Online Focus Group with Large Fuel Retailers

Objectives

- Determine general business practices and appeal of alternative fuels among fuel station owners.
- Expose fuel retailers to 4-6 ideas for a hydrogen station with high-level information about costs, ROI, incentives and space requirements.
- Understand the motivations and incentives for offering hydrogen fuel in an early commercial market, and understand the limiting and prohibiting factors.

Methodology

- One online bulletin board discussion was conducted over a four-day period, from January 26-29, 2010.
- Features of the bulletin board discussion format:
  - Participants and moderator were sent access instructions to log into a secure web site
  - At the beginning of each day questions are launched with probes posted later in the day, as necessary.
  - Participants are asked to log into the web site each day at a convenient time. They spent up to 30 minutes per day responding to the questions and follow-up probes.
- A total of 14 respondents participated in the session. Participants are key decision makers from fuel retailers and are involved in the decision-making about which fuel services to offer at their stations.
- Verbatim comments appear throughout this report. In some cases, the comments have been edited to enhance clarity.
- Jennifer Caughlin, Ph.D., moderated the bulletin board sessions.

Methodology – Statement of Limitations

- Bulletin board discussions seek to develop insight and direction rather than quantitatively precise measures. Because of the limited number of respondents and the restrictions and selectiveness of recruiting, this research must be considered in a qualitative frame of reference.
- The reader is reminded that this report is intended to clarify cloudy issues and point out the direction for future research. The data presented here cannot be generalized to a universe of similar respondents.
- The value of bulletin board discussions is their ability to provide unfiltered comments from a segment of the target population, for respondents to interact and build upon others' responses, and for decision-makers to gain insights into the beliefs, attitudes, and perceptions of their consumer base.

Executive Summary

Future of Retail Fuel Sales

- Fuel retailers must figure out new ways to maintain their slim profit margins as non-traditional fuel retailers continue to cause market erosion.
- Convenience stores will continue to own the convenience market and 'hyper marketers' (Kroger, Costco, etc.) will own the price market in fuel sales.
- Renewable fuels will likely increase in the marketplace as government mandates apply pressure. Biofuels, particularly in the form of ethanol blends and biodiesel, are likely to make up a large portion of the alternative fuel progression.
- The transition to alternative fuels is expensive and will likely eliminate smaller retailers.
- Consumer demand may be a factor in alternative fuels, but only if gas prices continue to rise. Consumers tend to be 'green' only when it is economical. Therefore, if oil prices decline, the demand for alternative fuels is also likely to fall.

Advantages to Adding Alternative Fuels

- The primary benefit is fuel sales. Secondary benefits include meeting federal RFS standards, acquiring a new 'green' customer segment, and competitive advantage.

Disadvantages to Adding Alternative Fuels

- Fuel retailers have concerns about entering the alternative fuel market due to a variety of factors potentially influencing business and the fuel market. Concerns include:
    - Large financial investment
    - Government backing out of financial commitment, leaving blenders to carry the financial burden
    - Auto companies not producing a sufficient number of alternative fuel cars
    - Consumers not buying a sufficient number of alternative fuel cars
    - Consumers' lack of understanding and negative perception around biofuel performance
    - Consumer interest in being 'green' is based on economics
    - Inconsistent product availability and distribution.
- With the variety of alternative fuels available, retailers also worry a fragmented market may further hinder their success as they try to anticipate 'the' alternative fuel of the future.

Factors Influencing the Adoption of Alternative Fuels

- Most impact—profit from fuel sales and ancillary sales
- Second—subsidies and tax credits because they help make the economics more palatable.
- Least impact—government regulation compliance and marketing/brand position

Affects of Global Warming Regulations on Future Retail Fuel Sales

- Federal and state-mandated fuel changes will result in higher costs for retailers and consumers. These regulations will ultimately increase the cost of fossil fuels, forcing consumers to consider alternative fuels.
- Cap and trade proposals, the current revision of RFS-2, and future Stage II vapor recovery rules all have potential negative financial implications for fuel retailers.

Initial Interest in Hydrogen

- Reactions are mixed, but most retailers are interested in the future development of hydrogen. With appropriate incentives and co-funding options to offset the initial costs, and a sufficient number of hydrogen vehicles produced by the auto industry, there may be growing interest in this fuel option.

Evaluation of Five Station Configurations

- The high initial investment of all five models is likely to make them unaffordable without government grants or subsidies.
- While the storage cylinders are a unique and simple storage solution, the daily deliveries raise concerns about maintaining a consistent inventory.
- Underground storage minimizes the footprint required but suggests additional regulations and liabilities for station owners and operators.
- Using electricity to produce hydrogen on-site is risky due to the rising cost of electricity. Additionally, if electricity is pulled from the grid it is a polluting source of energy.
- Using a fuel cell to produce electricity, heat and hydrogen is appealing, particularly when it is owned by the retailer.

Key Findings

Focus Group Respondents

ID	Years in business	# of locations	Types of stations	Types of fuel	Customer base
5	80+	76	Retail w/ fuel	Gasoline, ULSD, E85	Rural and interstate traffic
6	60+	600	Retail w/ fuel	Gasoline, diesel, E10	Primarily retail (consumers), some wholesalers & dealers
7	34	20	Retail w/ fuel	Gasoline, diesel, E85, CNG/LNG, propane, biodiesel,	Consumers – commuters and locals
9	35	298	Retail w/ fuel	Gasoline, diesel	Consumers
10	39	299	Retail w/ fuel	Gasoline, diesel, biodiesel	Consumers
12	14	320	Retail w/ fuel		
13	120+	900	Retail, travel plazas, retail w/ fuel	Gasoline, diesel, E85	Consumers, commercial and government fleets
14	80	68	Retail filling, card lock, travel plazas	Gasoline, diesel, E85, propane, biodiesel	Transient near highway & local customer base
15	<1	7	Retail, retail w/ fuel	E85, biodiesel, electric charging station	Consumers, state and federal fleet vehicles
16	30	1	Card lock	Gasoline	Private fueling station for company employees only
17	63	32	Retail, card lock, retail w/ fuel	Gasoline, diesel	Everyone
18	40	230	Card lock, retail w/ fuel	Gasoline, diesel, E-10, occasionally biodiesel	1 convenience store, private fleets, retailers
19	30+	1000+	Retail	Gasoline, diesel, E85, propane, biodiesel, hydrogen	Private and transportation industry
20	35+	15+	Retail w/ fuel	Gasoline, diesel, E85, biodiesel, kerosene	Consumers

Future of Retail Fuel Sales

Fuel retailers will continue to look for new ways to make a profit despite the current price margin erosion occurring in this rapidly changing industry. *"Operational excellence is essential for survival."*

- Traditional fuel retailers will continue to see price margin erosion with the increase of non-traditional fuel stations (Sam's Club, Costco, Kroger, Safeway) selling gas at cost. The big box stores are similar to convenience stores in that they make their profits on non-fuel sales, allowing them to price gas as their loss

leader.

- Rewards programs offered by grocery chains further impact fuel sale volume during rewards redemption periods.
- With the struggling economy, consumers continue to be price-sensitive, particularly with fuel purchases, increasing the overall appeal of these big box retailers.

- Traditional fuel retailers may have to rely on non-fuel sales to make a profit and stay competitive in the industries.
- The number of small operators will decline as they struggle with the economic impact of government regulations, credit card fees, and equipment upgrades.

Alternative Fuels

- The use of renewable fuels will increase as a result of government mandates and consumer demand. As automakers reintroduce diesel passenger vehicles, diesel demand will also increase.
- As a result of government mandates for renewable fuels, retailers will be forced to make changes, including upgrades in equipment and procedures, fuel handling, and maintaining tank integrity.
- Changes in the demand for alternative fuels will likely depend on the price of traditional fossil fuel. If gas prices remain low, price-conscious consumers have little incentive to change to an alternative fuel that may be more expensive.
- The retailers have an underlying concern that the retail fuel business may become so fragmented with fuel choices for consumers that retailers will not be able to provide all of the fuel types the public demands.
- The percentage of biofuel blended into gasoline and diesel will increase in the next 5-10 years as will the number of electric-powered vehicles. Overall, vehicles will be able to travel more miles before needing to refuel.
- They generally agree that biofuels, particularly in the form of ethanol blends, will be a large portion of the “alternative fuel progression.”

Advantages of ethanol blends

- E85 could be the fuel of the future if a cellulosic conversion is created that takes the ‘perceived’ pressure off the food chain.
- Ethanol blends are gaining acceptance in the corn belt.

Disadvantages of (or barriers to) ethanol blends

- Ethanol is produced from a product that is integral to the food supply.
- Sporadic distribution and inconsistent supply
- Price instability
- Difficulty in determining which blends to offer (E10, 14, 85) until entire fleets are turned over and all vehicles are compatible with E85.

- Negative consumer perceptions of performance issues with ethanol blends.
- Marine engines do not perform well on ethanol fuel blends.
- Current dispensing equipment is not UL certified for a blend greater than E10.

Comments about Alternative Fuels

"Retailers are going to be faced with the difficult decisions on what products we offer for sale."

"Over the next decade I expect we will see a tremendous increase in renewable fuels as well as the introduction of LNG and CNG. The first notable impact is that the transformation of this product is going to come with a hefty price tag. Today's dispensing equipment is not UL certified for a blend greater than E10. Additionally, the majority of vehicles on the road will not be compatible with blend rates higher than E15."

"Suppliers are providing blend at the pump modifications that allow customers to choose between E-5, E-10, E-15, and E-20. It is currently gaining acceptance in the corn belt and I'm sure we will see this technology spread as OEMs approve of the higher blends."

There are differing opinions about consumer acceptance of 'green' practices.

Some believe consumers will embrace it	**Others suggest interest is purely economical.**
"Many of our customers have commented on our move to bring E-85 to the market. They are grateful we have made this choice and have supported the products at our locations. We are looking to improve our green footprint through the use of energy efficient lighting and supplemental solar electricity and geothermal heat sources. The public has responded favorably to these efforts." *"Our biodiesel demographic is about the same as diesel. For ethanol, we get early adopters, environmentalists, and pro-U.S./anti-foreign oil and some super smart consumers that do the numbers. They know their mpg with gas and ethanol and make a decision based on finances. Ethanol is 15% less than regular unleaded but we have had spreads as high as 30%."*	*"In our markets the only benefits (of alternative fuels) are hitting required air quality standards and cost savings. The consuming public almost overwhelmingly resists the product, enough so that in one state we do not even offer them."* *"People talk green, but only when there is an economic benefit directly to them. Still, most people remain uneducated on FFVs and their ability to help save natural resources….It just shows the emotion attached to the public's input at the time, versus living with the reality of the issue day to day, and fill-up to fill-up."* *"The motoring public tends to let their wallets do the talking. They won't buy bio when it is more expensive than conventional."*

Affects of Global Warming Regulations on Future Retail Fuel Business

Federal and state mandates will result in higher costs for retailers and consumers. Regulations will ultimately increase the cost of fossil fuels, forcing consumers to consider alternative fuels.

- Most retailers acknowledge mandates are inevitable and are already implementing some of the required changes.
- Cap and trade proposals create several negative reactions. Cap and trade proposals will:
  - Create an undue tax burden on refineries
  - Increase price of domestic production
  - Decrease domestic production which will ultimately increase U.S. dependence on (less expensive) foreign oil.
- The current revision of RFS-2 also elicits some negative reactions about the lack of necessary support ethanol needs in Congress.
- Smaller operations subject to future Stage II vapor recovery rules may be forced to close due to lack of return on the expense associated with the new rules.
- The use of electricity charging will increase but will require the increase of clean sources of electricity (wind, solar) to replace coal plant production.

Advantages of Offering Alternative Fuels

While financial benefits are the key criteria when considering alternative fuels, retailers also recognize the potential marketing benefits of being an industry leader.

- Primary benefit is financial obtained through:
  - Increased business with a broader customer base
  - Competitive differentiation
  - Higher profit margins with blended fuels
  - Government rewards for meeting federal RFS requirements
- Secondary benefits:
  - Enhanced business image as an ‘earth friendly’ fuel provider
  - Capturing the emerging ‘green’ consumer segment as interest and involvement increases
  - Improved ‘green’ footprint
  - Environmental reward of helping preserve the planet

Disadvantages/Obstacles of Offering Alternative Fuels

- There are strong concerns about the financial costs and risks associated with entering the alternative fuel market. The investment required for the installation, storage and dispensing of alternative fuels is high and business owners are skeptical about the length of time required to see a return on the investment.

- Fear that the government may abandon support programs (tax breaks, subsidies, grants, etc.) of alternative fuels, leaving them to assume the full financial burden.
- Concerns that auto companies will not produce enough cars and/or consumers will not buy enough cars to support the alternative fuel infrastructure.
- Skeptical about consumers' willingness to adopt new fuel technologies due to their price sensitivity at the pump, distrust of certain biofuels, and the general lack of understanding of biodiesels among consumers.
- Inconsistent product availability and distribution, and pricing concerns are other common obstacles to incorporating alternative fuels.
- With the potential variety of alternative fuels creating a fragmented market, retailers are unclear about how to identify which one(s) will succeed.

"The biggest risk, in my estimation, is that we will dive into the renewable fuel and alternative energy business and then the demand will not materialize as projected… Installation of new UST's (underground storage tanks) will trigger implementation of newer, more strict EPA and state guidelines such as double wall piping - all resulting in additional capital dollars needed just to stay in business."

"Adding any alternative fuel to the business other than an E10 to E15 blend is going to be very capital intensive for retailers who have had to learn to live on razor thin margins already."

"Many customers expressed a lack of understanding of the product. They had heard that Biodiesel wasn't as good as regular diesel fuel. It would void warranties, it would freeze up in cold weather."

"E10 or any level of ethanol is not embraced within the majority of our southern markets. Historically, there have been problems caused by the heat creating vapor locks on systems, the cleaning effects of the fuel causing autos to miss or need fuel filters to be changed. Many people operate power saws, motor boats, motorcycles, weed eaters, lawnmowers and other small engine machinery that ethanol can create problems with. I also believe the media in many of the markets has flamed this distain by running features on the problems and lower gas mileage."

Maximum Acceptable Time for ROI

The maximum acceptable time to realize a return on investment is one to five years. Many agree any longer period of time would require some form of government co-funding.

"Capital is expensive and hard to get right now and there are plenty of places to invest it outside of alternative fuels to make it perform. We have a fiduciary responsibility to our shareholders."

"If you can't recoup your money in three (years), what's the point? In these changing times the next 'darling' of the media and the public will be entering the market and we will be expected (or required) to make it available. If we haven't recouped the money from the current venture, how will we afford the next?"

"It's hard to accept lengthy ROIs for income streams already working on tight margins for a new product that will almost certainly have low initial demand."

"I would want a quicker payback because of the rapid changes in the market place. In five years there could be new products on the market that are not sold through conventional liquid fuel methods or need special lines, gaskets, etc. or legislative requirements that could change everything. I feel comfortable predicting within the next five years that the entire model will not convert."

Influential Factors in Adopting Alternative Fuels

- Generating profit through fuel sales and ancillary sales are the most influential factors affecting the decision to adopt alternative fuels.
- Regulatory compliance is also important to a few but not the main driver for most.
- Subsidies and tax credits are other influential factors because they help make the economics more palatable.
- Marketing/brand positioning is the least influential factor for most.

"Fuel sales (at a profit if possible) and ancillary sales. We are a for-profit business and would like to stay that way!"

"We would like it to be about marketing and brand positioning, but without the current federal and state tax subsidies, it would really not make economic sense."

"Fuel sales, grants, and tax credits (are most influential)."

"Regulation compliance (is least influential). Right now there are no regulatory/compliance laws or rules in place or proposed that would have forced us to do this."

"Brand positioning (is least influential). Although it would be nice to be able to talk about all that we are doing for the environment, the consumer today is looking for the lowest cost of goods and that is not currently in the form of alternative fuels."

"Marketing and brand positioning would be the least influential. Within our (Southern) markets most consumers do not like the product (E10 or any level of ethanol) and have quickly realized they get less mileage and are fearful of the product especially in motorcycles, boats and small engines."

Alternative Fuels Likely to be Considered

- Many retailers are currently offering E85 and biodiesel and have little consideration for other alternative/renewable fuels.
  - Some, however, are less likely to consider biodiesel due to poor performance issues experienced during winter conditions.
- Others are willing to consider all types of fuel, assuming they can provide an ROI.
- Hydrogen and electric charging stations are not considered by many because test locations are primarily on the West coast or in large 'closed route' operations.

Initial Reaction to Offering Hydrogen

While reactions to offering hydrogen fuels are mixed, most fuel retailers express an interest in the future development of hydrogen.

- Entering the hydrogen market must be affordable for fuel companies. Co-funding and government incentives will encourage these companies to consider adding hydrogen fuels at the retail level.
- Being a leading provider of hydrogen in the retail fuel market will enhance the overall visibility of those stations and increase the PR value for those locations.
- Fuel companies agree those first to enter the hydrogen fuel market have the best chance of becoming a dominant player in the market.
- With the increase in production of hydrogen-fueled vehicles by auto manufacturers, fuel retailers will become more interested in supporting hydrogen development.

Positive comments about hydrogen	Drawbacks of hydrogen
"We already offer hydrogen and we see this is one of the very best alternative solutions for the future." *"(The most important reason to offer hydrogen) is to become a dominant player in the market."* *"We are not looking at hydrogen at this time, however it certainly is in our long range view. Of the approximately 65 hydrogen stations currently operating in the US, most are in California. ..Until a major auto manufacturer mass produces hydrogen fuel vehicles, it doesn't make economic sense in our market."* *"I am very intrigued with the possibility of hydrogen and it seems this alternative fuel does not get the attention of say, ethanol. From what I'm hearing it has many benefits and fewer drawbacks than ethanol, not to mention the food or fuel debate doesn't exist with hydrogen. I think we should all examine this option thoroughly."*	*"Hydrogen right now has no pros. There is such a high cost for the infrastructure $3 million or more and really no hydrogen vehicles have been deployed at this time. With the big push for electric there may never be enough hydrogen vehicles for a station owner to build hydrogen infrastructure…"* *"I do not view hydrogen as a short term answer in our marketplace. With our present E85 locations, we do not see customers willingly driving extra miles to fill-up with that product, even when owning an FFV… Hydrogen may be an answer in highly-populated urban areas, but not in the rural communities that we supply."*

Factors Affecting the Hydrogen Decision By 2015

Factors with the biggest economic impact, such as tax credits, government subsidies, and co-funding/subsidies, are most influential when making the decision to enter the hydrogen market.

Tax Credits	*"Tax credits are almost as good as profit! This would be highly motivating."* *"It would encourage us to move forward faster if it supported a case to improving profitability and supporting this product in the market."* *"It would help the cost of entry as well as sustaining the capital investment until demand grows."* *"It would have limited effect on our desire to implement."*
Gov't Subsidies	*"Government subsidies would help us to decide to invest, however, we all need to remember that the government subsidies came from our consumers and businesses like ours to begin with. I don't support additional subsidies if they are derived from a new tax or fee on the American people or businesses."* *"If government subsidies work to make the product price competitive with existing fuels then this would be a venture worth looking at. The buying public wants to be green. They just don't want to pay for it."* *"It would help the cost of entry as well as sustaining the capitol investment until demand grows."*
Co-funding	*"Partnering with a provider that needs outlets to offer their product would be attractive to us."* *"If these types of programs create a competitive environment then there is potential."* *"(The influence is) slight on co-funding, high on subsidies."*
PR/Marketing	*"PR value is a moderate incentive but not a driving factor."* *"We market ourselves as a 'green' company so PR would have value to us."* *"Becoming a dominant player and market leader would be secondary to our ability to be profitable."* *"Being first to a new product doesn't position you as the dominant player. It shows you have courage and faith. When things work you stand to profit. The downfall is you often have more expense in making it successful as you learn the pitfalls. Others coming in behind you get to learn from your mistakes."*

Carbon Credits	*"Carbon credits obviously have value…This would probably work best for an organization like ours if we could partner with a supplier."* *"The climate crisis can't be solved by buying offsets and claiming to be climate-neutral."* *"I do not see enough CC offset to warrant implementation. "*
Regulation Compliance	*"As a retailer, we don't have the resources to have much impact on government regulation. If we could partner with a supplier that does, this would entice us to enter the market sooner."* *"We would comply with any mandate created through regulation. It may encourage us to close less profitable sites."* *"I see zero government regulation being passed to force us to offer hydrogen."*
New Business Types	*"Potential for new business types and incremental sales of convenience store products would be a high motivation to enter the hydrogen business early."* *"It would have medium (Influence). Transit fleets would require more expense for physical layout of construction and for greater storage space. "* *"Probably not (much influence). Transit fleets that are large enough to revamp their fleets are large enough to have their own fueling stations. Smaller fleets won't support the cost of installation."*
Generate Electricity from the Fuel	*"We are an end-user of electricity. To the extent that it would help us lower our cost of doing business we would be very supportive."* *"I would see this as more of a fit for our residential home heat and propane divisions. Making deliveries to homes equipped with hydrogen storage tanks."* *"(The influence) is very slight especially if now all of a sudden you become a regulated utility. Can we put it back on the grid and get paid for it?"*

Reactions to Five Station Configurations

- The idea of selling alternative/renewable fuel in addition to conventional gasoline is appealing.
- The cost of entry, even on the least expensive option, is considered prohibitive by most participants. Without incentive, grants or subsidies, most of these options are not affordable. Features or incentives that help reduce the cost of entry, reduce O&M, and/or increase ROI enhance the overall appeal of all five configurations.
- While underground storage tanks (B) are preferred over the above ground storage cylinders (A) for their increased capacity, there are concerns regarding the regulations and liabilities of storing hydrogen underground. Some like the simplicity of storage the cylinders offer.

- On-site production (C & D) ensures consistent fuel supply but raises issues around the release of carbon dioxide as well as the regulatory hurdles for on-site production.
- Configuration E is most appealing when the off-site fuel cell is owned by the fuel company (alone or in a consortium) and the electricity can be sold back to the utility. This option ensures consistent inventory and helps reduce O&M expenses.
- Design suggestions for all stations
  - Smaller overall footprint
  - Larger footprint for retail. Inside sales necessary to support ROI.
  - Add E85 and remove one hydrogen pay point
  - Less obtrusive hydrogen infrastructure
  - Hydrogen dispensers on separate island
  - 'Green' hydrogen (made by 'green' energy)
  - Add canopy over dispensers

Factors Influencing Interest

When asked which features increase/decrease interest in these configurations, there is general agreement that any feature reducing the overall cost of entry and operational costs will positively impact perceptions.

- Five years of subsidy for O&M costs have the most positive overall impact on the overall appeal of any station configuration for most participants.
- A regulation multiplier for early adopters (for example, 5x CO2 credits) helps with the initial investment, but there are still concerns about ongoing operational expenses in this uncertain market.
- The ability to make heat/cooling and electricity for the business's use or to sell to the utility increases overall interest, particularly if the fuel cell is owned by the retailer, because it decreases operational costs and potentially increases ROI.
- From an economic perspective, serving more than 200 vehicles per day is essential for most models to be profitable, but most do not want to enter the market with a station this size. They are skeptical of initial 200 vehicle-a-day demand.
- Reducing the size of the footprint increases overall interest.
- The hydrogen production or delivery schedule and the ability to serve heavy duty vehicles or forklifts do not increase interest in this model.
- The ability to use waste products as fuel feedstock (e.g., wastewater, agricultural waste) does not greatly increase overall interest because it does not decrease costs or improve operations.

Investment Co-op

Respondents were shown the following table, representing the potential roll-out of hydrogen powered vehicles in the future and asked: If your needs for financing and co-funding were met, how many of your stations would offer hydrogen in your city by (year)?

2010-2012	2013-2015	2016-2018	2019-2022
450	3,500	45,000	500,000

- Of the few respondents who answered this question, most agree they would enter the market slowly. Business and demand would be evaluated and stations added accordingly in subsequent years.

  "We would start with one station and evaluate its performance before additional stations would be built."

  "We would start with one location with limited dispensing."

- A consortium to help minimize the financial outlay and risk is appealing to respondents. Financial institutions, hydrogen producers, a local utility company, or energy supplier would be logical players in a consortium.

  "I would think there would be a lending institution or investment group, a hydrogen producer/and/or supplier, possibly a power company or local utility, an equipment supplier, possibly a large fleet owner or university that would be the 'buyer' once the station was constructed."

Business Cases

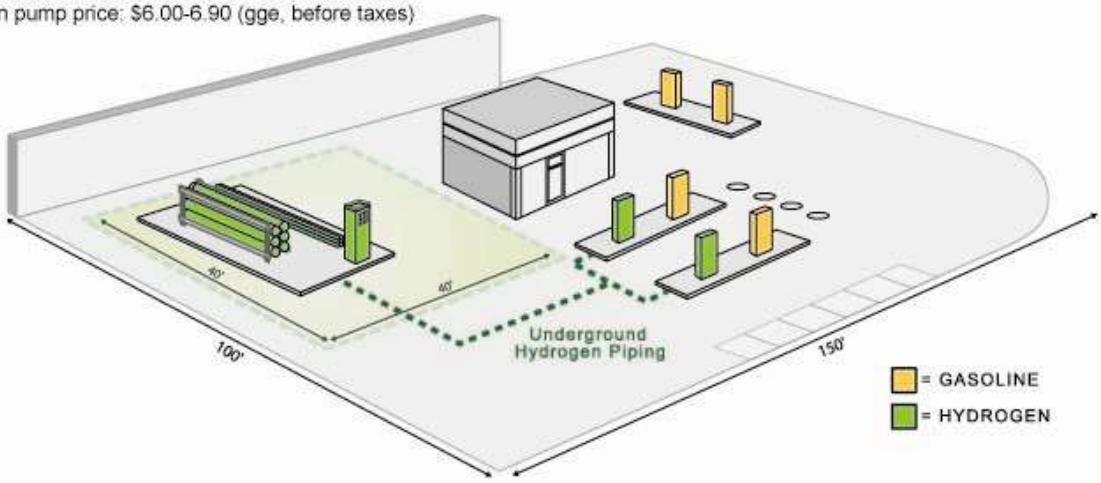
The National Renewable Energy Laboratory (NREL) developed five business cases to represent possible near-term hydrogen fueling station configurations. Each business case assumed adding hydrogen to a traditional urban gasoline station.

NREL used the following references and assumptions:

- Costs are calculated using H2A costs.
- Adjustment of H2A costs are made for low-volume production, using assumptions of 2x capital costs. Cost adjustment is recommended by:
  - "Roadmap for Hydrogen and Fuel Cell Vehicles in California: A Transition Strategy through 2017", 12/21/09, Institute of Transportation Studies, University of California, Davis, A Collaborative Effort by Public and Private Stakeholders
- Set-back distances were determined using NFPA 55
- Dispensing equipment sizes used H2A default values

Station A: Hydrogen is delivered in tubes as a compressed gas

700 kg/day station serving 200 vehicles a day (85% equipment utilization)
Filled tubes are delivered twice a day
Capital cost: $3.7 million (equipment, site prep, installation)
Annual feedstock and O&M: $940k
Annual anticipated revenue: $1.45m
Hydrogen pump price: $6.00-6.90 (gge, before taxes)



About this station

Most of the hydrogen used today in refining, manufacturing and food processing is made from natural gas at a large steam methane reformer central production plant and delivered by truck or pipeline. In this station configuration, a truck delivers cylinders of compressed gaseous hydrogen twice a day. The cylinders would either stay on the back of the trailer or be mounted on a skid that the delivery driver would drop off. It does not involve unloading tubes one by one. Gaseous hydrogen can be made from high- or low-carbon energy sources, but we do not include carbon credits for this case. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	**10% IRR**	**7% IRR**	**5% IRR**
- Pump price of H2 (with incentives*) ($/gge)	6.70	6.30	6.00
- Pump price of H2 (without incentives) ($/gge)	6.90	6.40	6.1
- Payback period in years	7	9	11

Pump price is what the customer will pay, excluding taxes and including after-tax internal rate of return
**Includes $200,000 alternative fuel infrastructure tax credit*

gge (gallon gas equivalent)—the energy in a kilogram of hydrogen is equivalent to the energy in a gallon of gasoline. Fuel cell vehicles are 2-3 times as efficient as a combustion engine, needing less fuel to travel the same number of miles.

Cost Details

Capital cost:

Site preparation cost	$ 934,000
Hydrogen storage & dispensing	$ 2,279,000
NPV of replacement costs*	$ 546,000
Total cost	$ 3,759,000

**Replacement of compressors and dispensers after 10 years.*

Annual cost:

Annual O&M	$ 171,000
Electricity for storage and dispensing	$ 30,000
Delivered hydrogen (@3.40/kg)	$ 738,000
Annual total	$ 939,000

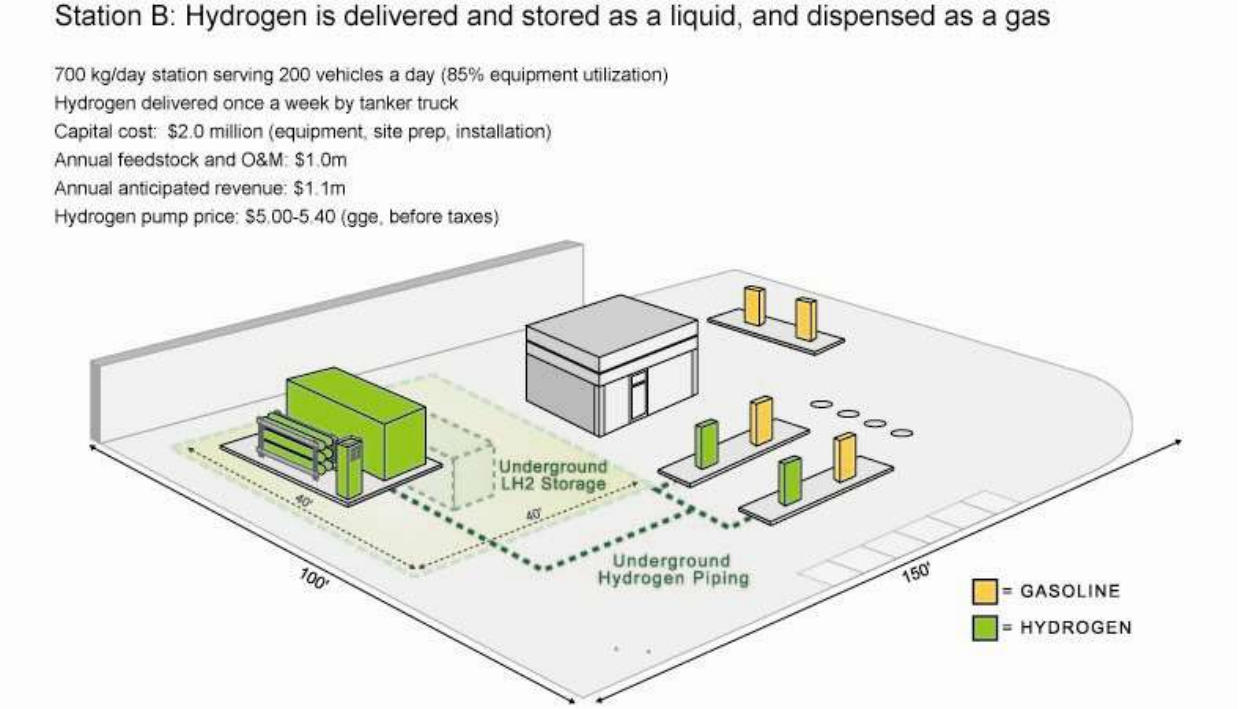
Focus Group Responses to Station A

The above ground storage is polarizing – some like it as a simple storage solution while others dislike the above-ground aspect.

Benefits	Drawbacks
▪ Initial capital expense ▪ Delivery of hydrogen as a compressed gas ▪ Simple solution for hydrogen storage ▪ Acceptable ROI	▪ Initial capital expense ▪ Daily truck load deliveries create potential for safety issues and possibility of running out of fuel ▪ 40'x40' footprint too large
"I see this as a good solution in big cities where space and power supply are limited." *"It makes a healthy annual profit after expenses."* *"The only interest I would have would be in the drop-off nature of the replacement tubes."*	*"A cylinder exchange program is not the most appealing. There are multiple points of (potential) error that could result in the station not having product to sell. It is not very efficient because you have a human element involved and a potential safety issue with the cylinder delivery."*

Suggested Improvements

- Permanent cylinders with refill option
- Lower total cost either through larger infrastructure tax credit or lower storage and dispensing cost
- Subsidies to help defray O&M costs



About this station

Most of the hydrogen used today in refining, manufacturing and food processing is made from natural gas at a large steam methane reformer central production plant and delivered by tanker truck or pipeline. In this station configuration, a large underground tank holds liquid hydrogen in a vacuum—the tank does not need electricity to keep the hydrogen cold. Several times a day, the equipment automatically opens the tank to warm and compress the hydrogen, and then stores gaseous hydrogen in cylinders before it is dispensed into a vehicle. About once a week, a tanker truck refills the tank with liquid hydrogen. Liquid hydrogen can be made from high- or low-carbon energy sources, but we do not include carbon credits for this case. The codes and standards for underground liquid hydrogen at a retail station are currently being revised, and we have assumed here that setbacks will be similar to gaseous hydrogen. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	**10% IRR**	**7% IRR**	**5% IRR**
- Pump price of H2 (with incentives*) ($/gge)	5.20	5.10	5.00
- Pump price of H2 (without incentives) ($/gge)	5.40	5.20	5.10
- Payback period in years	8	10	12

Pump price is what the customer will pay, excluding taxes and including after-tax internal rate of return
**Includes $200,000 alternative fuel infrastructure tax credit*

gge (gallon gas equivalent)—the energy in a kilogram of hydrogen is equivalent to the energy in a gallon of gasoline. Fuel cell vehicles are 2-3 times as efficient as a combustion engine, needing less fuel to travel the same number of miles.

Cost Details

Capital cost:

Site preparation cost	$ 934,000
Hydrogen storage & dispensing	$ 713,000
NPV of replacement costs*	$ 364,000
Total cost	$ 2,011,000

**Refurbishment of pump and replacement of dispensers after 10 years.*

Annual cost:

Annual O&M	$ 132,000
Electricity for storage and dispensing	$ 30,000
Delivered hydrogen (@4.00/kg)	$ 838,000
Annual total	$ 1,090,000

Focus Group Responses to Station B

The larger underground hydrogen storage and lower start-up cost pique initial interest in this model.

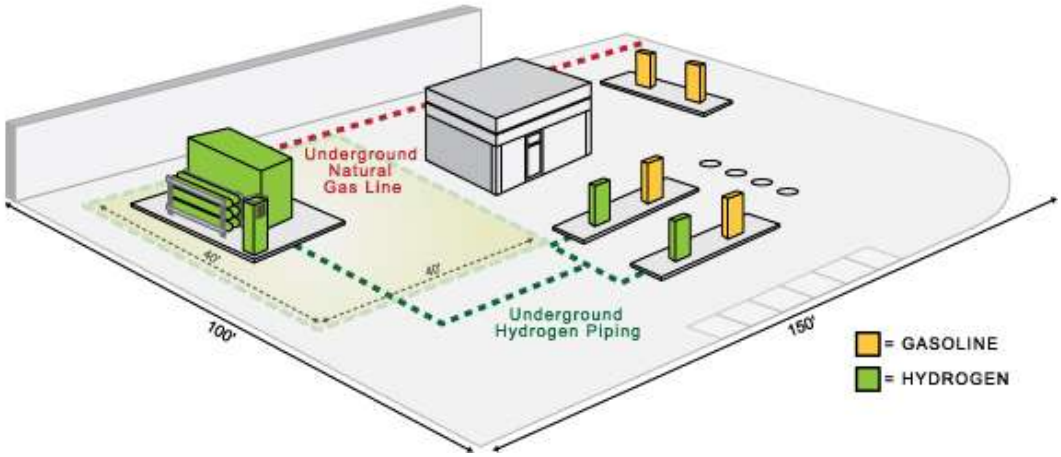
Benefits	Drawbacks
▪ Lower initial cost ▪ Underground storage ▪ Larger storage capacity = higher daily volumes and fewer deliveries	▪ More expensive annual costs ▪ Concerns about regulations surrounding underground storage of liquid hydrogen ▪ Concerns regarding effects of storage container on different soil types and varying water tables
"The appeal of this configuration is the underground storage tank that requires fewer steps and less effort to maintain sufficient inventory versus station 'A'." *"It seems logical that the most quickly adapted step would be 'B' where the hydrogen is stored as a liquid. We are already selling liquid fuels so maybe the conversion could be quick and cost effective."*	*"The lower capital expense is appealing but the high annual cost makes this scenario a non-starter."*

Suggested Improvements

- Lower cost of entry/ lower annual costs/ improved IRR
- Higher pump price

Station C: Hydrogen is produced onsite from natural gas or biogas

700 kg/day station serving 200 vehicles a day (85% equipment utilization)
Capital cost: $7.2 million (equipment, site prep, installation)
Annual feedstock and O&M: $585k
Annual anticipated revenue: $1.6m
Hydrogen price at pump: $5.90-7.50 (gge, before taxes)
LCFS carbon credit: $50/metric ton



About this station

Hydrogen is produced onsite from natural gas or biogas that is supplied from a pipeline to an above-ground reformer. The gaseous hydrogen is compressed and stored in above-ground tubes until it is dispensed into a vehicle. This method of producing hydrogen, called steam methane reforming (SMR), is the most common way to make hydrogen today. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	**10% IRR**	**7% IRR**	**5% IRR**
- Pump price of H2 (with incentives*) ($/gge)	7.40	6.50	5.90
- Pump price of H2 (without incentives) ($/gge)	7.50	6.60	6.00
- Payback period in years	7	9	10

(all explanations as in earlier business cases)

Cost Details

Capital cost:

Site preparation cost	$ 934,000
On-site production cost	$ 1,370,000
NPV of replacement costs*	$ 714,000
Hydrogen storage & dispensing	$ 4,162,000
Total cost	$ 7,180,000

**Replacement of reformer catalyst, refurbishment of equipment, replacement of compressor and dispensers after 10 years.*

Feedstock prices (for station owner):

Natural gas ($/mmBtu)	$ 7.00
Premium for renewable biogas ($/mmBtu)	$ 4.00
Grid electricity ($/kWh)	$ 0.082

Annual costs:

	1	2	3	4
Fuel Pathway	Natural gas, no carbon credit	Natural gas, carbon credit	33% biogas content in NG*, carbon credit	100% biogas content in NG*, carbon credit
Annual O&M	$ 289,000	$ 289,000	$ 289,000	$ 289,000
Natural gas and electricity for reformer	$ 260,000	$ 260,000	$ 302,000	$ 393,000
Electricity for storage and dispensing	$ 36,000	$ 36,000	$ 36,000	$ 36,000
Carbon credit ($50/metric ton)	0	($ 85,000)	($ 126,000)	($ 192,000)
Annual total	$ 585,000	$ 500,000	$ 501,000	$ 526,000

** Renewable percentages refer to the biogas content of natural gas used to produce hydrogen.*

Focus Group Responses to Station C

The most appealing feature of this model is the underground storage line that eliminates concerns of running out of hydrogen. However, the $7mm cost of entry may put this option out of reach.

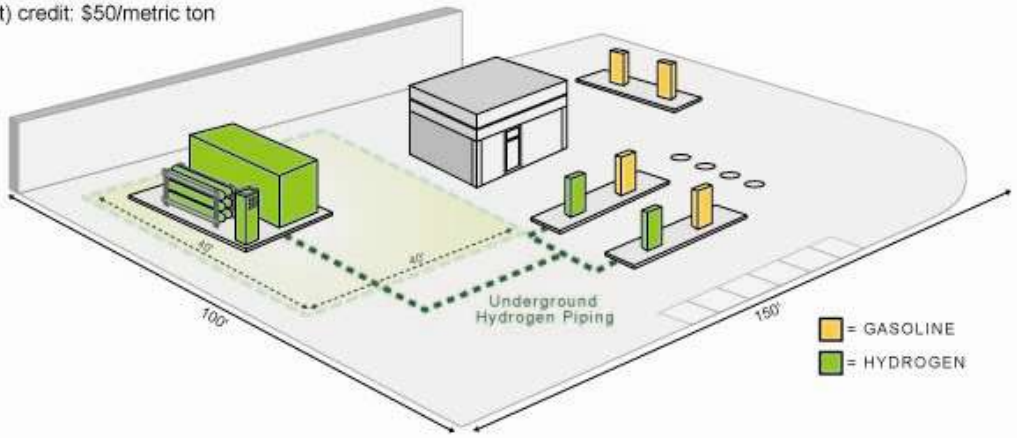
Benefits	Drawbacks
▪ Lower initial cost ▪ Underground storage ▪ On-site hydrogen production for better inventory management	▪ More expensive annual costs ▪ Perception that SMR releases high amounts of carbon dioxide. ▪ Capital expense ▪ Regulation and liabilities associated with onsite production
"The most appealing feature is the underground storage line that limits the amount of product stored by the retailer without causing concern for running out of stock."	*"It is my understanding that this method releases a lot of carbon dioxide and that, for us, negates the value of a hydrogen vehicle. I am intrigued by the onsite product but would be concerned, especially in California, about regulatory hurdles and higher insurance for onsite production."* *"The $7mm cost of entry makes this configuration un-doable for the standard c-store operator/owner."*

Suggested Improvements

- Lower cost of entry/ lower annual costs/ improved IRR
- Produce less CO2

Station D: Hydrogen is produced onsite using electricity and water

700 kg/day station serving 200 vehicles a day (85% equipment utilization)
Capital cost: $8.5 million (equipment, site prep, installation)
Annual feedstock and O&M: $1.8m
Annual anticipated revenue: $2.2m
Hydrogen pump price: $8.50-10.40 (gge, before taxes)
LCFS carbon (cost) credit: $50/metric ton



About this station

Hydrogen is produced onsite using water and electricity. Deionized water and electricity from the grid or a renewable source are fed into an electrolyzer. The electricity splits water into hydrogen and oxygen. The oxygen is released into the atmosphere. The hydrogen is compressed and stored in cylinders until it is dispensed into a vehicle. Electrolysis using all or partially renewable electricity can earn carbon credits, but using average U.S. grid electricity can result in paying carbon costs. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

Financial Performance	**10% IRR**	**7% IRR**	**5% IRR**
- Pump price of H2 (with incentives*) ($/gge)	10.30	9.20	8.50
- Pump price of H2 (without incentives) ($/gge)	10.40	9.30	8.60
- Payback period in years	7	8	9

Cost Details

Capital cost:

Site preparation cost	$ 934,000
Cost of electrolyzing equipment	$ 2,617,000
NPV of replacement costs*	$ 800,000
Hydrogen storage & dispensing	$ 4,162,000
Total cost	$ 8,513,000

**Refurbishment of electrolyzer and replacement of compressors and dispensers after 10 years.*

Feedstock prices (for station owner):

Grid electricity ($/kWh)	$ 0.082
Premium for renewable electricity ($/kWh)	$ 0.02

Annual costs:

	1	2	3
Feedstock Pathway	Grid electricity, no carbon credit	Grid electricity*, carbon cost	Renewable electricity, carbon credit
Annual O&M	$ 279,000	$ 279,000	$ 279,000
Electricity for electrolyzer	$ 601,000	$ 601,000	$ 878,000
Electricity for storage and dispensing	$ 22,000	$ 22,000	$ 22,000
Carbon credit or penalty ($50/metric ton)	0	$ 245,000	($ 217,000)
Annual total	$ 902,000	$ 1,147,000	$ 962,000

** Based upon the carbon intensity of the average U.S. grid. Regions with higher or lower carbon intensities would have higher or lower carbon cost penalties.*

Focus Group Responses to Station D

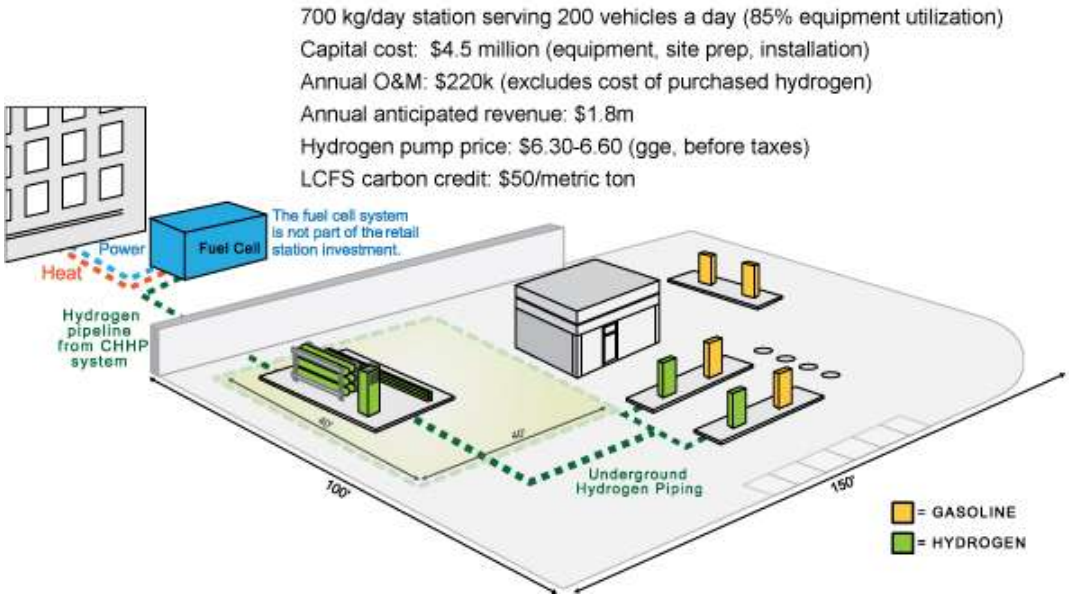
The $8mm cost of entry makes this configuration unacceptable to participants.

Benefits	Drawbacks
▪ On site production of hydrogen to ensure consistent supply ▪ Underground piping	▪ Capital expense ▪ Operational expense ▪ Polluting power supply (electricity pulled off the grid) ▪ $8 - $10 per gge pump price
	"Why would anyone choose to spend $8mm for the privilege of dispensing hydrogen at an average price of $8- $10 per gge?" *"For the $8mm price tag, we could build 4-5 new large format c-stores on very high traffic corners and strengthen our market presence, therefore improving our chance of survival. There are better ways for us to invest the capital than in a single hydrogen facility with (initially) low demand."* *"The cost of generated electricity is spiking in this market. It will be difficult to create a model where this is competitive."*

Suggested Improvements

- Lower cost of entry or upfront grants
- Lower annual cost
- Wind and/or solar power supply

Station E: An offsite fuel cell uses natural gas to produce electricity, heat and hydrogen



About this station
A CHHP system uses a stationary fuel cell to create electricity, heat and hydrogen from natural gas or biogas. The heat (or cooling) and power are used in the building and hydrogen is sent to the station via an underground pipeline. The gaseous hydrogen is compressed and stored in cylinders before it is dispensed into a vehicle. All equipment is electronically monitored; operating the hydrogen supply does not require additional staff.

This configuration assumes that a nearby business, such as a hospital or office building, owns the CHHP system and sells the hydrogen to the station. A CHHP unit could be installed at a big box store or manufacturing facility to provide heat, power and fuel.

Financial Performance	**10% IRR**	**7% IRR**	**5% IRR**
- Cost of H2 purchased by station owner ($/gge)	4.60	3.90	3.40
- Pump price of H2 to customers (with incentives*) ($/gge)	8.40	7.10	6.30
- Pump price of H2 to customers (without incentives) ($/gge)	8.60	7.20	6.40
- Payback period in years	8	10	12

Cost Details

Capital cost:

Site preparation cost	$ 934,000
Onsite production cost	N/A
NPV of replacement costs*	$ 545,000
Hydrogen storage & dispensing	$ 2,985,000
Total cost	$ 4,464,000

**Replacement of compressor and dispensers after 10 years.*

Feedstock prices (for station and/or fuel cell owner):

Natural gas ($/mmBtu)	$ 7.00
Premium for renewable biogas ($/mmBtu)	$ 4.00
Grid electricity ($/kWh)	$ 0.082

Annual costs:

	1	2	3	4
Fuel Pathway	Natural gas, no carbon credit	Natural gas, carbon credit	33% biogas content in NG*, carbon credit	100% biogas content in NG*, carbon credit
Annual O&M	$ 184,000	$ 184,000	$ 184,000	$ 184,000
Natural gas and electricity onsite production	N/A	N/A	N/A	N/A
Hydrogen purchased from fuel cell owner	$ 1,001,000	$ 1,001,000	$ 1,116,000	$ 1,351,000
Electricity for storage and dispensing	$ 36,000	$ 36,000	$ 36,000	$ 36,000
Carbon credit ($50/metric ton)	0	($ 26,000)	($ 79,000)	($ 186,000)
Annual total	$ 1,221,000	$ 1,195,000	$ 1,257,000	$ 1,385,000

* Renewable percentages refer to the biogas content of natural gas used to produce hydrogen.

Focus Group Responses to Station E

This configuration is more appealing when the retail operation assumes ownership of the fuel cell, decreasing risks associated with production and supply and increasing potential financial benefits.

Benefits	Drawbacks
▪ Lower cost of entry ▪ Generating hydrogen	▪ Reliance on another entity to provide fuel
"Generating hydrogen through the use of a fuel cell is both interesting and appealing to our business." *"What are the costs of the fuel cell? If we could own that and make electricity and hydrogen on demand, that would be very appealing."* *"It could be more appealing if there were an underground pipeline capable of distributing hydrogen to the retail station or some other back-up system, in the event that something goes awry with the co-op program. Retail business cannot afford to be out of their primary products."*	*"The prospect of being reliant on another entity to provide the fuel for sale at retail at an adjoining station seems to be a risk."*

Suggested Improvements

- Owning the fuel cell w/ ability to sell additional electricity back to utility
- Reducing cost of entry/lower O&M cost/improved IRR