USING INDUSTRIAL DESIGN TO MOTIVATE CHANGE TOWARD ELECTRIC VEHICLES

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THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Fine Arts in Art and Design with a concentration in Industrial Design in the Graduate College of the University of Illinois at Urbana-Champaign, 2012

Urbana, Illinois

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Abstract
Throughout the 20th century, there have been many advances in technology that improve our daily lives. These improvements have only tapped the surface of the transportation industry. Although the idea of “green” or eco-friendly technologies have become welcomed in society, electric cars still lack momentum in the industry. Since our remaining oil reservoirs are becoming depleted, drastic change must be made to manage the consumption of our remaining resources.

There have been breakthroughs in alternative transportation technologies, but none of them have hit the mass market due to society’s fear of change. In my research, I will analyze electric vehicle technologies and discuss their pros and cons. Along with that, I will explore the psychological factors preventing the public from transitioning effectively to green technologies. Analyzing the data I collect, I will use it to design a system that will fulfill the needs of consumers to allow for a pain free transition.

The prime focus of my thesis is to create a user friendly interface for electric vehicle charging stations. There are a few variations of charging stations out on the market that lack an intuitive interface. This makes these systems confusing and hard to use, repelling potential adopters of the technology. Along with these issues, there are other concerns that deal with security, convenience and efficiency. Since the electric vehicles need time to charge, they are left unattended, allowing vandals to unplug vehicles at any time. When it comes to
convenience, the act of using these charging stations every time you exit a vehicle is a big hassle. Preventing unnecessary steps in the charging process is always a benefit. In the efficacy category, I will address the lack of power management in our current systems. The three current methods of charging an electric vehicle include 120 volt, 240 volt and 480 volt systems. From my research, I have found that increasing the charging voltage by 1% will increase energy consumption by 0.297%. This means that the higher the voltage, the more energy is wasted, thus increasing the cost of the charge. Proper management of power will save consumers money at the charging stations, making the transition to electric vehicles more appealing.
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Chapter One: Energy Crisis

Within the last decade, transportation costs have risen dramatically due to the global depletion of oil resources. Currently, the United States is the second largest consumer of energy, falling just short of China. [Swartz & Oster, 2010] The United States has made tremendous advancements in technology, but we have not made many moves toward cleaner, renewable energy. The reason why our transition to clean energy has been so slow is because gasoline is still provided for reasonably affordable rates. However, this won't be the case in 20 years when our oil sources become completely drained from the earth. [Connor, 2009]

The energy we use today is supplied through five major sources: petroleum, natural gas, coal, renewable resources and nuclear energy. About 72% of our petroleum sources are used in the transportation sector. The rest is used in industry, residential heating and cooling, and electricity production. The petroleum used to fuel our vehicles is estimated to produce about 5.2 metric tons of carbon dioxide a year. [IER, 2012] The accumulation of carbon dioxide in our atmosphere has been the center of many environmental issues, such as the theory of global warming, acid rain, and smog formations in highly populated areas. Smog alone has caused numerous respiratory problems among the global population. The Great Smog of 1952 killed approximately 4,000 people in London within 4 days and about 8,000 people within the same month. [Nagourney, 2003] The possibility of global warming is another huge concern because it causes drastic weather changes that lead us to use more energy to heat and cool our
homes. Consequently, we create more pollution via carbon emissions. Acid rain is another huge concern in our environment. The acid rain is caused by excess in emissions from factories and cars, which is then collected by the clouds and rained back down to the ground. Acid rain does millions of dollars’ worth of damage each year to structures in city areas. It also can cause irritation as well as skin cancer if exposure is too high.

Currently, there are eight sources of energy that we use to fuel our vehicles: alcohol/ethanol, compressed natural gas (CNG), electricity, hydrogen, liquefied propane gas (LPG), liquefied natural gas (LNG), gasoline, diesel and biodiesel. Gasoline and diesel account for the majority of energy used in today’s automobiles. Although our usage of gasoline and diesel has harsh effects on our environment, we use them because of their benefits. For instance, diesel fuel has a very high torque output, which is why diesel is used in the majority of today’s semi-trucks. Any other substitute would run out within a very short amount of time as it would require a tremendous amount of the respective resource to propel a heavy-duty vehicle. Thus, transition to electric power would be difficult freight transportation. However, there are many opportunities in the consumers’ market.

Electric cars have existed since the early 1800s but have only recently caught traction in the global market. There is still a long way to go before electric vehicles become popular enough to be seen on every street corner. As battery technologies become increasingly more efficient, the feasibility of the electric car taking over the industry becomes more promising. Currently, the record for the
longest distance traveled on one charge is 1013 miles, by Boozer, a German electric car developed by Fraunhofer Institute for High-Speed Dynamics. [Boyle, 2011] In the average consumer vehicle, the longest distance on one charge varies between 80 and 150 miles. Although this is well above the distance that the average consumer travels in a single day, our society remains skeptical about transitioning to electric vehicles. Current consumers are resistant to change in the transportation sector because they are accustomed to the current system and are afraid they will run into complications if they make the move.

**Why are we resistance to change?**

- Benefits for making the change are not adequate for the trouble.
- Change threatens your wellbeing.
- Change is prone for failure.
- Reason for change is unclear.

We have all been around people that are so tied down to something that they will not change their ways no matter what the consequences are. The only way to reason with them is to educate them and show them that the alternative method is a smarter choice.

Considering our alternative fuel sources in the future, there are a lot of choices. Each has its pros and cons. As aforementioned, the eight sources of energy being used for transportation purposes are alcohol/ethanol, compressed natural gas (CNG), electricity, hydrogen, liquefied propane gas (LPG), liquefied
natural gas (LNG), gasoline, diesel and biodiesel. Each has its unique benefits. In Brazil, alcohol/ethanol is used in the majority of their vehicles due to its abundance in the country. Brazil is estimated to produce 87% of the world's ethanol. [EERE, 2010] Brazil is capable of doing this because of its prosperous agricultural economy and abundance of land for growing the crops used in ethanol production. If we look at countries such as India and Korea, they use a different type of fuel in their vehicles. Although Korea still uses gasoline in the majority of their vehicles, LPG is used mainly in their taxi services. Nearly all taxis in South Korea use LPG, which cuts down on both pollution as well as oil consumption. Looking at each fuel type, there are benefits to each. For the most part, these benefits concern availability and cost.

The United States is known for consuming a tremendous amount of oil and has not transitioned successfully toward a cleaner solution. Indeed, we have many sources of alternative fuels, yet we ignore the problem of overconsumption and pollution. In our ignorance, we resist real change. The Reagan Administration, for example, rejected any sort of clean energy source and cut funding on electric car research, such as that of GM EV1. [Paine, 2006] This allowed the oil companies to once again monopolize on the fuel economy, halting further research on the electric vehicle.

So why has the U. S. made so few moves toward alternative energy sources? Currently, the United States is the second largest producer of coal in the world. [IER, 2011] This would mean that the United States could be energy independent or at least cut a tremendous amount of reliance on foreign oil. Many
question the transition to electric cars, fearing that the pollutants would only be converted from oil to coal. However, changing to coal-powered electric cars would still be a cleaner solution. "A 2007 study by the Natural Resources Defense Council and the Electric Power Research Institute, which represents electric utilities, examined nine potential scenarios to determine the impact of plug-in hybrid electric vehicle use through 2050. The study found that in each scenario greenhouse gas emissions were reduced significantly." [EPRI and NRDC, 2007]. It is estimated that driving an electric vehicle will reduce carbon emissions by 60% if the source of electricity is generated by coal. Eventually, the industry will transition its methods of generating electricity to clean energy, which will lower the emissions greatly.

The greatest benefit of gasoline-powered vehicles is the convenience of having to refuel less often. Having a gas station on every street corner provides for our transportation needs, but how does the abundance of gas stations really help us as consumers? There are many steps involved in refining and transporting gasoline from the source to the gas station. The process includes the drilling, pumping, storing, shipping, refining, and finally the transporting of the fuel. This process produces about 450-500 grams/km of carbon dioxide for one gasoline powered car. In contrast, an electric vehicle produces only 40 grams/km after taking into consideration the process of mining, transporting and coal burning. [Gary & Handwerk, 1984] All the current energy sources being used for transportation pollute the air during their refinement processes. However, electricity produces the least amount of emissions and has the potential of
transitioning itself into green solutions such as solar, wind and hydroelectric power.

Electricity is the optimal solutions in consumer transportation because its low operating costs and efficiency. Although it is still in its infancy, it will grow as time goes on. Electric vehicles also leave a small footprint in the environment due to its flexibility.
Chapter Two: Role of Electricity in our Future

As stated in chapter one, the CO2 emissions produced by gasoline is far greater than what is produced by an electric vehicle. When comparing the two systems, we may conclude that electric cars produce less carbon at about 120 grams/km of carbon dioxide. However, when we compare the actual CO2 produced when drilling, pumping and transporting gasoline, it is a whole different story. If we take into account this total cost, gasoline powered cars then produce about twelve times as much carbon emissions as produced by electric cars.

There are noticeable inefficiencies in the current fuel refinement systems. For example, gasoline powered cars are extremely inefficient due to the laws of physics. An average motorized vehicle loses upwards of 75% of its energy to heat. [Bandivadekar, Bodek, Cheah, Evans, Groode, Heywood, Kasseris, Kromer and Weiss. 2008] This means that 75% of the pollution that is being caused is due to waste. Thus, the inefficiency of the current gasoline powered system is evident.

The cost of running an electric car varies depending on location, but on average an electric vehicle can cost three to four times less to run than a gasoline powered vehicle. If we put this into perspective, driving an electric vehicle would cost less than a dollar per gallon of gasoline. As we progress into the future, the energy sources for electric power transition toward cleaner alternatives such as wind, solar and nuclear energy. This would mean that electricity will eventually become cheaper and more eco-friendly. If we take a look at the cost of producing electricity compared to other energy sources, it
becomes even more evident that electricity is the future energy source.

Take hydrogen gas, for example. There has been a lot of buzz within the last few years concerning hydrogen usage in the future. However, after some research and development, it turns out that hydrogen is not that “green” and is very expensive. Hydrogen can be produced via several methods, including electrolysis and thermolysis. Thermolysis produces hydrogen by heating up and refining the gasses given off by fossil fuel, creating more pollution and defeating the purpose of an alternative energy source. Methods such as electrolysis and thermolysis require tremendous amounts of energy to produce hydrogen. These methods essentially heat the water up to a point where the hydrogen can be split from the oxygen molecule. In electrolysis, electricity must be added to the equation to break apart the molecules. So in some sense, hydrogen as an alternative fuel seems like more steps added to an electric vehicle. The hydrogen must be split using electricity and then used in a vehicle, which converts that hydrogen back into electricity. During this process a lot of energy is wasted and the potential gain from the hydrogen is minimal. There is also the issue of storing and transporting these fuels. The storage of hydrogen requires massive freezers and huge steel tanks. Also, since hydrogen has the smallest atomic structure, nothing can really contain this gas. Even when stored in these steel tanks and chilled to subzero temperatures, hydrogen still leaks out through the walls of the tank due to its small molecular structure. So with all these problems, the hydrogen model slowly lost its traction in the market and its potential of becoming the future energy source. In contrast to hydrogen, electricity requires no
transportation cost because it can be fed directly through the grid to the consumer.

If we look at the current technologies being developed, we can clearly see that electric cars are becoming a trend in our society. Recently, the big name car companies such as Nissan, GM and Mitsubishi have stepped up to provide consumers with these future electric vehicles. The Nissan Leaf, for example, is being implemented in parts of Japan, Europe and the U. S. California has been a large supporter of electric vehicles in the past and still is the biggest supporter of electric vehicles in the United States. California, with a population size that is only three percent of China's population, consumes an amount equal to 23% of the oil that is consumed in China. [Chu, 2010] California being a huge supporter will provide a huge benefit to increasing electric vehicle popularity as well as help the environment.

Electric car charging stations have been on the rise in major cities in California. California is home to the Tesla Motor Company, which has been relatively successful in the luxury car market. The company owes its success to the popularity of the Tesla Roadsters with car fanatics. Many Tesla charging stations have emerged due to the high sales of the Tesla vehicles. Due to the long range of the roadster, Tesla owners are not as reliant on stations as other electric vehicles. The Tesla Roadster averages around 200 miles on a single charge but has reached a maximum of 347 miles on a single charge.

Some argue against the efficiency of electric cars, claiming that electric cars lose range when driven at high speeds. However, gasoline powered cars
that are driven at high speeds also diminish in fuel efficiency due to air resistance. For both, the range of power efficiency depends on how fast a person drives and the terrain that the vehicle is driven on. The Tesla Roadster is not targeted toward your average consumer, but to consumers in the luxury market. This being said, other companies have stepped in to fill the gap that Tesla left behind. For example, Nissan and Mitsubishi have been developing their electric vehicle concepts for quite some time. The Nissan Leaf has already been implemented in many countries around the world. These cars do not have the range of the Tesla Roadster, but who really needs to go more than 200 miles in one day? Your average consumer does not drive more than 40-50 miles a day. In rare cases, for business commuters, a higher mileage vehicle is needed.

The majority of the population is fully capable of transitioning to electric vehicles at any moment, but is struck by fear by the media’s portrayal of range anxiety toward electric vehicles. For the small group of people who require long ranged vehicles, they can rely on companies like Better Place to provide the battery swapping services that they require. Shai Agassi, the CEO of Better Place, has been working on alleviating range anxiety. His company has developed a system in which the battery from the electric vehicle can be changed out at a station within minutes. These systems are fully automated and provide the user with the assurance that they will never get stranded without power.

In this system, Better Place will essentially buy your car battery and give you credit for the cost of the battery, which you can then use to swap out your battery for free until the credits run out. Although this seems like the perfect
solution to prevent range anxiety, there are still a lot of flaws in the system. The manufacturer of electric vehicles must work at parallel with Better Place for the system to be integrated successfully. Another problem with this system is that the battery lives need to be monitored continuously since battery lives are greatly reduced every time they are switched out. Lastly, stations must store an enormous volume of batteries as well as monitor each battery’s individual charge in order for this system to work. In light of all its flaws, Better Place has still been able to make its mark in the world. Although we are a long way from implementing Better Place models on every street corner, we are slowly making the electric transition. Israel, Japan, Denmark and Canada are some of the places that Better Place has emerged successfully.

There will be a point in our history when the standards for electric vehicle charging solutions will be chosen, but until then there were be a lot of chaos. Currently we have a mix of charging stations and battery swap stations. Each system has its is unique and has no form of standardization. This means that you must go to the charging station that is supported by your vehicle’s manufacturer. This brings up a second fear of society: the fear of complications and confusion. The average consumer wants ease of use and simplicity, but in the current electric vehicle market, there is a lot of confusion. Until the dust settles, the average consumer will be disinterested in the electric vehicle market.

In the meantime, GM has entered the electric vehicle market with its Chevrolet Volt. The Volt is half electric and half gasoline powered. It can run for 40 miles purely on electric power. Since an average consumer drives less than
40 miles per day, it is the perfect solution to the problems related to range anxiety. Thus, the Chevy Volt alleviates the consumers’ fear of being stranded on the road. Although the Volt can provide a temporary solution, hybrid vehicles remain counterproductive because they waste energy lugging around extra weight from the gasoline motor and fuel.

Currently electric cars have not made a huge impact, barely scratching 1% of the car market. Market researchers estimate that the global market for electric vehicles will rise to 5.5% by the year 2020. [Lache, Galves & Nolan, 2009] As we move into the future, the market will shift inevitably towards an alternative solution in transportation. No one knows how it will shift but electric cars seem to be the most appealing solution on the market.
Chapter Three: History of Electric Vehicles

“Who Killed the Electric Vehicle?” is a documentary about how GM implemented a new vehicle called the EV1, which failed due to unknown reasons. The documentary shows how the GM EV1 was popular when it was tested on the Californian population. Although there was a large supporting group that loved the EV1, the EV1 was killed off by GM due to the lack of governmental funding. Also, the oil companies have been suspected of bribing government and GM. The users of these electric vehicles were very pleased with the overall experience, and some fought back when these electric vehicles were taken back from their test run and were dismantled. [Paine, 2006]

The reason why companies like GM fold under the pressure is because of bigger companies taking control of the economy. The economy is a brutal battlefield where companies will do anything in their power to prevent their opponents from gaining power. The current giant in the automotive industry is Exxon Mobil, who provides most of our oil in the United States. Exxon Mobil, having trillions of dollars in oil left to be sold, would do anything in their power to prevent competing technologies, such as electric vehicles, from entering the market.

In 1912, electric vehicles hit approximately 40% of the U. S. population’s registered vehicles. The electric vehicles at that time were very quiet and smooth, but they only traveled at around 20 mph. [Wakefield, 1994]. The electric vehicles were targeted toward the wealthy, which loved the smooth and pleasant rides. These vehicles were furnished luxuriously to please this market audience.
If we look at today’s modern electric car, we can see the same sort of trend occurring. Tesla is focusing on the luxury market, which is why they are so successful. Today’s society views the electric car as being a hot commodity as it did in the 1900’s. The reason why electric vehicles failed in the past, however, is that there was a lack of charging stations and battery swap stations.

Back then, the Harford Electric Company provided battery swap stations called GeVeCo for electric vehicles. In some sense, Better Place is the new Harford Electric Company. So the real question is: will this system succeed the second time around? The answer comes down to how much funding and public support is provided in the electric vehicle market. The funding has already started to emerge through companies like Better Place and big motor companies like GM, Nissan and Mitsubishi. However, our society still fears change. The only way to help ease the transition into the electric vehicle market is to provide services in a user friendly and cost effective way. I believe that this is where Industrial Design comes into play. Designing methods to simplify the use of electric vehicles will provoke consumers to change.

Additionally, Industrial Design will help electric vehicles become more appealing to investors. In the case of the GM Volt, not enough consumers were willing to pay its MSRP of $50,000 for the vehicle to become a success. Consumer had to pay a premium for the vehicle because it introduced a brand new form of technology. When hybrid cars were emerging, their cost was extremely high. However, prices dropped drastically as the years went by. Today, the cost of a hybrid vehicle is comparable to the cost of a gasoline-powered
vehicle in the same class. The majority of the cost of the electric cars goes into the batteries. As the market leans toward electric vehicles, the cost of producing these batteries will go down, as did the cost of cellphones after hitting the market. The public thought that cellphones would never catch on because of their short battery lives. However, cell phone technology has improved so much that even children have them now. In its development, cell phones have developed much longer battery lives. In the electric vehicle market, the same sort of trend should occur. Electric vehicle technology will improve and the cost will decrease.

With the Nissan Leaf and the Mitsubishi MiEv arriving on the market, the growth of the electric vehicle market is inevitable. Eventually, electric cars will become a daily part of our lives. The Nissan Leaf is already being adopted in many parts of the United States, such as California. Charging stations are already stationed across the United States. The more stations that emerge, the more willing customers will be to buy electric cars.

It is in our human nature to be attracted to new things. For instance, when we see a new vehicle design on the street, we are inclined to turn and look at the passing car. Our brains are wired to perceive the "new" as being appealing, thus forcing us to focus on these new things. As designers, we have numerous opportunities to motivate the public's interest toward electric vehicles. Furthermore, as designers, it is our job to improve the image of the electric vehicle. In order to do this, we should focus on two main themes of human emotion: curiosity and status.

When we were kids, the most appealing thing to us was toys.
Whichever kids had the best toys were the most popular because the best toys gave them status. This popularity, in turn, made those children happy because they felt important. This is the same concept that must be used to change the public’s opinion on the electric vehicle. Although we are far from children, we still have the same type of feelings when it comes to status. People in today’s society thrive on popularity and will do anything to gain it. As a designer, we must use this tool to change society’s negative views concerning electric vehicles and motivate change within the public.
Chapter Four: Existing Systems

There are flaws, as well as benefits, to each of the electric car systems currently on the market. The systems that are in existence range from electric charging stations to battery swapping stations. Charging stations range in many shapes and sizes. This is a problem because consumers become frustrated and confused when charging stations are not standardized. If we look at the current gas stations around us, we see that all gas stations function identically. This allows the user to feel comfortable in going into any gas station to fill up their vehicle.

Figure 4.1 Current method of refueling the vehicle.

If you look at figure 4.1 filling up your vehicle is essentially the same at Mobile, Shell, and any other gas station.
Figure 4.2 Gasoline station layouts

Figure 4.3 Electric station layouts

In figure 4.2, the electric car charging stations differ severely. Each system has its own unique way of charging vehicles. Users are not only required to know how to use each system, but they also need to provide their own wire at certain charging stations. Another problem with these stations is that anyone can tamper
with the wires while you are away from the vehicle. They can essentially steal the wire or unplug it from the vehicle. There is also poor management of electricity in these systems, as the power is directly drawn from the grid.

Looking at different countries around the world, there are countries that manage their power very efficiently. These countries lack sufficient power, forcing them to come up with alternative solutions. For example, Japan has advanced far beyond many other countries around the world by developing new types of smart grid technology that allow them to manage their power usage. A normal grid system consists of the standard electric grid and the power source. The power source comes from coal burning plants, natural gas plants or nuclear plants. The generators, at these plants, are turned on based on the demand from the consumers.

Smart grids allow for efficient management and storage of power. Smart grids have gradually been integrated into Japan's energy grid system and have greatly improved efficiency.

In Japan, homes are supplied with fuel cells that store power and minimize the cost of electric bills. The houses are also equipped with “smart” appliances, or appliances that use less energy and monitor the energy being used within the smart grid system. This means that energy is being used efficiently, which prevents strain within the grid system as well as on the pocketbook.

In the United States, Professor Donald Sadoway has been developing a system that uses liquid metal batteries to hold tremendous amounts of energy to
aid in the power management within the power grid. Sadoway’s batteries can be mass-produced for a fairly reasonable cost, which would allow the power grid to be much more efficient. Currently, we waste tremendous amounts of energy just supplying consumers with power. Power plants generate power at an excess to prevent blackouts, which happen when the consumers’ power demand exceeds the power supply. There is no way to predict when power would be insufficient, so extra power is produced as a buffer. We need a system where power can be stored instead of lost as excess energy. Another portion of the smart grid integrated green power sources to power the grid. Eventually all the power being drawn by the system will be replaced with clean energy sources.

Recently, there has been a lot of research and development concerning solar power and wind energy. These two energy solutions have been implemented in many sectors across the United States, as well as in many countries around the world. Since the Fukushima nuclear power plant disaster of 2011, many alternative power sources have sprouted up in Japan to compensate for the power loss from the disaster. Wind energy has been a popular solution in Japan because it is relatively cheap to produce and can also produce a tremendous amount of power over a large area.

Along with wind energy, there has been a lot of research on solar energy. There has been an interest in this category because solar energy has the potential of wiping out energy shortage around the world. Currently, the most efficient solar panels can only produce 17% of the sun’s power. [Blackers, 2008] Yi Chen, a student at the University of Illinois in Urbana-Champaign, has been
developing a solar panel that produces 100% more energy than traditional solar panels. The idea behind his invention is to increase the surface area of the solar panel at a microscopic level. The surface area is increased by producing nano mushrooms on the surface on the panel, which allows for the panel to capture more light. Although this technology has not been scaled for production, it is a step toward more efficient solar panels.

Indeed, The technologies and systems we currently use have many flaws to them and need to be addressed. These flaws are related to efficiency as well problems with user convenience. New technologies that have been emerging, showing promising results in improving some of the problems that are currently evident.
Chapter Five: User Research

The most important aspect of my research is the investigation of the factors that motivate consumers to switch to electric vehicles. To determine this, I gathered data on what people thought of electric vehicles and what would motivate them to change to an electric vehicle. The first thing I did was create a survey on people’s opinions about the electric vehicle market. In this survey, I asked a variety of questions to determine the public’s opinions on certain topics relating to my research. This survey was conducted on random students at the University of Illinois in Urbana-Champaign. Fifty people took the survey and the results were averaged. Figure 5.1 shows the survey.

Figure 5.1 Survey and Results

*On a scale from 1-10, 1 being the least likely 10 being the most, how likely are to drive more than 100 miles in a day?*

Average score: 2.1

*On a scale from 1-10, 1 being the least likely 10 being the most, would you be likely to change over to an electric vehicle within the next 5 years?*

Average score: 3.4

*On a scale from 1-10, 1 being the least likely 10 being the most, would you be likely to switch to an electric vehicle if it cost the same as a gasoline vehicle?*

Average score: 5.2

*On a scale from 1-10, 1 being the least likely 10 being the most, would you be likely...*
to change to an electric vehicle based on design?

Average score: 6.2

On a scale from 1-10, 1 being the least likely 10 being the most, would you be more willing to buy and electric vehicle if there were more charging stations?

Average score: 4.7

On a scale from 1-10, 1 being the least important 10 being the most, how important is the cost of gas when choosing a vehicle?

Average score: 7.6

On a scale from 1-10, 1 being the least important 10 being the most, how important is helping the environment which choosing your vehicle?

Average score: 3.7

On a scale from 1-10, 1 being the least important 10 being the most, how afraid are you of complications when switching to something new?

Average score: 6.6

On a scale from 1-10, 1 being the least important 10 being the most, are you more motivated to buy a product based on the status it brings, things like brand name goods and trending items?

Average score: 7.1

Figure 5.1 continued
On a scale from 1-10, 1 being the least important 10 being the most, how important is name brand when it comes to purchasing a vehicle?
Average score: 8.4

On a scale from 1-10, 1 being a dollar 10 being 10 dollars, how much would gas prices have to go up for you to consider changing to an electric vehicle?
Average score: 5.2

On a scale from 1-10, 1 being easy 10 extremely hard, how hard is it to use a traditional gasoline pump?
Average score: 1.2

On a scale from 1-10, 1 want 10 need, what motivates you to buy a product? [Want or Need]
Average score: 3.1

On a scale from 1-10, 1 being the least likely 10 being the most, how likely are you to survive without a car?
Average score: 2.6

Figure 5.1 continued

From this survey I realized that brand name and status is a very important aspect of buying a vehicle. People are prone to by a vehicle based on the name brand for a variety of reason. One being, it gives them status in society. The
average consumer buys the vehicle due to a variety of reasons, but the most prominent reason is because of the branding, design and cost. The branding is an important aspect because of the reputation it holds for its outstanding engineering and trust that backs it up. The design was another important aspect in buying a vehicle and it my server it score a 6.2 on average. Although people might not realize it at first, they make choices in buying a product based on design. This has always been the case in consumer automotive industries, which is why they invest so heavily on recruiting the best design talent into their companies. The last aspect that affects a person in buying a vehicle is cost. In the electric vehicle market, people are not going to transition into electric vehicles unless the cost is a beneficial part in the purchase. In order for electric cars to become competitive, it must cost the same or less than the current solutions that exist. This is why companies like Nissan have done a lot to lower the cost of these vehicles.

In the case of Nissan, a company that has been pushing their new line of electric vehicles, a big concern is indeed pricing. The cost of Nissan’s economical electric cars is still well above what an average consumer is willing to pay for. The cost of a Nissan Leaf is currently $27,000. Although at first it seems like a fairly hefty price, it is actually very affordable. The government has a program implemented where if you buy an electric vehicle; you get a $7,500 tax cut on the vehicle. Thus, the tax cut will drop the vehicle cost to $19,500. Additionally, certain states issue coupons for these vehicles. Illinois is currently giving a $4,000 coupon for the Nissan Leaf, bringing the car price down to
$15,500 dollars. [www.nissanusa.com] The cost of running an electric vehicle will only cost \(\frac{1}{4}\) the amount it would be to run a comparable gasoline powered vehicle. The problem with the Nissan Leaf is that it is a full electric vehicle, so if it were to run out of power the only place that you could charge it would be at home. There are charging stations currently being implemented in the west coast regions, primarily because of Tesla’s popularity in California.

California has been pushing toward green technologies for a while, trying to innovate new methods to cut down on pollution and consumption. The most noticeable system in California that has been implemented is the system of HOV lanes, which allow carpoolers to travel faster by avoiding traffic during rush hour. The requirement is two or more people in the car. Thus, this system minimizes the number of cars on the road and the emissions produced. The reason this system has been effective at reducing vehicles on the street is because people are drawn towards things that benefits to themselves. For the driver, it allows them to get to their destination faster, avoiding traffic during rush hours. They are motivated to change their average routine via the new system because they benefit greatly by switching over. The same idea applies to users that are motivated to change to electric vehicles, since the government is giving them incentive for switching to electric vehicles. This is why we need to use design to motivate the public to switch to electric vehicles.

Apple Inc. is a prime example of a company that was able to motivate change through industrial design. Recently, in China, a person even gave up his own kidney to buy an iPad. [Shanghai Daily, 2011] This kind of motivation could
only be provoked by intelligent design, which generates a feeling of want in consumers. A feeling of want comes from personal experience and trends. If a user has a good experience using a product, they are motivated to purchase the product. For example, the smartphone boom created a huge desire in consumers to purchase smartphones because of the convenience that smartphones provided. Essentially, smartphones allow for users to have a small computer and Internet access with them at all times. Before the iPhone and Android devices were popularized, society believed smartphones would never catch on due to its high cost. As time passed, society changed its impression of smartphones, allowing for smartphones to become a huge hit. The same trend must occur in the electric vehicle market for electric vehicles to be welcomed in our lives.

Consumers must realize the benefits and conveniences that an electric car will provide. In the documentary “Who Killed the Electric Car,” consumers testing electric vehicles respond positively toward electric vehicles after hands on experience. The users in the documentary were amazed at the performance and convenience of the electric vehicles. Furthermore, they could not understand why they had not switched earlier. Similarly, before the EV1 was commercialized, people were skeptical about electric vehicles and were astonished after testing them. As designers, we must generate a want of electric vehicles in order to motivate the public to test and ultimately buy these cars. Digressing back to the iPhone example, I was personally skeptical about purchasing my first iPhone. However, now I feel as though I cannot live without one anymore. The same sort of trend must occur in the electric vehicle motivate change towards a new idea.
Along with motivating change in the way we view electric vehicles, we must change our perspective concerning the big picture. The electric vehicle is only a small part of the system. The charging station is an essential part of making everything work properly. Current charging stations come in many shapes and sizes. The problem with having separate manufacturers is the lack of standardization among charging stations. Thus, it is the responsibility of both the vehicle manufacturer and the station manufacturer to construct the outlets and stations in a single, efficient manner. The lack of standardization of charging stations creates a hassle to the consumer because the consumer must carry countless adapters to cope for this disorganization. As portrayed in Figure 5.2, charging a car doesn't seem like much work at first glance, but if you repeat these steps everyday the lack of standardization in charging stations will generate discontent.

Figure 5.2 Electric station payment systems.
In short, the lack of standardization of charging stations generates annoyance toward the electric vehicle charging system.

One major difference between gasoline powered cars and electric powered cars is that we already have the necessary infrastructure set up to accommodate our fuel needs. Indeed, we have a gas station installed at almost every street corner. This means that users of gasoline powered vehicles do not have to worry as much about running out of fuel. In contrast, electric car owners are limited in the amount of charging stations. One, however, is that these electric vehicle charging stations are usually placed in parking lots, so consumers may charge their vehicles while running errands.

Aside from a lack of standardization of charging stations, security is another issue for electric vehicle users. At any moment, someone can trip over
the wire and unplug the car from the station, or vandals could unplug the car and steal the wire that is being used to charge the car. A person driving a gasoline-powered car would not just leave the car pumping unattended. Why should it not be the same when it comes to charging the electric vehicles? Industrial designers must find a way to design a system that solves the issue of security.

The final problem that I observed is that there is a lack of management concerning the cost of the electricity used. At traditional gas stations, price is one of the most important aspects that we use to determine which gas station to go to. When it comes to charging stations, there is no way to know what you are being charged except by getting a bill at the end of the month. This inconvenience is due to the fact that the price of electricity varies throughout the day. Inevitably, the users should have a choice in pricing when it comes to purchasing electricity.
Chapter Six: Psychology of Change and Status

Products on the market can be grouped into two very different categories: “want” products, or the products that consumers buy for personal pleasure, and “need” products, which are the products that are essential to our survival. Wants and needs are the strongest psychological aspects that drive us to buy products and so must be continuously monitored by sellers. The most successful companies are ones that play off of both the consumer’s need for a product as well as the consumer’s want for a product.

Let us use the car market as an example. Statistics show that the majority of cars on the street are workers driving between home and work. “On average, the nation’s 100 largest metropolitan areas have 63% of their jobs (64.6 million total positions) located outside the central city. And while most of those jobs are in near bus or rail line, the patchwork of suburban transportation systems makes it hard for their workers to get there without driving.” [Dougherty, 2012] Since most vehicles are used for commute between home and work, we must focus on improving the lives of the working group when considering design changes in their vehicles. Improving functionality and efficiency might create a benefit to the user and entice a “need” for these vehicles.

Aside from cultivating a need, we must instill a want for electric vehicles. As Industrial Designers, we can generate a want from consumers by observing trends in the economy and gaining momentum with the latest trends. For example, tech boom trends involve the frivolously spending on technology that consumers do not necessarily need for survival. Apple Inc. is one of the
companies that has figured out a way to increase consumer “want.” Indeed, the Apple iPad is nothing more than a portable computer, yet the iPad has created gained unbeatable traction in our economy. Before the iPad, the personal computer market had already been very steady. However, the release of the iPad created a huge boom in the already stable personal computer market. Statistics show that the majority of iPad owners use the device for accessing the web, emailing, social networking, reading and watching media. [Bullas, 2011] All of these functions can be accomplished on normal laptops or desktop personal computers, yet people spend hundreds of dollars on each iPad. This is because of the convenience and comfort factor administered by the device.

The iPad was designed to be ultra portable as well as extra efficient in power management. People who use these devices can use them anywhere. Apple Inc. designed the iPad to minimize the computer size and maximize portability. An average consumer does not need the computing power of most computers out on the market. Apple Inc. recognized this notion and learned to sacrifice computer power for computer portability. Additionally, the ergonomics and ease of use were taken into consideration. Apple Inc. has simplified the computing world so that anyone can use it without much prior knowledge of computers. Using the same approach, we can design a vehicle in a similar fashion. We need to design a system that is easy to use so that people are not intimidated to use it. Also, we must consider ergonomics and user friendliness when adjusting the design in order to it generate feelings of comfort and convenience at the user level. By doing so, we would advance past the notion of
need and entice a want for the product. Indeed, the needs for many products are there, but the want for these products must be induced.

Looking at Figure 6.1, we can clearly see how Apple Inc. motivates the consumer want of their products. They have enhanced the user experience even when the user opens the package for the first time. The user feels like they are getting their money's worth because Apple Inc. is so successful in their design concepts. When someone opens a package for the first time, they don't really think about the packaging the product comes in. Yet it gives a strong impact on the product that it packages. We tend to base the quality of the item off of its packaging. If a MacBook were to come in a raggedy box, for example, the consumer would view the product to be lower grade and feel like they got cheated out of their money. Apple products are known to cost a premium but the consumer is willing to pay for them because the Apple products are so intelligently designed. We must use this type of design to establish a “want” of electric vehicles. We must learn to cultivate the feeling that the user is getting what they paid for, rather than the feeling of getting ripped off. This feeling is the key to product success.
Another vital factor in generating a want for a product is how attractive the product is to the consumer aesthetically. Design can be used to please your senses. The material and shapes used in successful products are pleasing to the eye and induce positive feelings toward the products. Even the smell of a product can be an important factor when creating a want for a product. A new car smell,
for example, gives you a good feeling inside. Even when considering the packaging of a product, premium packaging causes a consumer to feel as though the package contents are premium contents as well.

After the “want” is established, we must increase a product’s traction in the market. The common hurdle in spreading new technology is distance. If we take Japan and Korea for example, technologies in these countries have expanded at a tremendous rate because small areas allow new ideas to spread rapidly. Also, the implementation of these new ideas can be set in place much more easily. Japan has already done wonders in implementing electric vehicle technologies within their counties and has been doing so much faster than the United States because of its small territory. The smaller the area, the fewer amount stations need to be implemented, driving the cost down significantly. Aside from Japan, Korea took the route of natural gases in order to reduce oil consumption. Koreans use LPG (Liquid Propane Gas) to power nearly half of their vehicles. This type of technology can be adopted without a significant monetary drain in building the system. The problem with the implementation of LPG technology in the United States is that there is a tremendous amount of land to cover. Thus, it would cost trillions of dollars to implement stations in all the necessary locations.
Chapter Seven: Efficiency

Efficiency is a huge part of our everyday lives, yet we often fail to realize its importance. The Kardsheew Scale measures the level of technological advancement in a civilization. There are four stages of a civilization. The first stage, stage 0, is where our current civilization is at. This civilization harnesses its energy from fossil fuels polluting its planet. A stage 1 civilization uses green energy by harnessing energy from nature and the sun. We are slowly evolving into a stage 1 civilization. [Michio, 2010] We must learn to harness the power of the sun as well as nature to ensure a better future for our world.

If we take a look at the efficiency of a gasoline-powered vehicle, we can clearly see flaws in the system. The system itself wastes a tremendous amount of energy to refine and transport the fuel from the source to the consumers. However, If we analyze the electric vehicle market, it is evident that the system is fairly efficient. Its only flaw is that the source of its energy is electricity. Electricity is produced mainly from coal plants, which makes the system a bit hazardous to the environment. The way we must solve this problem is to use cleaner energy sources by transitioning over to renewable energy. There is also a problem with managing power within the grid system. The problem with the current grid systems is that they waste a tremendous amount of energy since the power generated is based on the demand. Thus, the excess energy is gone to waste. Japan has been improving its smart grid system over the years.
Figure 7.1 Smart grid systems

As you can see in figure 7.1, the harnessed energy is efficiently managed within the grid system to optimize its efficiency. The current electric charging stations that we have in place have no management of power or a smart grid system to run off of. Thus, energy is wasted during the charge.

Learning and innovating from smart grid technology is essential in making electric vehicles more efficient as well as more cost efficient. The current system does not manage power efficiently and wastes a lot of energy when during its usage. Using the Japanese smart grid technology, we can determine the improvements that should be made to our current system and allow for a more effective charging method.

Another technology that has been slowly emerging as a giant for green energy is solar power. In the past, solar panels have not been used in many
applications due to efficiency issues and the high cost of their production. This led many companies to fail under harsh competition from other green energy sources. Recently, a lot of research has been going on in the solar market, because solar energy is considered the ultimate green energy source. The reason for this consideration is that solar energy is capable of satisfying the energy demands of the entire world. Obviously, however, solar energy research has not advanced to that level. Currently, we are capable of harnessing only 10%-15% of the sun's energy. As mentioned in the earlier chapters, Yi Chen has been developing nano mushroom solar panels that increase the power output of solar panels by 100%. This technology would boost solar panel performance to a level where we would be able to harness 20%-30% of the sun’s energy. However, the production process of these solar panels is extremely technical and requires a lot of time. Thus, it can only be accomplished on the small scale. Although this is not a breakthrough in solar technology, it is at least a step in the right direction. As time progresses, solar technology will continue to improve in efficiency and become a vital part of our lives.
Chapter Eight: Solutions

Through my research, I have found many areas of improvement in the electric vehicle market. The main problem with the current system that arose dealt with the efficiency and management of the electricity being used in the electric vehicle system. Generally speaking, our current system wastes a tremendous amount of energy to power vehicles.

The problem with the current electric vehicle system that I focused on concerned the lack of standardization among charging systems. Our existing system portrays many flaws that prevent consumers from taking interest in switching to electric vehicles. First of all, existing charging stations still use the traditional plug/pump type of system. We are transitioning over to a whole new type of system for charging but are still stuck with the old fashioned way of charging. This old fashioned system has messy wires to deal with and compatibility issues with different vehicles. When going to a charging station, a user wants to feel comfortable performing the task. Users do not want to be bogged down by complexity and added work. An important problem is that car companies have not developed a universal outlet that would support all vehicles. Communication is ineffective between charging station developers and electric vehicle manufacturers. Thus, the companies that develop the stations do not know what type of outlet to make because the outlets differ among various electric vehicle models. The lack of standardization among charging stations induces feelings of frustration in the consumer that deters the consumer in purchasing an electric vehicle. Since electric cars require constant charging, the
user must face his or her frustrations as often as he she visits a station. Thus, consumers are apprehensive toward electric vehicle purchases because of the constant inconvenience they have to face.

Figure 8.1 Charging stations problem areas.

To solve the standardization issue with charging stations, I brainstormed ideas that would help users feel more comfortable at each station. The best way to solve this problem is to minimize the amount of work that is needed from each user.
I focused first on where the vehicle could be connected to the station. The only logical place to place the outlet was underneath the vehicle where it would be hidden from view. By placing the charging port on the undercarriage of the vehicle, it allows the vehicle to step away from the traditional manual pumping methods. New technologies must be superior in all aspects to allow the consumer to grasp the idea. By taking the labor of charging a vehicle/pumping a vehicle, it becomes more appealing to the consumer.

My second way of attracting consumers to electric vehicles is by saving consumers money. Our current charging stations provide power to the customer by drawing electricity directly from the grid. This gives the electric company full control of the cost, leaving consumers without a choice in the pricing of the electricity. A good solution would be to mimic the charging systems in Japan. By using batteries to hold the excess power, power could be harnessed for later usage, depreciating the cost to consumers. Thus, consumers would save money and the outcome would be less harmful to the environment. By modeling the
Japanese system, I developed a charging station that incorporates smart grid technology with the integration of batteries and solar panels with the station.

As explained in the earlier chapters, there are a lot of technologies that are sprouting out that incorporate smart grid technologies to manage the power consumption and output of a grid system. In my design, I incorporated the same type of technology to the system with a twist. The difference in my system lies in where the user interacts with the system. In order for the system to manage the time efficiently, it must run based on the time it is running. By allowing the user to provide the amount of time they will be away from the station, the system will calculate the optimum efficient way of charging the vehicle. The system will also allow for the energy gathered from the sun, from your vehicle, to be sold back to the grid. This gives the user full control over what they are spending and saves them a tremendous amount of money in the long run.

Figure 8.3 Power management system.
Then, I provided a way to charge the vehicle without having the user do much work. The electric vehicle drives over the charging station, allowing the connectors at the bottom of the car to charge the vehicle. Thus, the work that users would normally have to put into the charging system is eliminated. When the user drives to the station, there are receiver ports placed at the undercarriage of the car. When driven over, the connectors rise from the dock and connect to the car automatically via metal connecting points. Then the user can set the amount of time they will be away from the vehicle to allow the system to calculate the optimum power output to charge the car. Additionally, solar panels lining the top of the vehicle quicken the charging process and help limit the length of the charging process.
The fourth part of my project was the development of a visibly appealing vehicle that would motivate consumers to want to buy the product. A visually appealing vehicle design will cause the consumer to want to buy the electric vehicle. I designed the vehicle to be very fluid and elegant to generate an emotional need for the vehicle in the consumer. The vehicle is also designed to be streamlined and aerodynamic to cope with the lower output of the electric vehicle.
Figure 8.5 Stylization sketches of iOn.
The last step of the project was to unify all of my designs into one functional system. A system in which the charging stations interacts with the vehicles to optimize efficiency. As stated earlier, the solar panels within the vehicle and the stations aid in the charging of the vehicles battery as well as the stations battery. The stations monitor the power to determine the optimal way to
charge the vehicle. This in turn saves the user money when at the station and can provide added benefits such as being paid for the power. By standardizing the charging port, users will be carefree when pulling up to the station and when they leave.

When redesigning the charging station, I incorporated a theme to it. If you observe nature, you can see that energy is being recycled and used efficiently. Plants use the process of photosynthesis to gather energy from the sun and use to produce glucose. When I was designing the station I took nature as an inspiration, because as humans we must learn to value the precious energy that is being wasted every day.
Power Efficient Design

iOn integrates the charging station with the vehicle to allow for optimum efficiency when charging. The station has a built-in system battery that stores energy gathered by the sun or low-cost grid energy when it is not being used.

When the vehicle is parked at the station with a full battery, the user will be compensated for the energy that is generated by his/her vehicle.

The station uses a smart time management system where the user can set the amount of time they will leave the vehicle and the system will automatically calculate the optimum voltage to use. (Higher voltage wastes a lot of energy and costs more)

Figure 8.7 Power Efficient Design
The ion is an electric vehicle that is designed to use solar energy to aid in charging the vehicle. The vehicle also allows for a more convenient and user friendly way of charging the car.
The charging station has a secondary outlet, which allows users without a dock port, under their vehicle, to charge using an external wire.

The user will set the time they will be away from the vehicle to allow the system to calculate the most efficient way to charge.

Figure 8.9 Ion Charging Station Interface
Figure 8.10 UI Design: Home Screen

Figure 8.11 UI Design: Eco Charge
Figure 8.12 UI Design: Fast Charge

Figure 8.13 UI Design: Pay and Statistics
Chapter Nine: Conclusion

The energy crisis that has been growing thought the years and will eventually catch up to us and cause a tremendous problem within society. Before this crisis occurs, society must find a way to welcome new technologies in transportation. The problem is that consumers are afraid to transition into electric vehicles due to a number of problems.

Thought my project I observed the problems that lie within the current systems that might disinterest the consumer. Problems such as high cost and inconveniences were the most noticeable issues with the current systems. Improving on these issues is essential when it comes to allowing for an easier transition to consumers. Providing an easier way to charge the vehicle without adding more work would provide the user with a comforting feeling. Along with removing the work of charging the vehicle, saving money is another appealing aspect that I have incorporated into my design. Within my survey I noticed that the cost has a huge effect on the consumers. Consumers are attracted to saving money in any way they can. By incorporating systems that saves the user some money, as well as have a potential to earn them money, is a huge advantage over the current systems.

Another huge part of attracting consumers is by making the product appealing. In the vehicle industry, companies strive to design the most appealing vehicle because of its potential to sell more cars. In the electric vehicle market, there has yet to be a strong reliance on design to market their vehicles. If you take for example the MiEV and the Leaf, both vehicles are fairly plain and
unappealing. The reason behind this is that, there is not much completion in the electric vehicle market since only a hand full of companies are producing them. This is why companies have slacked in these areas and need immediate attention. That is why I have created an electric vehicle that can compete in any vehicle market without discrimination.

The last problem I focused on was the issues relating to inefficiencies in the current systems. By designing a smart electric charging station, energy is not wasted. The energy is managed to allow for environmental benefits as well as cost savings.

The world has a long way to go till it transitions into greener technologies, but steps must be taken to allow for growth in the electric vehicle market. I hope that my project will influence more innovations in this area and inspire society to transition into electric vehicles.
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