidies, laws, and grants that promote the adoption of alternative fuels and infrastructure surrounding them are tracked by the Alternative Fuels Data Center. Their website contains the most pertinent and up to date list of available incentives. The website address can be found in the appendix of this report.

Below is a sampling of available programs, which are tracked and listed by the U.S. Department of Energy *Clean Cities National Program.*

U.S. Department of Transportation Federal Highway Administration:

Congestion Mitigation and Air Quality Improvement Program (CMAQ)

- Flexible funding source for state and local government to fund transport projects and meet requirements of the Clean Air Act

- Reducing mobile source emissions in EPA nonattainment zones
- Includes funding for public fleet conversions to cleaner fuels
- Federal share for most CMAQ-eligible projects is 80%
- Paid upfront by state or local government, reimbursed after completion

In North Carolina, these funds are administered by the Department of Natural Resources under the Diesel Reduction program.

Federal Aviation Administration
Voluntary Airport Low Emission Program (VALE)
- Designed to reduce all sources of airport ground emissions
- Airports are prime candidates for alternative fueling stations
- Provides funding incentives to finance refueling and recharging stations for vehicles used onsite

Environmental Protection Agency
- Most funding opportunities is for research, enhancing public awareness, and decision making for environmental awareness
- Brownfield Grants and Funding for redevelopment of contaminated sites

National Clean Diesel Campaign
- Diesel Emission Reduction Act Grant
- Up to $100 million annually through 2016
- RFP closes every June

School Bus Replacement Program
- Fall 2014 will begin 2nd round of program
- $3 million in rebate funds for public and private school bus owners

Grants.gov
- Single access point for all 26 Federal grant-making agencies and over 1,000 grant programs

Airport Zero Emission Vehicle Infrastructure
- Up to 50% of eligible cost to acquire Zero Emission Vehicles
- Priority to airports in non-attainment zones
- Installing fueling infrastructure is also included in the program

Public Private Partnerships: DOE Clean Cities

Many examples of public - private partnerships exist across various industries across the country and the development of multi-alternative fueling stations within this model has potential to create further adoption of such infrastructure.

Public Property Land Utilization
- Government could provide public owned land to be used as a host site.
- The private organization would then be responsible for installing the fueling and charging equipment, supplying the commodities, and managing the station operations.
- With this model there would be no upfront public investment, yet would benefit public organizations, private companies, and the public users.
- The entity developing the project could also benefit from tax incentives or Federal/State grants.
- If a target return is reached is reached for the proprietor of the station, a model could be put in place for the state to receive excess revenue, which would benefit both parties. This is known as a *percentage of gross revenue* transaction.

Co-Location
- Private developer would design and implement alternative fuel station at government facility
- 2 access points: one for both public citizens and private fleet use, one for public organization to utilize singularly
- Recommended: both Quick Fill and Timed Fill for use across fleet operations overnight and private vehicles utilizing on their driving route.

Private Property Land Utilization
Conversely, another model which could be explored is the use of a privately-owned property for a publicly-funded MAFS. In such a scenario, a private sector developer may be motivated by increasing the value of an adjoining property she/he owns, or by the desire to make a planned development more attractive to a wider market of potential customers by providing a MAFS destination and a legitimate facet of "green" marketing.

Open to Public vs. Fleet Specific Access

With minimal investment, both governments and private operators of alternative fuel stations can provide opportunities for citizens to utilize their facility. Enabling access for citizens will increase adoption of alternative fuel vehicles: if citizens understand there are easy to access fueling stations

within close proximity of their commute, a portion of the population interested in saving on fuel costs will then be able to switch from traditional fuel vehicles to alt or bi-fuel options.

Considerations into opening a station to the public versus a fleet vehicle only station will include:

- Security of the station: who can gain access to the station and how to locate to ensure secure operations
- Return on investment projections: if developing the infrastructure for both Timed and Quick Fill options will prove financially viable
- Liability: who will be responsible for insuring the station; how to limit exposure for the owner of the station if open to the public
- Operations: more oversight may be required for a station which is open to the public.
- Construction: The capital expenditure for a public station, such as the example design presented in this guide, are higher than a large-vehicle fleet only station.

Useful Tools

Critical Pre-Feasibility Questions

Below is a thorough questionnaire that should be administered to fleet managers and organizational decision makers prior to engaging vendors or technology providers. Minimum thresholds of potential volume being met are crucial to the long term viability and sustainability of alternative fuels.

Highest Importance:

1. Does your organization operate a fleet of vehicles?
2. What is the current fuel used for transportation?
3. How many heavy and light duty vehicles are currently in the fleet?
4. Is your fleet vehicle depot located in a high traffic area?
5. Is there desire to allocate money for a station inside the organization?
    a. What is the minimum threshold return on investment within the organization?
6. What is the plan for further growth of the fleet operation in a sustainable manner?

Secondary Importance:

1. Are other fleet operators, both public and private, in close proximity to your facility?
    a. Can a Letter of Intent to use be established with those organizations?
2. What is the key driver for diversity in fuel sources and adopting alternative fuel into the fuel mix?
3. Does your current fleet facility have the available space for a station?
    a. Is the station zoned such that vehicles outside of your fleet could utilize?

Important but not deal killers:

1. What are the major concerns for your fleet manager? (For example: mitigating technology risk)
2. Does your organization have sustainability goals? (For example: transportation carbon reduction)
    a. What are they and how are they going to be met?
3. Has any research been done into potential grant funding?

Next Steps:

1. Financial modeling and return on investment for fleet vehicle alternative fuel investment

Conclusions

In some ways the concept of a fueling station that provides a range of alternative fuels to private fleets and the public completely upends the existing model of a petroleum-based station. As in any paradigm shift, there are difficulties in finding the market, proving the revenues that exist in the marketplace, and establishing the supply and pricing of goods sold. Because of these difficulties, challenges lie in securing funding for such a project.
This study contains a wide variety of information about the logistics, practical concerns, design and even aesthetic considerations of a MAFS; there is a wealth of information about each of these in the previous sections and in the appendix, and a high level summary is included in the findings below.

Findings

1. Location, location, location
    - Mostly to existing to fleets – they must be nearby and commit to use the fuel, especially if CNG is to be viable
    - Located in a high-volume vehicle area is ideal for future growth

2. Engage all key stake-holders early and often
    - Funding: What are the sources of funding, who are the decision makers? Start there
        - For public, engagement with the budget process
        - For private, identify where the money would come from early
        - Be realistic: a new station will start at $750,000
    - Site
        - Zoning suitability
        - Access
        - Safety
    - Permitting
        - Building officials
        - Fire Marshall
        - Department of Transportation

As noted in the financial modeling and considerations section, there are several important economic conclusions to consider as well:
Likely ranking of fuels from an economic perspective:

1. Biodiesel
2. Liquid Propane Gas
3. Natural Gas (unless fleet strong fleet commitments are ready)
4. Electric Vehicle Charging (but designing for future installation is recommended)
5. Ethanol

Finally, it is worthwhile to end the study conclusions with a discussion more general conversation about the feasibility and desirability of a MAFS. This study shows clearly that a MAFS station is not an easy undertaking. It is however, certainly possible and in the right circumstances, very attractive from a return on investment or fiscal responsibility perspective. Simply put, if a large, high-volume fleet is engaged from the beginning, the station is entirely feasible. One fuel for such a fleet can be leveraged for other fuels to create a MAFS.

If interesting design and aesthetic considerations are included in the planning, a location can be created which provides both fueling infrastructure and logistical support to alternative fuels and fleets, but also provides a highly visible "flagship" to the citizen and business community around it.

This flagship indicates that a government is committed to leading the way toward a different fueling future, where the direct and collateral costs of standard liquid petroleum are not necessary and accepted. It indicates to the public that a private company exists on the cutting edge of doing well by doing good – figuring out the economics of a different type of future while participating in cultural and environmental stewardship that is attractive, even necessary, to larger and larger segments of the citizenry and purchasing market.
For any organization that is dependent on those forces, citizenry and customers – and all are – it is well worth the time and effort to investigate whether a MAFS is feasible and desirable.