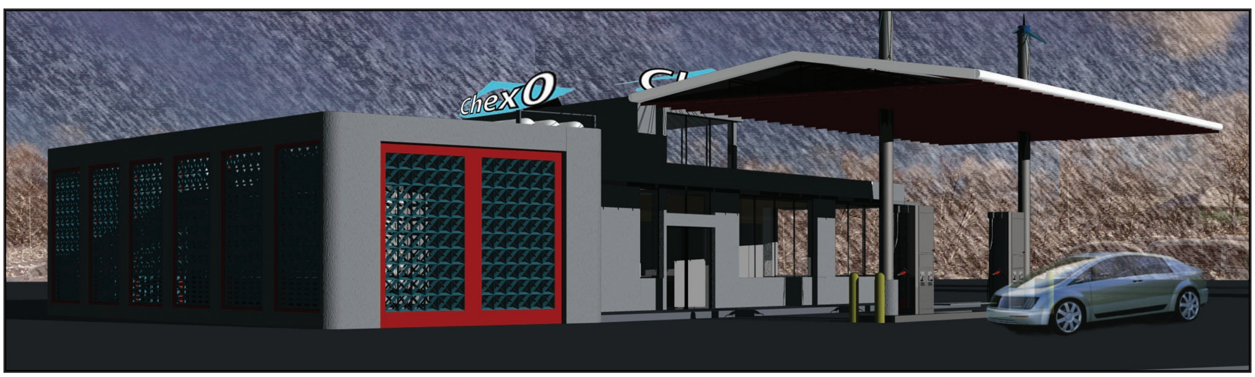
Hydrogen Filling Station

Competition elective report



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Hydrogen Filling Station Competition
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Paper for Terri Meyer Boake, Competition Elective Supervisor

HYDROGENICS ChexO FTI Fueling Technologies Inc.

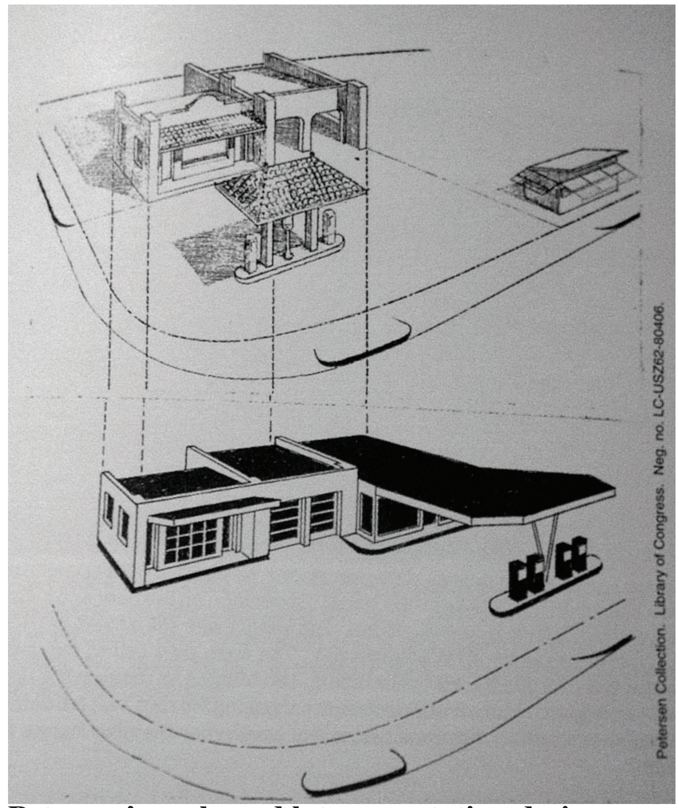
This paper is intended to support and explain the Hydrogen Filling Station Project which was an entry into the National Hydrogen Association's Hydrogen Filling Station Competition in 2004. It will discuss some of the precedents and design considerations we were looking at in the design of the filling station. It will also discuss some of the merits of and problems with interfaculty group projects.

We should not think of hydrogen as a fuel. It is found in abundance in the universe, but the forms that are accessible to us are nearly always combined with other elements. In order to get pure hydrogen it takes energy, and some systems are better than others. Hydrogen can be processed through fuel cells to create water and electricity. What this means for architecture is that a shift in the fuels that people use to drive their cars will require a shift in the type of filling station used. This project is intended as a practical prototype of such a station, but one with a specific site, and one which could have been constructed on a schedule to have it open in March 2006.

The competition brief called for a usage of 50 vehicles per day, and we needed to be able to accommodate 6 2/3 vehicles in a peak hour. We were also limited to 14,440 square feet for the maximum site area. It was not allowed to be fleet service only, rather it was necessary to make it publicly accessible. This meant working a convenience store into the project, and trying to service various kinds of people, as opposed to focusing our energies on a specific fleet vehicle. It also means that we need a prominent location and high visibility in order to solicit customers. Fleet vehicles would be just fine with a filling station off in an industrial park somewhere.

We had three major issues to deal with in the design of this station and system. We could make Hydrogen on-site or make it somewhere else and transport it to the station. We could design a large station which would also sell gasoline or to make it a small specialized station. We could build a new station or renovate an existing one to try to take advantage of its existing customer base and location. We decided to build a new, small station focused on Hydrogen, but reform the natural gas on site. We decided against using green hydrogen for the prototype station only because it was deemed too expensive.

The precedents for this project go back to the early days the motorist, where people would buy gasoline by the can. These stations were typically normal main street buildings. Eventually people developed visible pumping systems, where people could see the gasoline that they were buying. Later, people didn't need to see the gasoline anymore, as it was pumped directly into their tanks. It is easy to think of the archetypal gas station as being a vernacular type, not designed by anyone, simply springing forth from the landscape as a natural reflex of the corporate world to the increasing demands of the motorist. This would be a mistake. According to Stuart Brand's book How Buildings Learn, Carl Petersen created and revised the archetype in his designs for Gulf Oil and Pure Oil between 1914 and the mid 1950s. These designs were widely adopted and defined the archetype for the traditional gas station we think of today.



Petersen's early and later gas station designs.

Two kinds of modern stations have evolved. The highway superstation, and the local gas station convenience mart. The superstation has lots of pumps, and generally has a version on both sides of the highway, so that it can collect traffic going in both directions. Smaller local stations have two or four pumps typically, and combined with a small convenience store, serve smaller neighborhoods.

After looking at locations in Iceland and Hawaii for their wealth of clean geothermal energy and looking at Toronto, Waterloo, and Niagara Falls for their proximity and hydroelectricity, we selected a site in Rochester NY for several reasons. Designing for the US was more straightforward for the technical team, as they only had to work to one set of standards, rather than two standards if the station was in Canada but entered in the US competition. The head planner in Rochester was quite helpful, which helped sway things in favor of Rochester. The Lake Avenue & Ridge Road intersection is both a local intersection in Rochester and at the intersection of a major New York East-West Highway and the road leading to the Rochester side of the new fast ferry. Given that Toronto was going to be building a hydrogen community, it made sense to give them somewhere to go. With the option to fill up on both sides of Lake Ontario, it would give Fuel Cell Vehicles (FCVs) another selling point. Another feature of the site in Rochester is that it was right beside an automobile dealership, and would help solve the chicken & egg problem with the introduction of any alternative fuel. Demonstration vehicles should be available at the dealership next door by March 2006 when the station would open.

That intersection had been redesigned and will be modified in 2005, and we designed the hydrogen station to fit with the new, revised site. To accommodate this, we were limited to one curb cut into the site from Ridge Road. This required some site gymnastics in order to ensure smooth vehicular circulation through the site. In hindsight it might have been better to pick a generic intersection for the purposes of the contest, but we felt the specific site had some advantages with respect to public exposure and energy costs.

The Mob1l station southwest of our site in Rochester NY.

Inside the Mob1l Station. The convenience store displays dominate the interior of the station.

One of the gas stations we examined was the Mob1l station in Rochester just south of our site. It is a fairly straight forward gas station, and contains 6 two nozzle pumps and a window washing station. We did not expect the same level of demand, and decided to go with two pumps, but with room to potentially increase to four. The convenience store has become a predominant feature of the modern gas station as well. The necessity to include space for the sale of chips and pop is clear from most modern gas stations. The internal layout of the Mob1l station we looked at allows the cashier to see down the aisles, presumably to help deter shoplifting.

Other gas stations which we have seen over the course of our lives undoubtedly had an impact on our sense of what makes up a gas station, but influences like that are impossible to document.

Given the technical requirements of this interdisciplinary competition, it was important that we consider technical aspects for functionality. This gave rise to the solution of putting the reformer, which emits a lot of heat, outside, and putting the tanks, which leak minute amounts of hydrogen, on the roof. Cylindrical tanks were selected because they are much cheaper than slightly more efficient spherical tanks. With the cost-benefit on the tanks and the fact that we needed six to be able to fill each vehicle to the requisite 5000 psi, the six cylindrical tanks made the most sense.

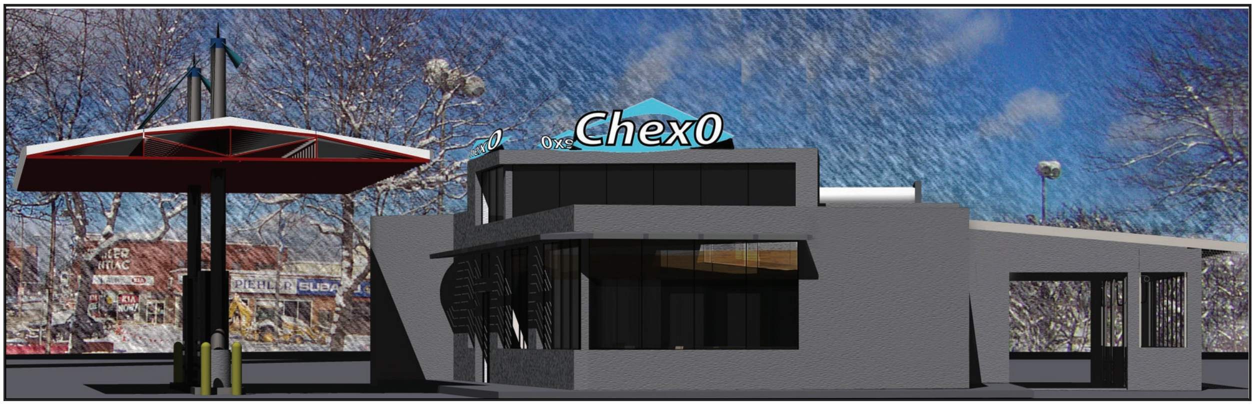
The station has clerestory lights to the south over the entryway, so that the station will not require electrical light in the daytime, and the circulation area will be reinforced by the height change in the ceiling and the lighting. The convenience area is located off to the right as you enter to keep it out of the way of people who just want to come in and pay, but easily accessible if people want to come in and pick up a bag of chips, a pop or some magazines.

The canopy was designed to appear light and protect people from rain, while protecting the pumps from the weather, and bollards protect it from wayward cars. This idea is widely used in filling stations, and would be impossible to ascribe credit to.

The car wash was an attempt to give the drivers of Fuel Cell vehicles the same level of amenity that regular car drivers can receive at other gas stations which often include automatic car washes, and will provide an additional source of income to the station.

The name, Chex0 was both a combination of the names of the corporate sponsors Chevron and Texaco, as well as being an acronym for Canadian Hydrogen EXample Zero. The zero suggests the prototypical nature of the project. In subsequent iterations of the station we would learn and adapt the design accordingly.

The interdisciplinary nature of the group brought out what I feel is one of the potential strengths of the University of Waterloo. When you create projects that inspire students across disciplines, you have the opportunity to be involved in projects where there is a clear sense of where each student's specialties lie and what they should be responsible for. These sorts of projects could enable realistic interdisciplinary discussions and projects that could yield significant academic dividends. For example, an urban design project involving economics, architecture, civil engineering, and urban planning disciplines would be a much fuller and well rounded project than a similar project that's made up exclusively of architects. It also more closely reflects the real world and the environment in which people will be working. Projects like these though more difficult to orchestrate now that we are no longer on campus, could provide valuable learning experiences to students of many disciplines. The fact that we are not on campus is an overcomeable obstacle. In fact, Erik Wilhelm, our team leader, was in Germany for a substantial portion of the project. Aside from the other Architecture Student on the project, Mark Longo and the faculty Advisor Michael Fowler, I did not ever meet any of the other participants face to face. We had meetings in an MSN chatroom, and exchanged information over email. It might have been easier to quickly hash out ideas in face to face meetings, but the project was successful even without these meetings.



We did not win the competition, but we learned about interdisciplinary co-operation, strict competition requirements, and what's possible with a strong interdisciplinary team. It was interesting to try to accommodate specific engineering related problems with the architecture, like the vast amount of heat released by the reformer. It was nice to be able to go into the depth of engineering that would be necesary to make the station operable. It was valuable to understand that not all architectural decisions are decided based on the architecture. Some of the factors are based on the economics of the situation. This leads to a question of when and how do you make the tradeoffs. Generally in architectural projects we aren't asked to address those issues, but almost every project has a budget of some kind, and almost every project has its roots in the real world. These limits demand a different kind of architectural design and problem solving than is normally achieved in architecture school, one that is budget conscious and has to meet specific technical criteria, as well as requiring a realistic business case. It is a useful kind of problem to solve.

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