About the Fuels Institute

The Fuels Institute, founded by NACS in 2013, is a 501(c)(4) non-profit research-oriented think tank dedicated to evaluating the market issues related to vehicles and the fuels that power them. Led by a diverse Board of Directors and driven by a Board of Advisors, the Fuels Institute incorporates the perspective of interested stakeholders affected by this market, including but not limited to fuel retailers, fuel producers and refiners, alternative and renewable fuel producers, automobile manufacturers, environmental advocates, consumer organizations, academics, government entities and other stakeholders with expertise in the fuels and automotive industries. The Fuels Institute helps to identify opportunities and challenges associated with new technologies and to facilitate industry coordination to help ensure that consumers derive the greatest benefit through education and independent, non-biased research.

2015 Fuels Institute Case Competition

The fuels and vehicles industries are facing a rapidly changing policy and technology environment. The sheer amount of new fuels and new drivetrains is truly breathtaking.

What if you had the power to reinvent the motor fuels and vehicles industry? That was the challenge accepted by 21 different collegiate teams represented by 11 different universities. After submitting abstracts and research papers, each submission was thoroughly reviewed and three teams were hand-picked by a panel of judges to present their findings to a group of industry professionals in New Orleans at the Fuels Institute Spring Meeting, April 29-May 1, 2015.

Each team, represented by three students, shared their findings within the framework of a 10-minute presentation. At the conclusion of each presentation, there was a Q&A session where attendees gave constructive feedback.

The team from the University of Wisconsin's proposal, "Electricity and Petroleum as Long-Distance Fuels," captured the $5,000 top prize in the first-ever national, multi-disciplinary student competition hosted by the Institute. Northwestern University captured second place and $2,500 for its proposal, "Integrating Electric Vehicles in the Future Transportation Value Chain," and third place and $1,000 went to the University of Texas at Dallas for "Monetizing Environmentalism."

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Electricity and Petroleum as Long-Distance Fuels

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Introduction

In the "2014 Future of Fuels," the NACS writes, "Liquid fuels (consisting of gasoline, diesel, and E85) will remain the dominant energy source for transportation...to [a 2040 market share of] 99.28%." The question that this paper seeks to answer is this: What is the most plausible scenario in which liquid fuels would *not* remain so dominant? That is, what must happen for a second fuel to be used by a sizable portion of the market? Most importantly, what would this fuel be and how would the fuels value chain supply it? In this paper, we boldly envisage a future that has been crafted by stakeholders in American motor fuels.

When we survey the landscape of transportation and fuels, we are excited by the incredible opportunity to innovate; this is why our team chose to invest ourselves in our case. As we move forward in our paper and outline our proposal of the fuel most likely to challenge liquid fuels, we suggest a theme that is in line with our education as industrial engineers and supply chain managers: that the fuels value chain has a unique opportunity to act now to craft a system that satisfies the consumer demands of the future, as opposed to reacting to those demands in a more costly and time constrained way in the future.

Importantly, we have completed our analysis under the assumption that *current technologies and market forces* will hold for the foreseeable future. We have created a solution that is not dependent upon any unexplained technological advancement. Certainly, *unfamiliar* technology is embedded in our case. However, as we will explain, our unfamiliar technology is not fictitious technology.

We suggest that the most plausible challenger to liquid fuels will be electricity. We argue this is the case because (1) electric vehicles are on the road today in numbers unmatched by other clean fuel vehicles (i.e. hydrogen fuel cell vehicles)[1], and (2) because electricity has the potential to be generated from multiple clean sources (such as nuclear, wind, hydro, solar, etc.).

We further suggest that electricity will be consumed through a battery swapping model. The consumer will own the vehicle but not a battery. When their charge is low, the customer will have the freedom to drive to any nearby retail location and swap their battery for one that is fully charged. We assert that this model will work best with the establishment and implementation of industry standards concerning the fit and function of batteries in vehicles. That is, in our model, OEMs, battery manufacturers, and retail locations will work together to develop standards so that a customer can swap their battery at any retail location, regardless of the brand of the station, the make of the vehicle they drive, or the company whose battery is currently in their vehicle.

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[1] "Alternative Fuel FAQs." EIA. EIA. Web. 15 Feb. 2015. <http://www.eia.gov/tools/faqs/faq.cfm?id=93&t=4>.

A key concern with a battery swap model is this: in a market environment, in which retail locations are owned and operated by many companies, large and small, who will own the batteries, and how can customers swap freely between stations? The solution we propose is the establishment of a retailers' cooperative. This organization would be responsible for purchasing and distributing all batteries to retail locations. As we describe later, the cooperative itself will earn no profits, but will facilitate intercompany cooperation among the retailers. This idea of cooperation is the central tenant of supply chain management theory, and will create otherwise impossible benefits for the American driver and the fuels industry.

Given the current political, social, and economic contexts in which business operates, we propose that electricity as a motor fuel will be born in a public-private partnership. The federal government, like it has done for nuclear, oil, and gas, will incubate electricity as a fuel as the industry expands. We propose that this expansion will take the form of a 15-year, five city, industry-development initiative.

The battery swap model has been tested before. Better Place, an Israeli multinational, has been a trailblazer for this model. The company itself is no long operating, but the concepts they pioneered, and, importantly, costs they incurred, are incorporated into our model.

Determining how we narrow our scope was by far the most difficult piece of this case. We have focused our analysis so that we consider our second fuel, electricity, in more depth than we could if the future of petroleum were given significant attention in this paper. A fundamental assertion in our case is that, because the number of American drivers is increasing, and that our model will only be implemented on a small scale, the market and economics for gasoline are essentially unaffected. Therefore, we assert up-front that traditional liquid fuels will have a strong market and be created, distributed, and sold profitably into the foreseeable future. Because we suggest that this model is implemented as a small-scope (5 city) project, and because even in those cities we expect liquid fuels to maintain at least an 80% market share, we devote this paper to understanding electricity as a fuel and not justifying the continued existence of traditional petroleum fuels.

Finally, we offer our own attitudes towards our case. Our goal in designing our model was not to argue what the world *should* be. Nor was it to dream about what the world *could* be. Our goal was to design the most plausible model, considering current technologies, customer attitudes, and government involvement in the industry.

We begin the body of our paper by identifying the stakeholders.

Stakeholders

For electric cars to truly emerge as a competitor in the fuel and vehicle marketplace, a battery swap infrastructure needs to coexist with the current petroleum infrastructure in place. Adding battery swap infrastructure would add many different stakeholders to the equation, as well as affect stakeholders already present in the current fuel model. Current stakeholders that will be affected by this change:

Consumer/drivers: All drivers on the road will be affected by adding a battery swap infrastructure to retail stores. Individuals who own electric cars will benefit, as they will have more flexibility in driving and will reduce "range anxiety:" a feeling of perpetually being on the verge of a dead battery that hinders widespread use of electric vehicles today. Having this infrastructure in place will also affect drivers of gas-powered vehicles. One hurdle that will need to be addressed is the fact that adding this infrastructure will add to congestion at retail stores, which could pose some frustration and potential issues for petroleum users.

Retail stores: Obviously, retail stores will be a large stakeholder in our battery swap model, as our recommendation is to integrate swapping stations with the current petroleum infrastructure the convenience stores possess. One problem that may occur, however, is lack of resources by the retail stores in implementing these swapping stations, whether it be money or space (as swapping stations will likely be approximately the size of a car wash). However, with a public partnership, as well as the fact that having swapping stations would drive more customers to the retail stores (which would increase total revenue), from a financial standpoint the retail store will benefit from the addition of a second fuel to the value chain.

OEMs: OEMs may arguably be the largest stakeholder to be affected by our battery swap model. Currently, OEMs who manufacture EVs have intellectual property rights in how they design their batteries and vehicles in general. One of the key necessities in our model is the assumption that there will be standardization in place in regards to how batteries are designed as well as how they are placed in the vehicle. Without standards in place, the model will not function effectively.

Battery manufacturers: Currently, battery manufacturers produce and distribute batteries to both OEMs as well as retailers. With our current model, battery manufacturers who produce electric vehicle batteries will supply to a cooperative (explained later) rather than to OEMs.

Stakeholders that will be introduced to the system or become more prominent:

Electric grid/electricity generators: With the addition of swapping stations at most retail stores, there will be a need for more generation from the electric grid, as well as electric generators. We consider the grid investment outlined in the White House's 2015 budget proposal, described later, as evidence that the grid will support growth in electricity as a motor fuel.

Swapping station companies: With the introduction of swapping stations at retail stores, companies will need to exist to provide swapping station technologies and the infrastructure in place. The swapping infrastructure itself need not be homogeneous across retail locations, so long as each is able to access batteries.

Government: The government will be an important stakeholder in our model. Within the government, there will regulatory agencies as well as agencies overseeing the management of subsidies to retail locations.

Cooperative: We offer that the most effective supply-chain strategy for the battery swap model is to create a cooperative of retail locations nation-wide. This cooperative will act as a middle-man between the retail locations. Essentially, a customer will pick up a battery from location A, drive, and return the battery to location B. The cooperative will collect payment from the customer through the systems in location B. The payment will be funneled to location A. Similarly, a customer may pick up a battery in location B and return it to location A. In the same manner as before, the cooperative will collect payment from the customer through the systems in location B and funnel the money to location A. In this way, a customer need never worry about swapping from a single location or a chain of retail locations.

All stakeholders aforementioned will benefit from a battery swap model. Retail stores will attract more traffic from electric vehicle customers, electric vehicle drivers will now feel more at ease when driving, manufacturers of electric vehicles will likely find increased sales, more businesses and jobs will arise from the emergence of battery swap companies, and battery manufacturers will be able to reduce complexity in their production through more standardized batteries, in addition to increased sales volume. However, challenges will exist, especially in OEMs. In our model, OEMs operate under a shared standard, so that a single switching station can change the battery from any make of vehicle.

Societal Goals

The implementation of this battery swap model will have numerous positive impacts on society. The use of electric vehicles presents the opportunity to improve the environment. One of the primary environmental benefits with the use of electric vehicles is the that there aren't any tailpipe emissions[2]. This would help reduce greenhouse gas emissions and is beneficial to air quality. Electric vehicles also help reduce carbon emissions, as well. A study in 2007 showed that electric vehicles produce 0.55 lbs of CO_2 per mile. This is lower than gas-powered vehicles.

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[2] "Are Electric Cars Good for Society?" Driving Electric NYC. City of New York. Web. 10 Feb. 2015. <http://www.nyc.gov/html/ev/html/society/society.shtml>.

In addition to the reduction of emissions, electric vehicles also help localize emissions to the power plants they get their electricity from[3]. Instead of cars spreading gases on the roads, power plants will be the source of emissions while they generate electricity from coal or natural gas. This will lead to the reductions of pollutants in more heavily populated locations.

Although it presents numerous environmental benefits, people still have concerns over the use of traditional, plug-in electric vehicles. One of the concerns is that charging an electric car battery takes time[4]. At a charging station with a 240 Volt outlet, an electric vehicle can take anywhere from 4 to 8 hours to fully charge[5]. In addition to charging time, people are concerned with the range that electric vehicles can travel. Electric vehicles can travel 50 to 100 miles (in this case we assume a standard of 100 miles) before they need to be recharged again. People won't be able to travel on long trips in there isn't a way to charge their vehicles frequently and easily. These concerns, along with the cost of electric vehicles, are inhibiting their widespread adoption and the environmental benefits associated with such an adoption.

A battery swap model will change society's viewpoint of electric vehicles in a positive way. Swapping a battery will allow drivers to recharge their cars more quickly than using a charging station. This, in turn, will make it more convenient to charge their cars. We suggest in our model that people would be more willing to drive an electric vehicle if the process to recharge their battery was less time consuming. The convenience of charging with battery swap technology will help attract more people to driving electric vehicles, thereby add weight to the impact electric vehicles have on our nation's environmental impact.

In addition to the environmental benefits, we offer that the battery swap model will create jobs. Battery manufacturing, maintenance, swapping station installation, and other functions will stimulate the labor force.

As we see, the battery swap model will bring many benefits to society. We suggest it will change people's viewpoint on electric vehicles. More electric vehicles on the road will mean that society will benefit environmentally and economically.

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3 Decher, Ulrich. "Economic and Emissions Impacts of Electric Vehicles." The Energy Collective. 15 Feb. 2011. Web. 11 Feb. 2015. <http://theenergycollective.com/ansorg/51761/economic-and-emissions-impacts-electric-vehicles>.

4 "Advantages and Disadvantages of Electric Cars." Conserve Energy Future. Conserve Energy Future. Web. 11 Feb. 2015. <http://www.conserve-energy-future.com/advantages-and-disadvantages-of-electric-cars.php>.

5 "How Long Does It Take to Charge a Plug-in Car?" Plug In America. Plug In America. Web. 11 Feb. 2015. <http://www.pluginamerica.org/faq/how-long-does-it-take-charge-plug-car>.

Policy Opportunities and Challenges

In its recently-released 2015 budget proposal, the White House proposes investing $6.9 billion in clean energy technology.[6] This includes "over $700 million in cutting-edge sustainable transportation technologies to increase the affordability and convenience of advanced vehicles and domestic renewable fuels," as well as "Modernizing the electricity grid through an investment of $157 million in Smart Grid R&D and other activities."

Certainly, we understand that these figures are proposals. We also understand that there are numerous programs and projects seeking federal subsidies. However, what we glean from these figures is that the federal government **is invested in supporting the creation of a clean energy fuels chain**. And, though a sizeable portion (68%[7]) of electricity today is generated using conventional fuels, the opportunity to generate fuels using clean technology gives the government reason to invest in electricity as a motor fuel.

There is a history of public-private partnerships in the early stages of a new fuel industry. An article from *Chemical and Engineering News* reports that the government has typically considered the first 15 years of a new industry as critical to developing new technologies.[8] The article describes nuclear energy as having received $3.3 billion annually in the first 15 years of its life, and $1.8 billion annually for oil and gas.

As we will describe in our financial analysis, the economics of electric fuel are volatile; they do not compare to traditional liquid fuels. This is a reason, we are sure, that the NACS does not foresee a challenger to traditional liquid fuels in at least the next 25 years. But, because of government's investment in developing new technologies, there is an opportunity for industry and the public sphere to form a public-private partnership that enables electricity as a fuel.

How would such a partnership operate? We think that the key here is that the public investment would both incentivize retailers to offer electric service as well as protect their business. This investment would be in the form of a subsidy that covers the retailers' costs above what they charge the customer, including maintaining a 3% profit margin for the retailer.

Because costs are, as we will see, largely dependent on an economy of scale in regard to end customer demand, this subsidy will be different for each station and for a single station in different years. At the end of a given period, say monthly, the retailer would report their revenue and expenses to the government agency supervising the public side of the partnership. The retailer would be reimbursed so that their costs and 3% profit margin are covered.

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6 Office of Management and Budget. "The President's Budget: Fiscal Year 2015." (2015): 2. Web. 7 Feb. 2015. <http://www.whitehouse.gov/sites/default/files/omb/budget/fy2015/assets/fact_sheets/building-a-clean-energy-economy-improving-energy-security-and-taking-action-on-climate-change.pdf>.

7 "What Is U.S. Electricity Generation by Energy Source?" U.S. Energy Information Administration, n.d. Web. 03 Feb. 2015. <http://www.eia.gov/tools/faqs/faq.cfm?id=427&t=3>.

8 Johnson, Jeff. "Long History Of U.S. Energy Subsidies." CEN RSS. Chemical and Engineering News, n.d. Web. 05 Feb. 2015. <http://cen.acs.org/articles/89/i51/Long-History-US-Energy-Subsidies.html>.

Importantly, because of the scope of the project, costs incurred by each station will be well-know. Subsidies will be distributed by the costs that a well-managed station could be expected to incur. In this way, poor-performing stations will not have any additional cost covered. The public's role is to insure well-run retailers that electricity as a fuel is as profitable as gasoline.

We also see public investment incentivizing consumers to move to an electric vehicle sooner than they would have otherwise, as justified by the age of their current vehicle. We envision this program to be similar to the 2009 "Cash for Clunkers" federal stimulus, in which consumers were given refund vouchers between $3,500 and $4,500 for trading in their vehicles with 18 mpg or less.[9] Such a program will enable the battery swap model to achieve volume faster than it would be able to do otherwise.

What policy challenges exist for electric fuel? We think two challenges are of the most concern. The first is competition from other clean energy sources, such as hydrogen fuel cells. These technologies have supporters and investors, and are similarly making a case to government that their concepts and models should receive the clean energy subsidies. The second challenge is competition from traditional plug-in electric vehicles. Because swap vehicles offer the option to extend the range, we suggest that swapping will be more demanded and therefore should receive more consideration from the government.

Economics

Our financial analysis focuses on the downstream end of the supply chain, retail convenience stores. We do this because it is the most difficult link in the chain to argue the economic feasibility of our model, and because of its proximity to the end user.

We begin with the consumer, and our first question is this: How much would a consumer be willing to spend to swap a battery? To answer this question, we consider the "economically rational consumer." This is the person who makes their decisions from a total cost perspective, and is indifferent towards the fuel that powers their vehicle. The rational consumer will make the decision for which they are burdened with the least cost. We have worked through the cost to the consumer to own and operate a gasoline vehicle. We will use this cost, as well as costs uncontrollable by the retailer, to determine the price that the rational consumer is willing to pay for a battery swap.

The first cost to this consumer will be the vehicle itself. We compare the cost of the Nissan Leaf to the cost of the Nissan Altima. Importantly, we remove the cost of the battery from the cost of the electric vehicle to make this calculation. If we assume that a battery costs $14,000, then the Leaf without a battery would cost (approximately) $7,000 less than the Altima[10]. If we assume that a standard electric vehicle can travel 100 miles per charge and that the consumer will swap the battery with 20% life remaining, and that the average lifespan of a vehicle is 150,000 miles, then the consumer will make 1,875 swaps over the lifetime of their vehicle ownership.

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9 "Cash for Clunkers Ending." CNNMoney. Cable News Network, 21 Aug. 2009. Web. 13 Feb. 2015. <http://money.cnn.com/2009/08/20/autos/cash_for_clunkers_end/?postversion=2009082018>.

10 "Nissan USA." Nissan USA. N.p., n.d. Web. 07 Feb. 2015. <http://www.nissanusa.com/>.

Considering the lower price of the electric vehicle, the consumer is willing to pay $3.73 more per battery swap than they would pay for a similar gasoline fill-up. (A similar fill-up is one which would provide the consumer 80 miles worth of gasoline.) If we assume the consumer's gasoline alternative has a 30 mpg rating, and that gasoline sells for $2.50 per gallon, we can determine that the rational consumer is willing to spend $10.23 to swap their electric car battery.

In this figure of $10.23 per swap, we have a first cost target. If this cost target can be achieved, and the cost equivalence of electricity as a fuel as compared to gasoline communicated, then the consumer will evaluate the two fuels on other considerations. We consider these other considerations and our market share estimates in the *marketing* portion of this paper.

Now that we have a target cost at the retail level, we estimate the *actual current cost* for a retailer to swap. An important consideration to keep in mind: As with all capital equipment, as the number of customers increases, the fixed costs are distributed over a wider body, meaning that each customer pays a lower price to cover their share of the fixed costs.

What is the cost to the retail station to offer battery swap service? We think in annual values here. If we assume that a charging station costs $500,000[11], its lifespan is 15 years, and the cost of capital to the retail store is 8%, then a swapping station costs $58,500 annually. We assume that a battery costs a station $14,400, and that its lifespan is 100,000 miles[12]. We further assume the cost to operate the equipment to be 10%, and conservatively estimate the cost of electricity to be $.15/kwh[13].

We will charge the customer $10.23 for a battery swap, so that price is removed from consideration when they determine whether or not to move forward with an electric vehicle. The cost we incur depends on (1) the market share of electric vehicles for the particular station, and (2) the percent of the battery "fill-ups" that are swaps as opposed to recharges. We assume here that, after four years of growth, we achieve a market share of 20% with a battery swap rate of 20% (consumers charge at home 80% of the time and swap at a station 20% of the time).

The key of our analysis is that the cost to the retail station will be, for the near future, greater than the price that we can charge the customer.

In the chart on page 9, we describe a forecasted market share growth, with a constant 80% rate of charge-at-home. We see that, for a single station, the required annual subsidy per consumer drops by 53% by year four. This is a direct result of scale economies derived from market share.

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11 "Better Place Unveils Battery Swap Station." *The New York Times*. N.p., 13 May 2009. Web. 07 Feb. 2015. <http://green.blogs.nytimes.com//2009/05/13/better-place-unveils-battery-swap-station/?_r=0>.

12 "How Long Will An Electric Car's Battery Last?" HybridCars.com. HybridCars, 30 Apr. 2014. Web. 13 Feb. 2015. <http:/www.hybridcars.com/how-long-will-an-evs-battery-last/>.

13 "Independent Statistics and Analysis." EIA. U.S. Energy Information Administration, 27 Jan. 2015. Web. 13 Feb. 2015. <http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a>.

Year	Demand	Consumers	Swaps	Cost to Swap	Required Subsidy/Swap	Total Subsidy/Station	Subsidy/Customer Served
1	5%	102	4,745	$29.97	$19.57	$92,860	$910.39
2	10%	203	9,490	$22.99	$12.59	$119,470	$588.57
3	15%	304	14,235	$20.67	$10.27	$146,193	$480.90
4	20%	405	18,980	$19.51	$9.11	$172,908	$426.93

In this chart we see the total public investment, per station, by year. This does not include the investment in the car-rebate program. We consider the economics of such a program inherently difficult to estimate and outside the scope of this brief introduction to our model.

If we estimate the population of the U.S to be 315 million, and use NACS data that there are 126,658 gasoline retailers in the U.S., we can estimate the population served by a single facility to be roughly 2,500 individuals. We understand that this figure would vary drastically by location, but for our purposes we analyze on the average.

A city the size of Madison, Wisconsin (population roughly 250,000), can be estimated to hold 100 fuel retailers. Therefore, to subsidize Madison after market share has reached 20%, the public investment would be required to be roughly $17 million annually. For the government to roll this project out into five cities the size of Madison, the investment would be $85 million annually. To support the project in five cities for 15 years, the length of time research has shown for industries to get off of the ground, the total public investment would be $1.275 billion. In comparison, the government invested $535 million in the much-debated Solyndra project[14].

To compare in another way, we recall that the White House budget proposes $6.9 billion annually in clean energy investment. Over 15 years, this would be $103.5 billion. So, 1.25 million Americans, spread across five mid-size cities, could have access to and build the industry for electric vehicles, at a cost of 1.2% of federal clean energy spending.

Infrastructure

The total miles driven by Americans is expected to increase by 40% in the next 20 years, according to the National Academy of Sciences. When we consider as well that our model would begin in just five cities, we understand that petroleum will continue to command the majority of the market. Therefore, retail stores with petroleum will not become diminished in the upcoming decades. Because electric vehicles are on the rise, we believe the optimal solution is to integrate battery swap stations in current retail stores. We imagine a similar infrastructure as what was designed from Better Place.

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[14] Stephens, Joe, and Carol Leonnig. "Solyndra Scandal." *Washington Post*. *The Washington Post*, 24 Jan. 2012. Web. 13 Feb. 2015. <http://www.washingtonpost.com/politics/specialreports/solyndra-scandal/>.

A Better Place swapping station in Israel.

Better Place's swapping stations consisted of infrastructure similar to that of a car wash, as well as a similar size. The vehicle will drive up to a gate at the swap station, where the customer will be able to swipe their credit card to enter their information into the system. A scanner at the gate will read the car's RFID in the windshield to identify the make and model of the vehicle and battery. The gate will open, and the car will be guided to an area where automated robotics will remove the battery from the bottom of the vehicle, retrieve a fully-charged battery from inventory (based on the type of battery defined by the make and model identified at the gate), replace it, and store the un-charged battery back into inventory. This current technology exists, and successfully was used by Better Place, as well as currently used by Tesla.

In regards to inventory, batteries will be stored adjacent to the swapping bay. Each battery would be automatically hooked up to a charging port via robotics. It was noted by Shai Agassi, the CEO of Better Place, that their stations with only 15 batteries had the ability to swap batteries for 2500 electric vehicles.

It is quoted by both Tesla (who has been making swapping stations of their own) as well as Better Place, that the approximate cost of materials and technology per station is $500,000. This is equivalent to about half the cost of a typical petroleum fueling station. For the swapping stations, they would be able to support multiple battery types of many types of electric vehicles as long as it could be removed from underneath the vehicle.

Marketing

We suggest that the increased number of "refuels" (whether a home charge or a battery swap) in the electric model will keep a segment of the driving population with gasoline. We also suggest that the significant population that drives SUVs, pickup trucks, and similar vehicles will stay with gasoline. Specifically, we find that of the 234 million vehicles on the road in the United States that the U.S. Bureau of Transportation Statistics has traditionally considered passenger cars, 22% are of the long wheelbase classification, meaning for us that they will continue to use gasoline.[15,16]

So, our question becomes, of the 78% of the passenger vehicles that could conceivably use electricity as a fuel, for how many do the benefits outweigh the requirement to refuel more often? That is, for how many drivers will the environmental cleanliness potential of electric vehicles outweigh their additional inconvenience? We assert that, in select markets, we can achieve 20% total market share of passenger vehicles, or 26% of the short wheelbase market.

In this section, we focus our efforts on how our model could be marketed to end users – American motorists. We understand that every link in the supply chain must be "marketed to" in a sense to accept the model, but we consider the arguments we make throughout the paper to be such internal marketing.

In an article in *The Fiscal Times*[17], an electric car lessee describes why he terminated his lease early: "The car was 'nearly useless in the winter,' lasting as little as 43 miles on a charge instead of the promised 73 miles...[and the owner] was forced to use a 120 volt charger provided with the car, which could take 20 hours [to charge the battery]." This from an individual with a 12 mile daily round-trip commute, the seemingly ideal candidate to drive an electric vehicle.

The dissatisfaction described above is representative of the negative rhetoric surrounding electric vehicles: (1) the vehicles' range is too short, and (2) the time to recharge the battery is too long. With the battery swap model, we address these issues. Though the range of the vehicle cannot be improved without improvements in battery technology, we believe that our model will reduce range anxiety in drivers. Considering that the average American drives less than 33 miles per day[18], we suggest that reducing driver anxiety could significantly drive demand.

Supply Chain

The value chain of the new model will involve many entities (many which were described in the 'Stakeholders' section of this study). A schematic of the supply chain is given at the end of this paper. The chain begins as raw material providers supply resources to the battery manufacturers. The battery manufacturers would manufacture the electric vehicle batteries, which will be able to be used in every make and model of vehicle and at every retail location through a system of industry standards.

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[15] "Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances | Bureau of Transportation Statistics." Table 1-11: *Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances* | Bureau of Transportation Statistics. U.S. DOT. Web. 13 Feb. 2015. <http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html>

[16] "State Statistics." RAND USA. Rand Corporation. Web. 13 Feb. 2015. <http://www.randstatestats.org/stats/transportation/us_vehicles.php>.

[17] Halpert, Julie. "Why Americans Still Don't Drive Electric Cars." *The Fiscal Times*. *The Fiscal Times*, 22 Jan. 2013. Web. 9 Feb. 2015. <http://www.thefiscaltimes.com/Articles/2013/01/22/Why-Americans-Still-Dont-Drive-Electric-Cars>.

The key to a successful network of battery swapping stations is the freedom of the customer to swap their battery at most retail locations. For this cross-company movement to be achieved, two core issue must be addressed. First, how will batteries be bought, maintained, and disposed of when they will pass between multiple companies? Second, how will payment flow from the customer and to the retailers? We envisage a retailers' cooperative being established and being charged with the following responsibilities:

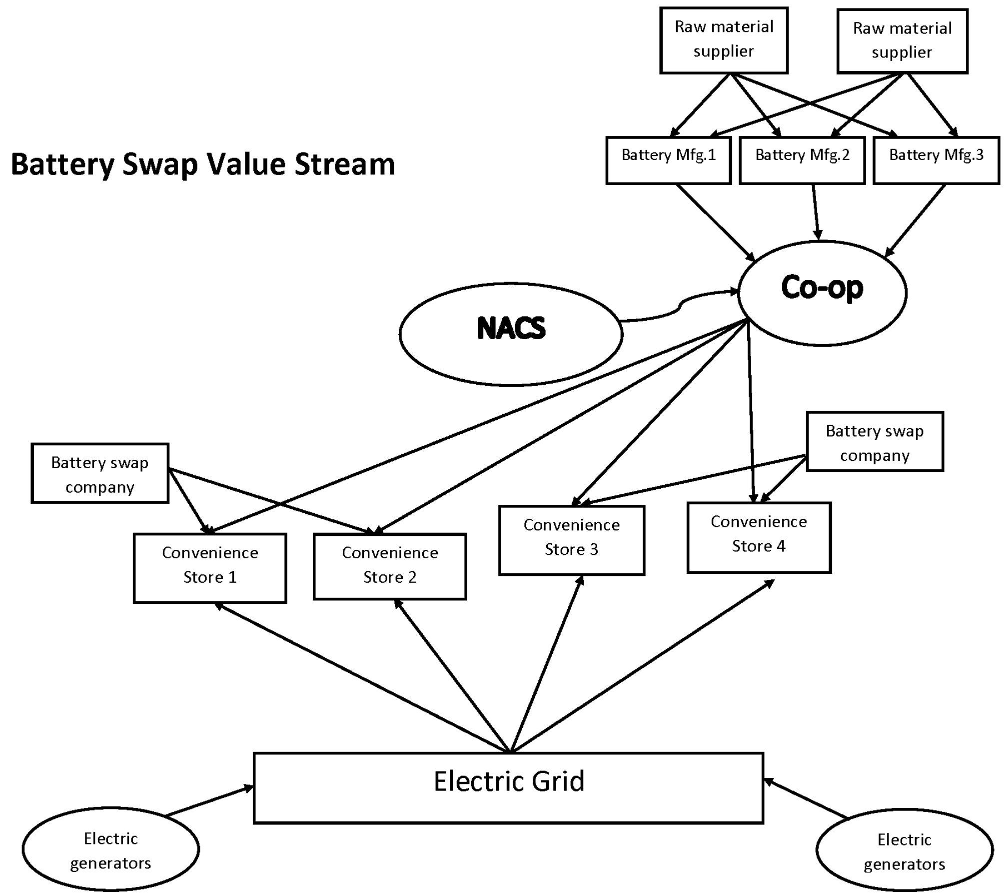
1. To facilitate the development of industry standards on behalf of retail locations, giving retailers one voice as they work with battery manufacturers, swapping station manufacturers, and OEMs
2. To purchase all electric vehicle batteries in the value chain from the battery manufacturers
3. To distribute new batteries to retail locations as batteries at their locations fail
4. To control maintenance of damaged batteries and reintroduce them into the value chain
5. To store information about each battery swap
    a. the customer that was involved
    b. the station from which the old battery was received
    c. the use from the old battery (e.g. the percentage points of charge applied to the battery for the duration of time the customer had the battery)
    d. the station from which station the new battery was received
6. The collection of payment from the customer for the old battery
7. The distribution of that payment to the retail store from which the battery had been taken
8. The collection of funds from the retailers to purchase new batteries, done on a period basis (e.g. monthly), and from each retailer by the proportion of total swap-outs for which they were responsible

Because, in our model, customers will have the option to either swap out the battery or charge it at home, the batteries themselves will be developed with the capability to record how often they are charged, and how much charge they receive. We offer the following examples to highlight the function of the cooperative in our supply chain:

1. A customer swaps out a low battery for a fresh battery at retailer *B*. They have never charged at home. The battery was picked up from a different retailer's station, *A*. The customer is charged $10.23, which they pay directly to the cooperative. The cooperative funnels this payment back to station *A*.
2. The customer above runs their new battery low on charge, say from 100% to 20%, then charge the battery at home, back to 100%. They do this for 5 consecutive days, and then swap out the battery (at, say, 30% charge) at station *C*. The battery records 5 "charge-at-home" instances, and the total percentage points of recharge (400 percentage points). From a calculation described in our spreadsheet appendix file, we have determined that a customer should be charged $0.148 per percentage point of charge.

Therefore, the customer will be charged 400*$0.148 = $59.20 for the battery while at their home, and $10.23 for the new swap. This total of $69.43 will be collected by the cooperative and funneled back to station *B*. When the cooperative collects payments from the retailers to pay for the period's new battery purchases, the total percentage points of battery life used by this customer at home (400) plus the 1 swap from station *B*, will be added to station *B*'s total (along with their other customer's transactions for the period). Retail station *B*'s total battery usage for the period will be divided by the grand total of all battery usage in the system to determine the cost to retail station *B* for the period's new battery purchases. We move on to describe the supply chain through the functions below:

- *Inventory Management:* The swapping stations will each maintain 15 batteries. Because key specifications (e.g. the fit of a battery in a vehicle, how the vehicle draws power from the battery) will be standard, every brand of battery will be compatible with every make and model of vehicle.
- *Distribution Management*: Batteries will be distributed by battery manufacturers directly to convenience stores. Optimization software could be used to determine most efficient and low cost routing patterns. The cooperative set up will calculate demand from each retail store, and route that information to the battery manufacturers to plan production and transportation.
- *Payment Management*: As described in the 'Infrastructure' section of this case, customers who arrive at a swap station will scan a credit/debit card to rent out their battery. One of the key points in our model is that batteries will not be owned by the consumer. Payment for batteries will be based on three different costs-the battery depreciation, the electricity used, as well as the service for receiving a fully-charged battery.
- *Financial Management*: One of the key objectives strived for in this model, is for customers to have the freedom to rent batteries from any retail store and return it at any retail store. To make this feasible, all retail stores would need to share an information system with customer payment information. This would prove to be a key asset of the cooperative. The cooperative would set up a single IT infrastructure utilized by all retail stores. For example, when a customer swaps a battery from station *A*, their credit card information and battery serial number would be stored in the IT system. If this customer swaps that battery at station *B*, the shared IT system would recognize the serial number of the battery that is returned, and charge the customer accordingly. Without a shared IT system, customers would have to return batteries from the same retail store company they rented from, which would reduce flexibility and render the model infeasible. The cooperative system in place would be essential in allowing this flexibility.



Strategy Outline and Conclusion

To conclude, we envisage electricity as a fuel complementing gasoline through a partnership with the federal government. We suggest that the most likely model for which electricity to succeed, given current technology, is a battery swap model. This model rectifies common driver issues with electric vehicles: their limited range and the time required to recharge the battery. Moreover, customer demand will reach levels unknown by electric vehicles with the option to swap or to charge at home.

A cooperative of retailers will facilitate the collection and dispersal of payments from customers and to the retailers, thereby eliminating the necessity for a driver to only swap at a particular company's stations.

We believe in this model. We believe, and we have argued with evidence that supports our position, that the fuels value chain is in a unique position to shape the future. By developing a battery swapping model now, and implementing it in a handful of American cities, the value chain is able to learn about and improve electricity as a fuel before a radical shift in government regulation, oil prices, or technology forces the chain to respond in a hurried and costly way.

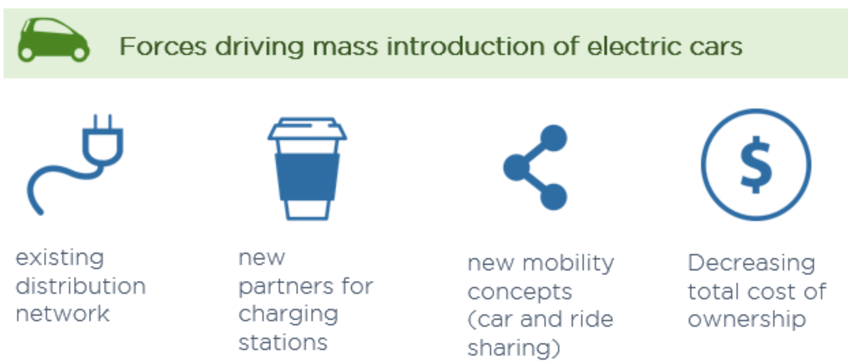
Integrating Electric Vehicles in the Future Transportation Value Chain

By Nathan Brower, Caio Dimov and Daniel Metzel
Northwestern University

Introduction

Our industry plan proposes that battery electric vehicles (EVs) will emerge as the winning technology among the myriad of alternative vehicle fuel options. Our solution leverages integration between automotive manufacturers (OEMs) and suppliers, energy providers, infrastructure builders, retailers and mobility solutions companies to overcome the chicken-and-egg problem. This integration will result in a clean, efficient and sustainable personal transportation system in the United States and around the world.

Our model was informed by research from universities, national agencies, and specialized consulting companies. We also considered existing cases from different American states and other countries as well as historical changes in other technological sectors. Our focus is primarily the U.S. market, but we see potential for global scale, and the transition to this new model might also be seen first in some European markets. Four primary factors will drive EV adoption under our plan:



- **The production and distribution infrastructure for electricity already exists**: An essential part of the EV value proposition is that they can take advantage of the existing electricity infrastructure and low electricity prices (relative to gas) for "refueling." What remains is a "last mile" to reach the car.
- **Untapped natural partnerships to build charging network:** In addition to charging at home, there is a tremendous opportunity to incorporate a host of new stakeholders to increase vehicle sales and build out charging stations. Our plan utilizes collaborative partnerships to accelerate both EV purchases and the building out of charging networks.
- **New car ownership models:** Accompanying the rise of car sharing and on-demand ride services is a decreased desire among young consumers to own cars. One consequence of these business models is increased vehicle utilization, which maximizes the economic benefits of EVs for the owners of these shared vehicles.
- **Lower Total Cost of Ownership (TCO):** Currently, EVs are perceived as being more expensive than internal combustion engine (ICE) vehicles due to the higher sticker price. However, the total cost of ownership, which includes maintenance and fuel, is already competitive and will move increasingly in EVs' favor as battery prices drop and automotive manufacturers progress down the cost curve.

This paper describes our industry plan in the following sections: forecast, stakeholders, societal goals, policy, economics, infrastructure, marketing, supply chain and strategy.

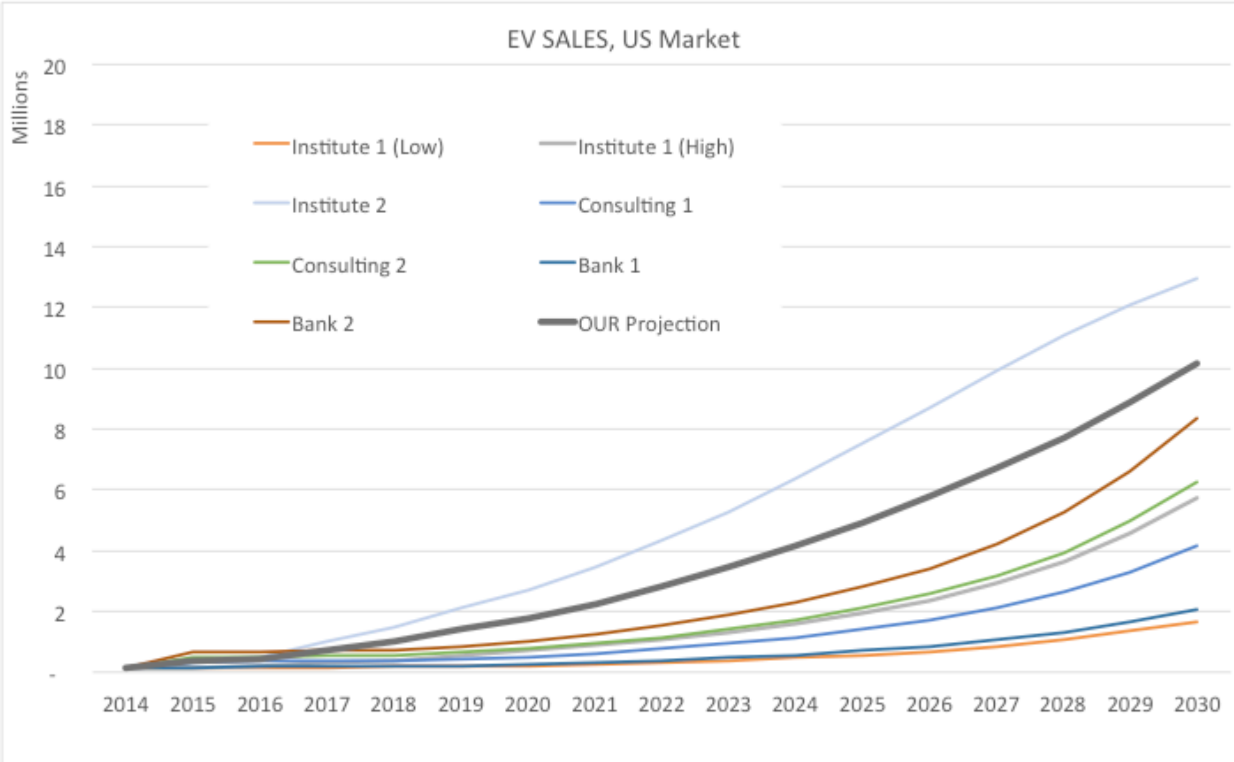
Forecast

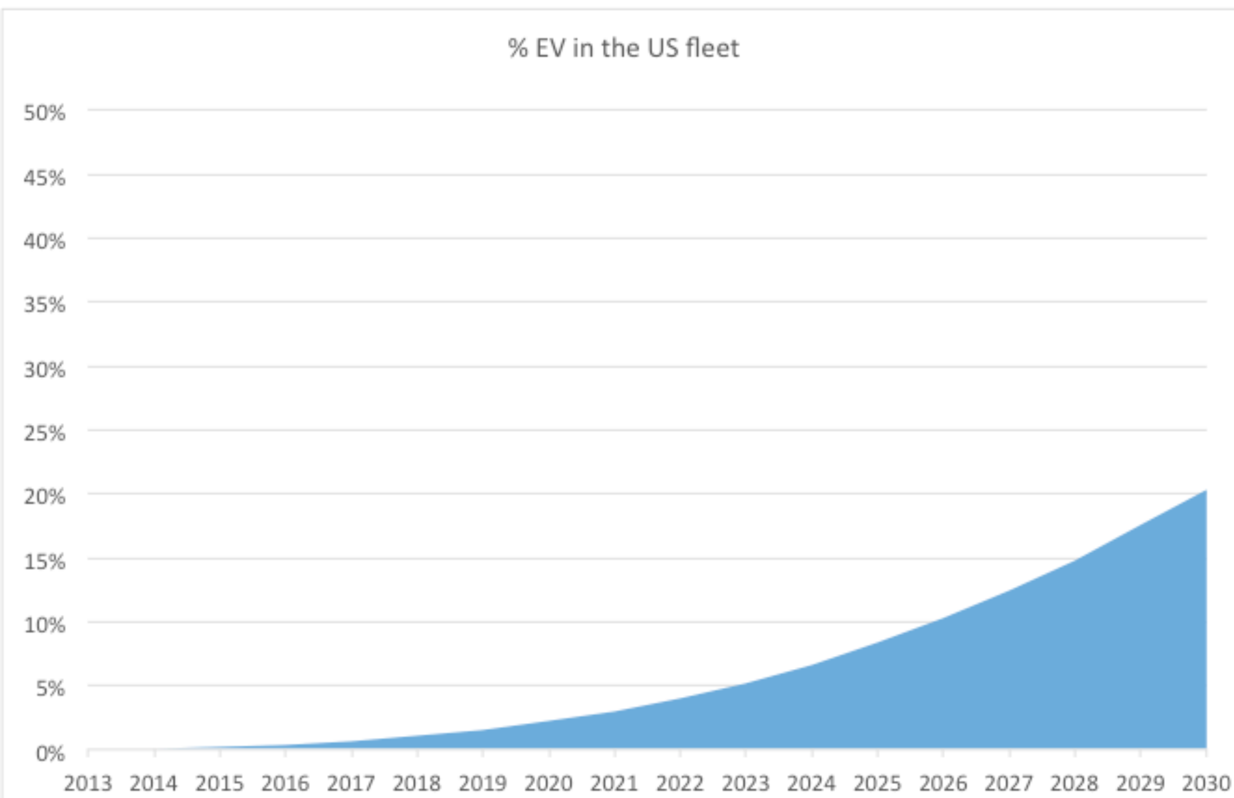
Our EV forecast includes fully battery electric vehicles as well as plug–in hybrid electric vehicles (PHEV). We expect the fully battery electric vehicles to ultimately dominate but PHEVs will play a significant role during the transition away from gasoline–powered cars. We began with a weighted average of projections from specialized institutes, consulting companies and investment banks, and then adjusted based on how our industry plan differs from the assumptions behind the forecasts of those reference groups.

In the case of institutes, we used the Electric Vehicle Transportation Center projections from January 2014 to incur growth in electric vehicles. This study considers several scenarios for plug–in electric vehicle growth, and we selected the lowest and highest scenarios to include in our projection. According to the study, the key factors considered in the construction of this analysis are vehicle cost, mileage between charging, maintenance cost, battery life, availability of charging stations, charging time, infrastructure, standards and public knowledge and education. We also considered a study from the University of California, Berkeley that forecasts EVs through 2030 and is higher due to assumptions of rapid recharge time, lower sticker price and total cost of ownership, which we consider feasible for the near future.

We also incorporated work from different consulting and banking companies regarding development of the entire automotive market. For instance, we considered a report from JD Power which forecasts US fleet growth of 1.0% per year, reaching about 270 million vehicles in 2020, and reports from Morgan Stanley and IHS Automotive that forecast strong sales growth to 18 million vehicles in 2018 before slowing down. To filter EVs from these market numbers, we considered four studies from PWC, and Navigant, Goldman Sachs, and Morgan Stanley. In general, these reports forecast penetration of EVs ranging from 1% to 4% of sales, also varying the value according to premises on vehicle cost, customer acceptance, and technical feasibility.

With this set of data and different observations from historical data and existing projections, we forecasted the future sales volume of EVs and their share of the total fleet. The outcome of our plan is depicted in the charts below. The first chart shows our predicted annual EV sales in the context of other existing forecasts, some of which have been extrapolated, from specialized institutes, consulting companies and investment banks. We forecast that EV sales will first break 10% of sales after 2020 and are expected to surpass 50% in 2030. The second chart shows EVs' share of the total fleet, which is based upon EV sales as well as the gradual retirement of ICEs. We predict that EVs will account for more than 20% of the total fleet by 2030.

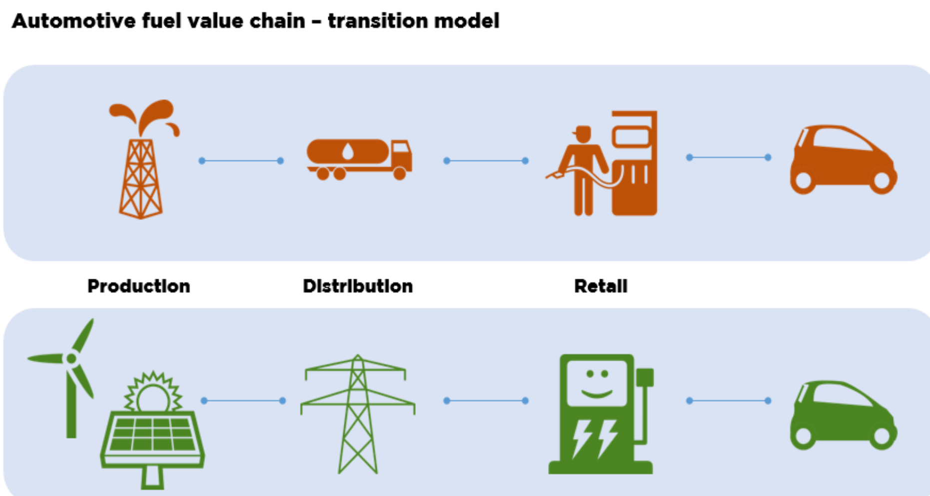

EV SALES, US Market
Millions
20
18
16
14
12
10
8
6
4
2
-
Institute 1 (Low)
Institute 1 (High)
Institute 2
Consulting 1
Consulting 2
Bank 1
Bank 2
OUR Projection
2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030


% EV in the US fleet
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
2013 2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030

Stakeholders

The stakeholders in the current fuel and vehicle market are clearly defined and can be broadly divided into three groups. First, there is the number of stakeholders that span the gasoline and diesel fuel value chain. This includes upstream exploration and production companies, oil services firms, refiners, and wholesale distributors of both crude and refined oil products. It also includes the fuel retailers that directly deliver fuel to vehicles. Second, there is the entire vehicle production value chain, which includes auto parts suppliers, auto OEMs, car dealers, and aftermarket service providers. Finally, there are stakeholders that do not participate directly in the fuel or vehicle value chain but are critically important. Chief among these is the consumer, but this group also includes the government, insurance companies, and companies involved in building road infrastructure.

An electric vehicle future will clearly impact all of the current stakeholders, but will also need to incorporate several additional ones. Stakeholders in the electricity value chain will play a major role, including electricity generators, distributors, and utilities. It is natural that these players tend to make alliances/compete with oil companies in the battle for customer preference in refueling or recharging their vehicles. Battery and battery materials companies will be a critical part of the vehicle production value chain. Interestingly, with the advent of small–footprint charging stations, the world of "fuel" retailers will most likely expand to include shopping malls, offices, municipalities, apartment complexes, and consumers themselves. The graphic below illustrates the evolution of stakeholders at each stage of the automotive fuel value chain:



Finally, parallel to the developments in fuel technology, the evolving model of car ownership will also impact the stakeholder mix. Car rental, vehicle for hire (e.g., traditional taxis, Uber, Lyft) and car-sharing companies are already an important set of stakeholders, but their importance will continue to expand. The importance of mobile communications to these business models suggests that device manufacturers and telecom providers will have an indirect impact on the vehicle market of the future, as well. The advent of self-driving cars will only speed the transition to shared vehicle ownership models, as it will no longer be necessary to have a third-party driver to make a vehicle available to multiple users. The table below shows how this disruptive behavior happened in the past in other industries and is now taking place in the automotive industry.

WE'VE SEEN IT BEFORE... AND IT'S HAPPENING AGAIN

	PC manufacturing	B&M retailing	Cell phone manufacturing	Automotive
Technology change (product/process)	> MS-DOS > Reverse eng. of BIOS	> E-Commerce	> Smartphone	> Connected vehicle > Automated driving
Entry of new, disruptive players	> Acer > Dell	> Amazon	> Apple > Samsung	> Google, Uber, etc. > Tesla
Large incumbents with baggage	> Hewlett-Packard > IBM	> K-mart > Borders	> Nokia > Motorola	> Multiple OEMs, suppliers and dealers
New customer needs	> Integrated service/ usage support	> Integrated reviews > Ease of shopping > Larger availability	> Integrated digital platform	> Digital consumer

(Source: Roland Berger Strategy Consultants)

Societal Goals

The most obvious positive societal impact of our proposed model is its effect on the environment and human health. Gasoline- and diesel-powered vehicles emit a wide range of air pollutants, including particulate matter, nitrogen oxides, carbon monoxide, and toxins that can damage human respiratory systems and cause cancer. The burning of fossil fuels also creates carbon dioxide and other greenhouse gases that contribute to global climate change. Cars and trucks are estimated to account for more than one-fifth of greenhouse gas emissions in the United States.[1]

By contrast, EVs have zero direct emissions, which means none of these toxins are emitted into the local environment. Pollutants are generated during electricity production from coal, oil, and natural gas, but research has shown that with the current generation mix in the United States, EVs still result in much lower emissions after this has been taken into account. By shifting emissions from vehicles to concentrated point sources of pollution (power plants), the adoption of EVs will also simplify future emissions control efforts and regulations. As the adoption of renewable sources of electricity (solar, wind, hydro, geothermal) increases, the associated emissions with charging an EV will be lower still.

There are other environmental benefits associated with a move away from fossil fuels. The production and refining process for gasoline and diesel emits significant amounts of air pollutants and greenhouse gases. Oil extraction techniques, especially hydraulic fracturing (fracking), use and contaminate large quantities of water, and some are concerned about potential groundwater pollution. As demonstrated by the Deepwater Horizon oil spill, extraction of petroleum comes with the risk of large oil spills that can impact the environment and marine ecosystems in profound ways, along with the routine water pollution from offshore oil and tanker operations.

The socioeconomic benefits of our proposed model stem, in part, from the switch to electric vehicles. Electric vehicles are already much cheaper to refuel than gasoline/diesel vehicles due to the low relative cost of electricity. While the cost of batteries currently makes electric vehicles more expensive to produce, we expect that within 10 years they will reach production cost parity with gasoline-powered vehicles. When coupled with reduced maintenance costs due to the relative simplicity of electric powertrains, the total cost of ownership for electric vehicles will be lower than gasoline- and diesel-powered alternatives by 2017 or sooner. A lower cost of ownership will improve access to transportation for poorer individuals currently at the margin of car affordability. See the Economics section for a detailed discussion of total cost of ownership.

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[1] http://www.ucsusa.org/clean_vehicles/why-clean-cars/air-pollution-and-health/cars-trucks-air-pollution.html

Separate from the switch to electric vehicles, there are socioeconomic benefits that will result from the reduction in individual car ownership and increase in car sharing that we project. Increased access to shared vehicle fleets will eliminate the large upfront capital expenditure needed to purchase a car and the recurring expense of maintaining and insuring it, and instead allow individuals to purchase access to a vehicle only when and where they need it. Car sharing will allow car owners to offset some of the costs of ownership. Together, these factors will increase access to transportation for those least able to afford it. More broadly, the higher utilization of vehicle assets through car sharing and vehicle for hire services will reduce the need for parking, especially in dense urban cores and free up real estate for more productive uses.

Lastly, there are opportunities to create new jobs with the development of battery, semiconductor and recharging industries. These would be partially offset by job losses in other sectors such as gas stations, mechanics (as cars will be simpler to maintain), and auto parts, but most estimates project that that the net employment impact will be positive.

	Industry	Baseline Scenario	High Price Scenario	Operator-Subsidized Scenario
Employment Gains	Charging Infrastructure	178,163	411,579	472,778
	Battery Manufacturing	60,065	80,630	81,168
	Total Gains	238,229	492,209	553,946
Employment Losses	Gas Station Attendants	-23,152	-37,353	-42,906
	Parts Manufacturers	-39,287	-63,386	-72,809
	Mechanics	-46,605	-75,192	-86,370
	Total Losses	-109,043	-175,931	-202,085
Net Employment Impact		129,185	316,278	351,861

(Source: UC Berkeley, *Forbes*)

Policy Opportunities and Challenges

Arguably the most visible current regulatory driver for electric vehicle adoption is the $7500 federal tax credit that comes with purchasing a new EV. On top of this, further state incentives are available. For example, up to $13,600 in tax credits are available in Louisiana for a new EV purchase. Other states offer credits to defray the cost of installing a residential charging station. Consumers can also benefit from reduced electricity rates for EV charging and access to HOV lanes on the highway. Some states have also set targets for EV charging station installations.[2]

Federal regulations have also been put in place to incentivize auto manufacturers to develop and produceEVs. The EPA has set a fleet average fuel efficiency requirement (CAFE standards) of 54.5 miles per gallon by 2025 that will require costly improvements to the internal combustion engine vehicle. Under this framework, EVs are given an equivalent fuel economy score of approximately 100 mpg and are therefore a means by which automotive manufacturers can reach their efficiency targets. Furthermore, California has passed a zero emissions vehicle mandate that requires a certain level of EV production and other states have agreed to adopt similar initiatives.[3]

Utility companies are also subject to regulations that are conducive to the development of charging stations and EV adoption. Increasingly, utilities are required to make certain levels of investment in both grid energy storage and demand response. As the adoption of intermittent renewable energy sources such as solar and wind increase, these grid management initiatives will become more important. EVs could help utilities by feeding

[2] http://theenergycollective.com/nrdcswitchboard/391311/state-action-plan-helps-power-electric-vehicle-market
[3] http://www.bloomberg.com/news/articles/2013-10-24/california-zero-emission-push-grows-to-8-states-3-million-autos

energy back into the grid when demand is highest. Utilities may find that building out EV charging stations and encouraging EV adoption may be less costly than some of the other options for meeting their mandates.

One political issue that works against EV adoption is subsidies for oil and biofuel. These artificially lower gasoline prices and encourage production of other alternative fuels. Fuel cost savings are one of EVs' primary benefits, and if prices of alternative fuels are low, then consumers may be less eager to invest in an EV. There is also the risk that energy and emissions mandates are made less favorable for EVs in the future due to political changes.

There are several policies and regulatory initiatives currently being discussed that would help increase EV adoption, most notably a carbon tax and higher gasoline taxes. The latter may be inevitable because gas taxes are used to fund road construction, which is often underfunded. A higher gas tax will raise fuel prices and increase the savings from owning an EV. Although politics at the federal level may prevent an increase in the gas tax, many states are moving forward with their own gas tax increases. Similarly, a tax on carbon will increase fossil fuel prices much more than electricity prices, improving the relative cost profile of electric vehicles.

Economics

To date, investments in EV vehicles have been driven by consumer demand, tax incentives, and fuel economy standards. Federal tax credits of up to $7500 per vehicle have helped defray the upfront investment cost of EVs and in some areas, additional state tax credits have also helped. However, the federal tax credit is currently set to expire after each vehicle manufacturer sells 200,000 EVs, so they will not be around past the next few years.

Going forward, a lower total cost of ownership (TCO) will be sufficient to drive consumer demand and investment in EVs. As shown in the graph below, hybrid and plug-in hybrid vehicles already demonstrate a lower TCO than traditional gasoline-powered vehicles. Battery electric vehicles (BEVs) are expected to surpass traditional vehicles by 2017 and be the lowest TCO option from 2020 onwards. The 5-year TCO is already equivalent depending on exact makes and models considered. [4] The TCO curves from 2012 shown below are based on a conservative assumption of $300/kWh for battery packs by 2020, a major driver of EV cost. However, battery prices have dropped faster than expected the past several years. The latest projections from McKinsey put 2020 battery costs at under $200/kWh, the US Department of Energy has set a target of $150/kWh, and Tesla is projected to beat both measures. Therefore, the 2020 TCO for EVs should be lower than originally projected. The lower TCO for EVs will be a critical driver of the goal of increasing access to transportation, discussed in greater detail in the Societal Goals section.

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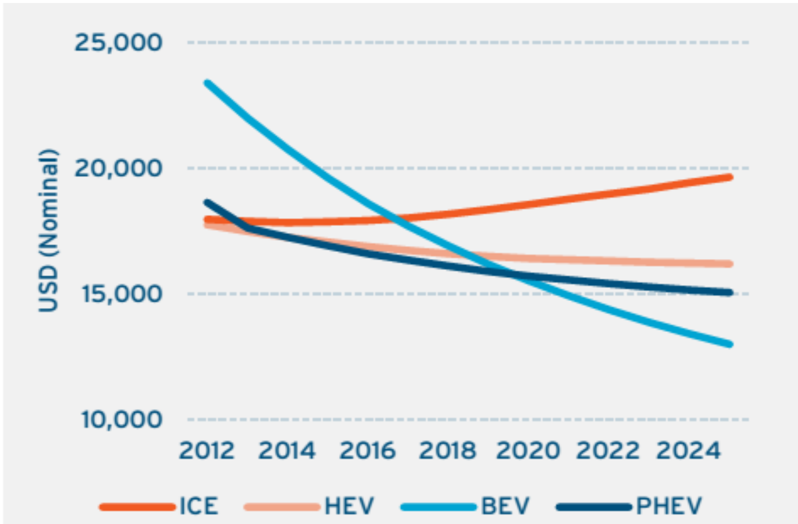
[4] http://www.edmunds.com/tco.html

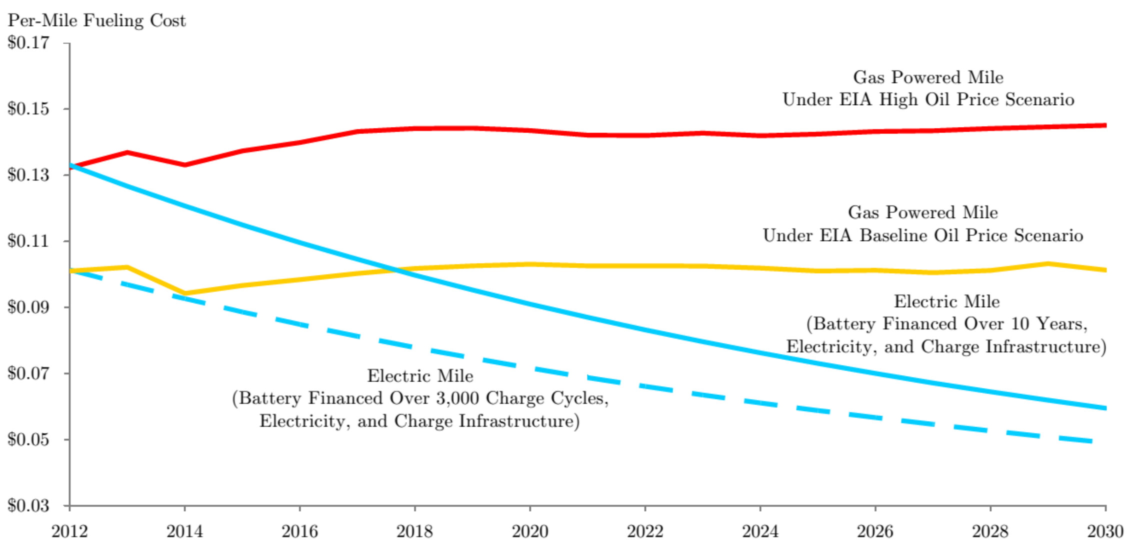
Exhibit: Total cost of ownership of internal combustion engine vehicles (ICE), hybrid electric vehicles (HEV), battery electric vehicles (BEV), and plug-in hybrid electric vehicles (PHEV) over time



(Source: Electrification Coalition)

The lower total cost of ownership of electric vehicles is driven in large part by lower fueling costs (electricity is much cheaper than gas), as shown in the exhibit below.

Exhibit: Battery + charging cost relative to gasoline fueling cost



(Sources: UC Berkeley, EIA)

At current list prices, it may take several years for a typical consumer to get paid back by the lower TCO. However, the trends in car ownership described previously will shorten the payback period of EVs due to higher utilization; the heavier the mileage, the faster fuel and maintenance savings are realized. The TCO economics are therefore even more favorable for owners of shared vehicles, which should increase EV demand.

From the perspective of automotive OEMs, the increase in consumer demand for EVs combined with ever more stringent fleet emission standards will ensure a positive business case for continued investment in EV technology, as efficiency improvements to gasoline-powered cars can be costly. As EVs begin to dominate vehicle sales, the OEM profit model will remain largely unchanged, although there will be some disruption among suppliers of parts for traditional vehicles (see detailed analysis in the Supply Chain section).

Investment in charging infrastructure will come from a mix of home and public charging stations. Home charging stations will for the most part be paid for by consumers and are factored into lower total cost of ownership. Public charging stations will be paid for through a combination of investment by utilities, automotive OEMs, profit–driven charging networks, and third–party businesses. A detailed examination of the infrastructure needs and investment model is presented in the Infrastructure section.

A detailed examination of current and future profit models at each stage of the fueling industry is laid out in the table below. At each stage, there is a clear sustainable profit model for fueling an electric vehicle fleet. However, it is important to note that the companies set to profit in each stage may be radically different in the current fossil fuel–based system than the future EV system (e.g., oil companies vs. electric utilities).

Table: Fueling profit model for each stage of the value chain

Fueling value chain stage	***Current profit model***	***Future profit model***
Production	– Oil companies extract and refine gasoline, accounting for over 40% of crude oil use – Profit is generated from sales to wholesalers, franchisees, or consumers depending on level of vertical integration	– Electricity generation companies will dominate fuel generation and sell to wholesalers or directly to consumer through utility and retail subsidiaries – Some consumers will produce their own electricity through distributed solar systems – Oil companies will continue to sell gasoline and diesel to legacy vehicles and for industrial and long-haul operations.
Distribution	– Fuel distributed through road, rail, pipeline, and maritime networks – Profits derived from fee per unit delivered.	– Fuel (electricity) distribution through existing transmission lines. Locating generation closer to customers can increase efficiency. Profits derived from fee per unit delivered. – Legacy distribution for fossil fuels will continue to serve legacy fleet of vehicles.
Retail	– Dedicated gas stations dominate the market with large networks of franchised locations – Profit model is driven by high volume, low margin fuel sales with merchandise sales and automobile services added on as higher margin profit streams.	– Large portion of charging will be done at home and consumers will pay through their regular electric utility. – Third-party businesses (e.g., dining, retail) will offer charging station access for free or reduced cost as an amenity to lure customers and increase in-store sales. – For-profit charging networks will offer fee- or subscription-based access to public chargers. – Automotive OEMs may build out proprietary charging networks to encourage uptake of their vehicles. – Gas stations, especially in urban areas and along highways, may offer fast-chargers. They will continue to serve legacy vehicles until complete fleet renewal, as well as long-haul trucking customers.

Infrastructure

Electric vehicles have a distinct advantage over other potential fuels of the future because the generation, transmission, and distribution infrastructure for electricity already exists nationwide. Most EVs can be charged from a standard 120V wall socket, although depending on the capacity of the car's battery a full charge this way can take 20 or more hours. For drivers that require a faster charge, all that is missing is a "last mile" network of vehicle charging stations. Charging stations have an extremely low footprint. No expensive tanks are needed, with their associated maintenance and monitoring costs, and no toxic and flammable fumes are generated, so stations can be located indoors. Electric vehicle owners can install a home charging station, something unthinkable for the owner of a gasoline-powered car. Typical home charging station installations cost approximately $1000 or less, but prices are falling fast, and they are often eligible for state tax credits.[5]

Because 93% of cars are driven fewer than 100 miles per day, with most work commutes coming in under 40 miles, home charging alone can sufficiently serve the refueling needs of most EV owners most of the time.[6]

For the rare occasions that home charging is not sufficient, public charging stations can serve much of the need. Significant investments are already being made in building out this network and there are signs that the pace of investment is set to increase dramatically. Tesla has invested in over 2000 Superchargers at approximately 400 charging stations across the US and Canada. ChargePoint has installed over 20,000 charging locations in North America and recently partnered with VW and BMW to expand fast-charging points along key high-travel corridors. Utilities are moving into the charging station space, with PG&E recently announcing its intention to build 25,000 stations across Northern and Central California.[7] Malls, offices, apartment buildings, and other businesses may also find it worthwhile to install charging stations in their parking lots and garages as an amenity for customers, workers, and residents, or to drive more business and generate additional revenue (see in-depth discussion in the Marketing section).

Gas stations could also install charging stations, given their prime locations alongside major travel corridors. Some gas stations in the Pacific Northwest and Canada have already taken this step. As discussed in the economics section, charging stations are unlikely to directly replace the revenue lost from gasoline sales, but the difference could be made up in increased retail food and beverage sales.[8] As drivers of electric vehicles will actively seek out charging stations, especially during fleet transition, installing charging stations will also provide a marketing boost for gas stations.

Marketing

In marketing electric vehicles to consumers, there are three main points on which we would position the product: affordability, safety, and environmental benefit. Affordability may not appear to be a natural fit for EVs because they currently have a higher list price than equivalently sized gasoline-powered vehicles. However, as described in the economics section, when the total cost of ownership is taken into account, including much lower fuel and maintenance costs over the lifetime of the vehicle, EVs are already competitive on cost.[9] Add to that the fact that battery costs are expected to drop dramatically over the next five years (a major cost driver) and EVs come out as a clear winner. Even with the expiration of federal tax credits meant to kickstart the market, EVs will be cost-competitive with traditional vehicles.

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[5] http://cleantechnica.com/2014/05/03/ev-charging-station-infrastructure-costs

[6] http://www.greencarreports.com/news/1071688_95-of-all-trips-could-be-made-in-electric-cars-says-study

[7] http://www.forbes.com/sites/uciliawang/2015/02/09/california-utility-aims-to-quadruple–the-states-ev-charging-stations

[8] http://www.greencarreports.com/news/1095425_electric-car-charging-station-at-gas-station-in-tar-sands-land

[9] http://www.forbes.com/sites/tomkonrad/2012/04/18/report-electric-cars-cost-less-but-watch-the-assumptions

Safety is an often overlooked but very real advantage for EVs that should be part of the marketing message shared with consumers. Due to the typical location of battery packs below the passenger compartment, EVs have a lower center of gravity than traditional vehicles, making them less likely to flip over in a crash. They also generally have larger crumple zones, especially in the front of the vehicle, due the absence of an engine. For this reason, the Tesla Model S has received the highest government safety ratings ever awarded. Despite some concerns in the media about the potential for EV fires, statistically EVs have been shown to have lower fire risk than gasoline vehicles (which, after all, are loaded with highly flammable gasoline).[10]

The environmental benefits of electric vehicles are explored in more depth in the Societal Goals section above; here we focus on how this message would be communicated to the consumer. We would highlight their personal impact on the environment if they were to drive a gasoline-powered car, in terms of tons of carbon dioxide emitted (about 5 tons per year) and the impact air pollution has on health in their community.[11] We would then contrast that with the low environmental impact of driving an EV.

When marketing electric vehicles, it will also be necessary to address consumers' concerns with the vehicles, which typically include their range and charging time and the extent of charging infrastructure. To address the range concern, it will be helpful to highlight the statistics mentioned in the Infrastructure section, including the fact that 93% of cars are driven fewer than 100 miles per day and that most work commutes are shorter than 40 miles. The reduction in battery prices and the anticipated improvement in battery technology (a hot area of development) will only serve to increase the range of future EV models.

Related to concerns about range, consumers may wonder if they do need to recharge on a longer trip, will it take too long to be practical? Fortunately, newer EVs are being built with "supercharging" technology, allowing much more rapid charging at properly equipped charging stations. For example, the Tesla Model S can be supercharged to approximately 170 miles of range in 30 minutes. Admittedly, this is still longer than it would take to refuel a traditional vehicle, but technology improvements will see this time reduced, as well. For consumers concerned about the extent of public charging infrastructure, the large number of charging stations and investments being made in building additional stations highlighted in the Infrastructure should address most of their concern. Furthermore, as driving range increases with advances in battery technology, access to fast charging stations will fade as a hurdle.

For those consumers who are still concerned about range and charging infrastructure, plug-in hybrid electric vehicles (PHEVs) may be a good option; at least until battery technology improves. PHEVs, like the Chevy Volt or the plug-in Toyota Prius, have both electric powertrain and gasoline engines that either charge the battery or can directly power the drivetrain. This allows them to operate on battery power for shorter trips (such as a typical commute), while preserving the flexibility of using gasoline for longer trips. Eventually, we expect the PHEV market to fade away as EVs emerge as the clear winner due to the increased cost and maintenance associated with a second, or dual, drivetrain.

There should be a parallel marketing effort to market charging stations to malls, offices, restaurants, apartment buildings, and other businesses. By installing charging stations at their establishments, businesses can attract EV owners and claim a bit of the environmental responsibility aura that surrounds EVs. The extended charging time of EVs is actually a positive for any business owner with a charging station – as drivers wait for their vehicles to charge, they will likely spend more time and money at the business. Many businesses have already recognized the clear benefits of installing charging stations, including Whole Foods, Walgreens, Kohl's, IKEA, and some McDonalds franchises.[12] [13] [14] While marketing charging stations to gas station owners may seem more difficult, an opportunistic franchisee would recognize the value of increased food and beverage sales and of hedging against the decline of gasoline as a transportation fuel.

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[10] http://greentransportation.info/ev-truths/safer-than-gas-cars.html

[11] http://www.epa.gov/oms/climate/documents/420f14040.pdf

[12] http://www.greencarreports.com/news/1083714_fast-food-fast-charging-for-electric-cars-the-perfect-combination-meal

[13] http://evobsession.com/180-more-ev-charging-stations-each-month-in-us-other-ev-charging-station-news/

[14] http://www.cnbc.com/id/101388967#

Supply Chain

As described in the Infrastructure section, the supply chain for electricity is already well established, aside from the charging station infrastructure. Over time, as electric vehicles become more prevalent, however, they will have a meaningful impact on the amount of electricity demanded from the grid. Our estimates put the electrical load created by EVs at 150-200 GW by 2030, compared with total capacity of generation in the US of approximately 1000 GW in 2011.[15] However, in many ways this additional load will be good news for electricity generators and utilities. Most EV charging occurs at off-peak times (e.g., at night) when other demand on the grid is low and can therefore be served by inexpensive base-load generation instead of expensive peaking plants. The advent of EVs will also help offset the stagnation in US electricity demand observed in recent years.[16] Finally, because EVs store power, they could eventually be called on by utilities to feed energy back into the grid to offset temporary spikes in electricity demand.

What is perhaps more interesting is the effect our model will have on the existing supply chain for gas an d diesel. While we expect EVs to gradually take over the market for personal transportation, fossil fuel supply chains will need to remain to provide fuel for older vehicles and for long haul trucking and other commercial vehicles. While it is conceivable that an electric solution will be found for highway travel by large commercial vehicles, there has not been nearly as much development in the space as in personal vehicles (there has been some discussion of hybrid trucks powered by overhead catenary wires, similar to some city buses).[17] The upshot is that over time there will be a gradual but significant decline in the demand for gasoline, with a much smaller decline (or leveling off) in the demand for diesel. Inevitably, this will cause many gas stations as they are currently operated to go out of business, especially in urban and suburban areas.

The gas stations most likely to survive will be those located along highways and those that are able to transition their business model to incorporate electric vehicle recharging and a greater role for retail sales. The good news is that while fuel accounts for approximately 70% of gas station revenue, it only drives 30% of profits, with the rest coming from merchandise sales.[18] Gas stations that embrace the shift to an electric vehicle future may be able to weather the change, so long as they can entice drivers inside to purchase merchandise while their cars charge.

For automotive manufacturers, the shift to electric vehicles presents a tremendous challenge but also a great opportunity. The OEMs that are able to offer compelling EV products will be able to gain market share at the expense of their competitors. However, those that fail to recognize the writing on the wall or prove unable to design EVs that appeal to customers will lose out and may eventually be driven out of business. The advent of EVs should not decrease sales volumes; they may even increase them temporarily, as owners of traditional cars demand more EVs before their cars reach the end of the useful lives or choose to purchase an EV, but keep a gas-powered car for longer trips.

Automotive parts suppliers are likely to face considerably more disruption. Makers of engine and transmission parts will lose out, while makers of parts specific to EVs will stand to gain, especially battery manufacturers. The losses will also extend to manufacturers focused on parts related to fossil fuel powertrains, such as emission controls and ignition systems. Some parts suppliers have recognized this trend and have already begun diversifying their portfolio. For example, Johnson Matthey, a leading producer of emissions control catalysts, has recently begun investing in battery technology. The exhibit below highlights how the mix of automotive parts suppliers will change with the transition to electric vehicles.

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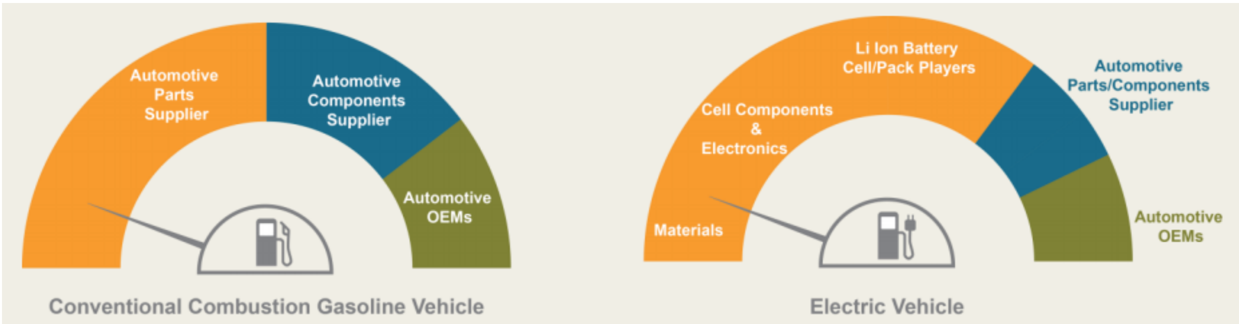
15 http://www.eia.gov/electricity/capacity/

16 http://www.ibtimes.com/power-demand-us-remains-steady-even-economy-grows-1810408

17 http://inhabitat.com/siemens-to-test-ehighway-overhead-electric-lines-for-trucks-in-california/

18 http://www.cnn.com/2009/LIVING/wayoflife/01/07/aa.confessions.gas.station.owner/index.html

Exhibit: Share of automotive production value chain in gas vs. electric vehicles



(Source: IEDC)

Finally, automotive dealers will face some changes that closely mirror the effects on OEMs. They will have to develop their ability to market and sell the unique attributes of EVs, as well as be able to answer questions about home charging and charging infrastructure. They will have to add new skills to their service departments, as well as prepare for a potential decline in servicing work due to lower EV maintenance requirements. If particular OEMs go out of business due to the EV transition, it will also impact their dealer networks. Overall, however, the introduction of EVs should not fundamentally disrupt dealers' business model. That is not to say that dealers may not face disruption in the coming years. Unrelated to the fact that they make electric vehicles, Tesla has set out to show that dealers are not a necessary piece of the automotive value chain. If this trend catches on, dealers will have to prove their value or risk obsolescence, but this is not driven by EVs directly.

Strategy

Consumers have shown willingness to purchase EVs either when there is a critical mass of charging stations in place or when they perceive them as being a good value. Our strategy will address each of these levers simultaneously to jump start EV adoption and beat the chicken-and-egg problem. Numerous stakeholders stand to benefit from EVs and untapped natural partnerships between them would accelerate their adoption.

Consumer education needs to be executed on two fronts: public awareness and ground level point-of-sale at the dealership. Non-profit and environmental organizations are natural allies for public awareness campaigns and all stakeholders should be willing to collaborate in order to grow the market for EVs. This public awareness campaign will focus on the existing availability of charging stations, of which many consumers are unaware, the current tax incentives available for EV purchases, and EVs' low total cost of ownership. On a more tactical level, public charging stations need to be made more visible, with additional signage, to raise awareness and alleviate range anxiety.

Customer education will continue at the dealership level. Fundamentally, a sales force will sell best what they know. Salespeople are incentivized to sell as quickly as possible to earn commission and focus on the next sale. Therefore, a strong educational campaign targeted at the salesperson level is critical. A salesperson may be able to secure a higher commission on an EV sale because tax incentives act as price cuts that do not cut into the sticker price. For example, Georgia has seen high EV adoption rates due to sales strategies and tax incentives despite having a relatively weak network of public charging locations.[19] Charging networks could also deploy their own salespeople and sales materials at dealerships to better answer questions about charging networks and enroll customers in charging plans on the spot. The first dealerships to target are those in areas where people have consistently long enough commutes to maximally benefit from fuel cost savings.

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[19] http://www.bizjournals.com/atlanta/blog/atlantech/2014/10/georgia-power-to-invest-12m-in-driving-electric.html

Innovations in vehicle financing can lower the purchase price for consumers without reducing the amount the dealership earns, which is conducive to other natural partnerships that benefit multiple stakeholders. Just as companies such as Solar City and Clean Power Finance have eliminated the upfront installation costs of solar panels for residential consumers and allowed them to benefit immediately from reduced electricity costs, similar strategies could increase the affordability of EVs.[20] Dealers could do well by partnering with a third party financer and offering the option as a point-of-sale strategy. Due to the complementarity of EVs and the lower electricity price of solar panels, there may be a potential for bundling as well as high probability sales leads.

Upfront EV purchase costs could also be defrayed through exchanges with wholesale electricity providers in deregulated electricity markets or grid operators. As discussed above, the batteries in EVs could provide electricity back to the grid, which would be valuable during times of peak demand when the spot price of electricity is prohibitively expensive. An electricity wholesaler could bundle an electricity plan at the time of sale, guaranteeing a fixed price for electricity, and in exchange for the right to use the EV's battery during high demand, they would subsidize the cost of the car. Grid operators would also value, and might pay for, the right to use the EV's battery for frequency regulation and demand response.[21]

Outside the home, the greatest demand for additional charging stations is at the workplace.[22] To address this opportunity, EV manufacturers, power companies, and charging networks should partner and lobby large employers and corporate office parks to install charging stations. Offices will want to install EV charging stations for at least two reasons. First, it can be a competitive amenity that helps with employee retention. Second, with current tax incentives and lower operating costs, enabling employees to purchase an EV can be the equivalent of a small raise. The charging station installation would be widely publicized to the employees in advance and automotive manufacturers and dealerships could provide employees with promotional incentives to purchase new EVs. After one major employer in the area does this, others will follow suit, so these efforts are best targeted where there are multiple large employers who compete for talent.

This same group of stakeholders should next target grocery stores, shopping malls, and retailers. Consumers with EVs will stay longer at retail locations in order to let their car charge. As described in the Marketing section, charging stations can generate higher revenue for merchants and create a positive brand image. Therefore, this strategy is best focused on areas with distinct commercial areas that compete with one another and on stores where environmental consciousness is part of their public brand.

Homeowners can easily install their own charging station, but the same is not true of apartment building residents who do not own their garage. Car sharing services can be a valuable addition to the multi-party partnership here. EV manufacturers would benefit by being able to sell to a large car sharing fleet, but car sharing services must acquire a parking space for each vehicle, which is further complicated when a charging station is also required. Car sharing services already have spots in many apartment complexes and this should only grow as the decline in car ownership among millennials continues. Therefore, a one-for-one type of arrangement in which a charging station for car share use is paired with a charging station for resident owned vehicles could lower the overall cost of charging station installation for both parties by splitting the fixed cost of installation.

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[20] http://www.greenchipstocks.com/articles/a-solar-ppa-but-for-electric-cars/2298

[21] http://www.greentechmedia.com/articles/read/emotorwerks-mines-for-data-gold-in-the-ev-charging-field

[22] http://www.timesfreepress.com/news/local/story/2014/jun/23/georgia-aims-for-more-electric-car-charging/250466/

In the future, charging stations could be a building amenity provided similar to the way washing machines are now.[23] An additional benefit of EV car sharing services in cities is the accompanying reductions in noise and pollution. This selling point could bring city governments in to the collaborative partnership.

Finally, in addition to car sharing companies, targeting corporate and municipal fleets may help drive EV purchases because they represent single sales points for large quantities of both cars and charging stations. The reduced maintenance requirements of EV's should be especially attractive to fleet operators because downtime is costly and the relative stability of electricity prices as compared to gasoline will make budgeting easier. For municipalities, which function with public money, not choosing a money-saving EV fleet could be costly politically. These lump purchases are important to jump starting the chicken-and-the-egg problem because they accelerate adoption and help move EV production down the cost curve increasing their affordability. Furthermore, they create a critical mass of vehicles and charging stations in a local area that will make it easier for other consumers to purchase EVs.[24] There is the additional benefit of increased public awareness and the fact that users of the fleet will obtain firsthand exposure to driving EVs, making them more likely to purchase one of their own.

Next steps: Industry plan considering mass introduction of electric vehicles

	2015-2020	2020-2025	2025-2030
Charging network	Electric utilities, charging networks, and car manufacturers install chargers in most dense customer areas Non-traditional fueling places (offices, apt buildings, malls, coffee shops, hotels) begin to install charging stations EV users get most of their charging needs at home	Gas station owners see decline in fuel revenues Increased competition among charging networks as local markets become saturated; results in new business/pricing models, including subscriptions	Gas stations that failed to attract EV customers begin going out of business Hospitality/restaurant companies take over highway-adjacent real estate & install charging stations to attract customers
Vehicle technology	Battery tech/cost advances such that range of EVs rivals gas vehicles & charging times are reduced Individual car ownership continues to decline as younger, urban consumers rely on car and ride sharing and public transportation	EVs become cost-competitive with mass market gas vehicles First fully self-driving mass market car sold in the US (also an EV)	EVs surpass gas vehicle sales in the US for the first time Fleet sales gain on private sales, rides in non-owned vehicles begin to surpass rides in driver-owned cars Some OEMs discontinue HEV and PHEV models
Industry players	Startups focusing on EVs and ride sharing start to get traction in large urban areas OEMs team up with technology companies to develop on-board systems Oil companies focus on energy generation and alternative uses for oil	OEM that failed to adequately invest in EVs goes bankrupt Car and ride sharing companies grow volume of vehicle sales (large fleet owners) Gasoline begins to gradually loses importance for oil companies	Several automotive suppliers go out of business due to major change in technology First super major oil company gets less than 10% of revenue from gasoline sales

[23] http://www.greentechmedia.com/articles/read/ChargePoint-Launches-An-EV-Charging-Product-Tailored-for-Apartments-and-Con

[24] http://www.mnn.com/green-tech/transportation/blogs/indianapolis-leads-the-way-for-electric-vehicle-fleets

How Do You Monetize Environmentalism?

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Problem Statement: Even though environmental sustainability is becoming globally critical, the fuel industry is unable to monetize sustainable practices while preserving the nation's economic interests.

I. Background

With the CAFE standards raising the MPG bar on an ongoing basis, it is predicted that there will be a reduction in US oil consumption by 30 billion gallons on a yearly basis through 2030[1]. On the other hand, studies show that over 1.2 million jobs were created during 2012 in the unconventional oil and gas producing states in the United States[2], making this industry one of the major pillars of the U.S. economy. In the meanwhile, the tussle between the environmentalists and the regulators has thrown light on the environmental drawbacks of the modern technologies employed; for instance, fracking in the oil and gas industry. This has culminated into many policy changes, especially the recent developments in Denton; making Denton the first fracking free city in Texas[3]. This juncture presents an interesting turf to build an optimal policy.

As a solution, we adopt a two pronged approach in the form of a rating system called E-star, which capitalizes on the customer's need for environmentally friendly option and at the same time smooths the transition from traditional fuels to clean fuels without creating economy shocks. The futuristic aim is to change the fundamental thought process that goes behind a fuel purchase decision at any given gas station. Due to the prominent rise of alternative fuels such as electric fuel, compressed natural gas (CNG), autogas, biofuels, ethanol and hydrogen, we anticipate a much more diversified fuel offering at the pump in the future. While today a fuel purchase decision is mostly dominated by price, studies indicate that knowledge about environmental cleanliness of different fuels could change purchasing patterns dramatically. In a diversified fuel pump, prices that are based on dollars per gallon will instead be based on cents per standard mile travelled for each type of fuel.

By displaying an E-star rating associated with each fuel retailed at the point of sale, the consumer is more effectively educated about the different fuel choices. This solution capitalizes on the rising environmental awareness of the public while providing an opportunity for fuel producers to monetize their environmentally friendly operations as they receive higher ratings at the pump.

II. Opportunity

The need for this model stems from the opportunity created through the shift in customer preference. Further research substantiates this sway and the cause progression is addressed in the form of answers to the following questions. Since the target customers are not clearly demarcated, data available on electric cars and other clean fuels were assumed relevant enough to make a clear case.

1. What do people want? (Change in Fuel Preference)

Though general studies suggest that the average American consumer is price sensitive, he does have an underlying concern on his immediate environment which can be leveraged into a marketing opportunity for the E-star scheme. A comprehensive study conducted by MIT Energy Initiative and

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[1] Bezdek, R., & Wendling, R. (n.d.). Potential Long-term Impacts Of Changes In US Vehicle Fuel Efficiency Standards. Energy Policy, 407-419.

[2] Munasib, A., & Rickman, D. (n.d.). Regional economic impacts of the shale gas and tight oil boom: A synthetic control analysis. Regional Science and Urban Economics, 1-17.

[3] Miller, C., Richter, J., & O'Leary, J. (n.d.). Socio-energy systems design: A policy framework for energy transitions. Energy Research & Social Science, 29-40.

the Harvard University Center came up with the following findings regarding the public opinion of Americans towards energy[4].

- People need change: they have preferences for new sources of energy like wind, solar, etc., over old ones like coal, oil, nuclear.
- People don't have favorites: they generally dislike fuel attributes and not necessarily the fuel itself. Therefore, reduction in environmental harm is a key factor in influencing their choice.
- Choice made by the people is influenced heavily by both harm to the environment and the costs, yet harm prevails over cost as the major factor.
- Hurting the earth matters less than hurting your town: people are more concerned about immediate harms to the environment like air or water pollution in the locality as opposed to an omnipresent phenomenon like global warming.

2. Who wants cleaner fuels? (Target Audience)

A recent market analysis study to assess consumer preferences for cleaner fuel vehicles identified three targeted market segments using a discrete choice experiment[5]. The study was carried out in Canada and a random sample of 1,500 commuters, who drive to work daily were chosen. The results of the study can be grouped as 3 distinct groups, namely actively concerned, passively concerned and unconcerned.

It was found that the majority of the actively concerned cluster were younger (66% under 40 years of age) when compared to the other groups. It was also found that individuals in the actively concerned group were more likely to make a joint decision with their spouse. This was not the case with the passively concerned and unconcerned groups of people. The unconcerned group was found to have the lowest annual income. Being economically weaker, it was also found that the unconcerned group only had 1 in 4 chances of buying a vehicle in the next 5 years.

While the study attempted to identify the target audience for a clean fuel vehicle, the study also identified important factors that are considered when choosing a vehicle. Vehicle performance was also considered key criteria, when making a decision. To summarize, while a majority of the consumers in the survey preferred a cleaner fuelled vehicle, it was clear that several factors like cost, performance and value were important decisions when choosing a vehicle[5].

3. How many are willing to pay for cleaner fuel? (Market Size)

As of December 2014, the United States has the largest fleet (290,000 +) of plug-in electric vehicles in the world[6]. The market share of plug-in electric passenger cars increased from 0.14% of new car sales in 2011 to 0.37% in 2012, 0.62% in 2013, and reached 0.72% of new car sales during 2014[7].

Pike Research projected that annual sales of plug-in electric vehicles in the U.S. will reach 400,073 units in 2020. While most consumers would choose to invest in a cleaner fuel vehicle, cost and performance of the vehicle have been important barriers when consumers consider switching to cleaner vehicles. This is evident in Europe where higher gasoline prices have given electric powered

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[4] Ansolabehere, Stephen, and David M. Konisky. Cheap and clean: how Americans think about energy in the age of global warming. MIT Press, 2014.

[5] Ewing, Gordon, and Emine Sarigöllü. "Assessing consumer preferences for clean-fuel vehicles: a discrete choice experiment." Journal of Public Policy & Marketing 19.1 (2000): 106-118.

[6] Jeff Cobb (2014-01-16). "Top 6 Plug-In Vehicle Adopting Countries". HybridCars.com. Retrieved 2014-01-18.

[7] Jeff Cobb (2015-01-06). "December 2014 Dashboard". HybridCars.com and Baum & Associates. Retrieved 201501-06.

vehicles higher market penetration[8]. Hence, while consumers would consider paying for an environmentally favorable choice, costs and performance are crucial when making this decision. Hence the original 400,073 units predicted (2020) would increase if significant advances in clean R&D technology could reduce costs and increase performance.

4. How much are people willing to pay? (Potential revenue)
An interesting Harvard study examines the general attitude towards energy and climate for the past 12 years. Overall, the respondents did not have any objection to pay a 5% increase in energy bill and this is identical to the measure in most developed nations.[9] With a conservative estimate of the US energy bill amounting to $10,010, this would translate to a bare minimum of $5 per month. EPA estimates that there will be an initial 2% increase in energy bills as a result of Clean Power Plan11.

Another econometric modeling states that the average household is willing to pay $44 for energy R&D designed to replace fossil fuels. In the case of energy bill the surge of 5% amounts to $5 which might be acceptable when compared to $100 paid monthly. But in the case of fuel, a 5% increase would amount to 15 cents, assuming that the fuel is sold at $3. The goal of the E-star scheme is to offset this premium by providing deals at partner green service providers and thus building a green eco-system that the consumer can benefit from. It is also to be noted that this premium is being paid only by those consumers who are willing to contribute to the environment.

Now that the big picture is clear, focus on the channels through which the consumers are willing to pay has been prioritized. The proposed recommendations have been derived from the previous discussions and the model built will inculcate these recommendations as its baseline:

- A reasonable assumption would be that Americans are willing to voluntarily pay a minimum of 5% over their fuel bill to support clean initiatives.
- If we start grading companies with this minimum requirement built into the ranks then the least rank can cause a 5% surge in revenue.
- The highest weightage in the ranking scheme would be attributed to the improvement caused by that fuel usage in the immediate environment of the consumer.
- The aim of the E-star rating is to educate the consumer about the overall health and environmental hazards caused by the fuel they use from its point of production to the point of consumption.
- E-star initiative should be advertised as an energy and environmental policy rather than as a climate policy.

III. Business Framework

With a sizeable market in sight and basic guidelines in place, the building blocks of the business plan is laid forward. A profit sharing model with two major pillars is proposed.

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[8] Pike Research (2013-01-02). "Pike Research forecasts hybrids and plug-ins to grow to 4% of European market in 2020". Green Car Congress. Retrieved 2013-03-03.
[9] Ansolabehere, Stephen, and David M. Konisky. Cheap and clean: how Americans think about energy in the age of global warming. MIT Press, 2014
[10] http://www.eia.gov/electricity/sales_revenue_price/pdf/table5_a.pdf
[11] Regulatory Impact Analysis for the Proposed Carbon Pollution Guidelines for Existing Power Plants and Emission Standards for Modified and Reconstructed Power Plants. EPA Report. June 2014.

1. An autonomous audit organization that publishes an E-score rating which ranks fuel companies based on their cumulative environmental impact at each step from the fuel's inception to the point where it is consumed. This is overlapped with the E-star rating that every fuel garners based on fuel class specific parameters.
2. A payment processing organization that offers credit cards through partner banks exclusively to be used for gas purchase wherein the credit card users pay an extra premium to incentivize highly ranked E-star fuel and earn redeemable carbon credit to match the premium paid.

The business plan is built on these two major pillars and the functioning is detailed below.

IV. Strategy

The focal strategy lies in the way the E-star rating is calculated. In essence, this is a four-step process:

1. Developing a dynamic E-score per company in the value chain by using the E-score matrix
2. Mapping all sell/trade transactions of the constituents that make up the fuel. At each step, the fuel constituent carries a weighted average E-score of all the companies that contributed to its value chain operations.
3. Setting up a generic Base E-star rating for each type of fuel.
4. Calculating the retailed fuel's E-star rating at the point of sale by superimposing the fuel's Escore onto its Base E-star Rating.

The E-star Rating is constructed as a weighted index that incorporates three major classes of criteria; general environmental sustainability of the fuel type, the fuel performance, and environmental performance of underlying activities that produce the retailed fuel. The first two classes are relatively static (updated yearly) and are captured in our Base E-star Rating Matrix which determines every fuel type's Base E-star Rating while the latter is dynamic.

First, a company specific E-score is developed based on the company's environmental practices. The E-score of a company uses the following sources of information for its calculation:

1. Similar to Alazzani's Global Reporting Initiative (GRI) indicator, all environmental disclosures made by each company are collected. Companies publish environmental disclosures in various sustainability reports (SRs) and corporate social responsibility reports (CSRs). The greater the number of disclosures a company makes relative to its size of operations, the higher the score premium it receives. This scheme monetarily incentivizes companies to disclose their environmental activities while maintaining minimal costs for collecting information by the E-star agency.
2. In addition to disclosures, partnership with environmental agencies that develop sustainability metrics will be evaluated. For instance, metrics like DJSI, Corporate Knights' Global 100, Climate Counts are a rich source of companies' environmental practices and can help construct companies' E-scores.
3. Environmental violations are captured by several bodies such as the EPA, Department of Energy and other environmental agencies. All such violations per company are used to calculate the impact it has on the company's E-score.
4. The audit body managed by the E-star agency will conduct spontaneous audits to document the authenticity of disclosures made and better capture E-star valuation criteria.
5. Investments and R&D expenditures into sustainable practices are monitored and valuated.

All these sources of information are evaluated in an E-score Matrix that calculates the company's resulting E-score based on a set of criteria. The criteria used are based on the degree of impact the improvement/damage captured has on consumer's "care abouts". Further analysis is required to construct an E-score calculation Matrix that incorporates all the possibilities for the explained sources of information. However, the final output expected is an E-score developed per company. The E-score carried by the fuel constituent is therefore, a weighted average of the E-scores of the companies that contributed to its value chain operations.

Next, once the E-score per company is developed, a Base E-star Rating is developed for each type of fuel that is sold at retail points. The Base E-star Rating serves as the mechanism of translating general consumers' fuel criteria preferences into their corresponding willingness to pay. It also helps educate the consumers about the health, environment, energy and consumption attributes of each type of fuel in order to consciously influence their purchasing habits and eliminate any misconceptions.

It is important to note that the following example is only for clarification. The actual weights assigned to each criterion will be a direct result of thorough market research that shall be conducted to quantify our target segment's behaviors and wants.

Table 1: Base E-star Rating Matrix

		Environmental Sustainability					Fuel Performance			Base E-star Rating
	Criteria	Air pollution	Water Pollution	Global Warming	Ecological Footprint	Renewability	Torque/power ratio	Mileage efficiency	Maintenance costs	
Fuel Code	Weight	**10**	**9**	**5**	**4**	**6**	**4**	**8**	**5**	
A	Gasoline	4	3	2	7	3	9	7	7	**2.5**
B	Diesel	3	3	2	7	2	8	8	7	**2.3**
C	CNG	7	4	3	4	4	6	5	9	**2.6**
D	LNG	6	5	3	4	4	7	6	8	**2.7**
E	Electricity (coal based)	3	2	1	2	5	7	4	6	**1.8**
F	Electricity (solar based)	10	10	10	3	10	7	3	6	**3.9**
G	Electricity (wind power based)	8	8	9	3	9	7	3	6	**3.4**
H	Hydrogen	10	6	8	8	7	6	9	7	**3.9**
I	Non-feedstock based biofuel	9	9	10	10	8	8	7	8	**4.3**
J	Feedstock based biofuel	9	8	4	1	6	8	7	8	**3.4**

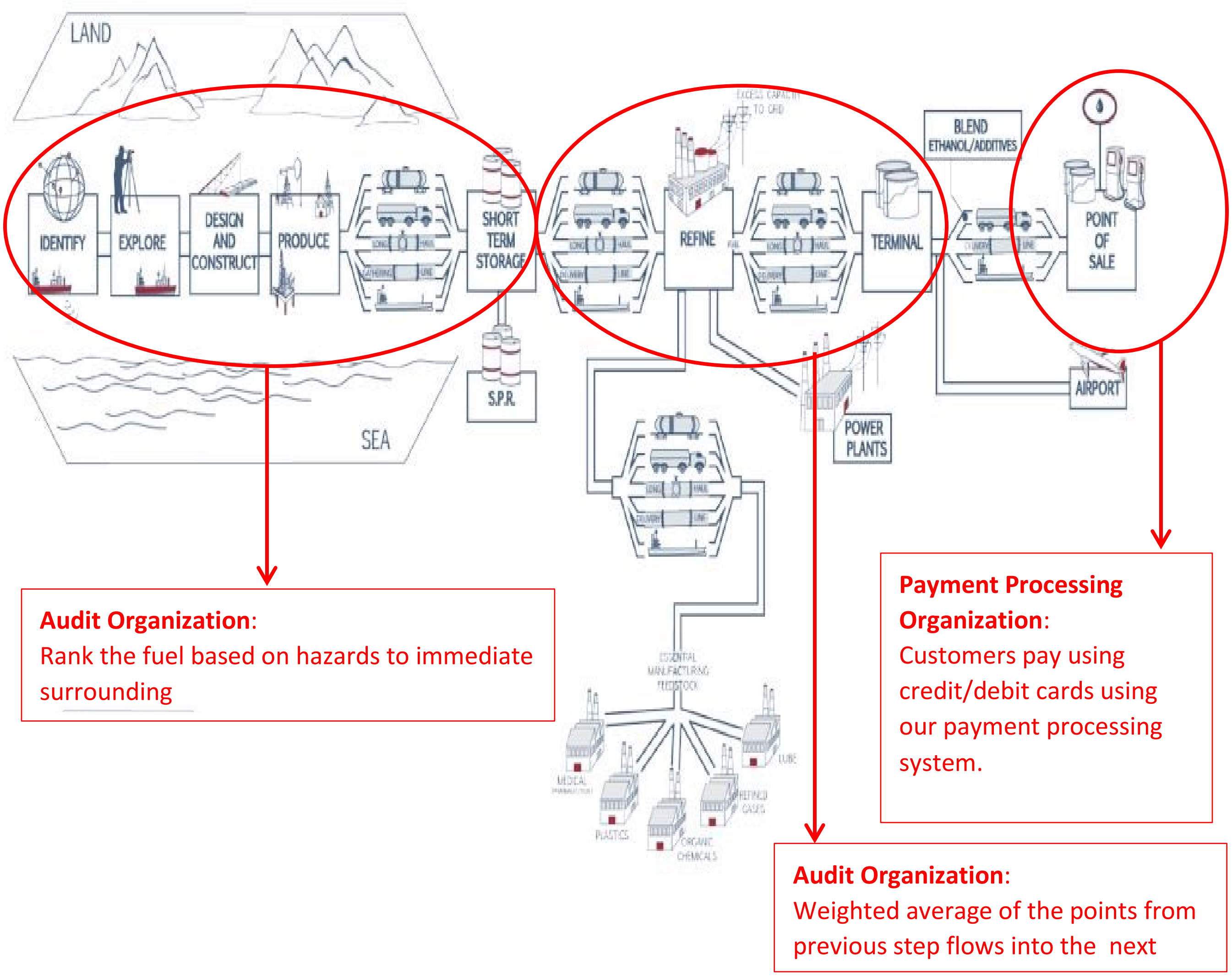
Through access to the personalized E-star website portal, an E-star customer will be able to view this matrix and display the underlying information that backs up each number. For instance, a user under the common misconception that electric cars are clean to the environment will be able to observe its low environmental ranking. The user will also be able to display the underlying study that estimates the amount of coal burned to supply electric cars and as a result how environmentally damaging electric cars are compared to gasoline.

Finally, the weighted average E-score of the fuel and its Base E-star Rating are superimposed to come up with the final E-star Rating for the fuel being retailed. This calculation ensures a strategy that develops environmental accountability of companies, as well as an educational hub to allow consumers to understand the impacts the different fuels have on their “care abouts” regarding the environment and fuel performance.

V. Supply Chain Model

Oil based fuels being the most popular ones in use today, it is essential to understand how the existing supply chain network functions and how the E-star rating plays a role. For this, a look at how the proposed solution interacts with the existing network is presented below:

Figure 1: Remodeled supply chain[12]



In the figure, the gray line shows the process flow of the traditional supply chain network. The red lines show the process modifications caused by super imposing our model on the existing network. The ratings we come up with will affect the fuel through the environmental impact of all the

[12] http://www.api.org/~/media/files/policy/safety/api-oil-supply-chain.pdf

operations carried out by the manufacturer and refineries to produce the fuel. Thus our rating system will cover the entire gamut of upstream and downstream operations to rank the fuel.

A detailed explanation of the newly included components in the overlapped supply chain is explained below:

- **Role of the audit organization**: Starting from the exploration stage to the point where the fuel is distributed to the terminal, the audit organization studies the flow and attributes points based on the suggested ranking criteria. The data for this will be collected through voluntary standard assessment declared by the units on their own. A content study of the reports published by eight major oil and gas companies shows that they are very much in accordance with GRI Sustainability Reporting Standards[13]. Hence, to begin with this would prove to be a more cost effective approach to collect data.
    - Moreover, it is observed that there is no point of discrimination between the different fuel sources since it all flows into the same pipeline from refineries. So, the use of a weighted average model to compute the ranking index is suggested.
    - For example, if a producer A supplies 'x' gallons into the pipeline and refineries P,Q,R take 70%,20% and 10% of the fuel at the outlet then the points accumulated by A will pass on to P, Q,R as follows:
        - Points attributed to P = 0.7 * Points achieved by A
        - Points attributed to Q = 0.2 * Points achieved by A
        - Points attributed to R = 0.1 * Points achieved by A
    - This would be a failsafe method because now the onus shifts onto the refinery in choosing the right partners and slowly the market segments would polarize and the companies would get bunched into two categories – companies following clean practices and companies that fail to do so.

- **Role of the Payment Processing organization**: The customer will use credit cards issued by partner banks that avail the services of our payment processing mechanism to purchase the fuel. Based on the choice they make (Low E-star or High E-star) they would be charged a varying premium aimed to incentivize the higher ranked ones for their best practices. The customer would in-turn earn redeemable carbon credits which would be used in partner outlets to purchase commodities that are manufactured through clean practices. The major advantage offered by the card is that it can be a one stop shop for all the fuel needs be it E-star or non-E-Star choice the customer makes. Thus, we create a supply chain eco-system wherein every counterpart is benefited one way or the other.

VI. Identify Stakeholders

Now that the supply chain network has been set up we can classify the stakeholders into two categories based on their interaction with the supply chain.

Type 1: Direct Stakeholders: These would include the elements that would be directly involved in the supply chain:

1. *Oil and Gas Exploration/Production/Refining companies:* They form the back-bone of the model, since they have to co-operate with the audit process and initiate the change.

[13] Alazzani, A., & Wan-Hussin, W. (n.d.). Global Reporting Initiative's environmental reporting: A study of oil and gas companies. Ecological Indicators, 19-24

2. *End Customers*: The model is customer driven and hence depends on the awareness level of the customer making this well-informed choice of choosing a high rated fuel over a low rated one.

Type 2: Indirect Stakeholders: These would include those elements that are not directly involved in the fuel supply chain, but on whom successful implementation of this model will be dependent and to whom a successful program could deliver benefits. Some of these indirect stakeholders can be,

1. *Regulatory wing – government*: To impose this model there is a need for stimulus from the government, for instance in the stage where sharing of self-published sustainability reports is required, not only from the oil companies but also the ones they received from their suppliers and distributors with whom the company is doing business. Also, the government has to step in and make the E-star rating a part of the procurement document the company would sign to buy crude oil from a producer. This would ensure that the data flow is uninhibited and evasion is curbed.
2. *Automobile manufacturers*: Auto majors play a crucial role in this model. For instance supporting this initiative would mean that there would be a rise in the demand for gasoline cars. This would comply with their tendency to maintain the existing gas regime[14]. This is advantageous in the fact that, these companies can use their existing expertise in gasoline car technology and save switching cost to new battery technologies.
3. *Credit Card Framework*: Partnering banks and credit unions will be able to earn money through the three sources namely store fee, interest fee and late fee.[16]

VII. Policy Opportunity and Challenges

The model built is not a radical transformation; rather it is a slow progression into a sustainable environment. During the implementation phase certain challenges would be faced and policy opportunity has to be employed to tackle these.

Government Support: No new policy can self-start itself without government stimulus. Though this model would need the initial support from the government, once it kicks off and reaches a breakeven point it has the inherent capability to transform into a self-propagating eco-system.

Challenges:

1. *Faced by oil manufacturers*: With the recent Presidential Referendum directing all government agencies to use 20% renewable energy[15], there would be further decline in demand for non-renewable energy which will face a tough market situation. So the real challenge will be to push the nonrenewable players to participate in this drive because the real benefits of the clean initiatives start appearing only in the long run. To compensate this initial risk the companies would face, government subsidy is needed.
2. *Faced by our model components*: Also, support (both monetary and policy wise) is required to enable gathering data pertaining to company wise market share of the various fuels and customer profile which will help strengthen our model. For instance, accessing the scanner

[14] Wells, P., & Nieuwenhuis, P. (n.d.). Transition failure: Understanding continuity in the automotive industry. Technological Forecasting and Social Change, 1681-1692.
https://www.bostonfed.org/economic/ppdp/2010/ppdp1003.pdf
[15] http://www.whitehouse.gov/the-press-office/2013/12/05/presidential-memorandum-federal-leadershipenergy-management

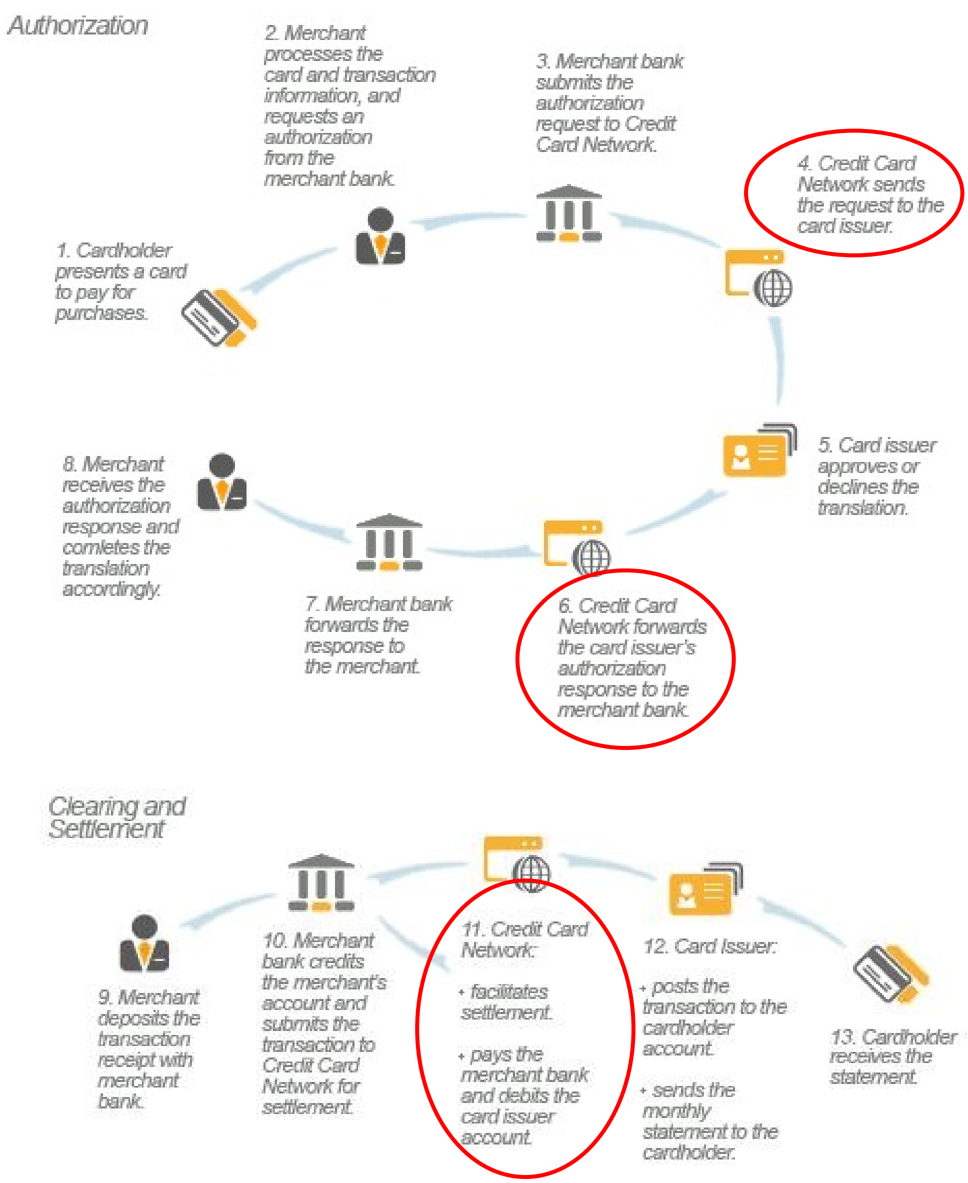
data can help in segmentation and sales projections. Government assistance is necessary in making this data available at a subsidized rate.

VIII. Economics/Financial

There are two major channels of revenue that are incorporated into the business model. One would be through the rating agency and the second would be through the credit card agency. The dynamics are explained briefly below:

1. *Revenue from the audit agency*: As discussed earlier, the audit agency verifies the sustainability data submitted by the various upstream and downstream counterparts of the supply chain. To ratify these reports, the audit agency would charge a fee depending upon the size of operation and there would be negotiable discounts available if there is a 100% match of data provided by the counterparts and the audit done by the agency. This can be considered as a marketing channel fee by the company, since the E-star rating would help boost the sales of the company and better its image amidst the consumers. While on the other hand, if there are discrepancies, sizeable penalties would be levied. To sum it up, this would serve as a constant source of income since the companies have to get their reports ratified periodically.
2. *Revenue from Credit Card Framework*: As suggested earlier, the envisioned payment processing organization can be located in the process flow chart in Figure 2.

Figure 2: Payment process cycle[16]



As highlighted by the red circle, the payment processor is a middle man between the processor bank and the issuer bank. The source of revenue is from the Interchange fee and this is paid by the merchant through the financial institution he chooses, very much similar to the revenue model of Visa or MasterCard[17]. The only catch is that this card would be exclusively used for fuel (E-star or non E-star) and a premium would be charged for the high rated fuel which would be paid back to the customer in the form of redeemable carbon credits. Also this premium is used in incentivizing the downstream players including the manufacturer, distributer and retailer for their efforts in improving their contributions to the environment.

[16] http://blog.unibulmerchantservices.com/credit-card-transaction-processing-basics/

[17] http://usa.visa.com/download/merchants/interchange-brochure.pdf

IX. Infrastructure

This model is wound around the existing fuel supply system and hence wouldn't need high investments with respect to infrastructure. The two basic cost centers would be the two functional pillars of the model as elucidated below:

- *Audit Organization*: Though the data would be initially declared by the companies there is still a need to review audit and then document the gaps in their self-attested data. A strong audit team is needed to accomplish this and there has to be a central repository to store this data. Since this data would be made publicly available, a web team is essential to host this data, even though maintenance of the site could be outsourced.
- *Financial Framework*: To set up the payment processing facility there is substantial support required from the side of partner banks. Since there would be heavy competition from other payment processors like MasterCard or Visa, it would be better to partner with a trusted credible bank and bring out the credit cards through this partner bank and then slowly branch out to the rest. A better suggestion could be roping in the financial wing of auto makers who can set up a credit union like entity which will give out the credit cards using the E-star payment processing system. But to establish this, there is a need for market research and government aid.

X. Marketing

Once this infrastructure is in place, marketing campaigns have to swing into action to target the customer segments identified through research and cater to them through the various available channels.

There are two possible approaches one might take to market the E-star product. It could either be marketed as a niche project catering to the energy savvy young population in accordance with the Canadian study or as a commodity through public education about the hazards of low E-star fuel to the environment. But going with the former is advisable, as surveys suggest that the U.S. customers are price sensitive to oil prices[18].

To gather more data on the target segment, comparables can be used which proves effective in the case of new product introduction. A Bass Model analysis would come in handy to determine the peak sales, market size, early adopter and imitator population.

Once this data is established both direct and indirect marketing techniques can be used to target customers. Reaching out to the young population would serve as a key. The following channels can be targeted.

- *Partnership with retailers*: Hoardings and bill boards coupled with signboards at the dispensing machine can send out a strong message to the consumer
- *Partnering through clubs and pro-clean energy organizations*: E-star credit cards can be given as a part of the sign-up package with elite, clean fuel supporting clubs and thus can re-iterate its position as an exclusive product
- *Partnering with corporates*: As a part of CSR initiative by the Oil companies they can promote the E-star card amongst their own employees

[18] http://www.nacsonline.com/YourBusiness/FuelsReports/GasPrices_2013/Pages/Consumers-React-to-Gas-Prices.aspx

XI. Societal Goals

In totality, establishing this system would serve every facet of the environment, especially the immediate surroundings over which the common public is highly concerned about. Moreover, it is in line with what the young generation wants while preserving the economy's stability.

Though this plan would start as a niche part catering to the elite few who are ready to shell out a premium beforehand for a greener fuel, it indeed has the potential to transform into a much needed educational tool to help the common man identify the boons and banes of the kind of fuel he is using.

XII. Conclusion

The rise of fuel efficiency standards and introduction of alternative fuels is bringing a lot of uncertainty in the fuel market. Meanwhile, the raising environmental awareness of the public is creating a lot of pressure on the nation's biggest industry – oil and gas which threatens the loss of thousands of jobs. Our E-star solution develops a model that monetizes environmental awareness of the public while giving an opportunity for fuel producers to adopt safer operations. This is done by displaying an E-star rating at fuel pumps that assign higher ratings for cleaner fuels, while taking into account company specific operations that went into producing that fuel. In addition to the anticipated change in consumer purchasing behavior, a voluntary tax will be collected by E-star credit card users.

This tax, which amounts to 5% or higher of the fuel price, would finance building the infrastructure required for selling alternative fuels and displaying E-star ratings at fuel pumps. As the marketing costs of alternative fuels smoothly drop over time in an economically sustainable fashion, customers are rewarded with tax rebates, product discounts and money payback schemes.

The success of this initiative requires support from various key entities mainly the government in order to mandate E-star rating monitoring and the fuel retailers in order to incorporate E-star ratings in their point of sales equipment. In order to further refine this model and come up with a well-rounded policy proposal, extensive market research is required to identify the size of the consumer base, costs of the project, timelines of implementation and potential benefits. However, conceptually the system presents a promising opportunity to internalize a powerful externality that was long ignored in the fuel industry; the environmental awareness of the American people.

Mileage-Based Fuel Contracts

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1. Executive Summary

Today's current transportation system is ineffective at encouraging increased fuel efficiency for automobiles. Consumers do not largely consider fuel efficiency as an important factor in their vehicle purchasing decisions, and fuel providers are faced with long-term revenue loss as more fuel-efficient vehicles proliferate the market. We outline a proposal that serves to better monetize fuel-efficiency savings, allowing fuel providers to profit from environmental stewardship motivated through increased vehicle efficiency. This shift is by no means incremental, and requires a radical transformation across all levels of the vehicle and fuel supply-chains currently in place. To catalyze this change, we propose the following:

1. Ownership of automotive fuel (gasoline) may not be transferred on a volumetric or mass basis. This effectively prohibits the sale of gasoline on a gallon basis for use in vehicles.
2. All transfers of automotive fuel must be orchestrated as part of a mileage-based contractual agreement, in which the party receiving the fuel has paid for a service for which the transference of fuel is essential. This effectively causes consumers to purchase a given number of miles to travel in their vehicles, rather than a given volume of fuel.

Under these proposed changes, consumers, retailers and fuel distributors will effectively enter into mileage-based contracts with fuel providers. For consumers, gasoline retailers and service stations simply provide a service: allowing you to travel a given number of miles in your vehicle. Under this mechanism, fuel providers may realize additional profit by reducing the cost associated with providing the service. This can either be achieved by reducing the cost of extracting and refining oil (as is presently the case), or through reducing the amount of fuel required to travel a given distance. This market-based approach will allow fuel providers to enter into agreements with automotive manufacturers to increase the number of fuel-efficient vehicles on the road that utilize their fueling infrastructure.

The analysis we present in this proposal shows the tremendous profit opportunity that exists for fuel providers under this mechanism. **We show that gasoline retailers could double their existing per-vehicle profits by achieving efficiency improvements of only 4%.** Given the technological capabilities to far exceed a 4% improvement in vehicle efficiency, we expect fuel providers to be interested in close collaboration and strategic arrangements with automotive manufacturers. This will completely revolutionize today's automotive fleet, decoupling the use of gasoline from the service it provides, and providing the means for a market-based push to supply vehicles with higher fuel efficiency.

2. Introduction

A vehicle's fuel economy is not often a leading factor in vehicle purchasing decisions (Turrentine & Kurani, 2007). Furthermore, improvements to vehicle fuel economy reduce the demand for fuel, which is counterproductive to the business model of fuel providers. To actively monetize gains in fuel efficiency, we propose instituting a policy that prohibits the sale of gasoline on a volumetric or mass basis, and instead requires that gasoline be transferred only as a means of fulfilling the terms of a mileage-based contract.

Mileage-based contracts are agreements between fuel providers and fuel distributors or fuel users, where the provider of the fuel agrees to provide enough fuel to allow the user to travel a given number of miles over the contract duration. Legal action may be sought against parties that fail to honor the contractual agreement. A retail gasoline station will utilize two major mileage-based contracts: 1) a contract between themselves and the fuel distributor that provides fuel to their station, and 2) a contract between themselves and automobile drivers that purchase miles from their stations.

Under the first contractual agreement, a given station will have a contract with a fuel distributor to provide a certain number of miles in a given month. This, in principle, is not substantially different from current arrangements in which a retailer enters into agreements to be supplied with a certain volume of fuel. The fuel distributor, in turn, will require documentation from the retail gasoline provider such that they can estimate the amount of fuel they will need to furnish a station with to provide a given number of user-miles over the duration of the contract. This will likely require detailed record keeping associated with each vehicle that visits the fueling station, and the expected fuel efficiency of each of these vehicles. Existing technologies can be implemented to allow for this level of record keeping.

The second contractual agreement, between a fueling station and a driver, will require stations to be able to measure odometer readings and the fuel tank level at each refueling event. To mitigate concerns associated with drivers not getting the mileage that they pay for, fuel providers will pessimistically estimate vehicle fuel efficiency. Drivers, in turn, will be rewarded for optimizing their driving behavior such that they can drive further distances than they paid for in miles. If a vehicle does not receive the number of miles that the driver paid for, then they may return to the retail station that they purchased the miles from, or any other station operating under the same contractual agreement (i.e. gasoline station chains), to receive the remaining miles under their fueling contract.

This proposed solution circumvents current barriers to adoption of fuel-efficient vehicles by creating a market incentive for fuel providers to promote fuel-efficiency and form collaborations with automotive manufacturers and dealers to produce and distribute more fuel-efficient vehicles. Because fuel providers furnish roughly the same number of miles to vehicles independent of a vehicle's fuel efficiency, and more efficient vehicles can be provided miles at lower cost than less-efficient vehicles, fuel providers can profit by promoting the adoption and use of more fuel-efficient vehicles. Independently-operated fuel providers and small fuel retailers with limited fuel distribution networks will not be able to compete in the same way as larger fuel providers, and will have to form collaborations to similarly benefit from implementation of this policy.

An outcome of this competition model is that interesting partnerships may form at the point-of-sale for new vehicles, and we would expect to see increased involvement of fuel providers in the sale of fuel-efficient vehicles. Fuel providers, for instance, may create vehicle-purchase incentives by providing discounted fuel contracts for specific vehicles that utilize their network of stations. Larger station networks may therefore have an advantage for this kind of competition. Ultimately, fuel providers will compete over the value of the services that they provide, the miles you can travel, rather than the cost or quantity of the fuels they extract.

The main appeal of mileage-based contracts is that they provide a new, market-based solution for achieving environmentally beneficial outcomes and for transitioning away from gasoline-dependent transportation. In contrast to the business as usual scenario, where consumers purchase gallons of gasoline, the mileage-based contract incentivizes oil producers to increase the efficiency of the fleet that they serve. Oil producers will be able to improve the efficiency of vehicles they serve by partnering with automakers. In its simplest iteration, oil producers will partner with automakers that offer vehicles with higher-than-average fuel efficiency. Oil producers will compete among one another to partner with the automaker that offers the greatest efficiency gains over the overall automotive fleet at the lowest cost.

2.1 Societal Goals

An oft-repeated axiom of economics is that there is no free lunch. Increasing the efficiency of vehicles will incur increased costs, owing to the need for development and capital expenditure, as well as capacity and market building. Efficiency gains in the transportation sector have societal benefit, in the form of decreased environmental impacts from emissions and resource extraction, and economic benefit derived from decreased fuel costs. But these cost savings can be small on an individual basis, and payback periods are dependent on the steady generation of a large number of miles traveled annually. Currently, only buyers with significant fuel expenditures and access to capital can realize these cost savings by purchasing a fuel-efficient vehicle. In fact, consumers at higher income levels are more responsive to changes in fuel prices (Hughes, Knittel, & Sperling, 2008), likely because at higher income levels, more trips are discretionary (Kayser, 2000). This suggests that lower income households have both lower elasticity for vehicle travel and are less able to adapt (e.g. purchase new vehicles).

Currently, oil companies are discouraged by increased deployment of fuel-efficient vehicles, as they represent a decreasing market for their sole product. Under our proposed plan, expanding the market for fuel-efficient vehicles, particularly for households with less discretionary vehicle travel, represents increased profits for oil companies. Consumers would also still receive economic benefit from the purchase of a more efficient vehicle through decreased mileage costs in the mileage-based contracts they enter into with fuel providers. Since higher income households will be more responsive to fuel price fluctuations, oil companies are incentivized to increase adoption of more efficient vehicles by lower income households.

This proposal seeks to better align the economic incentives for fuel efficiency by adopting a progressive scheme for mileage pricing. Older vehicles or low-efficiency vehicles would likely pay similar prices to today under the plan, but as more vehicles transition to contract based pricing, the spot mile price could increase. Therefore, tax rebates should be implemented for those households who are both unable to purchase a new vehicle or adopt other modes of transport. Additional incentives or rebates would also be required for the addition of mileage-based transponders for older vehicles in poorer households.

3. Analysis

3.1 Stakeholders

All major parties involved in the current automotive system are relevant stakeholders. This includes, but is not limited to, automakers, dealerships, oil and gas companies, oil refiners, fuel blenders, retail fuel stations, the trucking industry, and consumers that purchase and utilize vehicles. Oil companies and consumers are the primary stakeholders directly affected by this plan, but there are key implications for retail fuel providers and car companies. Oil companies will fundamentally change the way they market their product to consumers, and consumers will be faced with a much clearer economic decision with respect to travel (e.g. cost per mile). Increased interaction between fuel retailers and oil companies is likely under the plan, as oil companies will now be required to ensure that the efficiency pricing scheme and purchase incentive programs are implemented correctly. This is not true for all ownership models, as company owned and operated stations might see little change under the plan. Franchise and independent fuel providers will likely enter into arm length contracts with fuel companies to provide mileage discounts to those company's contract customers. The impacts on fuel retailers are further discussed in the section on supply chain.

There is likely to be some pushback from implementation of this strategy across stakeholders, but ultimately consumers are likely to benefit from this model, and fuel providers will be able to realize a new revenue stream through the promotion of fuel efficiency across vehicles. Oil companies, by aggregating even marginal efficiency gains across a large fleet, can financially appreciate the value of efficiency far more than any single consumer. Aligning the efficiency incentive with oil companies will create stronger market pressures towards increased efficient vehicle deployment. Customers will still benefit from efficiency gains by entering into service contracts with fuel providers for fuel discounts. This will send much clearer price signals to consumers, who will be faced with a cost of travel per mile discounted by their vehicle fuel efficiency at each refueling event.

Some customers are likely to push back against changes under the plan; mile prices will appear abstract and foreign, and metrics like miles-per-gallon (MPG) may become meaningless. While selling fuel by the mile will make the economics of fuel and travel costs more clear, customers will likely be unhappy to have their driving habits more clearly represented in their fuel costs. Under the plan, customers who's driving behavior significantly reduced their mileage, would end up having less "range" than they purchased.

Policymakers should find mileage-based contracts much less onerous than blunt instruments like command and control regulation. The plan proposes no new taxes or performance standards for companies, but instead implements a market mechanisms to send clear price cues; a concept with strong theoretical and empirical underpinnings (Singh & Sirdeshmukh, 2000). Political feasibility is discussed further in the next section.

3.2 Policy Opportunities and Challenges

The US is beginning to see the effects of several years of pro vehicle-efficiency policies: from direct subsidies for vehicle retirement ("Cash for Clunkers" under AIRA) and new vehicle purchases (PHEV/EV tax credit), to the Corporate Average Fuel Economy Standard (CAFE). CAFE is expected to raise the average fuel economy of new vehicles sold by 24% (for light duty vehicles), and 35% (for small trucks), between 2011 and 2025 (Bastani, Heywood, & Hope, 2012). The projected share of transportation energy consumed by light duty vehicles is expected to decrease due to increased fleet efficiency, even as the number of vehicle miles traveled remains relatively constant (U.S. Energy Information Administration, 2014).

Under the business as usual case, oil companies are under pressure from both vehicle efficiency gains and alternative transportation fuels. Increased use of natural gas, biofuels, and electricity, combined with vehicle efficiency gains, are squeezing the market for conventional gasoline. But the underlying demand (e.g. mobility) remains unchanged, and by implementing this proposal, fuel companies can monetize increased efficiency by capturing more of the fuel sales to the most efficient strata of the fleet. The plan encourages vehicle manufacturers and oil companies to explore partnerships to capitalize on the considerable profits made available.

A structural limitation of CAFE is that it allows car companies to decide how they will meet an aggregate floor for fuel economy. This means that car companies can produce a portfolio with very bimodal distribution of MPGs, some very efficient cars and the rest very inefficient cars. Very high efficiency vehicles, much higher than the floor, are marketed, but at high prices points to affluent, early-adopting households. Under the plan, car companies would be pressured by oil companies to meet aggressive efficiency targets for affordable, mass-market vehicles. The plan could increase the selection of high efficiency vehicles available to low-income households, not just the selection of new technologies for affluent, early adopters.

Increases to the efficiency of the fleet overall under CAFE will occur by transitioning a portion of the market to very efficient vehicles. Government incentive programs have short life spans, and private sector partnerships are needed in order to support continued rollout of fuel-efficient vehicles. The plan, as proposed builds upon CAFE using a market mechanism (mileage-based fuel contracts) to create the opportunity for oil companies to profit from increased vehicle fleet efficiency. Faced with this new source of revenue, oil companies will be highly incentivized to encourage further growth in the market for highly efficient vehicles.

In addition to an act mandating per mile gasoline sales, the plan would by default require structural changes to the nature of both state and federal gasoline taxes. These taxes would be assessed at the mile level, meaning that gasoline taxes become a de-facto tax on vehicle transport. These taxes could also be structured to reward efficiency, and even be defined regionally. Under the plan, gasoline taxes become a more nimble policy instrument, better able to address equity issues than a flat gasoline tax. States would also have increased flexibility to use travel based gasoline taxes to support regional transportation or air quality objectives. Still, altering the gasoline tax is historically unpopular, and could represent an obstacle to the plan as proposed.

The plan faces other political challenges, not the least of which is that the sale of gasoline would become heavily restricted. Some exceptions are likely for institutional customers and fleets to purchase fuel in bulk, but this restriction is likely to engender opposition. Oil companies may view the move as disadvantageous, especially in the short run, and so may be opposed to the contract system.

3.3 Economic and Financial Implications

The economic and financial implications for adopting a mileage-based contract approach to fuel sales are significant. The following analysis showcases the tremendous profits that can be realized across the fuel supply chain through widespread adoption of this mechanism. To better assess the economic and financial benefits, we conducted Monte Carlo Simulations to determine fuel consumption and travel behaviors for 10,000 drivers accessing two retail gasoline stations. We ran 200 simulations for each station to determine how a station operating under the traditional gasoline-sale model would do compared to a station operating under a mileage-based contract model. On average, stations operating under a mileage-based contract model will do better than stations operating under a conventional-distribution model across a multitude of scenarios.

In the business as usual case (Figure 1), station profits will decrease each year as the average fuel economy for vehicles in the U.S. increases. The marginal cost of gasoline procured is unlikely to decrease due to rising demand in the developing world. Retail stations already operate at very low profit margins due to the hyper-competitive nature of retail station ownership. As such, the profit margins on a gallon of gasoline are also expected to remain relatively constant. Because fuel economy for vehicles increases gradually over time, the quantity of gasoline demanded by each vehicle will gradually decrease at the aggregate level. This will ultimately result in a decrease in the average profit realized per vehicle that is serviced at a given station. Switching to a mileage-based approach for fuel sales improve this result, as the demand for miles does not decrease to the same degree that the demand for gasoline does.

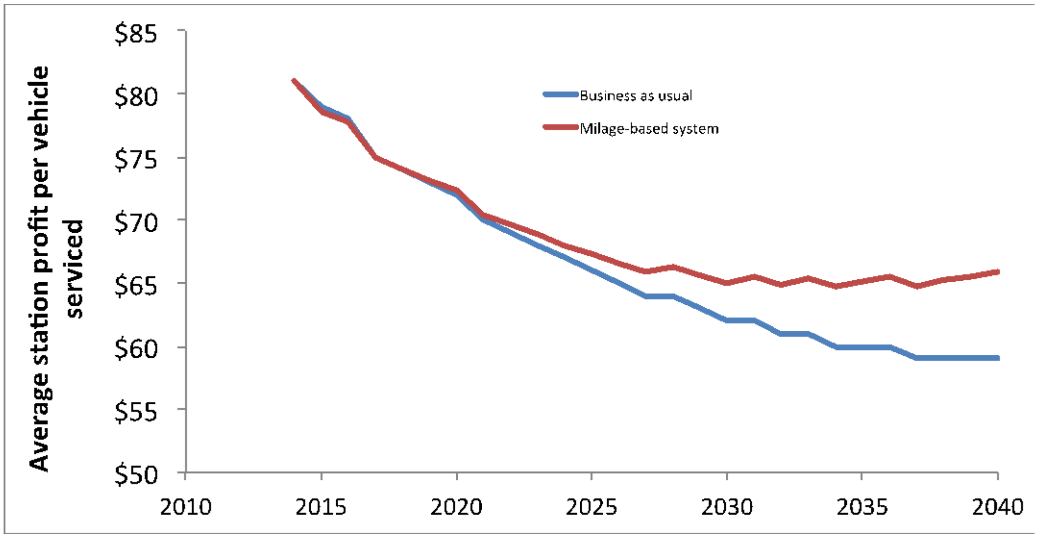

Figure 1. The profit per vehicle serviced at each retail station will decrease over-time due to implementation of the current CAFE standards, in addition to a projected decrease in the number of miles driven

Under our mechanism, in which stations sell miles as opposed to selling gallons of gasoline, the overall profit realized per vehicle will be substantially higher than under the BAU case. There is still a decline under the mileage-based scenario due to a decrease in the projection for the number of miles traveled each year over time. Projections used for this analysis were taken from the EIA's Annual Energy Outlook (U.S. Energy Information Administration, 2014).

In light of dwindling station profits, a mileage-based approach makes sense for gasoline retailers. Also, as we move further up the supply-chain, a mileage-based contract approach begins to make sense for fuel distributors and fuel producers due to the substantial profit that can be captured for each vehicle sold that operates at higher fuel efficiency compared to the fleet average.

If a set of retail stations operating under a contract with a given fuel producer are capable of attracting a distribution of vehicles with fuel economy slightly higher than the national average, tremendous profit can be realized. This is due to the fact that stations compete with one another on the visible price per mile. The quantity of fuel that must be obtained to allow drivers to travel that number of miles remains hidden. Because travel patterns are unlikely to be substantially different for each pool of drivers, the overall miles serviced by both stations is expected to be the same.

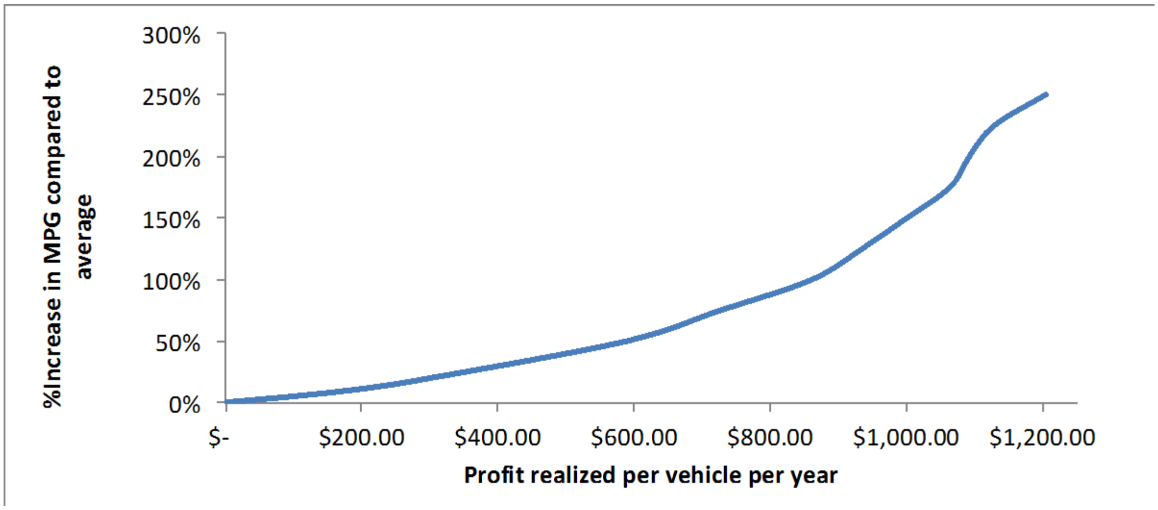

Figure 2. Amount of profit that can be gained per vehicle for improvements in fuel economy beyond the average fleet fuel economy.

As shown in Figure 2, the average annual profit to be realized from a vehicle with only moderate improvements to fuel economy is considerable. A 4% improvement in fuel economy at a given station could effectively double that station's profits compared to other stations operating under the average fleet fuel economy distribution. For this profit to be realized, however, fuel providers would have to be fully vertically integrated. Given that not all stations are owned and operated by the same entities that produce and distribute fuel, fuel producers will have to enter into profit-sharing agreements with retailers to further encourage retailers to support more fuel-efficient vehicles. There is tremendous potential for fuel providers to considerably expand profits under this mechanism, and therefore there is incentive to attract more fuel-efficient vehicles to their refueling infrastructure.

Given the profits that can be realized, we expect to see agreements between automotive manufacturers and fuel providers, as well as other strategic business decisions, that bring fuel-efficient vehicles to specific fuel-providers' stations. We look at the Net Present Value (NPV) to fuel producers for each new vehicle sold with a given improvement to fuel efficiency. To better assess this profit incentive, we have discounted the yearly profit advantage of a more fuel-efficient vehicle by the expected increase in average fuel economy (2% per year), and we assume 3% inflation over a 15-year period. We assume that fuel providers, interested in capturing profit, will promote the production of these fuel-efficient vehicles, and so are willing to pay the additional costs associated with improving fuel efficiency. We subtract the costs associated with improving fuel efficiency as given by Klier and Linn (2012) from the NPV for each vehicle. Based on this, Figure 3 shows the additional profit to be realized by fuel providers for each new vehicle sold with a given fuel-efficiency improvement over a 15-year period.

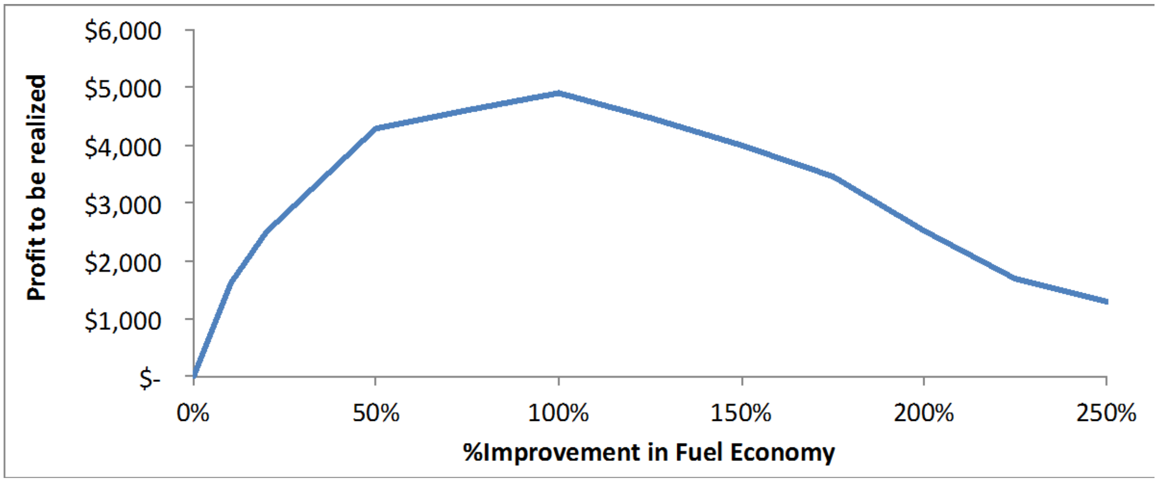

Figure 3. Additional profits to be realized by fuel providers for each vehicle sold with a given MPG improvement that continues to utilize their fueling infrastructure over 15 years.

To entice these fuel-efficient vehicles to use a given fuel provider's fueling infrastructure, some sort of corporate-incentives will be required to entice the user to fuel up at their stations. This could amount to discounts, rewards, or any number of other viable business practices to improve customer loyalty. Some options may include hardware restrictions associated with the vehicle that, when integrated, results in higher mileage-purchase prices at out-of-network stations. We suspect that one of the more compelling approaches under this mechanism is for oil producers to form direct partnerships with automakers, where vehicles under that partnership will be equipped with proprietary hardware that provides high-efficiency vehicles with discounts and rewards for utilizing a given provider's refueling infrastructure.

A direct partnership between automakers and oil producers will be advantageous and ultimately profitable for both parties. This partnership will likely drive the sales of the automaker insofar as an oil provider's efforts to attract customers into their customer loyalty program will simultaneously encourage purchases of the automaker's vehicles. A partnership with automakers allows oil producers gains influence over the fuel efficiency of the fleet which they serve.

4. Implementation Challenges

4.1 Marketing

The goal of the mileage-based contract is to increase the fuel efficiency of the current vehicle fleet. Encouraging consumers to adopt fuel-efficient cars under this strategy is straightforward. As has been mentioned above, the price of miles that consumers face under the mileage-based contracts depends on the fuel efficiency of their vehicle, and the discounts that a given fuel provider is willing to provide to entice customer loyalty; more fuel-efficient cars will be entitled to receive larger fuel discounts. The magnitude of these customer-loyalty incentives can be large, as seen in figure 4 below.

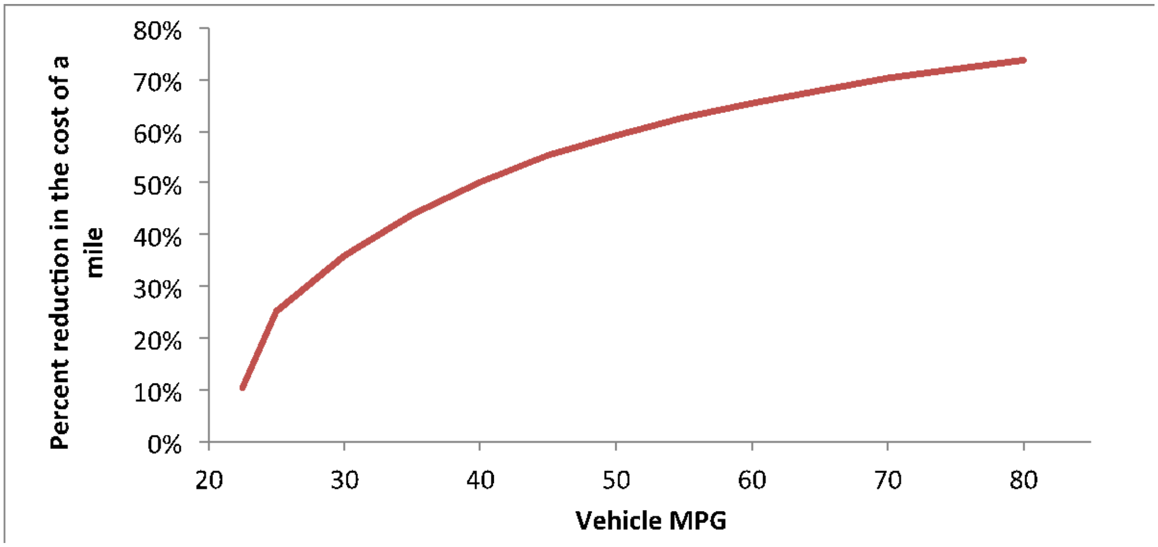

Figure 4. The percent reduction in fuel cost required for a fuel retailer, under the mileage-based contract scenario, to realize identical profits to fueling that same vehicle of a given MPG rating under the business as usual scenario.

Figure 4 depicts the maximum discount[1] a fuel provider would give vehicle owners for vehicles with different fuel efficiencies. This is the same reward that consumers currently receive under the business as usual case for purchasing a fuel-efficient vehicle. Although the discount is large, consumers presently do not largely factor this discount in to their vehicle purchasing decisions (Turrentine & Kurani, 2007). Consumers, however, may show loyalty to servicing stations for receiving only a moderate portion of this discount during regular fueling events. These discounts can consequently be monetized by fuel providers to entice consumers to utilize their fueling infrastructure.

Advertising will also play a large role in marketing mileage-based contracts. Upon forming partnerships, oil producers and automakers will engage in advertising campaigns informing consumers about the newly formed partnerships, as well as potential discounts being offered. Automakers and oil providers already conduct substantial advertising, and consequently publicizing the benefits of the mileage-based contract will be a straightforward endeavor. Additional synergies will likely exist, as partnering companies will provide similar messages to the public.

One final complication of the mileage-based contract stems from the fact that different vehicles will ultimately receive different prices for a mile from stations in their 'loyalty network'. Consequently, it is not clear what price should be advertised on fuel retailor signage. To reduce confusion, the market price for miles (i.e. the price with no discounts) will be the price conveyed by retailors. Consumers will obtain information about a given discount upon filling up. Section 4.2 below will discuss how this works in detail.

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[1] The discounts are obtained by first calculating the profit which a firm would make under the BAU scenario as well as the mileage-based contract without discounts. The discount is then introduced and the profits of the mileage-based contract are discounted until they equal the profits of the BAU scenario.

4.2 Infrastructure Requirements

Adequate implementation of mileage-based contracts would require substantial modifications of today's fueling system. On-board vehicle electronics would need to be standardized to enable fuel retailers to estimate the miles-per-gallon rating for any vehicle filling up at their station (so as to not provide too few or too many miles under the contract). Vehicle OEMs and third-party companies already have extensive software and hardware solutions that can readily detect, record, or transmit the model, make, and the unique identification of a car alongside odometer readings. For instance, service fleet transponders are already widely used for mileage deductions and expense reporting. These systems could easily be adapted, and could become standard components of vehicle electronic control units as car companies and fuel companies develop partnerships.

In addition to electronics on the vehicle side, refueling stations will also require technical upgrades to allow pumping stations to both sense vehicles, index contract pricing schemes, and display the appropriate price per mile after vehicle-efficiency discounts have been applied. These upgrades would present different economic challenges for differently integrated fuel providers, and may represents significant cost hurdle for independent fueling stations. Data security could also be an issue, as mileage data could be attached to sensitive consumer information and transmitted back and forth from the vehicle.

A variety of wireless communication technologies are increasingly being integrated into vehicles and could be used to transmit secure or anonymous fuel efficiency information. These include digital cellular communications, wireless LAN systems, Bluetooth systems, and digital short-range communications (DSRC). DSRC is a high frequency radio transmission system capable of both point-to-point and local wireless broadcast communication within a small area (Tengler & Heft, 2009). As vehicle information systems are already collecting data like fuel efficiency, information could be communicated with fuel pumps with just the addition of DSRC systems, and the US Department of Transportation is considering requiring implementation of DSRC into all new vehicles (Kenney, 2011). A range of patents exist for different types of transceivers, but typical costs for high-frequency transceiver chip sets range from ~$15 up when purchased in small volumes (Kamal, Lou, & Zhao, 2012). If these technologies become standard on all new vehicles, the cost of integration would solely be on the side of the refueling station. These costs would likely be offset by increased revenue under the plan.

To facilitate the adoption of hardware into existing on-road vehicles, the government will have to provide free installation services in addition to public service announcements and information for drivers. Information disseminated across all major retail stations may help facilitate this process. In turn, retail stations can incentivize consumers to obtain the necessary, free hardware by charging a higher cost for miles purchased by vehicles not carrying the required transponders. The cost of transponder installation can be offset by the social benefits from reduced emissions due to higher vehicle efficiency, in addition to the mileage-based tax that the government will levy which is a more progressive tax, effectively taxing consumers based on infrastructure use, rather than gallons of gasoline purchased.

4.3 Supply Chain Implications

The implementation of mileage-based contracts has the potential to create broad impacts on the supply chain for vehicle travel provision. For oil companies, the plan could increase vertical interactions with refueling stations, which would be responsible for implementing service contracts and be the front line in customer interactions. The plan could have different implications for different types of vertical contracts for gasoline retailers, and could further encourage vertical integration. Increased vertical integration of fuel retailers could provide a benefit to customers: substantially increasing the number of vertically integrated stations does not necessarily increase local prices for gasoline (Hastings, 2000), and there is some evidence to suggest vertical integration decreases the price consumers pay for fuel overall (Shepard, 1993).

Both the degree (extent) and type of vertical integration vary across the fuel sector, and this interaction has at least some impact on gasoline prices (Hastings & Gilbert, 2005). Mileage-based contracts could create additional benefits to integration, like lowering logistical costs of management and marketing, and could also impact the margins of independent gasoline retailers. Gasoline retailers could benefit from decreased uncertainty of profit margins, as the plan should encourage customer loyalty/dependability. Completely independent gasoline retailers would be faced with a difficult decision on which firm to enter into an arm length contract with, and whether they could be restricted from participating in multiple firm's mileage based contract programs.

Mileage-based contracts also have implications for the vehicle supply chain, as car companies will now have a much stronger interest in encouraging the market for more efficient vehicles. Oil companies will profit from capturing the most efficient shares of the vehicle fleet, and therefore have clear incentives for increasing the size of that market by working with car companies to incentivize the purchase of these vehicles. Car companies have already experienced considerable market pressure to meet increased fuel efficiency targets, both from regulatory policy and economic drivers (i.e. fuel price). Carmakers could therefore stand to benefit from the ability to differentiate themselves based on fuel price contracts attached to vehicles. They also benefit from customer exposure, as car buyers have much more frequent interactions with fuel providers.

Oil producers will ultimately be faced with two marginal cost curves as opposed to one: the marginal cost of oil extraction, and the marginal cost of improving vehicle fuel efficiency. As the fuel profit margin increases directly with increased efficiency, oil companies would be incentivized to push for ever-more aggressive fuel efficiency targets.

4.4 Strategy

Miles-based contracts are a market-based approach to increasing fuel-efficient vehicle ownership. Oil producers, under a mileage-based contract, are incentivized to increase the MPG of the fleet they serve. As has been outlined above, oil producers can conceivably achieve this goal with a two-pronged strategy. First, oil producers will partner with automakers. This partnership is natural insofar as it facilities a channel by which oil producers can increase the number of fuel-efficient vehicles which they serve. Second, oil producers will provide discounts to customers with fuel-efficient vehicles, thus incentivizing consumers to purchase fuel-efficient vehicles supplied by automakers, and to increase customer loyalty. Mileage based contracts, therefore, simultaneously increase the supply and demand of fuel-efficient vehicles and in doing so provide a least-cost solution to what has been referred to as the "chicken and egg" problem for improved vehicle efficiency[2].

The strategy for introducing the mileage-based contract can be split into two steps:

- *Political Phase*

The concept of the mileage-based contract is completely reliant on legislation mandating per mile gasoline sales. Without such legislation, mileage-based contracts are not feasible. Section 3.2 discusses the political feasibility of mileage-based contracts. In general, the mileage-based contract is beneficial to both consumers and producers. Consequently, it is politically feasible to pass legislation mandating per mile gasoline sales.

- *Marketing Phase*

After the legislation discussed above is passed. Oil producers will be incentivized to increase the average fuel-economy of the fleets that they serve. To do this, as has been outlined above in section 3.1, oil producers will partner with automakers. Upon forming this partnership, oil producers and automakers will proceed as follows:

1. As discussed in section 4.1, oil producers along with their automaker partners will advertise their partnership as well as prime their consumer base for the forthcoming transition to a mileage based contract.
2. In anticipation of the transition to a mileage based contract, oil producers will install all necessary infrastructure discussed within section 4.2. Further, oil providers need to engage in bilateral agreements discussed in section 4.3 with franchisees to assure that miles are discounted for loyal customers utilizing fuel-efficient vehicles.
3. Finally, oil producers will transition from selling gallons of gasoline to miles. Oil providers will engage in a customer loyal program, as mentioned in section 3.3, to attract customers with fuel-efficient vehicles.

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[2] The "chicken and egg" problem refers to the fact that the demand for fuel-efficient vehicles is not sufficient to allow automakers to realize economies of scale in production. The source of weak demand is due the fact that both the annual turn over rate of light-duty vehicles and the number of fuel-efficient vehicles, as a percent of all new vehicles purchased, is small.

5. Conclusion

While there are difficulties associated with implementing the mileage-based contracts mechanism, we find the arguments for implementation compelling. Today's government policies already require moderate improvements in vehicle efficiency over time. These improvements are set to erode profit margins for existing gasoline retailers. As we further move away from carbon-intensive fuels to low-carbon pathways for transportation, fuel providers will continue to experience decreased demand and dwindling business opportunity. By implementing mileage-based contracts, fuel providers will be able to transition to a service-model for business operations.

By moving to a service model, fuel providers will be able to maintain profitability while being faced with increased vehicle efficiency and the need to transition away from conventional fossil fuels. Vertically integrated oil and gas companies will find it beneficial to create business partnerships with automotive manufacturers to increase customer loyalty for drivers of fuel-efficient vehicles. As vehicle efficiency increases, fuel providers will be able to provide the same, or higher-levels of service at reduced cost, ultimately improving profits. Consumers will be rewarded through customer loyalty, and will receive obvious discounts from fuel providers for purchasing and using more fuel-efficient vehicles at the point of sale. Mileage-based contracts serve to align customer and producer incentives to achieve better environmental outcomes and to form profitable business models predicated on energy efficiency.

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Biodiesel and Electric Vehicles in a Multi-Fuel World

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While our goal is to have electricity and algae biodiesel produced for vehicles and consumed everywhere, it would be extremely difficult and ultimately unnecessary to launch a new fueling system across the entire United States at the same time. Instead, we will focus on launching a few sustainable, alternative fueling plans in select regions with select target markets. From this base, sales can be expanded into remaining markets as technology drives down costs, and profit margins can be increased as we gather more data on how to sell alternative fuels.

Our chosen alternative fuels for a cleaner environment and more sustainable fuel industry are electricity and biodiesel, since these technologies can utilize existing infrastructure in the form of existing electrical grids and existing fuel pumps designed for petroleum products. In addition, since biodiesel uses existing diesel engines, the automobile industry's cooperation is not essential to its success, meaning there are fewer stakeholders that must be coordinated. Meanwhile, electric vehicles require that automobile manufacturers take part, but don't require as many resources from the fuels industry. Finally, these two technologies have the potential to replace almost all petroleum products in the fuel industry today because biodiesel can act as a direct replacement for petroleum-based diesel. All of these factors contribute to making biofuels and electricity our chosen alternative fuels for the future of the transport industry.

Part 1: Stakeholders

Our plan is targeted towards those companies who currently produce, transport and sell petroleum to consumers, as well as automobile manufacturers, since they will need to produce the electric vehicles that we advocate for. Our plan also brings new stakeholders to the current fuels market, including those who would produce and refine algae biofuel into fuel for conventional engines, as well as local businesses surrounding supercharging stations. All of these businesses will have to cooperate with governments at every level to achieve profitability in a multi-fuel world.

Part 2: Satisfying Societal Goals and Making a Profit

Alternative fuels can only be attractive to stakeholders if they accomplish both business and societal goals, which are locked in a symbiotic relationship. So, we must ask ourselves two, mutually dependent questions: Does adopting an alternative fuel meet environmental, social and socio-economic goals? And, can adopting alternative fuels be profitable?

Alternative fuels will only get subsidies from federal, state and local governments if they show they benefit the environment, and that with those subsidies the fuel will be of a comparable price to traditional petroleum. Electric vehicles meet these goals by reducing fuel costs for the consumer, while producing 38 percent fewer pounds of carbon dioxide than "conventional gasoline vehicles", according to the Alternative Fuels Data Center, which is a part of the US Department of Energy. First generation biofuels, especially corn-based in the United States, do not meet these requirements because their production does not reduce emissions greatly enough. In addition, first generation biofuels depend on crops that could be consumed for food, making them societally impractical and an inefficient use of agriculture. This leads us to second generation biofuels, those which use algae or non-food crops to produce fuel.

Unfortunately, meeting societal goals for the improvement of our environment isn't enough. Businesses that engage in this venture must also make a profit to encourage new companies to join in and drive innovation in the industry. Since societal goals are being met by these technologies, many levels of government already offer subsidies for vehicles that run on electricity and biofuels, making it easier for businesses to make a profit (see: Appendices B and C). However, this does not guarantee profitability. To make a multi-fuel future based on the use of electricity, biofuels and traditional petroleum possible, we must examine where and how to roll out these fuels.

Part 3: Public Policy and Target Markets

Before we can market and sell alternative fuel, people need to buy the vehicles which run on alternative fuel. Since electric vehicles are initially more expensive to consumers than traditional gasoline-powered vehicles, and second generation biofuels will initially cost more than traditional petroleum, a wise strategy for automobile companies and electric utilities would be to first target the luxury vehicle market, where consumers can afford to purchase and operate such vehicles. We will outline this by examining state's markets for high-cost alternative fuel vehicles, how many subsidies and incentives those states offered, and their overall business environment.

Before we do that, we must address how this will achieve our end goals. Targeting only the rich with electric and biodiesel vehicles will bring some environmental and social benefits, but selling these vehicles and their fuels to the average consumer is our end goal. This can be achieved through the slow resale of electric vehicles as their owners decide to upgrade, meaning these vehicles will begin to make their way into the middle class, where they will help promote electric vehicle's quality and practicality. By combining these used car sales with lowering prices for batteries and therefore electric vehicles in general, it will become ever easier for consumers to purchase such vehicles, and therefore for our social and environmental goals to be achieved. However, first these vehicles must be sold to those who can already afford them, and that means targeting luxury vehicle markets.

In order to examine state's markets for high-cost vehicles, we chose to examine both their sales of luxury vehicles and luxury vehicle ownership per capita. Having high luxury vehicle sales volumes will enable the sale of cars that have higher up-front costs, without the need for as much customer education on the long-term benefits of electric vehicles. It should be noted that presently, the volume of sales of electric vehicles do not always correlate with luxury vehicle sales. Therefore, our examination of luxury vehicles sales must be viewed not as actual sales volume, but rather the potential for sales. To do this, we utilized a list of states who have the highest number of car sales as a fraction of total sales (Elliot 2009).

The states with the most luxury vehicles per capita were then calculated by dividing luxury sales by state's estimated population in 2009 (Statistical Compendia Branch, ACSD) (Appendix A). This produced a pair of lists: most total sales, which was led by California, and then Florida, New York and Texas, and sales as a fraction of the total population, which was led by Florida, then California, New York, and New Jersey. In this data, Georgia came in a distant eighth in total sales and ninth when examining sales per capita. This is significant because it may dispute other data we considered about the ownership rates of luxury vehicles (as opposed to the quantity of sales of electric vehicles in 2009).

In a survey conducted by Kantar Media TGI, a market research firm (Sullivan 2014) which looked closely at 8 states per capita ownership of luxury vehicles, only Georgia (14.2%) and California (14%) were more than one point above the national average of 8% among the 8 sampled states. Other states that were examined included (in order of per capita ownership rate) Texas, Florida, New York, Illinois, Pennsylvania and Ohio. Illinois, Pennsylvania and Ohio came in below the national average. This ownership data is in line with the previously examined car sales for the states of California, Florida, New York and Texas; all of which are candidates for rolling out alternative fuel vehicles. The ownership data also presents Georgia as one of the best markets for luxury vehicles, which wasn't obvious from our sales data. This could be because Georgians own their luxury vehicles for longer periods of time than other states, or perhaps 2009 was a bad year for luxury vehicle sales in Georgia.

After using state-by-state data to evaluate the U.S. markets for luxury vehicles, we found that California, Florida, New York, Georgia and Texas are the best candidates for selling alternative fuels. New Jersey, Pennsylvania, and Virginia also deserve honorable mentions for their per capita ownership of luxury vehicles. This concurs with our original assertion that luxury vehicle markets make good markets for electric vehicles, since the current top buyers of electric vehicles are California (by a lot), followed by Hawaii and Washington, and then followed again by Oregon, Georgia and Maryland (Hill 2014).

Another factor to consider when rolling out alternative fuel vehicles is how likely local governments are to help, especially when it comes to subsidies and tax breaks. We recorded data on the eight states previously mentioned as being among the first and second tiers of candidates for increasing alternative fuel using vehicle's market share (Appendices B and C). Colorado was also added because of the sheer size of its subsidies.

Although it's often unclear which subsidies would apply to which vehicles, what is clear is that some states are much more open to alternative fuels than others. The first alternative fuel type we examined was electricity, or plug-in electric vehicles. California's list of different subsidies for electric vehicles is much longer than every other state, but Colorado and Georgia actually have the potential for the largest subsidies, depending on if the vehicle itself meets certain criteria. The other top states appear to be, in order from most to least supportive, New York, Texas, Pennsylvania, New Jersey (surpasses Pennsylvania for vehicles costing more than $43,000), Florida, and Virginia. Virginia and Florida are last and second to last in these rankings. Virginia imposes a fee and awards no subsidies for electric vehicles, because owners of these vehicles are not contributing to the gas tax. Florida awards up to 1,000 dollars, and that is only for supply equipment, and only in areas under the authority of the Orlando Utilities Commission. New York, Texas, Pennsylvania, and New Jersey are more or less interchangeable in this list, depending on if customers can take full advantage of their mid-level subsidies.

In addition to examining subsidies and tax breaks for electric vehicles, we also evaluated them for biofuel-using vehicles (Appendix C). The best states for private-sector biofuel, as determined by those that provide subsidies but don't seem to levy additional taxes, are Texas, New York, and Florida. Texas requires state vehicle fleets to adopt renewable fuels, including biodiesel, and provides, "...grants for 50% of eligible costs, up to $600,000, to construct, reconstruct, or acquire a facility to store, compress, or dispense alternative fuels in Texas air quality nonattainment areas. Qualified alternative fuels include biodiesel...." (Afdc.energy.gov 2014). New York provides a state tax credit for qualifying biofuel producers up to $0.15/gallon. Meanwhile, Florida provides a large income tax credit for those involved, "...in the production, storage, and distribution of biodiesel (B10-B100), ethanol (E10-E100), or other renewable fuel....", but the tax credit is capped at, " up to $1 million annually per taxpayer and $10 million annually for all taxpayers combined," (Afdc.energy.gov 2014).

Next come the suite of states that either don't provide direct fuel subsidies or only offer the potential for sales to the public sector, namely Pennsylvania, Colorado, and New Jersey. The best option here seems to be Pennsylvania, which has a mandated biodiesel blend tied to in-state production after said production exceeds 100 million gallons. To make the deal even sweeter in Pennsylvania, the subsidy increases as production increases. Colorado mandates that, "all state-owned diesel vehicles and equipment [are] to be fueled with a fuel blend of 20% biodiesel (B20), subject to the availability of the fuel and so long as the price differential is not greater than $0.10 more per gallon as compared to conventional diesel," (Afdc.energy.gov 2014). New Jersey also forces the state to use biofuel, but only if it's cheaper than gasoline or diesel.

Other state's messages are mixed and sometimes negative, and these states include California, Virginia and Georgia, with Georgia being the worst among the nine examined states. California provides a myriad of incentives, but they were largely of questionable value, and a better use of political support seems to be in grants and biofuel research. Virginia's subsidies appear great, but because Virginia also taxes alternative fuels at $0.111 per gallon, they lose much of their advantage. Georgia, the last state, imposes a biodiesel tax of $0.075 per gallon. It does provide a subsidy of $2,500 for purchasing alternative fuel vehicles, but this subsidy excludes biofuels of all kinds.

Another factor to consider when sourcing a new fueling industry is a state's overall business climate. This is no doubt difficult to measure, since it depends on everything from business costs to the ability for the economy of that state to grow. Fortunately, Forbes compiles a list every year (Forbes 2014). Among the eight states we are examining for their large luxury markets for cars, Virginia (4) comes in first on Forbes' ranking, followed by Texas (6), Georgia (16), New York (17), Florida (19), Pennsylvania (30), California (37), and New Jersey (41).

From all of the above data, we can finally identify the best candidate states for launching a transition to alternative fuels. For electric vehicles, the best places to target the drivers of luxury vehicles are New York, Georgia, Texas and California. Pennsylvania is also an option, but not as attractive, with other states being poor bets. Overwhelmingly, the best state for biofuels is Texas. Florida is also a potential option, followed by New York and Pennsylvania. However, since sustainable and environmentally friendly second-generation biofuels are still largely confined to smaller scale operations, we will only focus on how to make these biofuels work in Texas.

Part 4: The Economics and Infrastructure of Alternative Fuel

Now that we have identified a number of places where a rollout of alternative fuels will have the highest chance of success, we must identify how to profit off of these fuels. Successful marketing on the part of automobile manufacturers will be integral to the success of the electric car venture, because without great marketing, their high up-front cost and a lack of consumer knowledge about long term advantages over petroleum could doom any rollout. Fortunately, there are a number of factors favoring alternative fuels. They are typically better for the environment, electric vehicles have lower fuel costs, and biofuels are an easy transition because they can be used in traditional internal combustion engines. Finally, it's a new market with the potential for a lot of growth, so early entrants have the potential to capture a large market share.

Since the strategies for making money off of electric and biodiesel fuels are dramatically different, we will examine these fuels separately, starting with electricity. Electric vehicles have the benefit of being less expensive to operate, but, there are relatively few existing commercial charging stations. Owners can charge their cars at home and sometimes at work, and only have to visit 'supercharger' stations when they're taking trips beyond the range of their batteries, which accounts for about five percent of all trips today (Solar Journey USA). This will lead to fewer visits to stations' convenience stores. To address this problem, a number of proactive steps should be taken to ensure profits in the fueling industry won't decline.

Perhaps the best solution is to shift away from having fuel as a major source of a station's income. This can be done with supercharging stations by marketing them not just as convenient places to 'fill up', but as places where the consumer can have find entertainment. Since it takes so long to fully or even partially charge electric vehicles, with times for a Tesla Model S being 40 minutes for an 80% charge and 75 minutes for a 100% charge from a Tesla supercharging station (Teslamotors.com 2015), the surrounding area could be a local business center. Stations could also offer to set up shop in local business centers only if they were paid for every customer who went to the station to charge their vehicle.

The expense of buying new land or converting an existing fueling station into one that can host electric vehicles can partly be paid or subsidized by electric companies, who should be bargained with until fueling stations receive better rates on their electrical bills than a consumer could get at home. Electric companies can already see the silver lining of electric vehicles (Edison Electrical Institute 2014), and offering them increased demand in exchange for the dramatic increase in electricity usage from the existence of the supercharging station is not unreasonable.

Unfortunately, not every gas station can become a supercharging station. There just isn't as much demand for stations when you can charge your vehicle at home. Therefore, many stations will have to adopt a different strategy, relying less on gasoline to pull in customers and generate revenue, and more on revenue from their convenience stores. This means smaller profits, and weeding out less efficient stores.

Companies that sell diesel will be able to adapt in other ways. There are avenues for growth in biofuels and the creation of their supply chain, and traditional petroleum will remain a major player in the fuel mix for decades to come.

Biofuels will be more difficult to make money off of, at least in the short term. Their long-term advantage is in their environmental sustainability, and that they can be carbon neutral. Their short-term cost is in a lack of existing infrastructure to make fuel out of algae or crops which could not be used as food. As is typical with alternative fuels, the infrastructure does not exist because demand does not exist, and demand does not exist because production lacks sufficient scale to be competitive with petroleum.

Consequently, biofuels are the ultimate challenge in terms of cooperation. Before a major launch can occur, test farms must be economical. Presently, biofuels derived from sustainable methods are too expensive, with prices "...two to three times as high as the current price of gasoline on an energy equivalent basis," (Carriquiry, Du and Timilsina, 2010). Therefore, in order to make money from second generation biofuels, there will have to be greatly improved production methods, followed by crop-based biofuel subsidies being reallocated to algae and non-food crop-based biofuels. From 2006-2012, the United States invested $92 billion in taxpayer dollars from the Energy and Farm bills to support the biofuels industry (International Institute for Sustainable Development 2007). Assuming technology for the production and refinery of algae into biodiesel continues at its current rate, these massive subsidies from the federal government could be much better spent on a fuel that does not require the loss food crop for a growing population, or the intensive agriculture that makes many of today's corn- and soybean-based fuels such an inefficient energy balance (Stauffer 2007).

Part 5: Marketing Electric and Biodiesel Vehicles

Marketing biofuels that aren't produced from food crops will take time, but should not require much effort. In the beginning, the price per gallon of sustainable biofuels may be higher than petroleum, making biofuels look like poor substitutes for petroleum. However, since there is no significant increase in the cost of the vehicle, it's reasonable to project that environmentally conscious consumers will use the fuel, and those environmental benefits can be marketed. Biofuel also runs more cleanly than traditional petroleum, so cars will need less maintenance, and can result in better fuel economy (Perritano).

As biofuels become more economically viable, this marketing pitch will change. At first, it will focus on the environmental benefits, since the fuel will still cost more than normal gasoline, even though the vehicle itself need not cost more. As biofuels approach the cost of traditional fuels, they can also be marketed as a fuel that won't fluctuate in price like traditional, foreign gasoline. Finally, as biofuels approach price parity, they will be just another fuel that a consumer can choose from, yet cleaner and more sustainable than even electricity.

Marketing electric vehicles may prove to be tricky, and since the primary participant in making electric vehicles feasible is the automobile industry, we'll focus on how to sell these vehicles to the public. The main problem that consumers see in electric vehicles is their high up-front cost. Marketing can show where this assessment of electric vehicles as being more expensive is wrong. The vehicle's operating costs consist of electricity and general maintenance. Both of these costs are significantly lower than they are in petroleum powered vehicles. The US Postal Service found that owning an electric car can save ten cents (46%) in maintenance costs per mile in addition to savings on fuel (Touchstoneenergy.com). Those savings add up to 16,500 dollars for the average car currently on the road (Tuttle 2012). In addition, if the price of a battery pack per kilowatt hour falls below 200 dollars by 2020, as is predicted in a McKinsey study (Berman 2012), electric vehicles will become price competitive with gasoline vehicles over the vehicle's lifetime, even when ignoring savings on maintenance. The best way to illustrate this to consumers is to factor in the average electricity and maintenance savings of consumers into the monthly price of a vehicle, much like how Tesla does today on their website (Teslamotors.com). Therefore, the marketing of electric vehicles for automobile companies will soon be able to focus on how much less expensive they are, in addition to informing consumers about how electric vehicles work. This will fall in line with what research shows as the most important thing consumers consider when purchasing a new vehicle: the vehicle's fuel economy (Fuels Institute 2014).

Part 6: An Examination of the Supply Chain and Infrastructure Requirements

Our primary goal when choosing electricity and biofuels as our alternative fuels was to minimize disruption to existing infrastructure- the supply chain and the general practices of the industry. Electric vehicles will work against the industry, in that they depend very little on existing infrastructure or supply chains to work. Biofuels are the exact opposite, relying heavily on today's infrastructure and supply chains to continue to supply regular gasoline and diesel to markets while biodiesel slowly becomes a viable option for consumers. Therefore, as we have in previously, we'll address both of these fuels differently.

Biofuel from algae will primarily be produced in warmer climates, although as technology and facilities improve, they can eventually be added to all regions of the United States, so long as there is a viable summer growing season. Algae can also tolerate salinity in their water, making it likely that the high volume of water required can come from the ocean or aquifers not suited for human consumption. This leads us to begin by sourcing biofuels near the ocean, and preferably in Texas. This is extremely convenient, as a lot of today's refineries, and therefore supply chains, already exist near Texas' coast. In fact, because second-generation biofuels have no traditional area to be grown in, they can be sourced from the very beginning next to existing supply chains, once again reducing the need for new infrastructure to just the bare minimum needed to produce and transport these fuels from the fields to the refineries. Companies that provide this service already have experience in this regard, since establishing new supply lines of this type is at the heart of whenever they expand as a company.

In the case of biofuels, the traditional automotive supply chain need not change since very little if any modifications are necessary for the production of vehicles that run on biodiesel, as diesel engines manufactured after 1987 are directly compatible (USDA 2004). Electric vehicles, however, fundamentally rely on fewer parts than traditional petroleum vehicles and therefore many parts suppliers will be cut off and die out unless they can adapt. The trouble for these suppliers is the sheer gap in technologies and the fundamental differences between electric and traditional petroleum vehicles. In the long run, these stakeholders would have to completely reinvent themselves, either moving into a totally different industry or dramatically changing their personnel. It's far more likely that many of these companies will simply go out of business, or have to reduce the scale of their operations. Thus, electric vehicle's new supply chains are focused on providing cheap batteries to the automobile manufacturers.

Electric vehicles will also only need a few new supply chains to provide them with power. These supply chains can focus on high-capacity transmission of power from local power plants to supercharging stations. As previously mentioned, these new power lines can be financed in part by electric companies, who should jump at the chance to expand demand for electricity. The other primary concern for electric vehicles is supplying every household with its own charging station. This can be easily accomplished with a few manufacturers of such equipment selling their product through car dealerships and online as needed, since this won't require the construction of large new power lines. This is especially true because cars charge at night, off the peak hours of electrical grids, so today's peak grid load should not be significantly impacted in a future where a significant proportion of drivers use electric cars.

Part 7: Strategy

There are a number of steps that must be taken to achieve a multi-fuel future based on the fuels of traditional petroleum, electricity and biodiesel.

One of the first steps is to stop investing in the construction of new petroleum infrastructure, as well as disinvolve government policy from attempting to improve gasoline vehicles and their market through fuel economy and emission standards.

The next step is to work out the long-term growth prospects for making money off of electric vehicles in those regions that already have a high concentration of electric vehicle ownership and incentives, such as New York, Georgia, Texas and California. The focus should be on electric vehicles first, then biofuel, since electric vehicles are closer to being ready for the market. This means trying out different strategies for making money from selling consumers electricity, including building supercharging stations that function as business centers and working out with utility companies how much of a discount they could get on electricity prices for the construction of a supercharging station. If a charging station could make its electricity price lower than that which a consumer would get at home, and could market itself as such in addition to its other amenities, and provide access to local businesses and its own convenience store when filling up, these supercharging stations can succeed.

While the development of plans to make supercharging stations profitable is occurring, research into biofuels must also occur. This research doesn't have to focus on how to make such fuels cost-effective, since only a few larger corporations have the resources to do that. Instead, research among fuel distributors and retailers should focus on identifying potential land that is both close to existing supply chains, especially potentially successful land in Texas, and could be converted to grow algae or otherwise collect the raw materials necessary to create second-generation biofuels.

The next actions to be taken should occur when electric cars are approaching cost parity with traditional gasoline vehicles. At this point, the marketing of electric vehicles as a less expensive alternative to petroleum-powered vehicles should begin. In addition, from among the researched techniques for making money off of supercharger stations, a few should be selected to push into the wider market and advertised to consumers. New owners of electric vehicles should be attracted by the inexpensiveness of their vehicle and the opportunity for activity while they wait for their cars to charge. At this point, electric vehicles can take off as a new choice, although many consumers in society will continue using traditional petroleum products to power their vehicles for the next few decades.

Finally, with biofuels approaching cost parity, they can be rolled out onto the larger market with production sourced near traditional gasoline supply chains. Biofuels don't have as much need for pre-rollout marketing since biofuels are more or less the same as traditional diesel, they're just better for the environment. These fuels, marketed as even better for the environment than cars that run on electricity but still able to run in older vehicles, will face severe competition from new electric cars. However, because they can be put into older cars that were made before the tilt towards electric vehicles, as well as in large trucks and SUVs, they will still have a significant market share even if electric vehicles do better than expected. This market can be exploited and the fuel still sold, and since these fuels produce less in carbon emissions than the electricity used to power electric vehicles, and by this point will still be able to receive government subsidies.

Fifty years from now, both biofuels and electric vehicles ought to be far less expensive and far better for the environment than traditional petroleum. With regular supply chains established and a more sustainable fuels industry, there will be significantly less need to use petroleum products to move goods and people around the United States, and soon, the world. To accomplish this lofty goal, with all of its environmental and social benefits, we have focused not on how much needs to change to make this happen, but rather on how little. With little infrastructure needing to be built to make such a world happen, and little in changes to the supply chain, our main challenge will not be funding such a revolution in the future of transportation, but in moving fast enough to keep up with the technology that will make it happen.

Appendix A: Calculating Luxury Car Sales as a Fraction of the Total Population

State	Luxury Car Sales (total sales*fraction of sales that are luxury vehicles)	Population (2009)	Luxury Car Sales/Population
California	127,014	36,961,664	0.0034
Florida	76,533	18,537,969	0.004128
New York	65,379	19,541,453	0.00335
New Jersey	19,882	8,707,739	0.0023
Virginia	15,246	7,882,590	0.0019
Georgia	15,308	9,829,211	0.00156
Illinois	12,031	12,910,409	0.00163
Texas	44,269	24,782,302	0.001786
Pennsylvania	23,446	12,604,767	0.00186
Ohio	16,025	11,542,645	0.00139

Appendix B: Vehicle Subsidies for Electric Vehicles

State	Electric Vehicle Subsidies and Notes (selected)
California	Up to 2500 for BEV vehicles, with the potential for more depending on the power company. Also give out a sales tax exclusion for, "...manufacturers of alternative source and advanced transportation products, components or systems."
Florida	Up to 1,000 dollars
New York	Tax credit for, "the purchase and installation of alternative fuel vehicle refueling and electric vehicle recharging property" up to $5,000.
New Jersey	Exempt from sales and use tax (7% of purchase price)
Virginia	Little, and imposes a fee, Dominion Virginia Power offers discounted power rates
Texas	Up to 2,500 dollar rebate; Alt fuel infrastructure grants, vouchers up to 3,500, cooperative Austin Energy
Pennsylvania	Up to 3000 for BEVs
Georgia	Up to $5,000 BEV; also can get tax credit of 10%/up to 2500 dollars for setting up a charging station at home
Colorado (not on original list)	$6,000 for alternative fuel vehicles, plus up to $8,260 in grants for adopting plug-in electric vehicles in fleets.

Appendix C: Vehicle Subsidies for Biofuel-using vehicles

State	Biofuel Subsidies and Notes (selected)
California	"Propel Fuels offers a rebate to qualified fleet customers for monthly purchases of more than 500 gallons of biodiesel blends and E85. Fleet customers must purchase the fuel directly from Propel public retail locations using the Propel CleanDrive Fleet Card. The program offers a rebate of $0.03 per gallon for purchases of less than 1,000 gallons of biofuel per month, and $0.05 per gallon for purchases of 1,000 gallons or more per month." "The California Energy Commission (CEC) administers the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) to provide financial incentives for businesses, vehicle and technology manufacturers, workforce training partners, fleet owners, consumers, and academic institutions with the goal of developing and deploying alternative and renewable fuels and advanced transportation technologies." "The South Coast Air Quality Management District (SCAQMD) requires government fleets and private contractors under contract with public entities to purchase non-diesel lower emission and alternative fuel vehicles." There were many other incentives and regulations, but they were of questionable value.
Florida	"An income tax credit is available for 75% of all capital, operation, maintenance, and research and development costs incurred in connection with an investment in the production, storage, and distribution of biodiesel (B10-B100), ethanol (E10-E100), or other renewable fuel in the state, up to $1 million annually per taxpayer and $10 million annually for all taxpayers combined."
New York	"Biofuel producers in New York State may qualify for a state tax credit of $0.15 per gallon of biodiesel (B100) or denatured ethanol produced after the production facility has produced, and made available for sale, 40,000 gallons of biofuel per year. The maximum annual credit available is $2.5 million...."
New Jersey	"New Jersey state departments, agencies, offices, universities, and colleges must purchase biofuels for use in motor vehicles if the cost of biofuel is the same or less than the cost of gasoline or diesel, and if the fuel replacement is reasonable."
Virginia	"The Clean Energy Manufacturing Incentive Grant Program provides financial incentives to clean energy manufacturers, including biofuel producers. A producer is eligible for grant if it commences or expands operations in Virginia on or after July 1, 2011. Producers must make a capital investment greater than $50 million and create at least 200 full-time jobs that pay at least the prevailing wage." "Qualified employers are eligible for a $500 tax credit for each new green job

	created that offers a salary of at least $50,000, for up to 350 jobs per employer. The credit is allowed for the first five years that the job is continuously filled." "Businesses involved in alternative fuel vehicle (AFV) and component manufacturing, alternative fueling equipment component manufacturing, AFV conversions, and advanced biofuels production are eligible for a job creation tax credit of up to $700 per full-time employee." "The Biofuels Production Incentive Grant Program provides grants to producers of neat advanced biofuels, which include fuels derived from any cellulose, hemicellulose, or lignin from renewable biomass or algae, and producers of neat biofuels, which include biofuels derived from cereal grains." Amount of subsidy: 0.025 from 2016-June 30, 2017 "Qualified biodiesel and green diesel producers are eligible for a tax credit of $0.01 per gallon of biodiesel or green diesel fuels produced. This credit is available for producers who generate up to two million gallons of biodiesel or green diesel fuel per year. The annual credit may not exceed $5,000, and producers are only eligible for the credit for the first three years of production." "Alternative fuels used to operate on-road vehicles are taxed [emphasis added] at a rate of $0.111 per gasoline gallon equivalent (GGE). These fuels are taxed at the same rate as gasoline and gasohol (3.5% of the statewide average wholesale price of a gallon of self-serve unleaded regular gasoline)."
Texas	"State agency fleets with more than 15 vehicles, excluding emergency and law enforcement vehicles, may not purchase or lease a motor vehicle unless the vehicle uses compressed or liquefied natural gas, propane, ethanol or fuel blends of at least 85% ethanol (E85), methanol or fuel blends of at least 85% methanol (M85), biodiesel or fuel blends of at least 20% biodiesel (B20), or electricity (including plug-in hybrid electric vehicles)." "The biodiesel or ethanol portion of blended fuel containing taxable diesel is exempt from the diesel fuel tax." "AFFP provides grants for 50% of eligible costs, up to $600,000, to construct, reconstruct, or acquire a facility to store, compress, or dispense alternative fuels in Texas air quality nonattainment areas. Qualified alternative fuels include biodiesel, electricity, natural gas, hydrogen, propane, and fuel mixtures containing at least 85% methanol (M85). The entity receiving the grant must agree to make the fueling station available to people and organizations not associated with the grantee during certain times."
Pennsylvania	"One year after in-state production has reached 350 million gallons of cellulosic ethanol and sustained this volume for three months, all gasoline sold in Pennsylvania must contain at least 10% cellulosic ethanol. All diesel fuel sold in Pennsylvania must contain at least 2% biodiesel (B2) one year after in-state production of biodiesel reaches 40 million gallons. The mandated biodiesel blend level will continue to increase according to the following schedule:

	5% biodiesel (B5) one year after in-state production of biodiesel reaches 100 million gallons; 10% biodiesel (B10) one year after in-state production of biodiesel reaches 200 million gallons; and 20% biodiesel (B20) one year after in-state production of biodiesel reaches 400 million gallons.”
Georgia	“Distributors who sell or use motor fuel, including special fuels, are subject to an excise tax of $0.075 per gallon. Motor fuels that are not commonly sold or measured by the gallon and are used in motor vehicles on public highways are taxed according to their gasoline gallon equivalent (GGE)” “A business that manufactures alternative energy products for use in battery, biofuel, and electric vehicle enterprises may claim an annual tax credit for five years. The amount of the tax credit is based on the number of eligible new full-time employee jobs.”
Colorado (not on original list)	“The Colorado Department of Personnel and Administration (DPA) requires all state-owned diesel vehicles and equipment to be fueled with a fuel blend of 20% biodiesel (B20), subject to the availability of the fuel and so long as the price differential is not greater than $0.10 more per gallon as compared to conventional diesel.”

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