Air Products H_2 City Project

San Antonio, Texas

EDSGN 100 Section 10: Professor Jeonghwan Jin

Team #2

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Jonathan Kitz (jdk5293@psu.edu)

Alexandre Blois (apb5166@psu.edu)

Kevin Vanbramer (kmv5123@psu.edu)

Fernando Alvarez (fpa5004@psu.edu)

Table of Contents

Abstract 3

Objective/Mission Statement/Introduction 3

Customer Needs Analysis 4

Introduction 4

Location 5

Population Analysis 6

Costs 7

H_2 Transportation Analysis 9

H_2 Safety and Considerations 10

Fueling Station Model 10

Conclusion 12

References 13

Abstract

A harsh reality we must face is that our excessive use of fossil fuels is not only negatively affecting the world we live in, but they will also last forever. One day in the near future we will no longer have fossil fuels for our transportation needs, so instead of waiting until that day comes, it is necessary for us to tackle this problem now.

In designing a city that runs entirely on clean hydrogen fuel we are laying the groundwork for tackling the energy problems of the future. It is not necessarily the solution nor is it expected to be, but it is a good place to start. The key will be to keep the price of everything economically viable while also achieving the goal of providing an entire city's fueling needs. Although, at first the numbers will look overwhelming, however we must look towards the future. Not only economic profits but environmental profits as well.

Objective /Mission Statement

Design a hydrogen fueling station to be used in a city that will undergo a complete energy reformation. All the fossil fuel use for travel is to be converted into clean hydrogen fuel. Using the population and driving statistics we must find out how many of these stations we will need, and then we will replicate this station citywide.

We need to design a station that uses space as efficiently as possible, yet still does not feel clustered, in order to increase the amount of customers we can serve per hour. This will lessen the strain on initial investment by needing fewer stations to be built around the city.

For the city converting completely to hydrogen vehicles and undergoing dramatic change, we will design a station, which retains the feel of an old station as much as possible, as to ease

the transition. Also, we are going to do what is best for the environment and the long run, while also keeping our initial financial losses at a minimum to feel the economic benefits much sooner.

Customer Needs Analysis

As we brainstormed possible fueling station ideas there were some key ideas about customers that we kept in mind. There will obviously be a lot of change happening when converting a city completely to hydrogen fueling. We figured that anything that remains constant during the change would help ease the process. For this reason we decided to create a station as similar to current gasoline stations as possible; and just as easy to use. The station would need all the amenities supplied by current stations. These include a convenient store, windshield washers at pumps, air pumps for tires, the ability to pay at the pump, and a user-friendly dispensing system. In addition, there is the need to design a station that is the most space efficient, so we can benefit the most out of it.

Introduction

"Many outfits have the wrong priorities when innovating. The right focus -- and the key to sales -- is products that create meaning for buyers" - Darrel Rhea

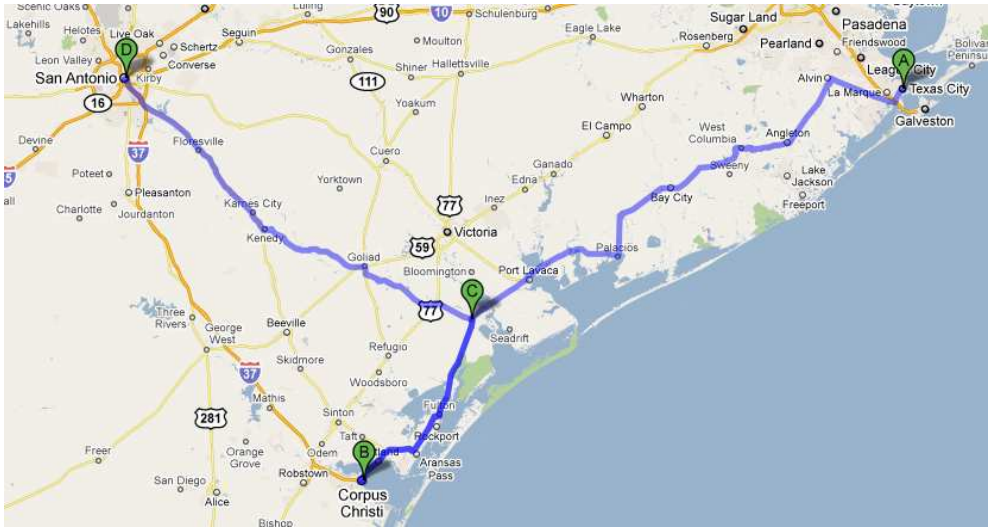
If it is important to create meaning for your buyers, how do you make something like an entire gas station have meaning? The thing is that gas stations already have meaning and a new design should be able to retain that meaning. Vehicle fueling stations have been part of American culture for nearly a century now, and even though the type of fuel provided must change the comfort and allure of the station does not need to.

Location

There were many things to consider when choosing a city to design and implement a station for. We could choose to produce the hydrogen we needed on site using renewable resources, we could take hydrogen from existing pipelines, or we could have the hydrogen delivered to us using trucks. We also had to provide hydrogen for every vehicle in the city so a small city would be more manageable while a large city would present more opportunities.

What it came down to for our group in choosing the city were three important things. First was the accessibility to existing hydrogen production plants because creating our own seemed too expensive. Second we wanted a city with considerable potential for renewable energy to help create a more environmentally friendly station. Lastly we wanted a city that was large and industrial enough to provide many opportunities for implementation of hydrogen fuel cell vehicles.

All these things considered we decided to transform San Antonio Texas from a fossil city to a new clean H_2 city. With a convenient location of about 130-150 miles from existing hydrogen pipelines located between Corpus Christi and Texas City, plenty of sunlight for solar power, and a large population, San Antonio seemed to be a great choice for implementing this clean energy.

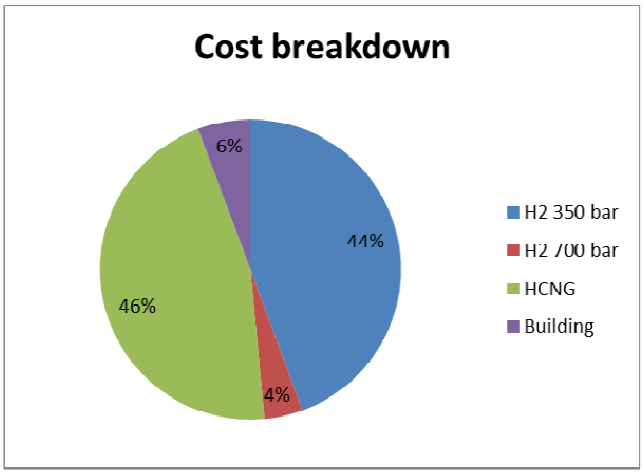


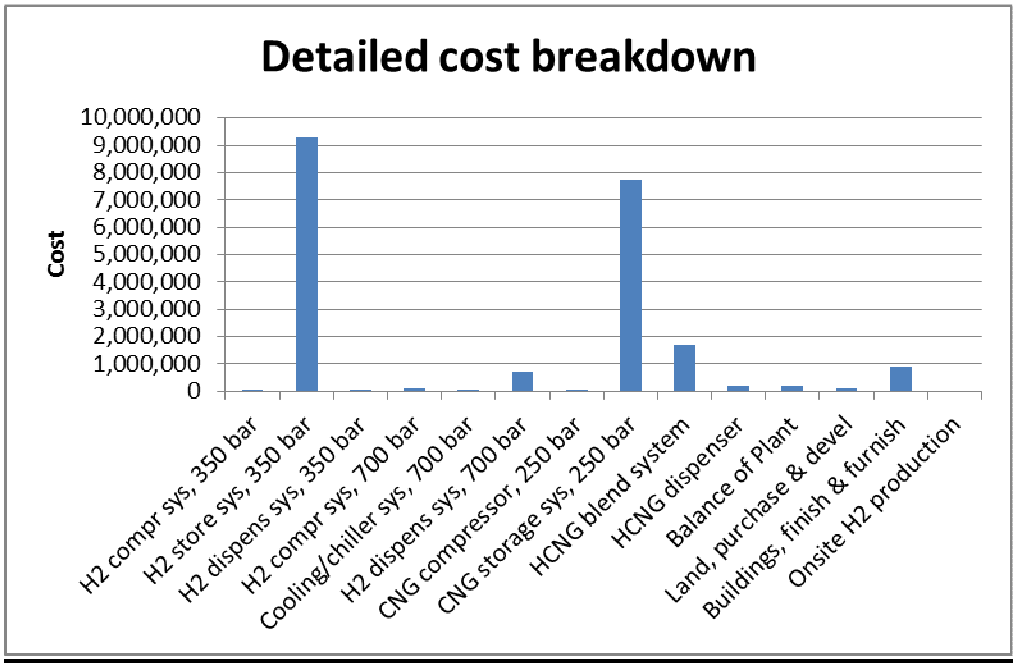
Population Analysis

The website provided by the Texas Department of Transportation provided us with almost all the population information we needed to compute how many fueling stations we would need and the pumps on each one. All the conclusions we drew were reached using simple mathematics and will not be shown here. We knew that San Antonio had a vehicle population of around 1.9 million, so we rounded up to 2 million in our calculations to overestimate the resources we will need. By overestimating slightly it will ease the problems caused during busy fueling seasons such as summertime. The Department of Transportation also gave us a statistic that said each vehicle drives twenty miles per day on average. Using this data and the known data about hydrogen car fuel efficiency we found that cars will have to refuel on average once every 2 weeks. Our stations would then have to fuel about 170,000 cars per day. Using this data we filled out an excel sheet to calculate the costs of our station.

Cost

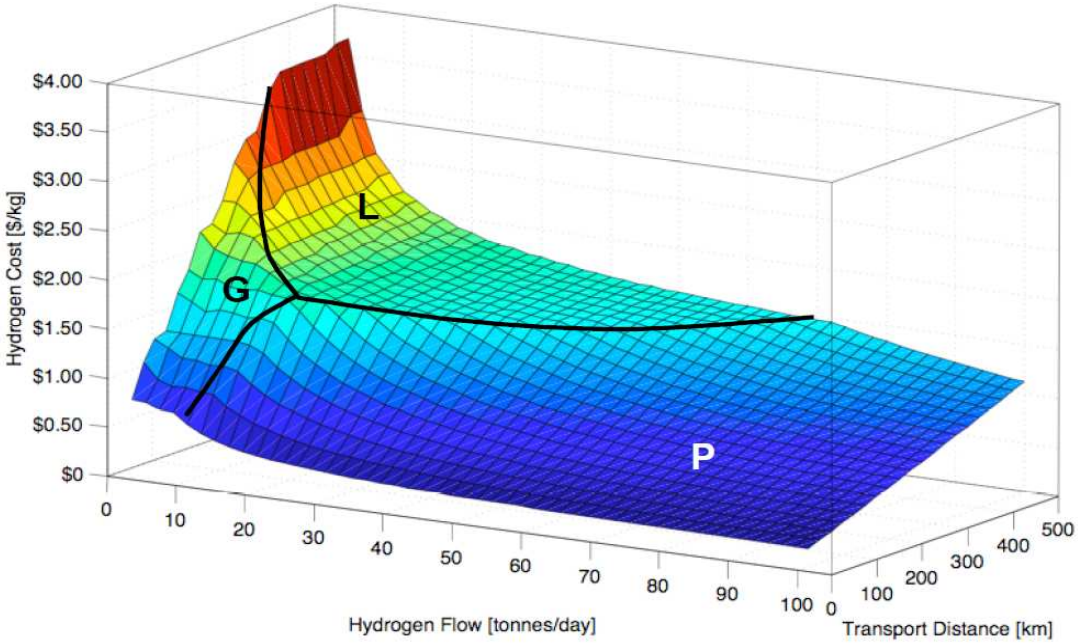
CAPITAL COST ESTIMATION GUIDE				
EDSGN 100 Spring Semester 2011 Fueling H2 City Project				
All costs are for representative purposes only				
Filling System Installed Costs				
(including piping, instrumentation, and ancillary components)				
			Inputs:	
Number of people in city			1907225	people
Average miles driven per person			14692624.23	miles/person/year
Miles driven per kg of H_2			60	miles/kg H_2
Number of stations			100	
Number of pumps, 350 bar			2	
Number of pumps, 700 bar			12	
Number of HCNG dispensers			4	
Area of station			1238.211717	m^2
Production capacity			0	kg/day
Hours pumping per day			18	hours
Labor rate, $			10	$/hr
			Outputs:	
Total miles drive by all people			28,022,140,237,526	miles driven/year
H_2 used per mile			0.0167	kg H_2/mile
H_2 used per year, all people			467,035,670,625	kg/year
H_2 used per day, all people			1279549783	kg/day
H_2 used per day, per person			670.90	kg/day/person
Working capacity			10102960	kg
Flow rate=			779.549	kg/min
H_2 Fueling station costs				
H2 compressor system, 350 bar	180000	$	77,316	
H2 storage system, 350 bar	38000	$	8,923,584	
H2 dispenser system, 350 bar	5000	$	10,000	
H2 compressor system, 700 bar	260000	$	96,403	
Cooling block/chiller system, 700 bar	90000	$	51,010	
H2 dispenser system, 700 bar	60000	$	720,000	
CNG compressor, 250 bar	80000	$	47,529	
CNG storage system, 250 bar	28000	$	7,429,575	
HCNG blend system	30000	$	1,630,149	
HCNG dispenser	50000	$	200,000	
Balance of Plant	210000	$	210,000	
Other Costs				
Land, purchased and developed	50	$	90,000	
Buildings, finished and furnished	3000	$	900,000	
Onsite H2 production (all methods)	9500	$	-	
Per station	Total=	$	20,385,567	
Total investment (First cost)		$	2,039	Millions
Sales				
Volume of sales			10102960	kg/day
Volume of sales (Number of units sold annually)			3687580400	kg/yr
Salaries		$	180	$/day
Salaries (PV Annual Cost)		$	65,700	$/yr
		$	6,570,000	


Cost breakdown
6%
44%
46%
4%
H2 350 bar
H2 700 bar
HCNG
Building


Detailed cost breakdown
Cost
10,000,000
9,000,000
8,000,000
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
H2 compr sys, 350 bar
H2 store sys, 350 bar
H2 dispens sys, 350 bar
H2 compr sys, 700 bar
Cooling/chiller sys, 700 bar
H2 dispens sys, 700 bar
CNG compressor, 250 bar
CNG storage sys, 250 bar
HCNG blend system
HCNG dispenser
Balance of Plant
Land, purchase & devel
Buildings, finish & furnish
Onsite H2 production

H_2 Transportation

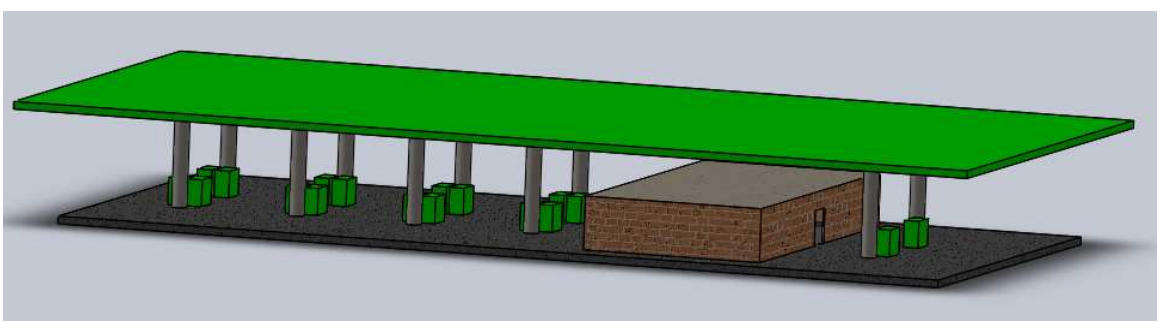
When deciding how to transport our hydrogen to our city we were faced with three main ways. A pipeline is about $1000/mm in diameter and about $1000/km. To transport liquefied hydrogen by truck to our city we estimated it would cost around 6,857.5 Dollars/Day. On the other hand, we estimated that if it were done in gaseous hydrogen it would cost around 4,114.5 Dollars/Day. This In all it would cost around 24 million for the pipeline for its whole lifetime, 2.5 million per year to ship by liquefied trucks, and 1.5 million per year to ship by gaseous transportation. The difference in cost between the gaseous and liquid transport is in the fact that it has to be more compressed to liquefy hydrogen, and thus it is more expensive. According to the table below using our distance to be around 150 km and 8.228 tonnes per day, the most efficient way of transporting our hydrogen is in gaseous form through trucks.



H_2 Safety

Since hydrogen is a colorless and odorless flammable gas, this makes safety a paramount issue. What makes this more so is the fact that we will be having it at high pressures, and temperature is a concern since we are in the state of Texas. In order to insure the safety and integrity of the station, its customers, and the people in the near vicinity, the following precautions will be taken: The hydrogen will be stored in cascading tanks that maintain a controlled and relatively constant flow to the pumps; there will be vents near the ceilings to allow eventual leaks to escape, since a cloud could form above on the ceiling, and finally the storage room will be at a constant regular room temperature.

Fueling Station Model

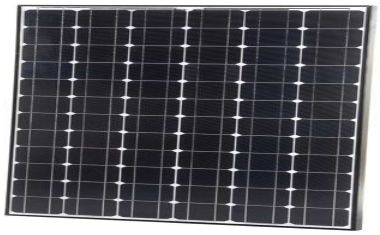


The station above is what we are proposing. Its land covers 1,800m^2, and every individual pump measures 2×1×1.75m (length×width×height), every column has a height of 7 m, the roof has an area of 2,275m^2. The store that is located in the middle of the complex has dimensions of 12×25×3.5m (length×width×height). The roof was established with such a large area in order to place photovoltaic panels to generate electricity in order to run the station in a more environmentally friendly manner. Additionally the inner complex will hold all amenities one would find in a gas station today. From food to toys, car accessories to coffee shops and

vending machines, and it will also be the place where our hydrogen will be stored, but separately form the store and the other public complexes.

Powering our Station

In the previous section we discussed the large roof capacity in order to place photovoltaic units to produce solar power and partially run our station. The specific panels that we are going to be utilizing are the Sanyo HIT© Power 225A and every Panel provides a monthly minimum average of 225W hr of power per panel. Considering if we cover our roof's area, we can obtain at least 4,870.8 kWhr per station in 1 year. Cost of 1,804 solar panels: $1,923,565.11 per station. Since we will not have enough solar energy to run all operations, we will have the remaining energy be provided to us by the local power grid. The positive side of this is that we will have one of the most environmentally friendly stations in the world.



Economic Viability and Environmental Impact

If we sum up all of our costs, the economic investment that would have to be made per station is roughly under 25 million dollars. This is including the land, development, transportation and compression of the hydrogen, and equipment of the solar panels. We estimate that despite the fact that hydrogen produces zero greenhouse gasses when it is burned as a fuel, the environmental impact is still comparable to that of fossil fuels. This is because we do not know the method the producers of the hydrogen from the Corpus Christi pipeline are utilizing, but in all likelihood it will be Steam Methane Reformer (SMR) because it is the most efficient

method known to produce H_2 today, and it sill has a negative impact in our environment because of the greenhouse gasses and other factors. It is because of this that we believe that hydrogen today is still as pollutant as fossil fuels, and it will probably remain like this until renewable energies become more cost and space efficient.

Conclusion

Overall, we believe that right now it is not economically viable to have a self-sustained hydrogen fueling stations because of the massive initial investments necessary. Despite the fact that this is the most environmentally friendly fuel once it is formed, it makes no sense to pursue this type of energy. This is because the cost of producing it is very high, and it also requires more energy to split the hydrogen bonds than the energy that it is yielding. Additionally its benefits of having zero impact in the environment depend on the way it is being produced. This is why we believe that producing hydrogen as a fuel for cars, for now, is not the long-term solution to solving our environmental problems, since vehicle emissions account for a large, but yet proportionally small portion of greenhouse gasses.

References

Yang, Christopher, and Joan Ogden. *DETERMINING THE LOWEST-COST HYDROGEN DELIVERY MODE*. Davis: University of California, Davis. PDF.

http://www.dot.state.tx.us/apps/discos/default.htm?dist=SAT

http://us.sanyo.com/dynamic/product/Downloads/HIT%20Power%20225A%20web-45533488.pdf

hydrogen*.its.ucdavis.edu/classes/HPC-Spr06/lectures/15_**Safety**_Miller --- .pdf file*

Google Maps

Professor Jin's Cost Estimates presentation