

Fuels Institute

2018

University Case Competition



FUEL RETAILING IN 2040



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Fuel Retailing in 2040

THE CASE

Through the lens of a fuel retailer, establish a timeline of the evolution of the light-duty vehicle fueling infrastructure in the United States through 2040.

CASE DETAILS

There are more than 124,000 convenience stores that sell motor fuel in the U.S. In fact, U.S. convenience stores sell 80% of the gasoline purchased by approximately 39 million Americans who fuel up their vehicles four to five times each month.

While alternative fuels grab headlines, projections show that by the year 2025, 96% of light-duty vehicles will still be powered by liquid fuel. The impact of electric vehicles is not projected to be felt by 2025; however, change in the market is coming.

You and your team are the owners of 75 of these retail outlets that sell motor fuel throughout the U.S. Your team is tasked with building a future business plan to maintain profitability through 2040, at a time when personal vehicles are traveling farther on less energy; alternative fuels and vehicles have gained significant market share; shared services (ride hailing) are becoming the norm and younger generations don't view car ownership the same as prior generations.

Your team will project the energy mix required to power the light-duty vehicle fleet and assess the relationship between consumers, personal transportation and retail outlets. In addition, you will assess the energy supply chain, taking into account all elements of the market, including production, distribution, infrastructure, labor, community relations, etc.



Components of the Case Analysis

KEY ASSUMPTIONS

- CAFE Program – In effect as of August 2017 and remains the same through 2040.
- Energy types to incorporate into your plan might include petroleum, electricity, hydrogen, biofuels and natural gas.
- In selecting your fuel options analyzed for this case, it is recommended that students familiarize themselves with current forecasts concerning market penetration of alternative fuels and vehicle technologies. As a foundation of understanding, students are recommended to review the U.S. Energy Information Administration’s “Annual Energy Outlook 2017” and the Fuels Institute’s report, “Tomorrow’s Vehicles.”
- Forecasts are by nature contingent upon assumptions made at the time of their publication and are subject to adjustment and changing market dynamics. However, if student’s projections deviate significantly from those of reputable organizations, they are expected to demonstrate compelling rationale to support such deviation.

PROPOSAL

Your future plan should address the following:

- Describe the markets in which your stores will operate between 2018 and 2040. What will change in terms of the vehicle market and energy demand? What will be the pivotal differences between fuel retailing in 2018 and in 2040? Describe your vision for your business in 2040 and compare it with your business in 2018.
- Detail your business plan’s evolution as it seeks to accommodate your anticipated changes in the market. What is your timeline for introducing your new strategies? Do the markets affecting each of your locations exhibit the same characteristics on the same time line (i.e., rural vs. urban, neighborhood vs. highway exit ramp location)? Describe your implementation plan—when will you begin to introduce your changes and on what schedule will you roll them out to your locations?
- Explain why and how you will design your fuel offer. Will you incorporate a variety of energy options at each store or will you diversify your product availability by location? If you intend to offer multiple options at a single site, how will you accommodate each one in terms of infrastructure (i.e., underground tanks for multiple liquid fuel options), refueling position (i.e., parking spaces for electric vehicle charging or additional dispensers for natural gas or hydrogen), etc.? What might be the associated costs with these new products and how would you calculate the return on investment?

- Considering your expected timeline for market evolution, how will your business plan provide flexibility to remain relevant to consumer demands over time? How will you capitalize on emerging market opportunities and protect against threats, especially those that might not be anticipated in your longterm plan?
- As you contemplate new market opportunities, who will be your competition? How does this competitive landscape differ from traditional fuel retailing? What advantages or disadvantages will you have over new format competitors? How will you secure or strengthen an advantage in the market?
- As you consider introducing new fueling options, what influence will government programs have on your decisions? What existing programs would support your product introduction decisions? What future programs might be necessary to enable the development of a new market?
- Describe your marketing strategy to entice consumers to purchase new products or services from your store. How will your relationship with your customer evolve? How will you measure the success of your strategy? How will you leverage new technologies to sustain customer engagement?



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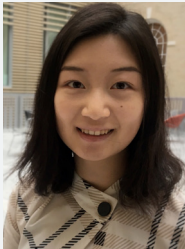
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Case Competition Winners

First Place

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How Gas Stations Will Cope with Future Transportation and Fuels Market – A Business Model to Maintain Profitability Through 2040



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How Gas Stations Will Cope with Future Transportation and Fuels Market

--- A Business Model to Maintain Profitability Through 2040

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I. Introduction

With growing climate change concerns, rising gas prices, and energy independence goals, fuel efficiency and alternative forms of fuel have gained unprecedented support in the United States. The projected decline in U.S. motor gasoline consumption as a result of improved fuel economy and rise of alternative fuels will soon be felt by conventional fuel retailers. In addition, younger generations growing up with ride hailing services no longer view car ownership the same as prior generations, which may change the composition of target customers in the future. In short, changes in the market is coming and fuel retailers are urged to cope with the new trends. Based on forecasts on market penetration of alternative fuels and vehicle technologies, along with predictions concerning future customer preferences, this report introduces a future business model and establishes a timeline for the evolution of light-duty vehicle fueling infrastructure in the United States through 2040.

II. Future U.S. Gasoline Consumption

Fuel retailing profits depend significantly on gasoline price and consumption. Our belief is that gasoline sales will decline more sharply than forecasted by Energy Information Administration's (EIA) Energy Outlook, for reasons to be elaborated on. The change in consumption will be discussed in response to future fuel economy standards, market penetration of alternative fuels and vehicles, and popularization of autonomous driving.

Fuel Economy

According to EIA, efficiency improvements will lead to decreased consumption of motor gasoline across all scenarios of future oil prices, as *Fig 1* indicates.^[1] The high oil

price case results in lower domestic consumption and greater exports, reflecting the domestic response to higher prices.

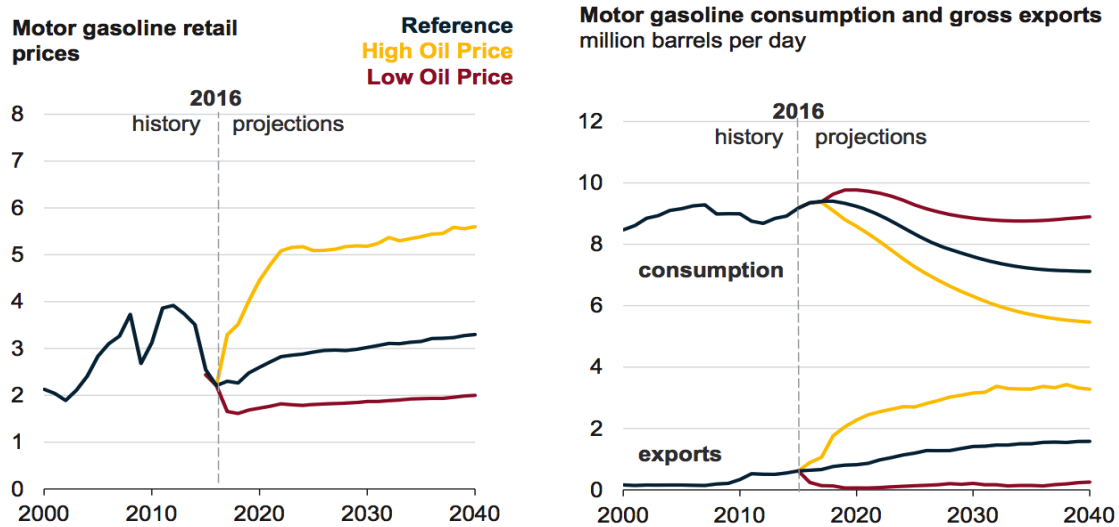


Fig 1. U.S. motor gasoline consumption and exports are sensitive to changes in prices (EIA)

In our analysis, we expect that the U.S. gasoline consumption is likely to follow predictions under the high-oil-price scenario in *Fig 1*, in which case U.S. consumption will decline by at least 20% by the year 2040. Such high-oil-price assumption can be corroborated by the increasing scarcity of oil^[2] and projected stable global demand. A study by the International Energy Agency (IEA), based in Paris, shows that a cut of only 2.5 million barrels per day of global consumption, or about 2% as of base year 2015, will take place globally by 2040 regardless of improved fuel economy and deployment of alternative fuels. The reason is mostly that consumption reductions induced by efficiency improvements will be easily eclipsed by the growing demand of the developing world, which will stabilize global demand and raise oil prices.^[3]

Alternative fuels and vehicles

For simplicity reasons, the only alternative energy types to be assumed to gain significant market share are electricity, biofuels, hydrogen, and natural gas. It is also assumed that no major technical breakthrough will occur in other forms of energy.

Electricity

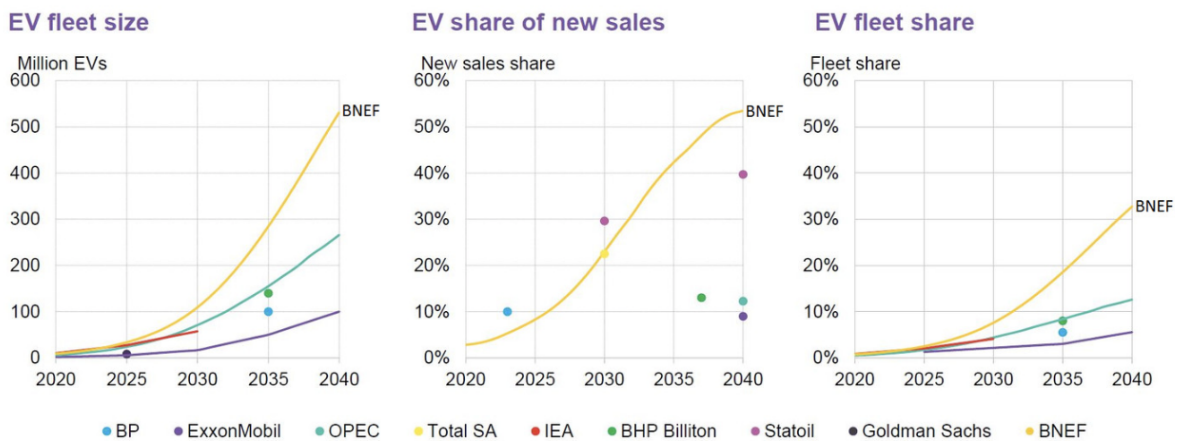


Fig 2. Global EV forecasts at a glance (Bloomberg New Energy Finance)^[5]

Promoted by short-term regulatory support from the government, falling lithium-ion battery prices, and increased electric vehicles (EV) commitments from automakers,^[4] EVs have the most promising future among all the alternatives in light duty vehicles. *Fig 2* shows forecasts for global EV markets made by Bloomberg, BP, ExxonMobil, etc. Due to numerous uncertainties, EV forecasts made by different organizations vary greatly. Yet almost all predictions are to some extent optimistic. More importantly, confidence in EVs has continued to swell in recent years, given the improved financial viability induced by technological breakthroughs and capital flowing into the EV industry.^[4]

To avoid corporate motivational biases, forecast made by EIA that “10% of total light-duty vehicles sold in the U.S. over 2016-2040 will be EVs” is used as baseline for

our analysis.

Ethanol

Signed into legislation in late 2005, the Renewable Fuel Standard (RFS) went so far as to mandate the blending of ethanol into the country's gas supply. Percent ethanol blended into gasoline has reached nearly 10% in 2016, which is known as the "blending barrier," over which the fuels are claimed to damage engines in most cars.^[6] More recently, E15, which blends 15% of ethanol into motor gasoline, is approved by EPA for light-duty vehicles with a model year 2001 or newer.

As a result of the mandate, the amount of ethanol mixed into gasoline has increased from 4 billion gallons in 2006 to 14.4 billion gallons in 2016.^[6] Corn ethanol accounts for roughly 80% of all biofuel production in the U.S. due to its relative ubiquity and the ease with which its starchy kernels can be transformed into ethanol. The large ethanol producers are Iowa, Nebraska, Illinois, Minnesota, and Indiana. The legislative support for ethanol blending of each state are shown in *Appendix Table 2*.

In an attempt to rectify conflicting opinions about the environmental effects of corn ethanol, EPA announced to carry out its own study in 2016. However, whether the "blending barrier" would change depends more on the political status of the RFS rather than on the study. While campaigning in Iowa last year, Trump pledged to protect ethanol and the biofuel mandate.^[7] Arguable as his commitment, in July 2017, EPA proposed requiring U.S. refiners use 15 billion gallons of conventional renewable fuels in 2018, which is the maximum allowed under the RFS. On the other hand, oil refiners pushed for a lower target because for them the blending mandate is costly and burdensome.^[4]

To conclude, views on ethanol's impact are divergent, and the future of ethanol

depends greatly on the political status of the RFS. Our assumption is that the political support for corn ethanol will continue throughout Trump's presidency and will probably extend for at least another 4-8 years, in that the corn-producing states will continue to be politically important and advanced substitutes (for example cellulosic ethanol) cannot be made commercially viable during this time.

Hydrogen

Hydrogen fuel cell vehicle sales are expected to grow to approximately 0.6% of total vehicle sales by 2040,^[1] among which the majority will happen in California.

Hydrogen may have the GHG reduction potential and can be quickly filled at stations unlike EVs; however, automakers are hesitant towards hydrogen engines because of their low thermodynamic efficiency.^[8] Moreover, hydrogen stations are less financially viable than electric charging stations, restricting the number of hydrogen stations and eventually the market growth. Hydrogen is thus excluded from our discussion and business plan, considering its slow expansion in the market by 2040.

Natural Gas

Natural gas consumption in transportation is projected to increase stably.^[9] However, the market for natural gas vehicles (NGVs) and corresponding refueling infrastructure remains a mixed bag, and is highly dependent on vehicle segment and region. The majority growth is expected to occur in the heavy-duty vehicle segment, because their dual-fuel systems can compensate for the lower energy density of natural gas. Since the scope of this study excludes heavy-duty vehicles, natural gas charging is not be considered when we established the business plan.

Autonomous driving

Automation is attracting investments from a myriad of companies including automakers, ridesharing services, and technology startups. Uber, for example, is hiring self-driving engineering teams across the U.S. not only because without a driver, Uber can retain all fares to raise its profitability, but more importantly, it is in a race for its survival in a foreseeable driverless future.

The Institute of Electrical and Electronics Engineers (IEEE) estimated that by 2040, up to 75% of the U.S. cars on the road will have autonomous driving features.^[10] Navigant Research estimates that between 20% and 25% of vehicles in use in the key markets of North America, Western Europe, and Asia Pacific will have full automation (NHTSA Level 4) by 2035.^[11] LoupVentures expects a market share of 94.5% for fully automated vehicles in year 2040.^[12] Such optimistic views are not without ground. Along with car sharing, automation will revolutionize the personal transportation market. In the near future, it is reasonable to expect that the new business model of autonomous-ride hailing services (AHS), which will be on-demand and driverless, will attract younger generation and further devalue personal car ownerships.

Furthermore, autonomous vehicles can be suitably combined with EV for the engineering reason that electric vehicles are easier for computers to drive. It will also be easier, cheaper and safer to recharge an unmanned car than to gas one up.^[13]

Consequently, this synergy of ride-hailing, automation, and electrification will give rise to more EVs on roads, assuming that autonomous ridesharing model dominates future market. This additional motivation for EV is not incorporated in EIA's energy outlook shown in *Fig 1*.^[1] Thereby, because of this game-changing synergy, we expect a

sharper decline in motor gasoline consumption and thus a more urgent need for fuel retailers to change their business models to remain profitability towards 2040.

III. Business Plan

Collaboration with ridesharing companies as a business model

To cope with the projected decline in motor gasoline demand and the foreseeable AHS future, we propose a business model for gas stations to fit into the transformed market. This model focuses on collaboration with ridesharing companies. As future vehicles for hailing will not have designated drivers, businesses need to find a way to recharge, park, and maintain these cars. In other words, we will design a long-term pathway for current gas stations to become a mixture of gas pumps, EV chargers, maintenance facilities, parking lot, and maybe less of convenient stores (with more driverless cars on the road), to serve the needs of AHS in the future.

Gas stations are advantageous in potential collaboration with ridesharing companies to make AHS possible, boasting resources such as pumping and charging facilities on site, parking spaces during non-rush hours, and experienced labor for vehicle maintenance. More importantly, assuming that the 75 stations are well distributed across the country, flexibility in the choice of location will facilitate efficient operation and deployment of ridesharing vehicles.

Notwithstanding our competitors that can provide similar services such as parking lots and on-street chargers, gas stations are favorable due to their flexible locations and ample parking spaces. Such a cooperation with ridesharing companies will be more profitable as opposed to our merely providing electric charging services, because in this way, we can ensure predictable electricity consumption. In addition, we can collect

parking and maintenance fees from such vehicles.

One underlying assumption for this business model to work is that the ownership of future driverless cars will shift to ridesharing companies or automakers. This shift will be inevitable, as personal vehicle ownership will devalue. In November 2017, Volvo announced that it would provide Uber with up to 24,000 of its flagship XC90 SUVs to boost Uber's self-driving systems and to help move the business from its current model of ride-sharing using freelance drivers to owning a fleet of autonomous cars.^[14]

The pace at which the business model should be deployed among the 75 gas stations owned should be carefully evaluated, as the refueling market will not change overnight. Therefore, the deployment can be divided into two phases, the incubation phase and the collaboration phase. During the incubation phase, the AHS model has not yet picked up, so this phase would entail some preparational work such as installing EV chargers and vehicle maintenance facilities at some locations and collecting information (payoff from these services, risks induced, additional space required, *etc.*) for future decision making and negotiation purposes. Phase two, or the collaboration phase, is when the collaboration with ridesharing companies should be negotiated and carried out. A detailed timeline will be elaborated on later.

Decision tree

A structured discussion on how and where to deploy different strategies is shown in the decision tree in *Fig 3*. The decision-making process takes into account current sales performance of gas stations, demographic conditions, available local gasoline sources and policy support, and potential EV adoption rate.

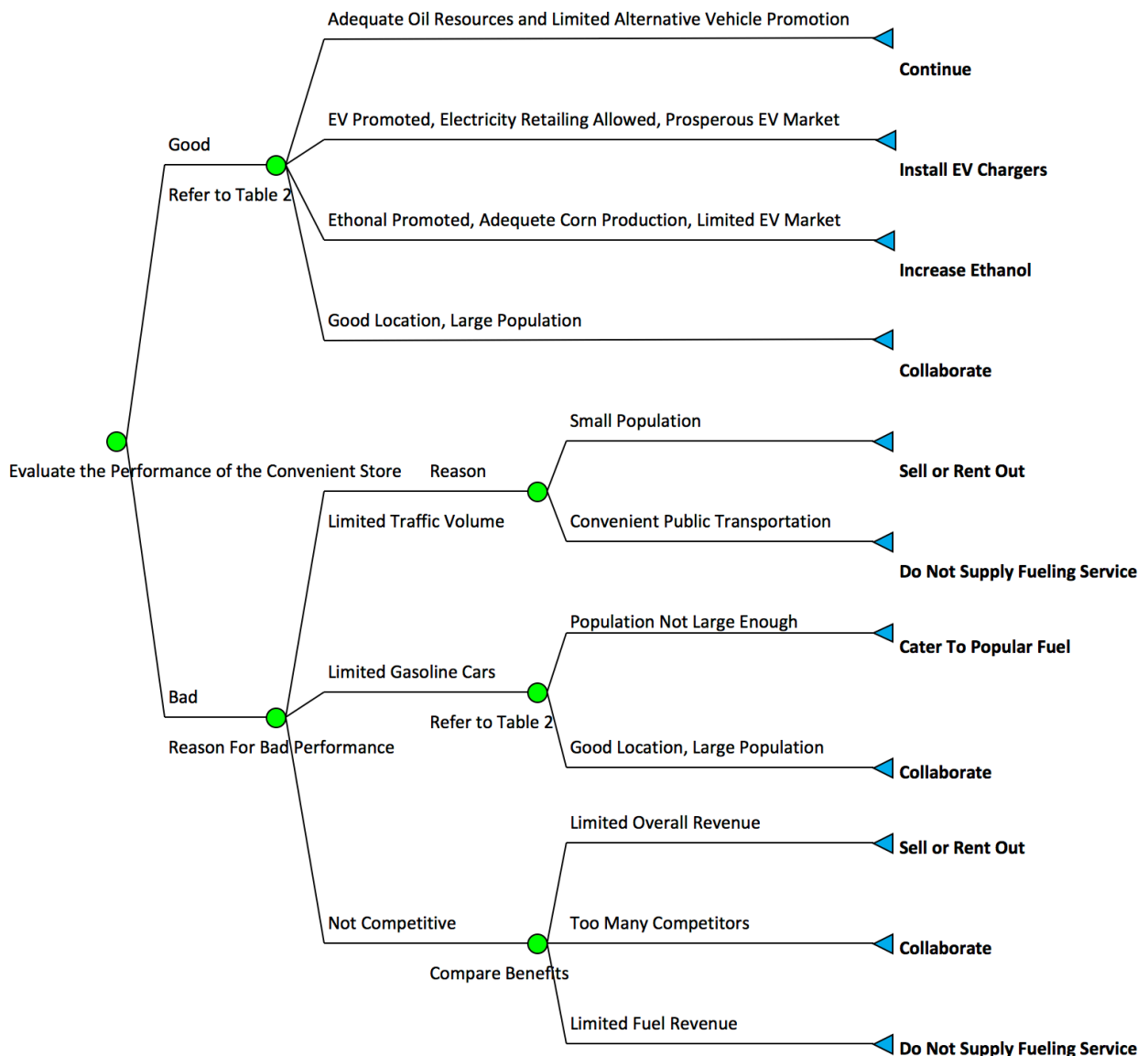


Fig 3. Decision tree

For the incubation phase, the most important decision to make is what changes should be made to each gas station so as to simultaneously get prepared for future collaboration and stay relevant to local energy needs over time. We mainly have four alternatives to choose from, closing or renting out the store, installing EV chargers, bringing in more ethanol-blended fuel, and immediately start collaborating with ridesharing companies. The four alternatives are not mutually exclusive. For example,

we must install EV chargers if collaborating with ridesharing companies, and biofuel and EV can be added to one single station if both needs are demonstrated.

When making this decision, the first criteria to consider is the current sales performance of each gas station. If the sales condition is satisfactory, we will look into the policy from state government, local natural resources prices, and existing market to explore a way to further improve our profits. A summary of state-level support policies on EVs, ethanol, and electric vehicle supply equipment (EVSE) are presented in *Appendix Table 2*. For example, providing more biofuel in Iowa is favorable in recent years considering the tax-exempt incentives in Iowa are only available to retailers that meet incremental annual renewable fuel goals. As for California, into which investment on EV is streaming, plus EV charging retailing is flexible, installing charging facilities as a means for preparing for future collaboration with ridesharing companies would be preferred. Meanwhile, if there exist great-performing gas stations located in areas with huge population density, and more ideally where autonomous vehicle testing centers have been or to be built, speeding into the second phase - the collaboration phase, at these stations would be a good option, considering the ephemeral opportunity to take over that market.

When the sales condition turns out to underperform, we ought to look into the reasons. A sparsely populated region with limited traffic volume indicates an unfavorable environment for gas stations and convenience stores to operate. In this case, it is reasonable to sell or rent out the store to others as a better use of storage warehouse. On the contrary, if a place with a large population and good in-store retailing business retains, the owner should decide to remove the pumps. However, if the business is overwhelmed by competitors, we may consider collaborating with ridesharing companies

to provide new services. Another good choice would be selling the station if a bid is high enough.

Considering the fast-evolving market, all gas stations need to be evaluated based on these criteria every five year for deciding if any conversions would be necessary.

Uncertainties

The decision tree provides a list of “here-and-now” decisions and “wait-and-see” decisions. The “here-and-now” decisions can be made based on current sales and local political as well as geographic conditions of gas stations. The “wait-and-see” decisions, however, involves a myriad of uncertainties, such as future market status of EV charging and the AHS model adoption rate, both of which will affect performances of the proposed business model. Several sets of information can be used to resolve some uncertainties, and should thus be followed by decision makers throughout.

Shortened charging time: As long charging time is a major unfavorable factor for EV purchasers, rapid charging technology or better battery will promote EV sales greatly. The implication drawn is that advancement in such technologies will act as a strong indicator for a booming of the EV market and can be taken advantage for deciding when and where to add more EV chargers.

Battery Price: Batteries make up a major portion of EVs costs. Research from Bloomberg New Energy Finance indicates that falling battery costs will mean that EVs will be cheaper in the U.S. as soon as 2025.^[19] Similar to charging time, battery price is also a strong indicator for the EV market.

Emergence of competitors: Availability of charging services at other locations is one major competitor of gas stations under the new business model. With declining

costs for charger installation, home-owned chargers as well as chargers at other public locations, such as hotels, on-streets, and parking lots, will become more available. As discussed before, gas stations is more advantageous because it can provide several types of services at one location. Yet ridesharing-companies-owned vehicles will not be the only vehicles that the gas stations will serve, hence more competitors providing charging services would still mean a profit cutdown.

Public attitude towards autonomous vehicles: Whether people like the driver-free idea or not is essential for the fate of ridesharing companies' autonomous business. Even if successful marketing strategies have been implemented, negative news on driverless cars could put this tech at stake and delay its popularization. The decision maker should always keep an eye on the accident rate of autonomous vehicles, as well as news and comments on accidents.

Cybersecurity: Another concern for driverless cars is cybersecurity. Demonstrated effectiveness in new cybersecurity technologies would not only render the public a sense of safety, but also raise the feasibility of the proposed business model.

Ethanol incentives: Our preference for biofuels originated from continued federal support for RFS and state level incentives, especially those of five major corn-producing states. As indicated above, relevant policies are the most important indicators for the profit margins of biofuels.

Governmental support: EV and autonomous driving depends greatly on governmental support, such as tax credit, rebate, and load. More importantly, the adaptation autonomous vehicle technology relies heavily on government's attitude. Although both the Obama and Trump government are autonomous-friendly, potential restrictions on driverless cars may rise due to the concern on safety when relevant

accidents are frequently reported.

Timeline

Despite emerging alternatives, fossil fuel vehicles do dominate the market and will continue to do so for the next ten years due to the existing large inventory of fossil fuel vehicles coupled with expected improvements in fuel efficiency. Indeed, by 2025, 96% of light-duty vehicles will still be powered by liquid fuel.^[21] Therefore, the timeline should remain relevant to customer demand over time. And as there exists so many uncertainties, we will gradually adapt our strategies on the way of energy transition.

The development strategies should be reconsidered every 5 years according to the decision tree. In most cases, convenient stores are renewed every 10 year. Given the rapid development of new technologies and market dynamics, reconsidering the strategy every 5 years is recommended, which would allow agiler response to changes. Moreover, forecast for the next 5 years is by nature more reliable than that for 22 years, so that misjudgment incurred by uncertainties could be reduced.

The development timeline takes into account both the gradual change in demand and the urgent need for establishing strategic cooperation with ridesharing services. While we may launch the collaboration business model with ridesharing companies in the 2030s when autonomous systems become affordable, we need to start installing electric charging systems in 2018 as well as to begin placing information pertinent to each charger online so that the status of chargers can be captured by those driverless cars in the future. Considering the prolonged charging time, the earliest EV chargers should be set where caterings are available so that customers can mitigate their wasted time of charging as pilot projects, and later on expand to other locations if the pilot

projects turn out to be a success. And to take advantage of existing resources, the collaboration business model with AHS should start where autonomous driving tests have been conducted and strongly supported by the local government, like Pittsburgh, Arizona, and California.

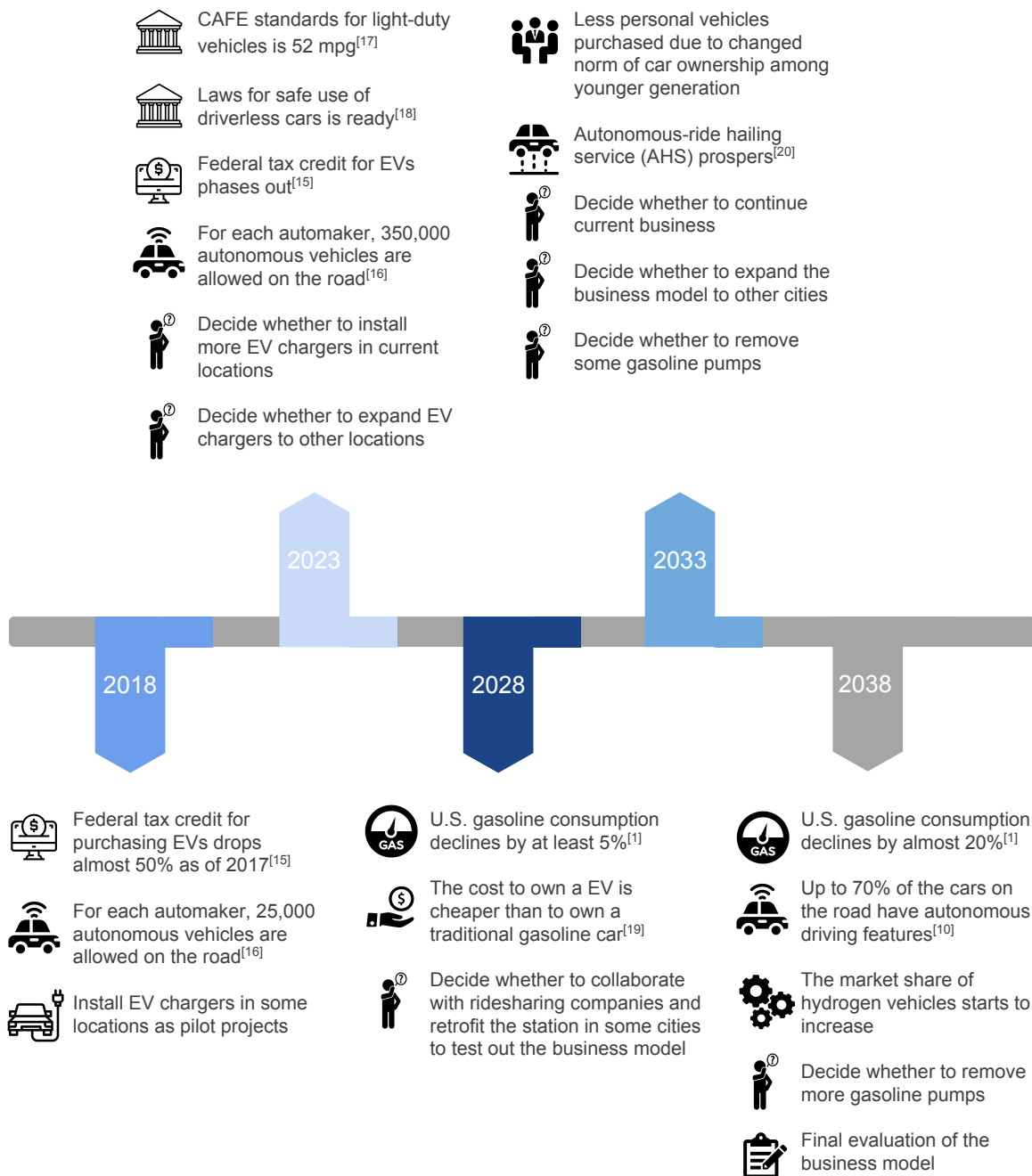


Fig 4. Timeline for California

Although forecasting the development timeline and strategies until 2040 is hard because of unresolved uncertainties and different situations region by region, it's reasonable to surmise possible evolution for a specific state. In this study, we will take California for example, which is EV-friendly, autonomous-friendly, and EV-charging-service-allowed. The timeline for California is shown in *Fig 4*.

IV. Conclusions

In the near future, alternative fuels such as electricity and ethanol will continue to gain market share. Along with improved fuel economy, alternative fuels would cause the motor gasoline consumption in the U.S. to decline by around 20% by 2040. The solution to maintain profitability is to selectively install charging facilities and increase ethanol blending in stations based on availability of state-level incentives.

On the long run, an inevitable AHS future is demonstrated. For gas stations to survive in the changed game, a business model based on collaboration with ridesharing companies is introduced. Under the new model, gas stations will be able to remain profitability by providing charging, parking, and maintenance services for autonomous vehicles. Due to the hazy picture of the future market, a deterministic long-term strategy for evolving into this new business model is impractical. Therefore, a decision tree and timeline for the transition is provided to aid decision makers to make right decisions under uncertainties at the right time.

Reference

- [1] EIA Annual Energy Outlook 2017
- [2] Available online at: https://www.eia.gov/outlooks/steo/report/global_oil.cfm
- [3] Available online at: <https://www.reuters.com/article/us-oil-outlook-iea/global-oil-demand-to-withstand-rise-of-electric-vehicles-iea-idUSKBN1DE007>
- [4] Electric Vehicle Outlook 2017 – Bloomberg New Energy Finance’s annual long-term forecast of the world’s electric vehicle market
- [5] Available online at: <https://www.bloomberg.com/news/articles/2017-07-14/big-oil-just-woke-up-to-the-threat-of-rising-electric-car-demand>
- [6] Available online at: <https://www.agmrc.org/renewable-energy/renewable-energy-climate-change-report/renewable-energy-climate-change-report/april-2017-report/us-ethanol-production-consumption-and-the-relevance-of-increasing-exports/>
- [7] Available online at: <https://www.bloomberg.com/news/articles/2017-10-18/trump-joins-debate-on-epa-ethanol-rule-in-call-to-iowa-governor>
- [8] Available online at: <https://www.forbes.com/sites/quora/2017/06/27/why-are-car-manufacturers-ignoring-hydrogen-engines/-2d1f16914027>
- [9] Tomorrow’s Vehicles – An Overview of Vehicle Sales and Fuel Consumption Through 2025
- [10] Available online at: https://www.ieee.org/about/news/2012/5september_2_2012.html
- [11] Navigant research / advanced energy now - 2017 market report
- [12] Available online at: <http://loupventures.com/auto-outlook-2040-the-rise-of-fully-autonomous-vehicles/>
- [13] Available online at: <https://www.usatoday.com/story/money/cars/2016/09/19/why-most-self-driving-cars-electric/90614734/>
- [14] Available online at: <https://www.theguardian.com/technology/2017/nov/20/uber-volvo-suv-self-driving-future-business-ride-hailing-lyft-waymo>
- [15] Available online at: <https://insideevs.com/us-federal-7500-ev-credit-expiry-date-by-automaker-estimates/>
- [16] Available online at: <http://www.latimes.com/business/autos/la-fi-hy-driverless-regs-chao-20170912-story.html>
- [17] Available online at: <http://www.autonews.com/article/20160718/OEM/160719863/54-5-mpg-target-is-off-the-table-u-s-regulators-say>
- [18] Available online at: <https://www.theguardian.com/law/2017/dec/14/laws-safe-use-driverless-cars-ready-2021-law-commission>
- [19] Available online at: <https://www.bloomberg.com/news/articles/2017-05-26/electric-cars-seen-cheaper-than-gasoline-models-within-a-decade>
- [20] Available online at: <https://www.vtpi.org/avip.pdf>
- [21] Available online at: <http://futurefuelstrategies.com/2017/07/19/liquid-fuels-will-continue-dominating-u-s-vehicle-fleet-in-2025-though-evs-will-grow/>
- [22] Available online at: <https://www.bloomberg.com/news/articles/2017-11-07/opec-says-oil-use-could-peak-in-late-2030s-if-electric-cars-boom>

Appendix

Table1 Prediction of Electric Vehicle Fleet^[5]

Organization	Time	Latest prediction	Previous Prediction
International Energy Agency	2030	58 million EVs in the global market	23 million EVs in the global market
Exxon Mobil	2040	100 million	65 million
BP	2035	100 million	70 million
Statoil ASA	2030	30% of new sales	-
OPEC	2040	266 million ^[22]	46 million
U.S. Energy Information Administration	2040	10% of total light-duty vehicles sold in the United States over 2016-2040 ^[1]	-

Table 2 State Policy on Ethanol, EV and EVSE

Region	State	2016 Ethanol (Name-plate Capacity; million gallon/yr)	2016 Ethanol Operating Production (million gallon/yr)	State Ethanol Incentives	State EV & EVSE Incentives	Electric Vehicle Supply Equipment (EVSE) Open Access Regulation
West	California	223.75	218.75	California Air Resources Board makes the limit of ethanol blended into gasoline 10%	EV buyers: <=\$7,000 rebate for zero emission light-duty vehicle EVSE: <=25% rebate for nonprofits, small businesses, and local government	EV charging stations are not regulated as public utilities.
South	Florida	8.00	0.00	County governments are eligible to apply waste reduction credits towards their recycling goal, up to one-half of the goal, by using yard clippings, clean wood	EV buyers: <= \$1,000 rebate and tax credits ranging from \$2,500 to \$7,500 for purchasing plug-in EV. EVSE: loan <= \$500,000 for small businesses	EV charging stations are not regulated as public utilities.

				waste, or paper waste as feedstock for the production of clean-burning fuels such as ethanol.		
	Texas	390.00	390.00	The biodiesel or ethanol portion of blended fuel containing taxable diesel is exempt from the diesel fuel tax.	EV buyers: \$5,000 rebate for first 1,000 applicants; \$2,500 rebate for first 2,000 applicants. EVSE: Electrification infrastructure can apply for Clean Vehicle and Infrastructure Grants.	None found
	Virginia	60.00	60.00	A county, city, or town may exempt, partially exempt, or set a lower tax rate for qualified equipment used by farmers or farm cooperatives to produce ethanol, provided that the ethanol feedstock consists primarily of farm products.	EV buyers: time-differentiated rates to encourage off-peak charging EVSE: <= \$10,000 for state agencies and local governments for the incremental cost of new or converted AFVs. Schools may operate retail, fee-based PEV charging infrastructure on school property.	EV charging stations are not regulated as public utilities.
North-east	Pennsylvania	110.00	110.00	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.	EV buyers: The Alternative Fuels Incentive Grant (AFIG) Program provides rebate amount as high as \$1,750 for qualified EVs and \$1,000 for qualified PHEVs, NGVs, and propane vehicles.	Legislation in process

	Massachusetts	/	/	Cellulosic biofuel tax exemption; All Massachusetts agencies must use a minimum of 15% biodiesel (B15)	EV buyers: <= \$2,500 rebates for purchase or lease of zero-emission and plug-in hybrid light-duty vehicles. Discounts on qualified EV purchased. EVSE: The MA EV Incentive Program provides grants for 50%, up to \$25,000, of the cost of workplace EVSE.	MA state does not impose strict regulation for eligible EVSE station applicants, but owners and operators of public EVSE that require payment must provide payment options that allow access by the public
Midwest	Iowa	4072.00	4046.00	Tax credit of \$0.08 per gallon of pure ethanol blended into gasoline if retailers can demonstrate at least 17% of renewable fuels among total sold as of 2017.	None found	None found
	Illinois	1785.00	1747.00	When awarding contracts that require vehicle procurement, state agencies may give preference to an otherwise qualified bidder who will fulfill the contract through the use of vehicles powered by ethanol produced from Illinois corn or biodiesel produced from Illinois soybeans.	EVSE: The Illinois Department of Transportation requires each interstate highway rest area must install at least one EVSE. Illinois Electric Cooperative members are eligible for loan financing at 0.5 percent for 60 months or the purchase of new PEVs.	EV charging stations are not regulated as public utilities.

Case Competition Winners

Second Place

CARNEGIE MELLON UNIVERSITY

Future Landscape of Fuel Retailing – Thinking Beyond the Conventional



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Future Landscape of Fuel Retailing- Thinking beyond the conventional

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May 2018

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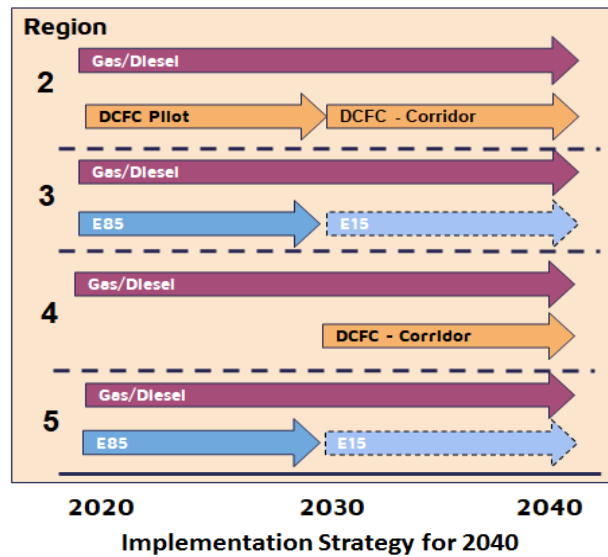
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Executive Summary

The light duty vehicle segment in the U.S. is evolving with a slow but gradual shift from gasoline to electric and other alternative fuels. As fuel retailers, it's important that we respond to this changing market dynamics with a strategic framework that ensures profitability in operations. Our convenience stores selling conventional motor fuels and E85 will evolve in coming years to additionally offer DC Fast Charging (DCFC) facility for the growing electric vehicle population on interstate highways connecting Dallas, Houston, Jacksonville, Raleigh, and Atlanta.

Our analysis of the market trends suggests that gasoline and diesel will continue to fuel the majority of vehicles by 2040, and thus will continue to remain in stock for sale. However, biofuels do not show a promising growth in the future with incentives for flex fuel vehicles expiring in 2019, and use of E15 in conventional vehicles approved only after model year 2018 by manufacturers (RFA, 2018). Other alternatives such as natural gas, hydrogen or fuel cells are still in infancy and will not cause much disruption in motor fuel sales.



Electric vehicles will lead the race among its counterparts due to multiple reasons including declining battery costs and the ability to adapt modern electrical infrastructure to support these. Our NPV analysis indicated that although commercial DCFC is a capital intensive project, incorporating the profit from in-store sales makes the project much more likely to break even at a demand of at least 19,000 charging sessions per year. Our model results indicate that a pilot installation of 3 DCFC stations at a charging fee of \$4 per 15 minute session allows us to break even in 10 years. Based on the success of our pilot implementation, we will further plan for the installation of up to 10 DCFC stations at new convenience stores or add capacity to our existing ones depending on the market conditions. The local electric utility is key in this entire set-up and we will make early attempts enter into an agreement with them. Ownership of the DCFC infrastructure by utility could significantly lower our costs while allowing us to generate profits from the in-store sales that happen during the EV charging times, and thus ensuring sustainable operations in the long term.

I. Introduction

The transportation sector plays a significant role in America's economy, contributing about 10% to the country's GDP and employing a similar percent of the total labor force (U.S. BTS, 2016). The U.S. automobile and petroleum refinery industries have played a major role in shaping the performance and outlook of this sector. Vehicle and motor fuel purchases made up about 70% of the overall GDP contribution from the sector in 2014 (U.S. BTS, 2016). In particular, the light-duty vehicle segment has been a key driver of transportation sector's growth in every aspect from total sales to revenue generation and energy consumption. In 2015, light-duty vehicles comprised 92% of the total registered vehicles on the highways and were responsible for 62% of transportation sector's total energy consumption (BTS, 2016). Although petroleum has been the primary fuel source for these vehicles over the past century, its demand has shown little to no growth over the last decade (Figure 1).

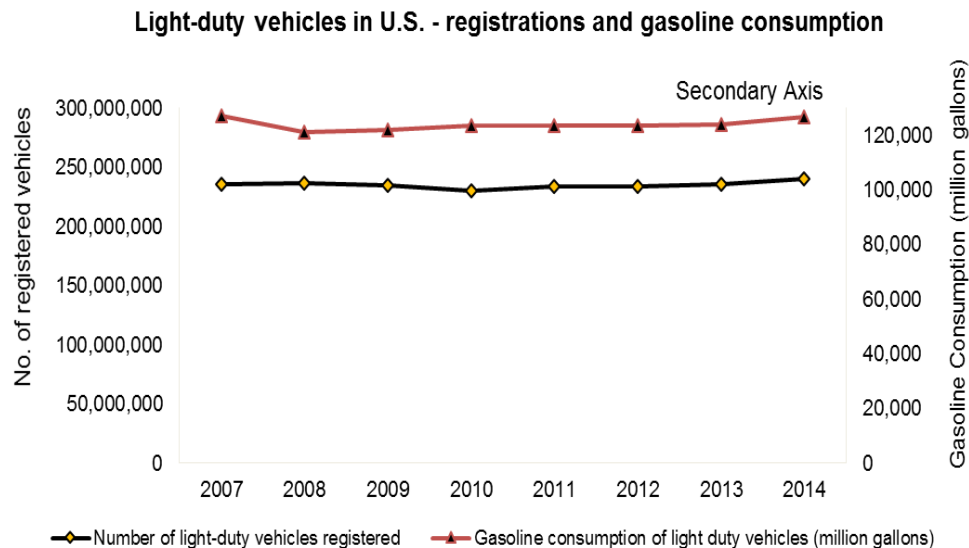


Figure 1: LDV population and consumption

Fuel retailers form an important link in the transportation supply chain, connecting oil drillers to the end users. The fuel stations cater to about 40 million users per day (NACS, 2017), making all possible efforts to ensure quality of service and consumer satisfaction. However, the fuel retailing industry has undergone significant changes in the past decade with major oil companies shifting focus to extraction and refining operations. The retailing segment is now dominated by independent entrepreneurs and convenience store owners. Although this shift has resulted in a positive trend in revenue generation for convenience store owners, it also exposes them to the volatility of the oil and transportation sector.

The transportation sector is undergoing transformation with a higher number of alternative fuel vehicles being launched every year. Government subsidies played an important role in providing a market-base for these alternative fuel technologies but they are phasing out slowly. In spite of this, some alternative technologies like electric vehicles are gaining popularity among consumers and are having an impressive sales growth every year. Under these evolving market conditions, the challenge for fuel station owners is to meet the needs of the present market while preparing themselves for the future shift in transportation technologies. Therefore, it is imperative that they adopt an open and flexible approach in their daily operations and seek an innovative way to capture the future market in alternative fuels.

II. Problem Statement

The U.S. convenience stores serve about half of the U.S. population across the fuel, food and merchandise segments on a daily basis (NACS, 2017). The fuel retail

sector of the U.S. is highly dependent on performance of these convenience stores that sell about 80% of total fuel annually (NACS, 2017). The past few years have challenged the sector with multiple issues such as low prices, high fuel efficiency standards, alternative fuels and technologies, and availability of ride-hailing services. All this has resulted in an environment of uncertainty among the convenience store owners as motor fuel sales dropped for the fifth consecutive year in 2016 (NACS 2016).

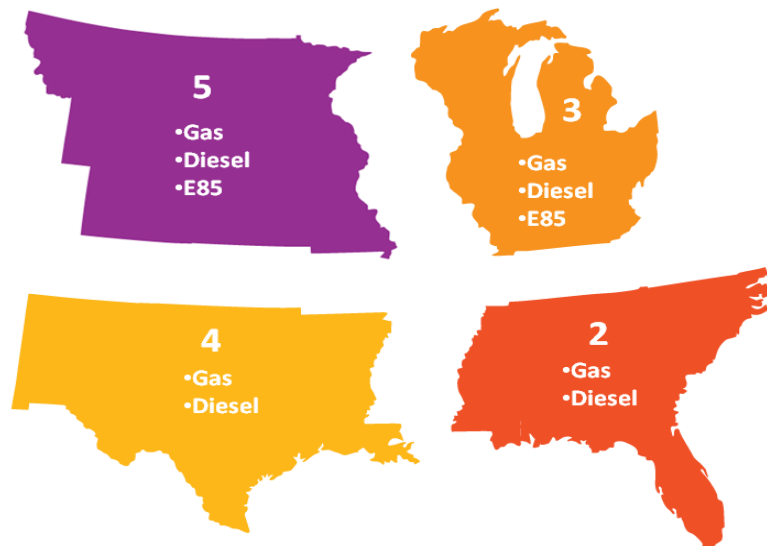


Figure 2. Our 75 stores offer these fuels in NACS regions 2-5.

As the owner of 75 retail stores across U.S., we need to gauge the future needs of consumers and direct our investment accordingly so as to stay competitive in the market. Our retail stores are located in NACS regions - 2, 3, 4 and 5. Figure 2 shows the current fuel mixes available at our retail stores located in these regions. To ensure sustainable and profitable operations through 2040 at our stores, we have developed a business strategy and action plan that help us to maintain and increase our consumer base in the uncertain future market. In developing this business case, it is intended to develop responses to the following research questions:

- What is the current landscape of the fuel sector (vehicle and fuel mix, policy, prices) and how will it shape up through 2040?
- What will the vehicle fleet for conventional and alternative fuels look by 2040? This includes assessment of different categories such as gasoline and diesel, electric vehicles (PHEV, BEV), hybrid vehicles, ethanol (E85) and hydrogen / CNG / LNG / Others.
- Which regions should be targeted as fuel retailers while anticipating future market and consumer needs?
- What business strategy should be adopted for these target regions?
 - Understanding of consumer needs and behavior
 - Planning investments in infrastructure, services etc. for short-medium term and long term (beyond 2040)
 - Developing a marketing strategy to engage customers
 - Developing an action plan for implementation of our strategy
- What will the national fuel policy in 2040 look like and how can it impact our business strategy?

III. Current Situation: Vehicle mix and Policies

The light duty vehicle segment in the U.S. is heavily dominated by gasoline vehicles, with alternative fuel vehicles constituting only 11% of the total segment (Figure 3). Fuel economy for light vehicles has improved from 13 miles per gallon in 1970 to 22.6 miles per gallon in 2015 (ORNL, 2017). However, recent sales trends indicate an increase in preference for light trucks in the passenger vehicle segment and the share of light

trucks as percentage of light duty vehicle sales has increased from 14.8% in 1970 to 60% in 2015 (ORNL, 2017). This might pull down the overall fuel economy in future.

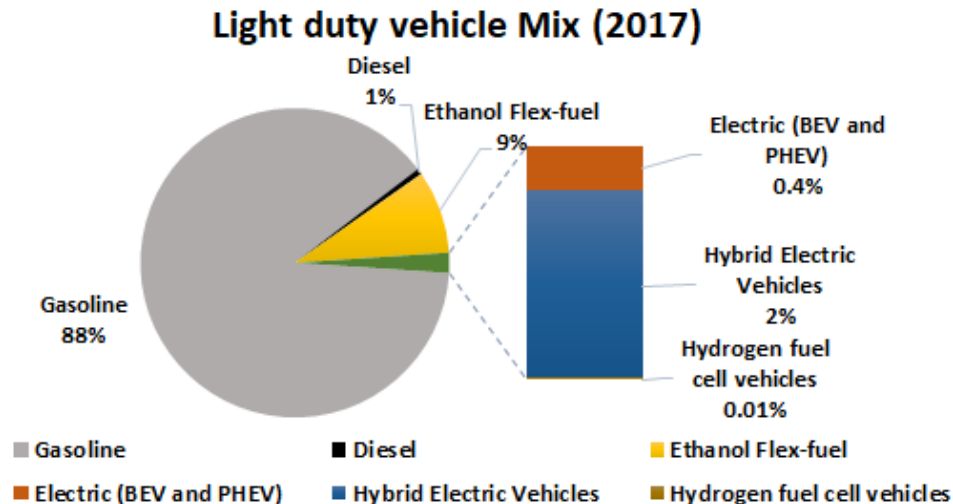


Figure 3: Current LDV population in the U.S.

The presence of alternative fuel technologies is increasing and the number of alternative fuel vehicle models available in market have increased from 43 to 146 over the past decade from 2007 through 2016 (AFDC, 2016). Of the 146 models, 45% are fueled by E85, 20% are electric vehicles (including plug-in hybrid electric vehicles), 21% are hybrid electric vehicles and the remaining 14% are fueled by hydrogen, compressed natural gas (CNG) and propane in total. Of the nearly 30,000 alternative fueling station¹ in the United States, California leads all the states with 19% of the total stations, followed by Texas and Florida which have about 2,000 and 1,500 stations respectively (AFDC, 2017). Retail gasoline prices (Figure 4) have seen a considerable decline from \$3.61/gallon in 2012 to \$2.12/gallon in 2016 (NACS, 2016) but the prices remain volatile and the trend may reverse in future.

¹ Electric Vehicle charging station is counted as one geographical location and not on the number of plugs available.

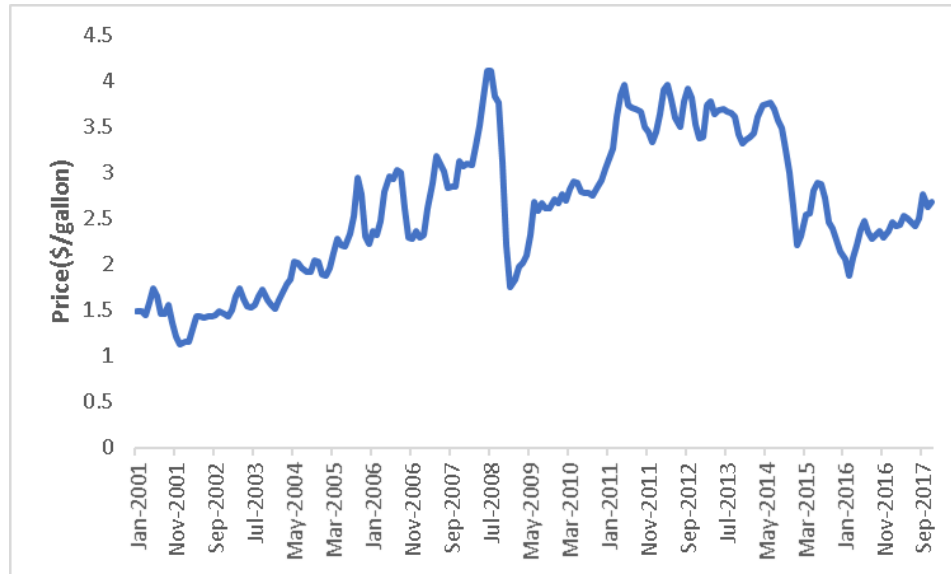


Figure 4: Retail price of gasoline since 2001.

Vehicle and Fuel Policy: Fuel policy is targeted at- increasing fuel economy of new vehicles to reduce greenhouse gas emissions and promotion of alternative fuel vehicles. Corporate Average Fuel Economy (CAFE) Program by National Highway Traffic Safety Administration (NHTSA) aims at improvement of vehicle efficiency to reduce fuel consumption and greenhouse gas emissions. CAFE standards require manufacturers to meet a combined average fuel economy of 48.7- 49.7 or higher by model year 2025 for passenger vehicles. There are several federal and state tax incentives and disincentives available for promoting alternative fuel vehicles and discouraging the purchase of low economy vehicles. A federal tax credit of \$2500-\$7500 is available to electric vehicles (AFDC, n.d.). The Gas Guzzler tax has been in existence since 1991 and is imposed on purchase of a new vehicle having a fuel economy of less than 22.5 miles per gallon. This tax is applicable on cars only and does not apply on light trucks and SUVs and vans (ORNL, 2017). Many state governments allow alternative fuel vehicles drivers to use high occupancy lanes.

According to the Annual Energy Outlook for 2018 report released by U.S. EIA, the share of electric vehicles (of total light duty vehicles sold) will grow from 4% in 2017 to 17% in 2050 (U.S. EIA, 2018) . Hydrogen fuel cell vehicles share is expected to be about 0.4% by 2040 (U.S. EIA, 2018). The growth rate (CAGR) in light-duty vehicle use is likely to be around 1.01% from 2015-2035 and 0.78% from 2035-2045 (FHWA, 2017). During the same period, the heavy-duty truck segment is also expected to observe a growth rate of about 1.5% in the annual vehicle miles traveled (FHWA, 2017). Due to the combined effect of improved fuel economy of light duty vehicles and increased vehicle miles traveled by heavy-duty trucks of lower fuel economy the motor fuel consumption is expected to remain flat or decline only marginally.

IV. Future Situation: Assumptions and Propositions

A profitable strategy must address the most likely future while being flexible in the face of change. We anticipate the year 2040 seeing definitive changes to the American transportation sector. But despite this change, motor fuel powered engines will remain the dominant technology on the road. It is critical that our convenience stores provide gasoline and diesel fuels to the majority of American drivers, but we can leverage the growing interest in electric vehicles to gain a competitive advantage in the future as the market develops.

To define the convenience store environment of 2040, we came up with following propositions:

- Population of drivers: The sales of light duty vehicles will continue to grow at a modest rate of 0.33% from 2017-2040 (U.S. EIA, 2018) and the fleet will reach a total population of approximately 265 million vehicles. We do not anticipate any

major increase in vehicle ownership due to a declining population growth rate (Chokshi, 2016) and the migration of young workers to major cities with established public transportation systems. Young workers may not be as motivated to purchase vehicles as previous generations due to a combination of economic factors, views on climate change, and the rise of ride-hailing services.

- Population of vehicles: In the absence of a significant spike in the price of oil, Americans will buy more trucks and SUVs than fuel-efficient passenger vehicles. Moreover, the increasing popularity and sales trend of crossover utility vehicles (CUVs) coupled with the abundance of inexpensive oil provides no monetary incentive to change their purchasing preferences. A Navigant Research (2017a) report shows that the sales of light duty vehicles in 2025 will comprise of 85% gasoline powered, 4% diesel, 3% hybrid, 6% electric, and 2% ethanol. Based on this report and U.S. EIA projections, we anticipate that the relative market share of vehicle technologies in 2040 will be similar, with gasoline dominating the market and EVs having the second largest market share. We also anticipate that most consumers who value alternative fuels will purchase electric vehicles over flex fuel vehicles (FFVs) as the variety of electric vehicles increases and CAFE credits for automakers of FFVs disappear after 2019 (Navigant, , 2017b).
- Fuel consumption: Despite a small increase in the absolute number of light duty vehicles in use, the consumption of gasoline and diesel will not show a significant growth. In fact, fuel consumption among passenger cars and light trucks is likely to decline due to the increase in ride-hailing services and improvements in vehicle fuel economy. However, the increase in vehicle miles of heavy-duty

trucks (EIA, 2018) coupled with their lower fuel economy will likely offset this reduction, thus resulting in a flat to marginal decline in overall trends of conventional motor fuel consumption. This indicates that our business strategy cannot rely solely on the sale of gasoline and diesel.

- Electric vehicles: We anticipate the electric vehicle industry growing by ten times its current market share in 2040 (Navigant, 2017a) as a result of the following factors: (1) the decreasing costs for batteries, (2) the rise in the luxury electric vehicle market, (3) social attitudes toward energy and climate issues, and (4) the ability to adapt modern infrastructure to support electric vehicles. We anticipate the capital costs associated with charging infrastructure to continue decreasing as charging station manufacturers gain production experience, i.e. the learning curve effect. We assumed a price reduction of 20% for our analysis (Nigro & Frades, 2015). Although urban areas offer free or low cost charging options at libraries, supermarkets, and offices, fast EV charging facilities along interstate corridors can be offered at a higher price due to the consumer's lack of options.
- Biofuels: Ethanol will continue to be mixed with gasoline and sold as a standard E10 fuel at all stations. E15 fuel sales will grow in the future as 90% of the manufacturers have accepted the satisfactory use of the fuel only for model year 2018 and beyond (RFA, 2018), however their demand in the near term is expected to remain low. Also, the sales of flex fuel vehicles that can utilize E85 will decline as the CAFE credits for automakers for manufacturing these vehicles disappear by 2019 (Navigant, 2017b). This makes us anticipate that the demand of E85 will reduce in future and E15 sale could be beneficial only after 2030.

- Other alternative fuels: Vehicles based on other alternative fuels, such as hydrogen, will not achieve the popularity of electric vehicles due to the current lack of infrastructure, technical and economic barriers in fuel production, and limited offering of fuel cell vehicles from automakers. Natural gas may find a growing market in commercial trucking and busing segment, but these segments are outside the focus of this analysis as it is focused on the light duty vehicle segment only.

V. Our Strategy

Our strategy for 2040 is built on four considerations that will allow our convenience stores to appeal to current consumers and draw in future consumers as the markets evolve over time. **The first and most important consideration** is to remain true to the convenience store's core competency, which is to save customer's time during the purchase of goods and services. Regardless of the fuels offered, it is imperative that our store owners optimize the store's ability to receive a customer, meet their immediate needs, and allow them to depart as quickly as possible. As stated in the NACS industry report (2017, p. 30), "convenience sells time" and our stores must be ready to provide fuel, food, restrooms, or entertainment in a timely manner.

The second consideration is the array of products and services offered. Fuel in 2040 will maintain its position as the foundation of store revenue and we will continue to offer gasoline and diesel at its current locations. Stores located in NACS Regions 3 & 5 will continue to offer E85 if the infrastructure for it is currently installed, but no new E85 capacity will be added. As stated earlier, we anticipate gasoline and/or diesel consumption to reduce in passenger vehicles but increase in pickup trucks and SUVs,

which results in a relatively flat overall consumption. However, any unexpected event (war, natural disasters, and supply quotas) can raise the price of oil and quickly reduce truck and SUV sales. If this were to occur, the consumption of gasoline/diesel would certainly drop and so would our revenues from fuel sales. Therefore, our strategy includes offering an additional fuel to attract customers who no longer own gasoline/diesel engines.

The third consideration is the rise of electric vehicles. While it is tempting to think that offering a variety of alternative fuels is the key to capturing future revenue, it would be an incorrect conclusion. Vehicles utilizing fuels such as E85, hydrogen, LNG/CNG, and biodiesel will be miniscule in comparison to the rising population of electric vehicles and hybrids in the LDV market (Navigant, 2017a). The infrastructure and O&M costs for offering a variety of alternative fuels is too high to maintain profitability past 2040. Electric charging stations, however, show the promise of being becoming profitable circa 2040. The dilemma is that electric vehicle owners will not regularly charge their vehicles at convenience stores when they can do it at home for cheaper. Therefore, electric vehicle owners will primarily use our stores to recharge on interstate trips or when their battery is critically low. However, drivers still use stores for restroom breaks and to purchase food and incidentals. Offering DC fast charging could be enough to entice these consumers to stop at the store. The store would make less profit on the sale of electricity, but would offset the loss through the sale of other products (food, coffee, entertainment, etc.) to the driver.

The last consideration is a deliberate focus on building a positive emotional shopping experience. In looking to the future, we acknowledge that a commitment to

time savings and fuels may not be enough of an edge to remain competitive. Repeat customers are critical to sustaining revenue in 2040, and our store managers must do everything within their budgets to motivate customers back to their stores. This will involve improving security at the store, maximizing cleanliness of the restrooms and facilities, and maintaining high-quality products and services. Building customer loyalty is more than simply offering discounts it relies heavily on the emotional component of the shopping experience, and we will achieve this by promoting the store's values, improving its layout to create a more engaging experience, and training employees to cultivate positive customer interactions (Shukla & Babin, 2013).

VI. Implementation Plan

Our strategy assumes that electric vehicles will own a large portion of the American LDV market in the long term (beyond 2040). It will likely take 50 or more years for the population of electric vehicles to be comparable to gasoline vehicles, but we anticipate that this will occur. The challenge is in determining where and when electric vehicle markets will emerge. Currently, there are 16,400 electric charging stations distributed primarily in major cities along the East and West coasts (AFDC, 2017). Our business strategy is focused on capturing emerging electric vehicle markets in NACS Regions 2 & 4, rather than compete in established markets along the East and West coasts. Our goal is to establish electric vehicle charging stations along interstate highways connecting major cities in these regions, such as Houston, Dallas, Jacksonville, Raleigh and Atlanta (Figure 4).

Our NPV analysis (Appendix B) determined that in order to maximize profitability, the installation of electric charging stations must occur when electric vehicle sales surge and the cost of electric chargers have lowered. Installing chargers in 2020 would incur high capital costs, which could be reduced by waiting for improvements in DCFC manufacturing to lower the purchase prices. However, waiting too long to add electric charging stations can result in the loss of market share to rival convenience stores who establish their electric charging capacity early. Determining where and when to commit to electric charging stations is a central part to our strategy.

Our implementation plan adheres to the following steps:

- **Conduct survey among customers:** The store manager can gauge their customers' interest in electric vehicle to better time the adoption of electric chargers. The survey would also gauge their interest in new products, as well as receive feedback on the store's current image and ability to meet customer needs. An example survey questionnaire is provided in Appendix A.
- **Track the growth of electric vehicles in the local area:** Battery Electric Vehicles (BEV) demand is a chicken and the egg dilemma: BEVs are not likely to use the interstate highways in mass due to the lack of charging infrastructure, and commercial DCFCs are unlikely to be installed without a demonstrated flow of BEV traffic. The store manager will track how many electric vehicles are registered each year to provide a good indication of an area's transition to electric vehicles. Our NPV analysis indicated that commercial DCFC is currently a very risky project--the demand for DCFC is too low to recoup the high capital costs associated with DCFC equipment. However, incorporating the profit from

in-store sales makes the project much more likely to break even at a demand of at least 19,000 charging sessions per year. Our model results indicate that with installation of 3 DCFC stations, we can break even in 10 years by charging \$4 per session, where each session provides the EV driver with 15 minutes of charge at 50kW. The ability to install chargers without incurring a large loss is critical to getting a second mover advantage over other fuel retailers. With Tesla and other players like Chargepoint, EVgo, Blink already offering DCFC charging services, we have businesses that we can observe in terms of r best practices and avoid pitfalls while seeking to capture the emerging EV market ahead of other competitors.

- **Conduct an electric charging station pilot study in a promising EV corridor:** Electrical consumption requirements for DCFC are significant and acting early allows us to secure better agreements with the local energy utilities in terms of electricity rates. This is a long-term strategy that will allow us to have a significant presence in our planned inter-state corridor by the time BEV traffic increases dramatically in 2040. Our NPV analysis shows that the majority of the capital costs associated with the DCFC installation belong to the charging unit and the electrical infrastructure. We will channel our efforts to engage with the local electric utility to conduct the pilot project, in which utility maintains ownership of the charging infrastructure and revenues from charging fee, while we benefit from the lower project costs and greater footfall of consumers in our stores that will increase our in-store sale margins.

- Focus on Texas, Florida, and Georgia:** Electric vehicle population is growing fast in Texas, Florida and Georgia and it is important that we capture the rising traffic of EVs on the well-travelled corridors between these states. Our preliminary study shows that there are not enough market players offering DCFC services in these corridors and thus an early mover's advantage could be easily gained. Based on our financial analysis, we adopt a phase approach - in **Phase 1**, we install 3 DCFC stations along the I-75 corridor between Atlanta and Jacksonville to conduct the pilot program (Figure 5). Spacing of these charging stations will be done at a 60 mile interval that increases the probability of getting a customer as well as aligns with the typical range of existing EV models.

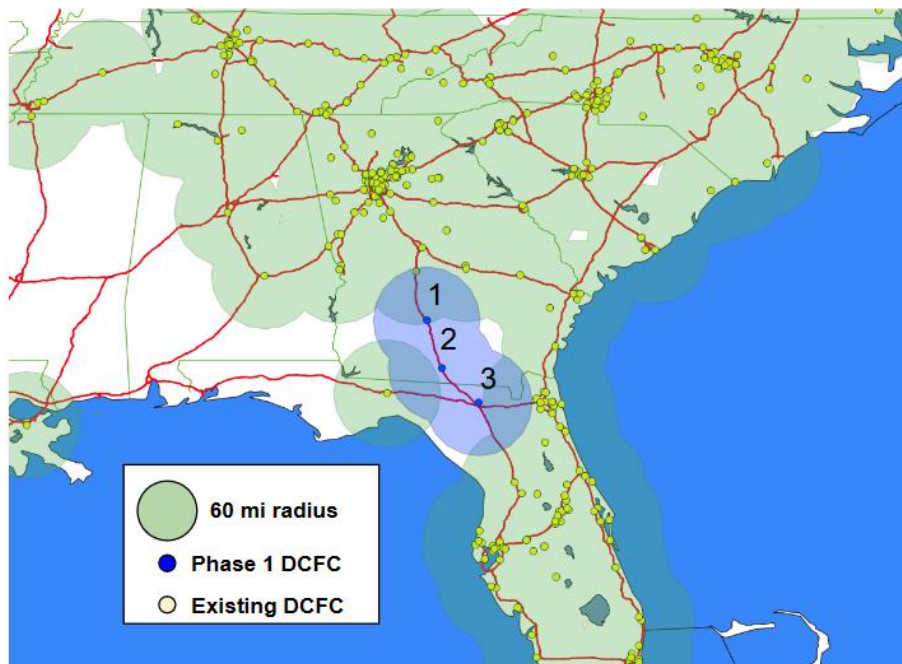


Figure 5: DCFC Pilot Program along I-75.

Our Phase-2 implementation plan and strategy will depend upon the growth rate of electric vehicle market and the success of our pilot projects. Based on current EV growth data our financial analysis suggest that the success of our pilot projects would allow us to install up to 10 DCFC stations. For this phase, we will

focus on the busy corridors between Jacksonville and Raleigh, and Dallas and Houston, as well as the I-10 corridor between Houston and Jacksonville (Fig. 6).

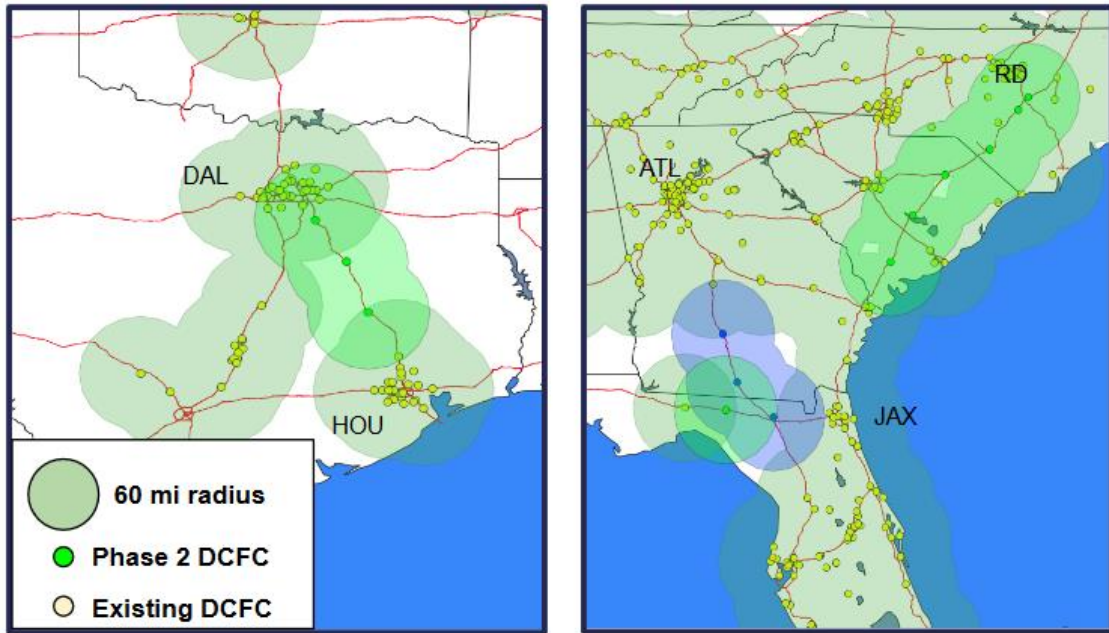


Figure 6: DCFC Phase 2 implementation along I-75, I-10, I-45, I-95.

We will be flexible about the positioning of these chargers and it will also depend upon the entry of other players on these corridors by 2040. We will not prefer to position our charging infrastructure at locations which are already crowded by other installers as such DCFC stations will not be able to much profitable for us.

- **Review store design to electric vehicle customers:** As stated in our strategy, all stores (regardless of fuel mix) will review its ability to serve the customer with quality products and services in the shortest time possible. Over the next 20 years, we will review store layouts, employee schedules, and other processes for optimization. There are several industrial engineering concepts that can assist us in minimizing customer wait times while maximizing revenues. The addition of DC fast charging at select stores presents new considerations- the vehicle owner will need about 15 minutes to charge their batteries sufficiently, so the ultimate

goal is to have these customers purchase food or drinks during their wait time. It is important to make the customer feel engaged during the charging process by provision of free wi-fi, sitting area, etc.

VII. Looking beyond 2040

The fuel retail sector will continue to face sustainability and profitability challenges in future as the market for alternative fuels and technologies evolve and climate change agenda assumes paramount importance. The industry and its stakeholders need to plan for future and ideate strategies that are innovative as well as aggressive in nature. As a part of the long-term strategy beyond 2040, we propose to explore market segments that are in infancy at present or in short-medium term to ensure resilience to changing market dynamics, government policies and other external factors.

First, post our Phase-2 implementation, at least ten years will pass before electric charging stations should be added to our existing convenience stores along interstate highways in the surrounding states of Louisiana, Arkansas, Missouri, Mississippi, and Alabama. We will add charging stations in these states once they achieve a significant population of electric vehicles. The monitoring of surveys and registrations will provide a quantitative way of assessing their progress.

Second, penetration of electric vehicles will continue to increase in future resulting in more demand for charging stations and supporting infrastructure. Thus, forging partnerships with commercial spaces such as malls, movie theatres, and corporate parks in cities to develop the AC Level 2 charging infrastructure could also support revenue generation and ensure sustainable operations.

Third, there is no similarity among the battery models utilized in electric vehicles among different manufacturers. With maturity in the electric vehicle markets over next few decades, it could be expected that batteries will have to comply with certain uniform standards. In such a battery standardized market, provision of battery swapping at the fuel retailing outlets can be a potential business segment to enter.

VIII. Conclusion

Our analysis shows that despite the changing dynamics of the automobile industry, gasoline is likely to remain the primary fuel source for light-duty vehicles. Light duty vehicle segment that dominates the transportation energy consumption is in the midst of a transition to more efficient and alternative fuel vehicles. This makes fuel retailing sector susceptible to profitability related challenges in the future if they continue to operate in the same way as presently. Thus, in order to ensure sustainable yet profitable operations in future, we have devised a holistic strategy for 75 of our retail stores through 2040.

Our research and analysis shows that gasoline will remain the dominant fuel for light duty vehicles and thus will continue to be offered as primary fuel. Among alternate fuels, we believe that only electric vehicles will capture significant market share by 2040 and therefore we will pay attention to the development of Electric Vehicle Supply Equipment (EVSE) infrastructure at our stores by providing DCFC chargers DCFC at our convenience store will put our stores on electric charger location websites, effectively directing the EV consumer base to our stores. We will however adopt a well calculated and flexible approach while entering this emerging market segment.

Enhancing customer experience and understanding their needs will be critical in sustaining the traffic at stores. Our strategy is therefore to focus on improvisation in customer experience through proper engagement and adjust to future alternative fuel market. Our implementation plan will involve store modification to accommodate the requirement of electric vehicle owners by offering DC fast charging stations and improved convenience. The implementation timeline will be designed in a flexible manner in accordance with the trends in growth of electric vehicles in the local area. However, besides technological developments, government policies and external market forces will continue to reshape our operating strategies so as to be profitable in this highly volatile business segment of fuel retailing.

References

- Accenture (April 2016). *Accenture petroleum review- retail marketing survey*. Retrieved from : https://www.accenture.com/t20160623T023223Z__w__/_us-en/_acnmedia/PDF-21/Accenture-Petroleum-Review.pdf#zoom=50.
- Alternative Fuels Data Center (n.d.). *Qualified plug-in electric drive motor vehicle tax credit*. Retrieved from: <https://www.afdc.energy.gov/laws/409>.
- Alternative Fuels Data Center. (2017). *Alternative fueling station locator* [GIS]. U.S. Department of Energy. Retrieved from <https://www.afdc.energy.gov/locator/stations/>.
- Ayre, J. (2017, January 20). California has ~50% of US electric cars. *CleanTechnica*. Retrieved from <https://cleantechnica.com/2017/01/20/december-2016-us-ev-sales-2011-2016-sales-figures-state-ev-volumes/>.
- Bainbridge, R. E. (2012). Site essentials of convenience stores and retail fuel properties. *Appraisal Journal*, 80(1), 61.
- Bureau of Transportation Statistics. (2016). *Transportation statistics annual report 2016*. Washington, D.C.: U.S. Department of Transportation.
- Clifton, K., Muhs, C., Morrissey, T., & Currans, K. (2016). Consumer behavior and travel mode: An exploration of restaurant, drinking establishment, and convenience store patrons. *International Journal of Sustainable Transportation*, 10(3), 260–270. doi:10.1080/15568318.2014.897404.
- Chokshi, N. (2016, December 22). Growth of U.S. population is at slowest pace since 1937. *The New York Times*. Retrieved from <https://www.nytimes.com/2016/12/22/us/usa-population-growth.html>.
- Federal Highway Administration. (2017). *FHWA forecasts of vehicle miles traveled (VMT): Spring 2017*. Retrieved from: https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.cfm.
- Fitzgerald, G. & Nelder, C. (2017). *From gas to grid: Building charging infrastructure to power electric vehicle demand*. Basalt, CO: Rocky Mountain Institute.
- Fracfort, J., Salisbury, S., Smart, J., Garetson, T., & Karner, D. (2017). *Considerations for corridor and community DC fast charging complex system design*. Idaho Falls, ID: Idaho National Laboratory.
- International Energy Agency. (2017). *Global EV Outlook 2017*. France: IEA Publications.

- National Association of Convenience Stores. (2017). *State of the industry report of 2016 data*. Alexandria, VA: NACS.
- Navigant Research. (2017a). *Tomorrow's vehicles: A projection of the light duty vehicle fleet through 2025*. Alexandria, VA: Fuels Institute.
- Navigant Research. (2017b). *Tomorrow's vehicles: An overview of vehicle sales and fuel consumption through 2025*. Alexandria, VA: Fuels Institute.
- Nigro, N. & Frades, M. (2015). *Business models for financially sustainable EV charging networks*. Arlington, VA: Center for Climate and Energy Solutions.
- Oak Ridge National Laboratory. (2017). *Transportation energy data book: Edition 36*. Retrieved from: http://cta.ornl.gov/data/tedb36/Edition_36_Full_Doc.pdf.
- Renewable Fuels Association(RFA).(2017). Automakers approve E-15 in nearly 90% of the new 2018 vehicles. Retrieved from: <http://www.ethanolrfa.org/2017/11/rfa-analysis-automakers-approve-e15-in-nearly-90-of-new-2018-vehicles/>.
- Sari, Y., Shaari, Z., & Amar, A. (2017). Measurement development of customer patronage of petrol station with convenience store. *Global Business and Management Research: An International Journal*, 9 SI(1), 52.
- Shukla, P. & Babin, B.J. (2013). Effects of consumer psychographics and store characteristics in influencing shopping value and store switching. *Journal of Consumer Behaviour* 12, 194-203. doi: 10.1002/cb.1411.
- Smith, M. & Castellano, J. (2015). *Costs associated with non-residential electric vehicle supply equipment*. U.S. Department of Energy report prepared by New West Technologies, LLC. Retrieved from https://www.afdc.energy.gov/uploads/publication/evse_cost_report_2015.pdf.
- U.S. Energy Information Administration. (2018). *Annual Energy Outlook 2018*. Retrieved from: <https://www.eia.gov/outlooks/aeo/>.
- U.S. Energy Information Administration. (2017). *U.S. All Grades All Formulations Retail Gasoline Prices*. Retrieved from: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=emm_epm0_pte_n_us_dpg&f=m.

Appendix A

Example Survey Questionnaire for understanding consumer behavior and expectations from a fuel retail outlet

Name:		Age:	
Gender:		Resident of:	
How many cars does you/your family own?	Zero	·	
	One	·	
	Two	·	
	More than two	·	
What type of cars do you possess?	Gasoline/Diesel	·	
	Electric (any type)	·	
	Hybrid	·	
	Flex Fuel type	·	
	Other alternative fuel	·	
How frequently do you drive?	Daily	·	
	Weekly	·	
	Monthly	·	
Do you prefer a particular fuel brand?	Yes	·	No ·
Will you travel extra miles if your choice of brand is not available?	Yes	·	No ·
Do you refuel your vehicle from this station often?	Yes	·	No ·
How much time on average do you spend at the fuel station?	10 min	·	
	10-30 min	·	
	30 - 60 min	·	
	>60 min	·	
What do you specifically like/ prefer about the fuel station?	Fuel Price	·	
	Staff behaviour	·	
	Customer convenience (time)	·	
	Convenience store stock	·	
	Cleanliness of toilets and area	·	

	Restaurant/Pick up food service ·
Do you plan to buy a alternative fuel vehicle in near future?	YES Electric (any type) · Hybrid · Flex Fuel type · Hydrogen/CNG · NO ·
How likely it is for you to shop or dine-in if the fuel station offers DC fast charging facility for your hybrid/battery electric car?	Not at all · Same as before · Very likely ·
Any other comment/feedback:	

Appendix B

B.1. NPV Model

Year	BEV on Corridor	# Charging sessions	MTBS (hr)	Energy Sold (kWh)	Revenue (charge)	Revenue (store)	Principal Cost	Interest Cost	O&M Cost	Depreciation	Taxes	ATCF	PVCF	NPV at year
2020	29,500	0	0	0	0	0	0	0	0	0	0	0	0	0
2021	31,692	19,015	0.92	237,689	\$76,060	\$18,825	\$23,214.62	\$26,904.00	\$50,579	\$8,640	\$1,840	(\$7,652)	(\$6,956)	(\$6,956)
2022	34,047	20,428	0.86	255,349	\$81,712	\$20,224	\$25,071.79	\$25,046.83	\$54,181	\$8,640	\$2,954	(\$5,319)	(\$4,396)	(\$11,352)
2023	36,576	21,946	0.80	274,322	\$87,783	\$21,726	\$27,077.53	\$23,041.09	\$58,052	\$8,640	\$4,153	(\$2,814)	(\$2,114)	(\$13,466)
2024	39,294	23,576	0.74	294,704	\$94,305	\$23,341	\$29,243.73	\$20,874.89	\$62,210	\$8,640	\$5,443	(\$126)	(\$86)	(\$13,552)
2025	42,213	25,328	0.69	316,600	\$101,312	\$25,075	\$31,583.23	\$18,535.39	\$66,676	\$8,640	\$6,832	\$2,759	\$1,713	(\$11,839)
2026	45,350	27,210	0.64	340,124	\$108,840	\$26,938	\$34,109.89	\$16,008.73	\$71,475	\$8,640	\$8,327	\$5,856	\$3,306	(\$8,533)
2027	48,719	29,232	0.60	365,395	\$116,926	\$28,939	\$36,838.68	\$13,279.94	\$76,631	\$8,640	\$9,936	\$9,180	\$4,711	(\$3,822)
2028	52,339	31,403	0.56	392,544	\$125,614	\$31,089	\$39,785.77	\$10,332.84	\$82,169	\$8,640	\$11,668	\$12,748	\$5,947	\$2,125
2029	56,228	33,737	0.52	421,710	\$134,947	\$33,399	\$42,968.64	\$7,149.98	\$88,119	\$8,640	\$13,532	\$16,577	\$7,030	\$9,155
2030	60,406	36,243	0.48	453,043	\$144,974	\$35,881	\$46,406.13	\$3,712.49	\$94,511	\$8,640	\$15,538	\$20,687	\$7,976	\$17,131
2031	64,894	38,936	0.45	486,704	\$155,745	\$38,547	\$4,771.32	\$5,529.60	\$101,378	\$8,640	\$16,536	\$66,077	\$23,160	\$40,291
2032	69,715	41,829	0.42	522,866	\$167,317	\$41,411	\$5,153.02	\$5,147.89	\$108,755	\$8,640	\$18,099	\$71,574	\$22,806	\$63,096
2033	74,895	44,937	0.39	561,715	\$179,749	\$44,488	\$5,565.27	\$4,735.65	\$116,680	\$8,640	\$19,778	\$77,478	\$22,443	\$85,539
2034	80,460	48,276	0.36	603,450	\$193,104	\$47,793	\$6,010.49	\$4,290.43	\$125,194	\$8,640	\$21,582	\$83,820	\$22,072	\$107,611
2035	86,438	51,863	0.34	648,286	\$207,452	\$51,344	\$6,491.33	\$3,809.59	\$134,340	\$8,640	\$23,521	\$90,633	\$21,697	\$129,308
2036	92,861	55,716	0.31	696,454	\$222,865	\$55,159	\$7,010.63	\$3,290.29	\$144,167	\$8,640	\$25,605	\$97,952	\$21,317	\$150,625
2037	99,760	59,856	0.29	748,201	\$239,424	\$59,257	\$7,571.48	\$2,729.44	\$154,723	\$8,640	\$27,844	\$105,814	\$20,935	\$171,560
2038	107,172	64,303	0.27	803,792	\$257,213	\$63,660	\$8,177.20	\$2,123.72	\$166,064	\$8,640	\$30,250	\$114,260	\$20,551	\$192,111
2039	115,135	69,081	0.25	863,514	\$276,324	\$68,390	\$8,831.38	\$1,469.54	\$178,247	\$8,640	\$32,835	\$123,332	\$20,166	\$212,276
2040	123,690	70,080	0.25	876,000	\$280,320	\$69,379	\$9,537.89	\$763.03	\$180,794	\$8,640	\$33,495	\$125,109	\$18,597	\$230,873

Table B1. The NPV model used for determining the financial viability of DCFC stations.

We assessed the financial viability of electric superchargers using net present value (NPV) calculations for 10 year and 20 year time horizons. The model (Table B1) calculates demand for chargers based on the estimated population of electric vehicles. The model caps the maximum number of charging sessions based on demand or based on availability, meaning each charger has a finite amount of charges in a year. The mean time between sessions (MTBS) indicates how much time should elapse between charging sessions. Revenues are group into charging and in-store purchases, to better capture whether effect of in-store purchases on financial viability. Capital costs have a uniform payment schedule over 10 years at an interest rate of 8%. O&M costs are the sum of maintenance, upgrade, and fuel costs, which are based on peak demand pricing of \$0.204/kWh. The tax rate is 21% and the discount rate is 10%, while depreciation uses the straight line method over a service life of 10 years.

B.2. Key Inputs

Input	Unit	Base	Low	High
# units in added in year 0	#	3		
# of sites in year 0	#	3		
# units in added in year 10	#	10		
# sites in year 10	#	10		
BEV on interstate	#/year	2.95E+04	2.07E+04	3.84E+04
BEV battery capacity	kWh	30	24	40
DC Charging use	# visits/year	1	6	48
% of cars that use I-10/I-95	%	1	0.2	
Customer Profit	\$/session	1.32	0.5	1
P(cust. buys something)	%	0.75	0.5	1
DCFC Power Rating	kW	50	24	350
DCFC Installation	\$/unit	19300	4.00E+03	5.10E+04
DCFC Hardware	\$/unit	28800	10000	6.00E+04
Load center/conduit	\$/site	15500	7750	23250
Permits & Fees	\$/site	1000	650	1400
480V transformer	\$/site	17500	1.00E+04	2.50E+04
Project Management	\$/site	30000	15000	45000
Electricity cost	\$/kwh	0.204	0.125	0.32
Fixed Charge	\$/year	125	50	200
Repair component	\$/year	400		
Software & Upgrades	\$/year	255		
Interest Rate	%	0.08	0.05	0.1
Discount Rate	%	0.1	0.08	0.12
Session Time	min	15	15	30
Charging Fee	\$/session	4	3	5
Loan Period	Years	10		
EVSE Availability	%	0.666667	0.5	1
BEV growth rate	%	0.0743	0.03	0.1
EVSE Hardware Cost Dep.	%	0.2		

Table B2. The inputs to the NPV model.

Parameter	Unit	Low	High	Source
DCFC Station Hardware	\$/unit	10,000	40,000	NWT (2015)
DCFC Station Hardware	\$/unit	12,000	35,000	RMI (2014)
DCFC Station Hardware	\$/unit	15,000	60,000	CCR Guidebook (2014)
DCFC Station Hardware	\$/unit	8,500	50,000	Inside Evs (2013)
Installation	\$/unit	4,000	51,000	NWT (2015)
Installation	\$/unit	10,000	25,000	CCR Guidebook (2014)
Installation	\$/unit	7,000	19,000	RMI (2014)
480-volt transformer	\$/unit	10,000	25,000	https://www.fleetcarma.com/dc-fast-charging-guide/
480-volt transformer	\$/unit	10,000	25,000	RMI (2014)
Permits & Fees	\$/site	650	1,400	RMI (2014)
Unit maintenance	\$/year	400		CCR Guidebook (2014)
Sale computer maintenance	\$/year	255		CCR Guidebook (2014)

Table B3. Research on capital costs for DCFC equipment.

The key inputs for the model are listed in Table B2, and we estimated from previous studies published by the Idaho National Laboratory, Rocky Mountain Institute, and National Renewable Energy Laboratory. We selected a generic 50kW DCFC unit as the basis for our analysis. The capital cost for charging units, installation fees, and additional infrastructure costs

are the average of several estimates provided in the aforementioned studies (Table B3). Annual maintenance and upgrade costs are for a single charging unit. The \$1.32 in profit per visit is based on 2016 NACS State of the Industry report, and is a large determinant in the financial viability of commercial DCFC. The charging fee is the average of charging fees offered by EVGo, Chargepoint, and Blink.

Demand Estimation for EV charging	
Length of the state highway under Texas (miles)	878
Average annual daily traffic (vehicles)	119,700
Number of automobiles registered in the state (private+commercial)	7,679,657
Total number of vehicles on interstate	19,694,583
% of automobiles	0.39
Annual number of Texas automobiles traveling on highway	17,036,740
BEV population in Texas	10691
% of BEV in Texas	0.0014
Annual BEV traffic on highway	23,717
% of Tesla vehicles	35%
% of other EVs (CCS, CHAdeMO)	15,416
Similar calculations for other selected interstate regions	
Total annual BEV traffic on selected interstate corridors	29,553

Table B4. Calculating the BEV demand for I-10, I-45, I-75, & I-95.

BEV demand is a chicken and the egg dilemma: BEVs are not likely to use the interstate highways in force due to the lack of charging infrastructure, and commercial DCFC is unlikely to build the infrastructure without a demonstrated flow of BEV traffic. In order to estimate true BEV demand, we identified the daily average vehicle traffic on Interstates 10, 45, 75, and 95 in Texas, Georgia, and Florida from the Federal Highway Administration. We then assumed that 39% of these vehicles were passenger vehicles, based on the ratio of registered vehicles to total vehicle traffic. We then multiplied the annual daily traffic (119,700 vehicles) by 39% to estimate the population of vehicles on the interstate that is based within the state. We

then estimated the size of the BEV population as 0.14% of the total registered vehicles in Texas, and applying this percentage to annual vehicle traffic (17 million) we estimated 23,700 BEVs on I-10 in Texas during the course of a year. We again filtered this result since Tesla vehicles have their dedicated charging network, which reduces this population by 35% (Table B4). Finally, we employed this method for the other interstates and averaged the results to get an overall estimate for BEV demand in the Gulf area of the United States (29,500 vehicles).

B.3. Results

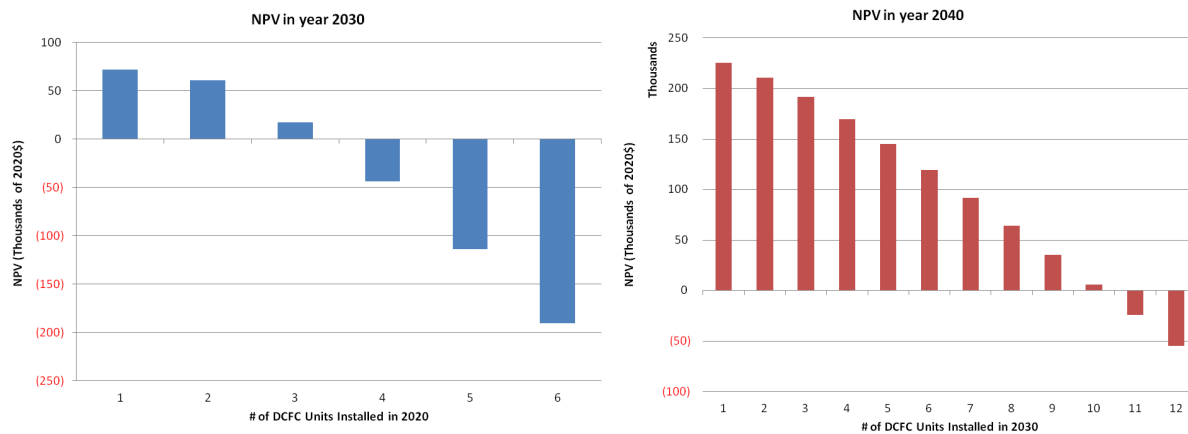


Figure B1. NPV decreases as more chargers are installed, but the break-even point grows as expected BEV demand grows.

NPV analysis indicates that commercial DCFC is currently a very risky project. The demand for DCFC is too low to recoup the high capital costs associated with DCFC equipment. However, incorporating the profit from in-store sales makes the project much more likely to break even. The highest NPV is obtained from installing the fewest chargers, but we can still break even by installing 3 chargers in 2020 and 10 more chargers in 2030 (Fig. B1). The ability to install chargers without incurring a large loss is critical to getting a second mover advantage over other fuel retailers. With Tesla acting as first-movers, we can observe their best practices and avoid pitfalls while seeking to capture non-Tesla BEV business ahead of other competitors. We feel that the electrical requirements for DCFC are significant and acting early allows us to secure better agreements with the local energy utilities. This is a long-term strategy that will allow us to dominate a corridor by the time BEV traffic increases dramatically circa 2040.

B.4. Sensitivity Analysis

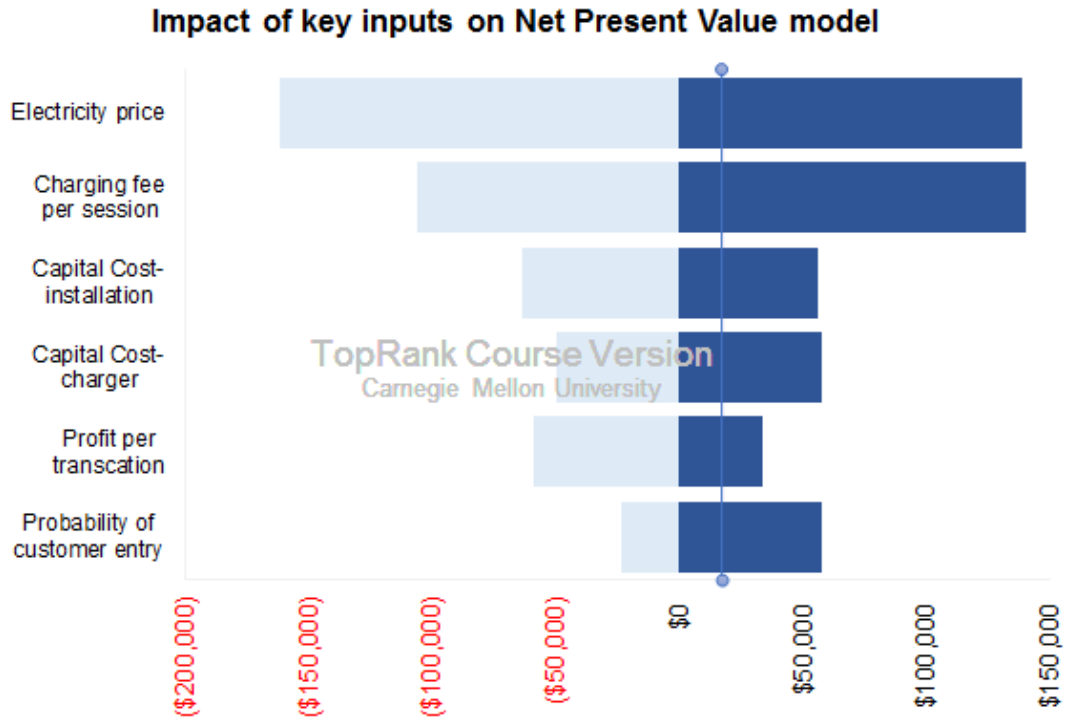


Fig. B2. Sensitivity analysis for the NPV model.

We examined the uncertainty related to eight input to our model, and found that the model is most sensitive to the price of electricity charged by the utility and the price we charge per charging session. These two factors can significantly change the NPV of our implementation plan. This further supports the importance of getting a good deal on the commercial price of electricity, which is more likely if we are an early mover on DCFC in an area. Additionally, our charging fee is not depressed due to stronger competition, which will certainly exist if we wait until the market fully develops.

Case Competition Winners

Third Place

CARNEGIE MELLON UNIVERSITY

Strategic Planning of a U.S. Fuel Retailer's Light-Duty Fueling Infrastructure through 2040



Aaron Milhorn



Hunter Reagan

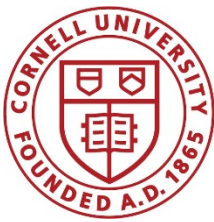


Owais Sarwar

Strategic Planning of a U.S. Fuel Retailer's Light-Duty Fueling Infrastructure through 2040

An Optimization-Based and Data-Driven Approach to Maximizing Profitability in a Dynamic Market and Changing Regulatory Environment

A Case-Study



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Executive Summary

A Need for Innovation. The next few decades will see more fuel efficient light-duty vehicles, increasing price of oil, greater government regulations and incentives for cleaner vehicle technologies, and rising penetration of electric vehicles on American roads. Coupled with changing consumer driving behavior, fuel retailers will be compelled to reformulate fuel offers and adjust business strategy to remain profitable.

Optimization-Based and Data-Driven Decision-Making. With advances in computing, businesses now have the capability to consider complex trade-offs between variables and gain insights from large amounts of data in order to make optimized decisions. This is the core of our strategic plan; optimizations using models and data will allow us to pursue strategies that are not readily obvious but are guaranteed to be the best possible practice. This technology will allow us to maintain flexibility in the face of unforeseen disturbances, maintain profitability, and stay steps ahead of our competitors.

A Comprehensive Strategic Plan. In addition to the optimization and data-driven approach, we also present other strategies that capitalize on digital technologies to enhance customer experience at our stores, lower operating costs at our stores by introducing automation, explore strategic partnerships with ridesharing corporations, and revision our marketing approach. Supplementing our primary optimization strategy, these ancillary strategies are the foundation of a comprehensive strategic plan.

Costs of Implementation. As the owner of 75 profitable retailing locations across the U.S., our group is well-positioned—in relation to our smaller competitors—to mobilize significant capital towards technological investment. Initially large investments in computer-system and digital infrastructure are expected to pay dividends long-term.

Market Assessment: Evolution of Key Drivers and Competitive Threats

Understanding the American fuel retailing market is essential to maintaining profitability in the years ahead. The number of fuel retailers has decreased steadily in past decades, from 200,000 in 1994, 170,000 in 2004, and 124,000 in 2016 [1] [2]. Here, we examine trends in the key industry drivers that are causing this decline.

LDV Fuel Efficiency, Government Regulations: Increasing efficiency putting downward pressure on industry growth. In 2015, the average fuel efficiency (FE) of an American light-duty vehicle (LDV) was 22 mpg (miles per gallon gasoline) [3]. Federal Corporate Average Fuel Economy (CAFE) legislation signed in 2011 has put pressure on automakers to increase FE for new cars from 36.7 mpg (energy equivalent) in 2017 to 51.3 mpg by 2025 [4]. Assuming new legislation continues this trend, the FE standard for model-year 2040 will be in the 75-85 mpg range and the average LDV on the road will likely be 40-50 mpg efficient. Increase in FE will lead to a decrease in gasoline demand, while being slightly off-set by the *rebound effect* caused when consumers drive more with increasing FE [5] [6]. However, LDV gasoline consumption is still expected to decrease 6-7% from current levels by 2025, and, assuming trends continue, 20-25% or more by 2040 [7]. Less demand for gasoline will be a barrier to long-term growth in the fuel-retailing industry.

Car Mobility Model: Decreasing car ownership, increasing public transport and ridesharing causing downward pressure on industry growth. The share of 16-24 year old Americans with drivers' licenses has declined from 76% in 2000, to 71% in 2013. Moreover, projections indicate that 10% of cars sold in 2030 will be shared vehicles and roughly 25% in 2040 [8]. More aggressive projections indicate that 95% of total

passenger vehicle miles will be travelled in a shared vehicle by 2030 [9]. While the latter scenario seems extreme, trends indicate that growth in private vehicle ownership will slow and likely decline, especially as hundreds of billions of dollars are expected to be invested in American public transportation in the next 40 years [10]. This will put pressure on the fuel retailing industry to compete for a declining consumer-base. Additionally, after 2030, mostly electric and autonomous shared vehicles are expected to begin replacing human-driven shared/hailed vehicles.

Price of Oil: Increasing price of oil will lead to tighter margins. The price of oil is a key driver in the gas stations with convenience store industry. Crude price constitutes about two-thirds of the cost of gasoline [11]. Lower prices of crude allow retailers to have higher profit margins. As crude prices rise, consumer driving falls and thus increases competition among retailers for business, leading to lower margins [12]. Crude prices also catalyzes the development and adoption of alternative fuel vehicles (AFVs).

The price of crude per barrel is expected to climb from \$57 in 2018 to \$86 in 2025, \$95 in 2030, and \$109 by 2040 [13]. Aggressive scenarios predict a rise to over \$150 by 2040 [7]. These prices will challenge fuel retailers to stay profitable at lower margins.

Emerging Powertrains, Government Incentives: New fuels expected to impact industry long-term. Higher gas prices and stricter FE standards are driving the increasing development and demand for AFVs. In addition to environmental regulations, government incentives in the form of tax credits for using AFVs, such as those brought-about by the Energy Policy Act of 2005, are promoting the wider adoption of new vehicle powertrains [12] [14].

Conventional liquid fuels (gasoline, gasoline-ethanol, diesel) currently dominate the market share of new LDVs—constituting about 95% of new vehicles sold currently. In the near future, flex-fuel vehicles are expected to decrease in market-share from 9% to just 2% of new cars by 2025, yet gasoline-based LDV sales are likely to remain stable at around 84% through 2025 [15]. By 2030 however, internal combustion engine LDVs are expected to fall to 68% market share and to continue falling through 2040 [16].

Despite the shale gas revolution, which has dramatically lowered the price of natural gas (NG) in the United States in the last decade, and despite projections that prices will remain below \$5/MMBTU through 2030, NG-based powertrains are unlikely to increase their market share much beyond the roughly 0.2% predicted in 2025 [15] [17] [18]. Even more pessimistic penetration numbers are expected for hydrogen fuel cell vehicles [15]. Both the NG and hydrogen-based technologies suffer from low energy-density and the difficulty of deploying gas-fueling infrastructure, among other issues [18] [19].

Battery-based LDV technologies are likely to see the greatest growth in the next few decades. This growth is propelled by the rapid decline of lithium-ion battery pack costs, which cost >80% less than in 2010 and are expected to well-exceed 50% cost decrease by 2030 [20]. Consequently, electric vehicles are expected to become cost-competitive (unsubsidized) with internal combustion engine technology by 2025. As a result, market share for hybrid electric vehicles (HEVs) will increase marginally from 2.4% to 3.6% in 2025. Plug-in HEVs (PHEVs) however will increase market share from about 0.65% to between 3-4% in 2025 [15]. Combined, PHEVs and HEVs are expected to reach nearly 19% market share by 2030 with more growth by 2040 [16]. Battery electric vehicles (BEVs) are expected to significantly increase US market-share from <1% today to 3-5%

in 2025, and 8% in 2030 [15] [16]. By 2040, 34% of vehicles on the road will be electric (primarily BEVs with big declines in the PHEV market) [21]. Consequently, our group will need to expand our fuel offer to meet emerging consumer demand for electric LDVs.

State of the Economy. The health of the fuel retailing industry is heavily dependent on the health of the overall economy. Healthier economy results in lower unemployment consumers with greater disposable income to spend on fuel [12]. Recent periods of economic downturn and high unemployment significantly impacted fuel retailing. Fortunately, unemployment is expected to remain low (<5%) at least through 2027 [22].

Opportunities for Innovation

Computing, Optimization, and Big Data. Dramatic increases in the processing power of modern computers have made high-performance computing economically accessible to individuals and small businesses. These capabilities allow businesses to solve mathematically complex optimization models and to analyze huge data-sets (i.e. Big Data) to gain non-obvious insights. These insights can be used to optimize operations and decision-making [23]. These optimization and data-driven techniques can be applied to fuel retailing to reduce costs and increase profits.

Mobile Digital Technology and the Internet of Things. The advent of mobile digital technology provides a promising opportunity to link fuel-retailers to their current and potential consumers. Smartphone applications, for example, could allow consumers to develop new means of interacting with fuel-retailers and convenience stores. Additionally, the “Internet of Things” concept, in which “things” can transfer data through

internet cloud-based technology without human-human or human-computer interaction, can allow automobiles to connect and communicate directly with fuel retailers [24].

Strategic Plan: Strategies, Timeline of Implementation, Economic Impact

The goal of this plan is to maintain profitability past 2040 while: (1) maintaining flexibility in changing markets and protecting against threats and (2) strengthening our position against competitors. Timelines for implementation are shown in Figures 1 and 2.

Overall Philosophy

Embracing Decision Sciences and Technology. Advances in operations research and computer science present new opportunities for business decision-making using scientifically informed methods and mathematical optimization, as opposed to inexact trial and error. In order to compete in an evolving market, it is vital that our business strategy makes use of all available technological resources that could provide an edge. This philosophy is evident in our technology-heavy primary and secondary strategies.

Emphasis on Non-fuel Products. Although optimizing gasoline retailing is a core-focus of our strategy, two-thirds of industry margins are from merchandise and foodstuff [2]. Increase in crude price will further decrease profitability of gasoline retailing. Therefore, optimizing profit on non-fuel products will be a point of emphasis.

Location-Informed Practices. Because our 75 stores are distributed widely across the country, it is imperative that we tailor our business strategy to account for local variations in the market. Some variations are the result of state-level regulations and incentives. However, properties of individual cities themselves (e.g. density, public transportation) will become increasingly relevant as the segmentation dimension that

determines AFV adoption and consumer mobility choices, leading to variation between states' rural and urban centers, but also variations between states' urban centers [8].

Primary Strategy: Optimization-Based and Data-Driven Business Practices

The heart of our strategy is optimization—i.e. taking our existing resources and deriving the maximum possible amount of economic benefit from these resources.

Establishment of Computing Infrastructure and Expertise. It is imperative that our group establish in-house computing infrastructure and expertise upon which we can implement our technology-driven primary and secondary business strategy. This will require the hiring of 2-3 computer systems engineers and scientists, as well as an expert in optimization, to develop and deploy hardware and software infrastructure, eventually across 75 stores.

Introduction of Electric Charging Stations. By 2040, our group expects electric vehicles to represent a significant number of vehicles on the road. Thus, the gradual incorporation of fast-charging DC Charging Stations into existing gasoline-retail centers must be part of our future. It is imperative to invest in fast charging infrastructure, because—although more expensive than slower Level 1 and Level 2 (L1/L2) charging—fast charging is unlikely to be come as ubiquitous in long-term parking areas (i.e. such as homes and parking lots) as L1/L2 and thus provides a clear value proposition to attract consumers [25]. Moreover, the presence of a convenience store on-site presents a competitive advantage over dedicated fast-charging stations alone.

Initially, charging stations would be placed in urban locations near highways, before being expanded into our rural locations. Stations would mostly be placed in current

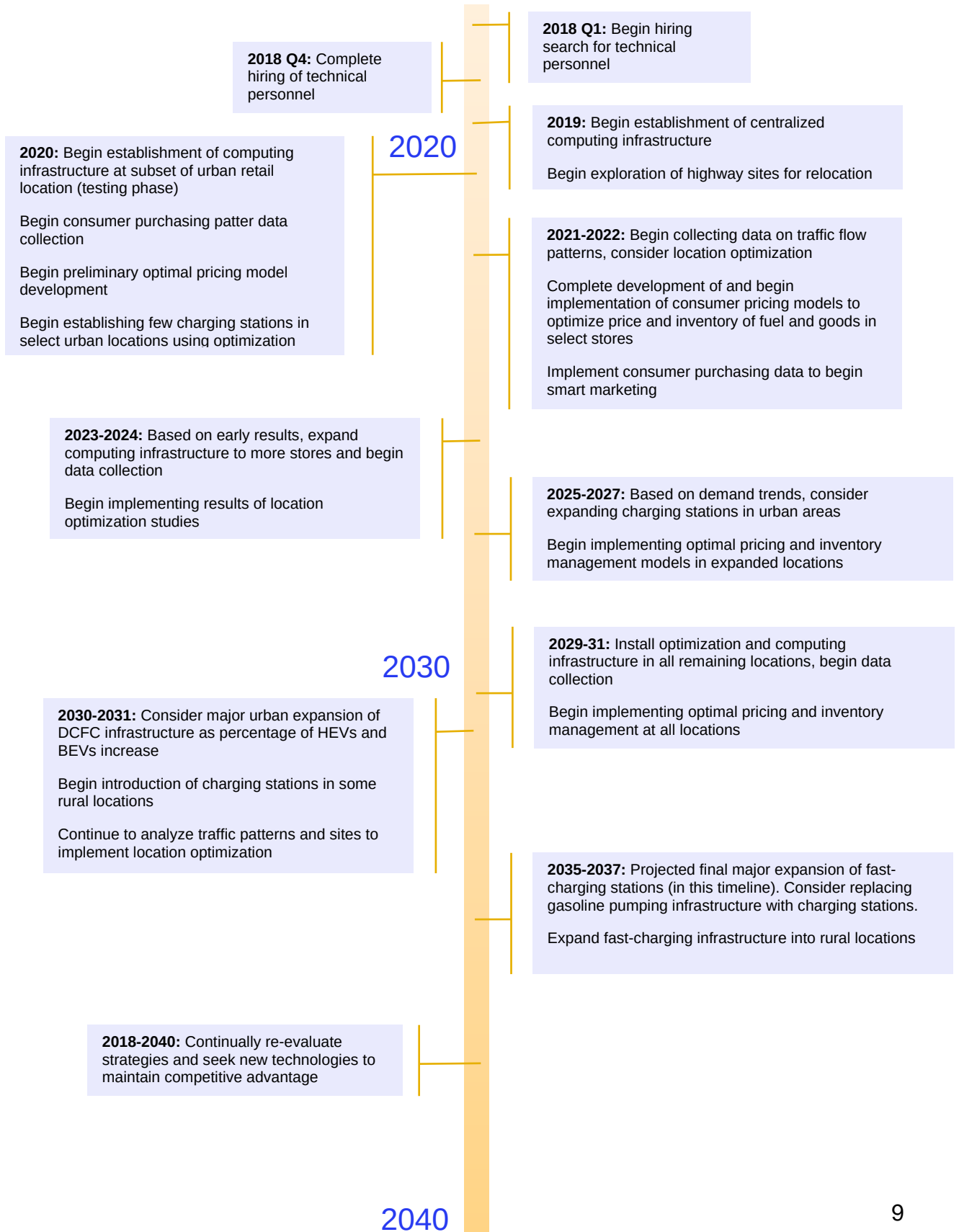
convenience store parking spaces, while, long-term, some gasoline pumps may be removed to accommodate more charging vehicles, if necessary. Considering consumer behavior, current charging ports, and other factors, mathematical optimization can be used to determine the optimal placement of charging ports to maximize profitability—known as the “Charging Station Placement Problem” [26].

Optimizing Product Pricing and Inventory Management. Big Data analytics and optimization can be used to price fuel and non-fuel products and manage inventory of fuel and non-fuels. By tracking and analyzing data on consumer purchasing patterns over time and at each particular store location, in conjunction with cost data and knowledge about local prices of competitors, we can develop optimal time and location-varying prices for products to maximize profit. Analysis of data regarding consumer purchasing patterns can be used to inform inventory management. These strategies, when used in conjunction with price forecasts, are particularly crucial for optimizing gasoline inventory (e.g. determine when to buy, how much to buy, etc.). Improvements in gasoline inventory management can have a significant effect on improving margins and keeping prices lower than competitors, thereby attracting consumers.

Monitoring consumer purchasing of non-fuel products will allow us to keep pace with changing consumer demand on the micro and macro scales and maintain optimal inventory of products relative to their expected demand.

Smarter Marketing. By using insights from data on temporal and spatial variations of consumer product purchasing trends, we can develop smarter marketing strategies by (1) directly applying purchasing trend data to inform advertising campaigns and (2) determining the effectiveness of various marketing strategies on consumer product

Figure 1: Timeline of Primary Strategy



purchasing. Effectiveness can directly be measured by customer purchasing activity. These insights will allow our group to optimally allocate our marketing budget to achieve the greatest amount of profit.

Potential Relocation. Increasing fuel efficiency of LDVs, emergence of BEVs, and changes in consumer driving behavior are likely to shift need for gas stations from neighborhoods towards highway exits [27]. Additionally, gentrification has greatly increased land value in neighborhoods, providing economic incentives for fuel retailers to sell their properties [28]. Thus, our group will need consider strategically relocating to align with future fueling trends—potentially buying cheap land near highways in the near-term while waiting for neighborhood land prices to rise before relocating from neighborhoods to highways. Predictive data analytics and optimization can aid in determining optimally profitable sites for relocation by examining traffic flow data and population growth scenarios while considering trade-offs with land prices.

Secondary Strategy: Digital Technology and Enhancing Customer Experience

Payment Options and Customer Engagement. Incentivizing cash or even debit-card gasoline payments, by returning money that would have been paid in credit card fees directly to the consumer, could increase margins and attract customers [11].

Moreover, it is important that fuel-retailers keep up with evolving modes of payment among consumers. In particular, mobile payment is expected to become increasingly popular. Already, ExxonMobil is experimenting with a cloud-based mobile payment app that allows consumers to pay for gas remotely using virtually any payment method including Apple Pay [29]. Investing in similar technology at our locations to allow

consumers to pay in the most convenient way possible is likely to yield strong returns as payment trends change in the coming decades.

The development of mobile applications could provide additional opportunities for consumers to engage with our fuel retailing locations beyond just payment. Consumers could use smartphone or even car-based applications to monitor availability of charging stations or as part of a customer loyalty program that rewards repeated business.

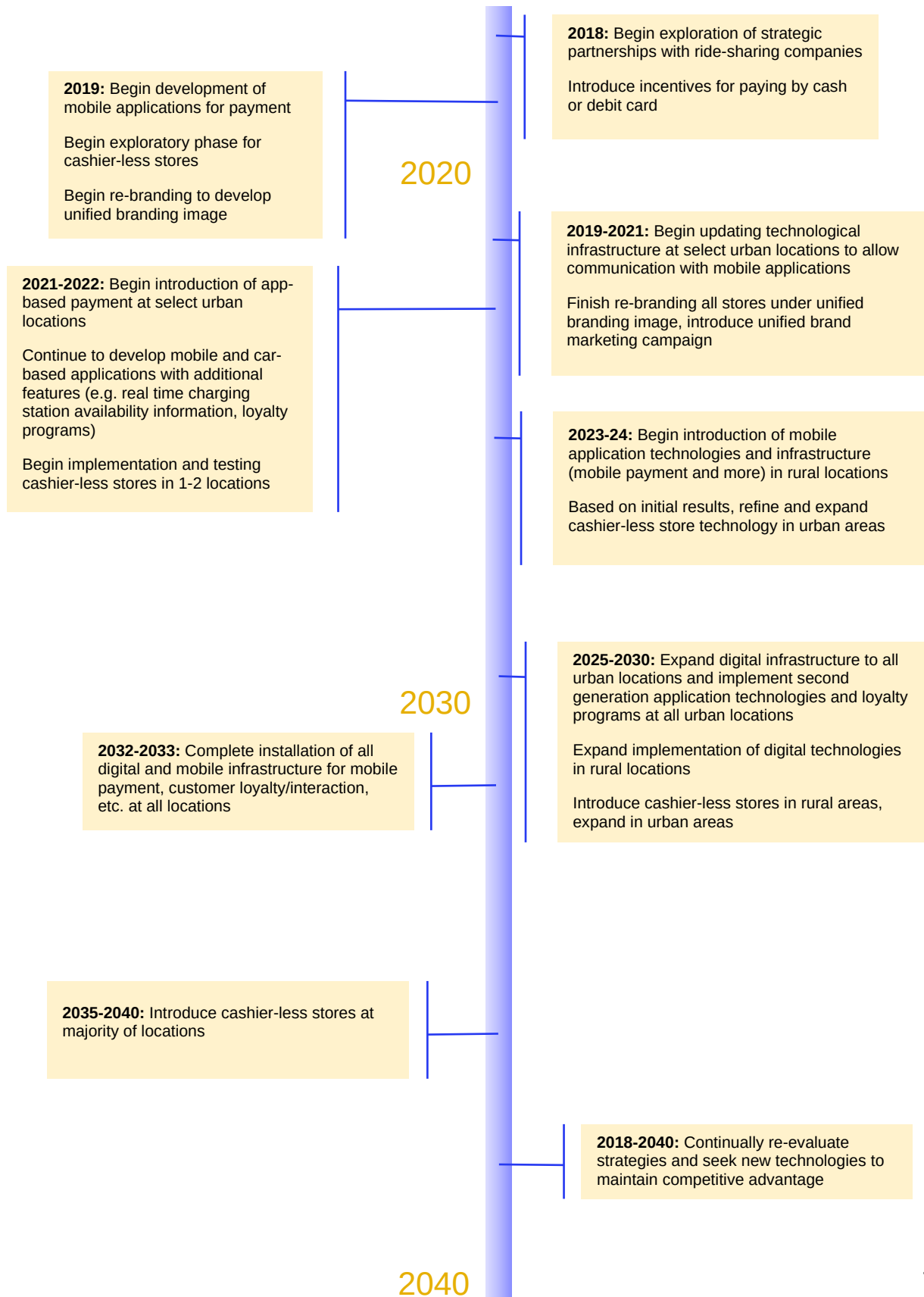
Mobile capabilities could be expanded towards the later part of our strategic timeline to allow direct interaction between internet-connected autonomous vehicles and our fuel retailing stations.

Store Automation. Amazon and Walmart have already announced plans to open cashier-less stores in the very near future [30]. Convenience stores are much smaller operations and therefore implementing cashier-less stores would be very achievable within our strategic timeline. As a part of the automation process, we would integrate product purchasing with our mobile applications. Consequently, our stores would see dramatic increases in profit by decreasing wages needed to man a store.

Tertiary Strategies: Strategic Partnerships and Brand Loyalty

Strategic Partnerships with Ridesharing Services. As discussed previously, increased ridesharing is expected to have a significant effect on the fuel-retailing market by decreasing private car ownership. However, because many of the 75 outlets we control are concentrated in a few urban centers across the US, partnerships with ridesharing companies in these urban centers—who own or manage a large number of vehicles in these urban centers—have the potential to be mutually beneficial to the ridesharing company and fuel retailers. By pursuing agreements to provide fuel at

Figure 2: Timeline of Secondary and Tertiary Strategies



discounted rates to the ridesharing company, we can ensure our urban fuel retail outlets maintain a dependable revenue stream even as private car ownership lessens.

Establishing Brand Value and Loyalty. Surveys indicate that, after price and location considerations, consumers choose fuel retailers and convenience stores base on a loyalty program with store, perceived safety of the outlet, and perceived cleanliness of the outlet [11]. These qualities are strongly related to brand-perception as a whole. Because our group owns so many locations, this presents a strong opportunity to present unified branding and a single brand-image across all locations. We can capitalize on this unity in branding by introducing customer loyalty programs and a single cohesive brand marketing campaign, distinct from product marketing strategies. As in the case of Texas convenience chain Buc-ee's, aggressive brand marketing strategies, in some cases, have resulted in a near 'fandom' of the store brand [31].

Maintaining Flexibility and Competitiveness

Flexibility. In order to account for unforeseen disturbances, it is essential to develop a business plan that is robust. In operations research, methods called *stochastic optimization* and *robust optimization* specifically incorporate uncertainty in data and projections into the optimization model itself [32]. By using these methods to inform our strategy, even if actual real-time values of different variables (e.g. of future gasoline price) differ from our predictions (e.g. due to disruptions), our business strategy will still be near-optimal and likely superior to our competitors. Moreover, the data-driven methods discussed will allow us to keep abreast of changing consumer demands for non-fuel goods. Finally, it is imperative that we re-evaluate and adjust our strategic plan on an annual or biennial basis.

Competitiveness. Currently about 58% of owners of convenience stores that sell fuel own just one store and 71% own less than 50 [11]. Because our group owns 75 outlets, we are well-positioned to achieve a higher return on investment for spending on computing and optimization infrastructure simply because this infrastructure has very good economy of scale (costs to service each additional location is marginal after the first location). Moreover, because of the size of our group, we have significantly more capital to invest than our smaller competitors. This provides us with a clear competitive advantage against smaller firms who do not have the capital to develop this technology in-house and must outsource or forgo it. The fuel-retailing industry as a whole has not seen any major technological innovation in years [12]. Thus, early adoption of emerging technology will keep us steps ahead of the majority of our competitors.

Cost and Return on Investment Considerations

Here, we discuss the expected cost of implementing the strategies previously discussed and contextualize these expenses in within our current capital deployment capabilities. We assume, very conservatively, that by implementing our strategic plan, each store will be able to maintain net after-tax profits of \$15K per month through 2040 [2]. Across 75 stores, this is \$13.5 MM/y. Strategy costs are shown in the tables below.

It is important to note that these costs are given on an order-of-magnitude basis and neglecting important variations in location and time. They are intended as a useful first approximation of required costs, to be supplemented with a more detailed economic analysis closer to the time of investment.

Cost To Establish Computing, Optimization, and Data Analytic Infrastructure and to Implement

Salary/benefits for hiring 3 computer, software, optimization experts [\$ /y]	260,000
Cost of centralized computing infrastructure (hardware, facility, etc.) [\$]	600,000
Cost of new computing infrastructure at each store (computers, sensors, etc.) [\$/store]	30,000
Total cost of new computing infrastructure at all stores [\$]	2 MM
Computing infrastructure maintenance cost [\$/yr]	30,000

Costs To Implement Charging Stations

Cost to purchase and install DC Fast-Charging Station (single port) [\$/unit] [25]	50,000
Total cost to purchase and install DCFC stations (assume 4 per location by 2040) [\$]	15 MM
Total maintenance and repair costs for charging stations (all stores) [\$/y]	30,000
Expected pay-back period for charging station (15 charges/day, \$2/charge) [years]	4-5

Costs of Implementing Digital Technology and Store Automation

Cost do develop mobile applications for payment, customer interaction, etc. (depending on complexity) [\$] [33]	100,000-500,000
Costs to install and integrate hardware and software with digital applications [\$/store]	50,000
Total costs to install and integrate hardware and software with digital applications for all stores [\$]	3.75 MM
Cost to make store cashier-less and integrate with existing digital applications {\$/store}	80,000
Total cost to make store cashier-less and integrate with existing digital applications for all stores [\$/store]	6 MM
Savings from reduction in wages at all stores due to automation (assuming \$13K wages eliminated /month/store) [\$/y] [2]	11.7 MM

Costs of Unified Branding and Brand Marketing

Cost to rebrand each store to single brand [\$/store]	15,000
Total cost to rebrand each store to single brand [\$]	1.1 MM
Total cost to market brand per year [\$/y]	1.2 MM

The figures above indicate that the strategies suggested are well-within the capital deployment abilities of our group. Initially high capital investment is likely to yield strong returns by keeping margins strong, attracting customers, and keeping stores open.

References

- [1] National Petroleum News, "2004 Station Count," www.fueleconomy.gov, 2004.
- [2] National Association of Convenience Stores, "State of the Industry Report of 2016 Data," Alexandria, VA, 2017.
- [3] Bureau of Transportation Statistics, "Table 4-23: Average Fuel Efficiency of U.S. Light-Duty Vehicles".
- [4] Environmental Protection Agency - Department of Transportation , "Corporate Average Fuel Economy - Final Rule," 2012.
- [5] G. W. Ruiwen Lee, "The Rebound Effect in a More Fuel-Efficient Transportation Sector," Institute for Policy Integration - New York University School of Law, New York, 2013.
- [6] National Highway Traffic Safety Administration, " Final Regulatory Impact Analysis - Corporate Average Fuel Economy for MY 2012- MY 2016 for Passenger Cars and Light Trucks," 2010.
- [7] NAVIGANT Research, "Tomorrow's Vehicles: An Overview of Vehicle Sales and Fuel Consumption through 2025," Fuels Institute, Alexandria, VA, 2017.
- [8] H.-W. K. D. M. a. D. W. Paul Gao, "Disruptive trends that will transform the auto industry," McKinsey and Company, 2016.

- [9] J. A. & T. Seba, "Rethinking Transportation 2020-2030: The Disruption of Transportation and the Collapse of the Internal Combustion Vehicle and Oil Industries," RethinkX, 2016.
- [10] D. C. C. D. Glen Weisbrod, "Economic Impact of Public Transportation Investment," American Public Transportation Association, Washington D.C. , 2014.
- [11] National Association of Convenience Stores, "2015 Retail Fuels Report," Alexandria, VA.
- [12] D. Diment, "IBIS World Reprot 44711: Gas Stations with Convenience Stores in the US," IBIS, 2017.
- [13] K. Amadeo, "Oil Price Forecast 2018 - 2050: How High Oil Prices Will Rise in 2018," the balance, 2017.
- [14] Environmental Protection Agency, "Summary of the Energy Policy Act: 42 USC §13201 et seq. (2005)," [Online]. Available: <https://www.epa.gov/laws-regulations/summary-energy-policy-act>. [Accessed December 2017].
- [15] NAVIGANT Research, "Tomorrow's Vehicles: A Projection of the Light Duty Vehicle Fleet Through 2025," Fuels Institute, Alexandria, VA, 2017.
- [16] M. M. J. S. N. O. L. V. Gert Berckmans, "Cost Projection of State of the Art Lithium-Ion Batteries for Electric Vehicles Up to 2030," *Energies*, vol. 10, no. 1314, 2017.

- [17] "Natural Gas Prices Forecast: Long term 2017 to 2030 | Data & Charts," knoema, [Online]. Available: <https://knoema.com/ncszerf/natural-gas-prices-forecast-long-term-2017-to-2030-data-and-charts>. [Accessed December 2017].
- [18] U.S. Energy Information Administration , "International Energy Outlook 2017," 2017.
- [19] D. C. P. J. M. S. Nancy L. Garland, "Hydrogen and fuel cell technology: Progress, challenges, and future directions," *Energy Procedia*, no. 28, pp. 2-11, 2012.
- [20] R. P. B. D. Y. Bill Canis, "Natural Gas for Cars and Trucks: Options and Challenges," Congressional Research Service, 2014.
- [21] C. Curry, "Lithium Ion Battery Costs and Market," Bloomberg New Energy Finance , 2017.
- [22] "Electric Vehicle Outlook 2017: Bloomberg New Energy Finance's annual long-term forecast of the world's electric vehicle market. (Executive Summary)," Bloomberg New Energy Finance, 2017.
- [23] "Forecast of the unemployment rate in the United States for fiscal years 2016 to 2027," [Online]. Available: <https://www.statista.com/statistics/217029/forecast-to-the-unemployment-rate-in-the-united-states/>. [Accessed December 2017].
- [24] "Big Data: What it is and why it matters.," SAS Institute , [Online]. Available: https://www.sas.com/en_us/insights/big-data/what-is-big-data.html. [Accessed December 2017].

- [25] M. Rouse, "Definition: Internet of Things," TechTarget: IoT Agenda, [Online]. Available: <http://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT>. [Accessed December 2017].
- [26] L. New West Technologies, "Costs Associated with Non-residential Electric Vehicle Supply Equipment," U.S. Department of Energy, 2015.
- [27] J. G. B. A. C. M. A. L. C. B. Yanhai Xiong, "Optimal Electric Vehicle Charging Station Placement," *Proceedings of the Twenty-Fourth International Joint Conference on Artificial Intelligence*, pp. 2662-2668, 2015.
- [28] J. D. Stoll, *Why the Gas Station Isn't a Model for Electric Cars*, The Wall Street Journal , 2017.
- [29] D. Gross, *America's Gas Stations are Running Out of Time*, Slate, 2016.
- [30] O. S. Diamante, "Future Payment Trends: Shell and ExxonMobil take the lead in payment apps," Island Pump and Tank Corp. , [Online]. Available: <https://islandpumpandtank.com/convenience-store-news/future-payment-trends-shell-and-exxonmobil-take-the-lead-in-payment-apps/>. [Accessed December 2017].
- [31] "Amazon Go," Amazon, [Online]. Available: <https://www.amazon.com/b?node=16008589011>. [Accessed December 2017].
- [32] P. Carbonara, "How Two Texans Made Buc-ee's a Phenomenon," Forbes, April 2017. [Online]. Available:

<https://www.forbes.com/sites/petercarbonara/2017/08/22/buc-ees-game-of-porcelain-thrones/#4367e0df7626>. [Accessed December 2017].

[33] R. T. Rockafellar, "Optimization Under Uncertainty: Lecture Notes," University of Washington, 2001.

[34] "How Much Does an App Cost: A Massive Review of Pricing and Other Budget Considerations," SavvyApps, [Online]. Available: <https://savvyapps.com/blog/how-much-does-app-cost-massive-review-pricing-budget-considerations>. [Accessed December 2017].

Honorable Mentions

Fourth Place

DUKE UNIVERSITY

**Fuel Retailing in 2040:
A Choice Rather than a Need**

Fuels Institute 2018 University Case Competition

Fuel Retailing in 2040: A Choice Rather than a Need



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1. The Future of Fuel Retailing

The business model for the fuel retailing industry has not changed significantly over the past decades as gasoline continues to be the predominant fuel for light-duty vehicles in the United States: gas stations sell large volumes of fuel at low margins, while the bulk of the profits are gained through in-store merchandise sales, occasionally supplemented by other auto services. However, this will undoubtedly change as the landscape of fuel retailing shifts due to changes in refueling behavior and the fuel mix for the light-duty vehicle fleet. In response to these disruptive trends, fuel retailers need to account for evolving consumer demands and behaviors in order to remain profitable. Of these trends, ride-sharing becoming the norm and electric vehicles gaining more market share will be the biggest disruptors in the fuel retail industry.

As the light-duty vehicle fleet becomes increasingly electrified, gas stations will stop being a necessary destination as electric vehicle infrastructure investments introduce new refueling options in residences, offices, highways, and other public spaces. The challenge lies in attracting customers to our retail stations as we adapt our business model to incorporate EV charging and associated services in our operating locations.

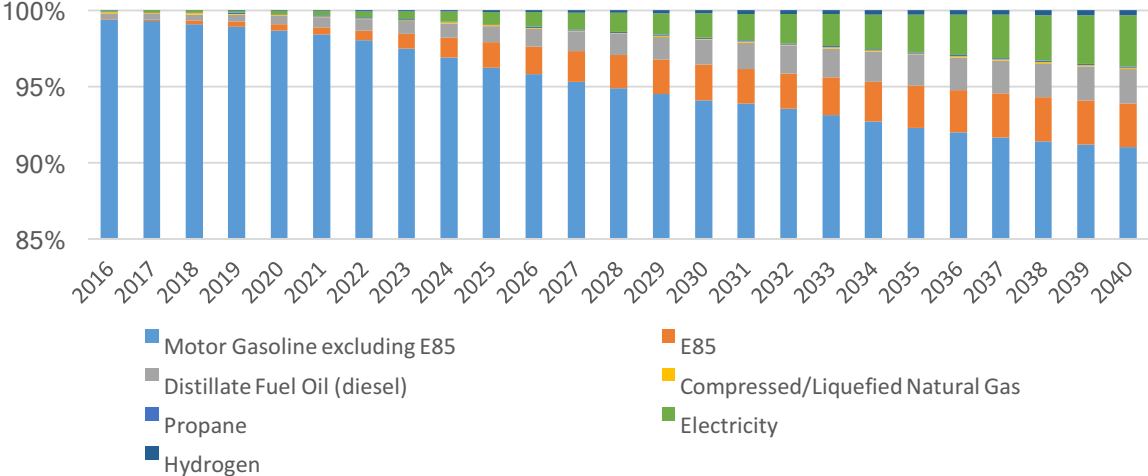
To accomplish this, we must leverage mobile technology and the digital space to transform current and future customer and stakeholder relations. We envision our future business as a place that consumers would choose to go based on our unique service differentiation and strong customer loyalty, rather than as a simple need for fueling their vehicles. Fuel retailing in 2040 will give rise to many new competitors and challenges. Whether we remain profitable or not will depend on successful partnerships

with key stakeholders in the ridesharing, car manufacturing, and utility industries, along with the smart provision of charging stations and EV services such as battery swapping.

2. Projections

The U.S. Energy Information Administration projects that 91% percent of total fuel consumption in the transportation sector in 2040 will still consist of petroleum and other liquids fuels¹. Despite the dominance of traditional liquid fuels in the fuel retailing market, non-conventional fuels such as E85 and electricity are projected to increase significantly compared to other alternatives. It is projected that in 2040 electricity will compose 3.36% of total LDV energy consumption, with E85 following closely at 2.86%.

Figure 1. Energy Mix for Light Duty Vehicles



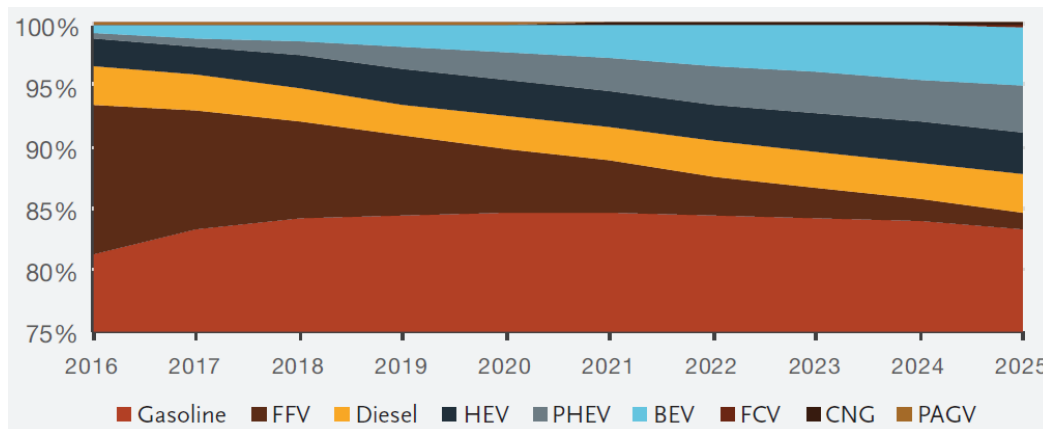
Source: EIA 2018 Annual Energy Outlook

According to Bloomberg New Energy Finance (BNEF), electric vehicles will be the majority of new car sales worldwide by 2040, with 58% of new car sales in the U.S. being electric. Furthermore, EVs are projected to account for 33% of all light-duty

¹ The U.S. Energy Information Administration. (2018). [Annual Energy Outlook](#).

vehicles on the road. The future trajectory of electric vehicles shows great promise, given the rapid rise of EV market share, despite oil prices staying low.

Figure 2. U.S. Market Share of LDV Sales



Sources: Navigant; Fuels Institute

According to the Fuels Institute's projection on U.S. market share of LDV sales, FFV will only be 1.72% of the market in 2025, which is an 85.96% reduction from 2016. In addition, it was found that the lower energy density in Ethanol lead to a 25% decrease in vehicle fuel economy, which reduced overall consumer acceptance of E85. Thus, E85 will not be adopted in our future retailing strategy.

3. Retailing Strategy

Strategy Phase 1- Years 2018 to 2025

Given that liquid fuel vehicles are projected to represent 96% of all vehicles in the United States in 2025², the starting point of our strategy, spanning from years 2018 to 2025, will capitalize on the ridesharing market and its growth potential in the future. The electrification of the LDV fleet, coupled with changing demographics of the incoming

² Fuels Institute: "Tomorrow's Vehicles: An Overview of Vehicle Sales and Fuel Consumption through 2025"

generation of consumers, will influence the goods and services we will have to provide in order to remain competitive and a preferred future destination. Based on the projections cited in the first part of this report, a more conservative approach in these early stages of alternative fuel adoption would be appropriate because accommodating for new fuel infrastructure in the short term would be too capital-intensive and risky.

Ridesharing companies

The first step of our business plan would require forming partnerships with ridesharing companies. Currently, the most salient issue that the convenience retailer faces is declining inside customer counts³ so it is crucial to establish a steady stream of consumers that will be able to contribute to our profits from both fuel and in-store goods and services. The increasing trend of shared mobility and ridesharing can provide a consumer base that will contribute to a small portion of our operating profits at first, but with good potential growth as ridesharing continues to expand and become the norm. Attitudes towards private car ownership are also changing as urbanization trends continue and people look for convenient and affordable forms of transportation in metro areas. Not only has ridesharing provided a solution to these rising transportation needs, but it will also contribute to an expanding consumer segment that is rideshare drivers, some of which have used this platform as a full-time career.

Partner Programs

To capture and retain customers within the growing rideshare market, we can add to our services offered a loyalty program that includes discounts for ridesharing

³ NACS: State of the Industry Report of 2016 Data

partners. Customer loyalty is a key goal of marketing and market research efforts in nearly all industries. It has long been recognized that it is easier to retain existing customers by meeting their needs at a reasonable price than it is to attract new customers. The key value components that our marketing strategies must address are convenience, a sense of making the “smart” choice, affordability (especially for food services) and reliability for all customers that visit our retail stores. Some of the features that can be included in this rewards system include deals on in-store goods when paired with a fuel purchase, trackers on visits and savings on fuel, as well as customized offers based on user preferences.

Mobile Platforms with Enterprise Software

Equally important is the development of a platform where we can easily provide information on our participating stations and offers of our loyalty programs. Through a user-friendly and flexible digital platform, expanding our business into the mobile scene will ultimately market convenience as one of our core strengths and enhance the customer's experience when visiting our stations.

To help decide the goods and services included in our discount/loyalty programs for our consumers, it is necessary to have a system that keeps track of operations in all of our stores. By using enterprise software, we can use data analytics and visualization for many aspects of our business, such as daily volumes of sales by geographic area and the gross margins associated with different sales categories like foodservice, packaged beverages, and candy. Not only would this help us identify trends, but it would also set the stage for more advanced targeted marketing techniques that are flexible with respect to changing customer demands.

Strategy Phase 2- Years 2025 to 2040

From 2025 forward, gasoline will undergo a significant decline as the primary fuel for the light-duty vehicle fleet and we will begin to see more EVs on the road. Resulting from this large-scale infrastructure development, a range of stakeholders in the energy business will pursue collaboration efforts in this growing market. To keep up with these changes, we will begin incorporating EV charging stations and battery swapping services into our retail locations. Utilities, electric vehicle service equipment (EVSE) providers, and car manufacturers will all play a part in building charging infrastructure for the EV fleet. Engaging with these stakeholders will help mitigate risk on capital investments into EV charging infrastructure.

- ***Utilities***

EVs entering the market will increase electricity demand and raise questions on how to prepare for this surge. It is in a utility's interest to accommodate this load through infrastructure investments as they can benefit from selling charging as a service. For example, utilities can act as providers of both the distribution grid and EV stations, receiving cost-based payments for charging⁴. Ownership structures will depend on state regulations, but utilities engaging in new EV infrastructure planning can capture benefits for both its operations and customers. If managed correctly, EVs can reduce emissions, facilitate renewable energy integration, and reduce electricity costs.

- ***Car manufacturers***

⁴ Rocky Mountain Institute: "Electric Vehicles as Distributed Energy Resources"

In addition to our collaboration with utilities to provide EV infrastructure, we have to coordinate partnerships between rideshare companies and car manufacturers. The rising number of rideshare users will be a primary motivation for car manufacturers to procure a fleet of EVs for rideshare drivers. And by providing charging stations and battery swapping services in our retail stores, we can establish a network that can support a sizeable fleet of EVs. Collaborating with car manufacturers can also lead to a combined battery swapping and rental service program. Not only could this attract customers with a lower price for EVs, but it could also address the problem of battery standardization. Regular customers commuting within our operating area may also be influenced to switch to EVs given that there is a robust charging infrastructure present.

- ***EV Charging***

Choosing the appropriate charging stations and services will be dependent on location and user traffic. There are three main charging stations that would compose a network of EV charging: Level 1, Level 2, and DC fast charging (DCFC). A 2015 report from the US Department of Energy's Alternative Fuels Data Center estimated the average costs of installing non-residential charging stations, presented in Table 1⁵:

Table 1. Estimated Average Costs of Non-residential Charging Stations

Classification	Description	Range	Notes	Associated Costs
AC Level 1 EVSE (i.e., Level 1)	<ul style="list-style-type: none"> • Includes a cord and connector • Charges through a common 120 volt three-prong household plug 	2-5 miles for one hour of charging	Plug-in vehicles come standard with Level 1 EVSE	<ul style="list-style-type: none"> •\$300-\$1,500 for the unit •\$0-3,000 for installation
AC Level 2 EVSE	<ul style="list-style-type: none"> • Uses the same connector and charge 	10-20 miles for one hour	EV owners can install 240-volt service for	<ul style="list-style-type: none"> •\$400-\$6,500 for the unit

⁵ U.S. Department of Energy: "Costs Associated With Non-Residential Electric Vehicle Supply Equipment"
https://www.afdc.energy.gov/uploads/publication/evse_cost_report_.pdf

(i.e., Level 2)	port as level 1 • Requires a 240 volt or 208-volt electrical service	of charging	home charging	•\$600-\$12,700 for installation
DC Fast Charging	• Provides DC electricity to the battery directly through a special charging port •Mainly used for in-transit charging rather than home charging	50-70 miles for 20 minutes of charging	The type of DC fast charging system will vary depending on the charge port on the vehicle. EVs that use DC charging generally have one of three different ports.	•\$10,000-\$40,000 for the unit •\$4,000-\$51,000 for installation

The cost of installing these stations varies by region depending on labor cost requirements, need for additional infrastructure, and existing policies that can lower the price of installation through rebates or credits. Commercial electricity ranges typically range from \$0.08 to \$0.15 per kWh. Additional costs can also come as demand charges from the utility if the station draws electricity from peak demand times. Other operating costs include maintenance, which tend to increase for Level 2 and DCFC stations.

Service 1: Highway Fast-Charging Corridors

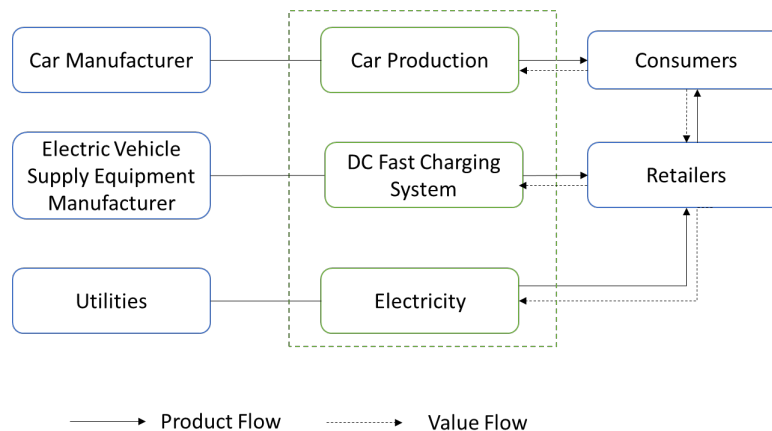
Highways have some of the highest traffic volumes and will be an ideal location for implementing DC fast chargers. It is estimated that by 2025 all new cars sold will be connected⁶, enabling us to pair our mobile platform with vehicles' embedded navigation and accessibility technology. Customers can view the location of our chargers, online ratings, and rewards program goods and services provided at our retail locations.

Financially, installing charging stations will be hardest in low-density suburban areas because of the stations' close proximity to homes. Consumers could easily charge their car at home at predictably lower electricity rates overnight. Therefore, we will focus on installing charging infrastructure on high-traffic highway locations.

⁶ Accenture: "Connected vehicle-Succeeding with a disruptive technology"

Supply Chain

For the fast charging model, the supply chain consists of the car manufacturer, electric vehicle supply equipment (EVSE) manufacturer, and utility companies.



Service 2: Battery Swapping

Battery costs can greatly determine the profitability of manufacturing electric vehicles- there are several EV models where the battery costs can reach 50% of the total price. It is also hard for manufactures to agree on altering a battery's specifications due to considerations of charge, size, and range of the vehicle. Other challenges for introducing a battery swapping service are the charging methods and scheduling of the depleted battery packs and, more importantly, battery performance degradation.

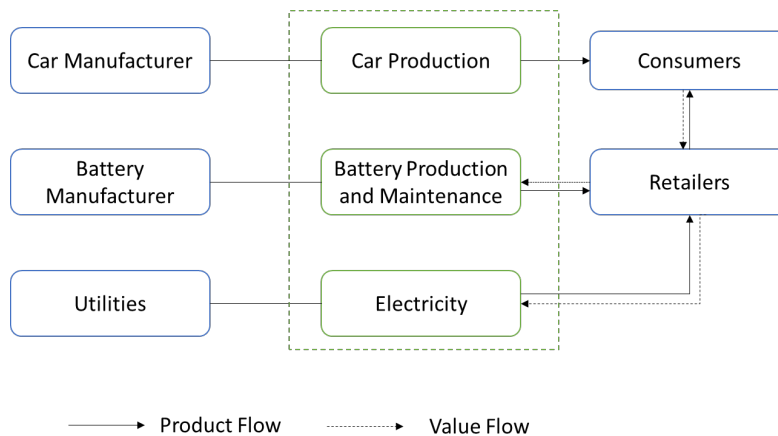
It is estimated that there are 7 million Uber drivers⁷ (84% of the ride-hailing market) in 2017, and shared mobility services will undoubtedly increase exponentially throughout 2040. With the change of people's norm towards driving, both the number of ride-hailing drivers and the EV market share are increasing at a tremendous speed. For

⁷ <https://expandedramblings.com/index.php/uber-statistics/>

ride-sharing drivers, the waiting time during charging can mean significant foregone earnings. Capitalizing on reducing this downtime will be vital to securing a steady consumer base as we transition to a more electrified LDV fleet. Introducing battery swapping as a service in our retail locations is a unique solution to this issue. Having this service marketed towards ridesharing drivers in our partnership can also greatly influence their adoption rate of our loyalty programs as well. Using collected data and commuting behavior, we can then modify our loyalty program strategy. For example, discounts based off of total rides given could be implemented for drivers in dense cities where shorter trips are more common, and for locations with greater mileage per ride a mileage-based approach to calculating rewards could be more appropriate.

Supply Chain

The swapping model assumes that the government implements a uniform standard for the interface of battery. In this model, consumers (ridesharing drivers) swap batteries in the retailer and pay for the mileage they travel. Retailers can buy the battery from battery manufacturers and outsource battery maintenance needs to the manufacturer.



The maintenance fees are included in the battery price. Unlike a fast charging service, battery swapping can also be good for extending the lifetime of the battery. Every swap would involve a quick maintenance check to ensure safety standards are met and prevent the circulation of a bad battery.

Financial Analysis

This part of the proposal will focus on the profitability of EV charging and battery swapping services from 2025 to 2040. The unit analysis is made for one retailer store.

1) EV Charging

Our stores with DC fast chargers will mainly be distributed along the highway to create charging corridors. 20 minutes of charging would add approximately 50-70 miles in range. We assume there are 6 EV chargers at each site. Theoretically, the maximum charging capacity for a day would be 432 full charges. Assuming a 0.2 capacity factor for the charger, the volume of business will be 86 charges per day. According to EIA data, the electricity price for transportation sector is 9.54 cents per kWh.

Table 2. Assumptions for Fast Charging Service

Assumptions	Value	Unit
Discount Rate	5	%
Capital Cost (facility installation)	500,000	\$/site
Electricity consumption for each charge	40	kWh
Electricity Price	9.57	Cents/kWh
Volume of business	86	Counts/day
Charge Rate	14	Cents/kWh

Results

Based on the assumptions, the fee is charged by the kilowatt-hours used by the consumer. If consumers were charged at 14 cents/kWh, the NPV of the total profits for 2025 to 2040 is \$126,639.65. The Internal Rate of Return (IRR) is 9%.

2) Battery Swapping

The assumptions of the analysis are mainly based on the data from previous case studies (Better Place⁸, Tesla⁹, Nio Power, Pilot Projects in China).

Table 3. Assumptions for Battery Swapping Service

Assumptions	Value	Unit
Discount Rate	5	%
Battery Lifetime	8	years
Capital cost	600,000	\$
Cost of battery ¹⁰	130	\$
Battery stock	50	Packs
Battery size	70	kWh
Mileage travel for each swapping	186	mile
Electricity price for transportation	9.57	cents/kWh
Rent for Battery	40	\$/month
Charge Rate	4	cents/mile

We assume that 90 consumers would rent a battery and perform 30% of their swaps within this store. If a driver works 8 hours a day and drives at an average speed of 37 miles/h, he will need to do about 1.6 swaps per day. With a battery stock of 50 packs, the volume of business is 42 swaps per day.

Results

The total cost of the swapping model includes the cost of capital, batteries, and operations (the cost of electricity). We assume the capital cost is \$600,000 (Tesla's pilot swapping program is estimated to have a capital cost of \$500,000). Since the lifetime of a typical battery is 8 years, the store would need to buy a new battery every 8 years in the optimal scenario. The store would buy its first 50 packs in 2025 and will need to replace them by 2033 (in reality, the battery's degradation would depend on its usage-

⁸ Better Place. Wikipedia. Retrieved from [https://en.wikipedia.org/wiki/Better_Place_\(company\)](https://en.wikipedia.org/wiki/Better_Place_(company))

⁹ Zhang. (2015). [Tesla's Battery-swapping Plan Has a Mere Shadow of the Promise it Once Showed](#). *Business Insider*.

¹⁰ The cost of battery includes the battery cost predicted by Bloomberg, which is \$100 in 2025, supposed that the maintenance is outsourced to the battery manufacture with a cost of \$30 per battery

to simplify the calculation, we assume that all the batteries will be replaced at the same time in 2033). Batteries are assumed to be charged from zero to full charge.

The total revenue consists of the charge for mileage traveled and the rental fee for the battery. At a discount rate of 5% and an IRR of 5%, the NPV value of the profits from 2025 to 2040 is \$5,502.13. With new technology developments, battery prices for these vehicles are projected to decrease. This means that profits still have a good potential to increase as these advances are made. In the battery swapping model, one possibility to consider would be to have consumers buy cars with batteries borrowed from the retailer, which could greatly reduce the cost of purchasing a whole electric car and the subsequent maintenance fee. This could be attractive to ridesharing partners that are price-sensitive to the higher listed price of battery-electric vehicles.

4. Policy Opportunities and Challenges for the EV Market

The American Recovery and Reinvestment Act of 2009 established tax credits for purchasing electric vehicles and conversion kits to retrofit conventionally powered vehicles with electric vehicle capability. New Corporate Average Fuel Economy (CAFE) standards will encourage the expanded market entry of electric drive technologies. Researchers also found that CAFE regulations can accelerate EV market penetration¹¹. In 2013, the governors of eight states (CA, CT, MD, MA, NY, OR, RI, VT) signed a MOU to work on the implementation of zero-emission vehicle programs, which include battery-electric vehicles, plug-in hybrid electric vehicles, and hydrogen fuel cell electric

¹¹ Sen, B., Noori, M. and Tatari, O., 2017. Will Corporate Average Fuel Economy (CAFE) Standard help? Modeling CAFE's impact on market share of electric vehicles. *Energy Policy*, 109, pp.279-287.

vehicles. The states also established a commitment to have at least 3.3 million ZEVs operating on their roadways by 2025.

Table 4. Available Programs for PEVs and Charging Infrastructure¹²

Programs	Type	Applicable Object	Effective Date
Clean Cities	Funds	Projects to accelerate the deployment of alternative fuels and alternative fuel infrastructure	1993 - Current
Congestion Mitigation and Air Quality Improvement Program	Funds	Projects/programs that help reduce regional congestion on transportation network/mobile resource emissions	2015 - Current
Surface Transportation Block Grant Program	Funds	For construction of electric vehicle charging stations	2015 - Current
Alternative Fuel Infrastructure Tax Credits	Tax Credit	Fueling Equipment for electricity, E85, liquefied hydrogen, propane, natural gas, or diesel fuel blends	January 1, 2015 to December 31, 2016
Alternative Fuel and Advanced Vehicle Technology Research and Demonstration Bonds	Tax Credit Bonds/Direct Payment Bonds	Research/projects related to cellulosic ethanol and other non-fossil fuels, as well as advanced battery manufacturing technology	-
Qualified Plug-In Electric Drive Motor Vehicle Tax Credit	Tax Credit	Purchase of a new qualified plug-in electric drive motor vehicle	Vehicles acquired after December 31, 2009

Numerous policies and incentives have been greatly motivating the deployment of EVs. However, with the fast-growing EV market, the increasing demand of electricity will bring extra burden to the grid. Since 65% of electricity generation comes from fossil fuels, the load brought by EVs may deviate from the goal of the Clean Power Plan to lower the electric power sector's CO₂ emissions from existing fossil-fuel power plants.

5. Conclusion

Prior to 2025, fuel alternatives will remain at an early stage of adoption given the difficulty of installing the respective fueling infrastructure. Electric vehicles, however, show the most promising growth and potential for strategic partnerships. The move to

¹² Guide to Federal Funding, Financing, and Technical Assistance for Plug-in Electric Vehicles and Charging Stations, U.S Department of Energy and U.S. Department of transportation, July 2016.

wide-scale EV deployment will inevitably change the traditional business model of fuel retailing, and to remain profitable it is essential to keep up with trends in EV adoption and ridesharing. As the country moves towards an increasingly electrified vehicle fleet, fuel retailers will be forced to adapt to a new generation of consumers, preferences, and stakeholder engagements.

The present and future impact of shared mobility services presents an opportunity to market towards this growing customer base of rideshare drivers. Phase 1 of our strategy proposal will expand our business to a digital platform while providing a steady, trackable customer flow into our locations. This will help secure customer counts and serve as a marketing platform for our new EV services in Phase 2.

The transition from gasoline to EVs will raise the challenge of installing and maintaining a reliable and efficient charging infrastructure during Phase 2 of our proposal. By pursuing mutually beneficial partnerships with utilities and car manufacturers, we can leverage our retail locations as strategic locations for installing charging equipment. Not only does this spread the burden of capital investments, but the established customer base in the ridesharing market can also promote and maintain widespread EV adoption through a network of charging facilities at our retail locations.

Convenience will be a major concern as EVs become the new norm in the transportation sector. Introducing highway charging corridors and battery swapping in high-traffic city locations can be a profitable service that would greatly reduce the downtime between charging periods. Our success as fuel retailers will depend on marketing innovative EV services to an increasingly urbanized, convenience-focused customer demographic.

Honorable Mentions

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Incorporating Battery-swap Service into Fuel Retailing Business through B2B Model

Incorporating Battery-swap Service into Fuel Retailing Business through B2B Model

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Part 1. Introduction

With the combination of varied favorable factors - maturity of technology, declining cost of battery packs¹, and growing customer awareness, among others - the market of electric vehicles (EVs) is expected to land on the window of opportunity in the S-curve of market development (Figure 1)

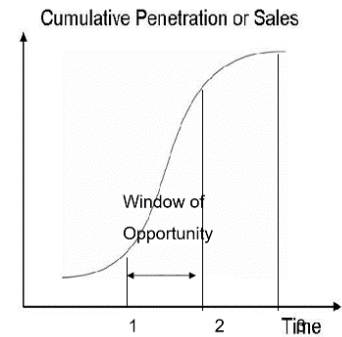


Figure 1. S-curve of Market Development

in the next twenty years².

Figure 2 displays current EV market share across major cities in the U.S.

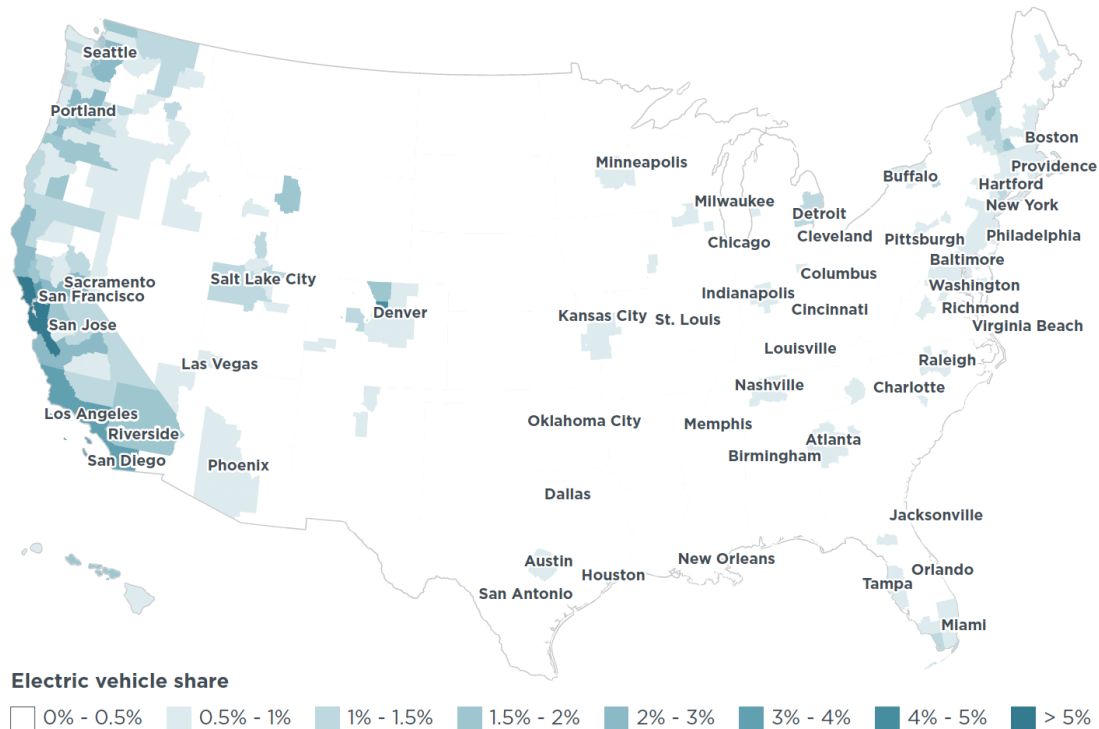


Figure 2. EV Share of New 2016 Vehicle Registrations by Metropolitan Area

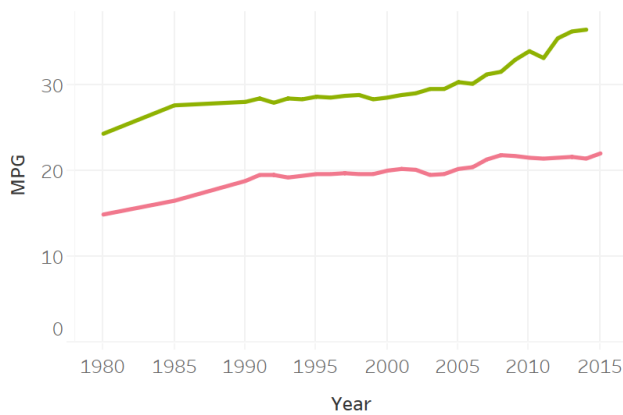
¹From a McKinsey report, battery pack price fell approximately 80% from ~\$1,000/kWh to ~\$227/kWh in the period of 2010 to 2016. Bloomberg New Energy Finance forecasts that EV battery pack price will drop below \$190/kWh by the end of 2020, and predicts that pack price will potentially fall below \$100/kWh by 2030.

²<http://www.theicct.org/publications/expanding-electric-vehicle-market-us-cities>. The map presents the share of new registered EVs across the U.S. 50 most populous metropolitan areas in 2016. San Jose area had the highest share at 10%, followed by other California areas (4% to 6%) such as Los Angeles, San Diego, and San Francisco. Cities like Colorado, Hawaii, Oregon, Vermont, and Washington among others take a fewer (2% to 4%) EV market share.

Since California enjoys denser EV users compared to other states, we posit that our 75 convenience stores operate in CA. Despite simplification, this assumption will not weaken our analysis: along with the expansion of the overall EV market, the EV market share in other states will eventually reach the current level in CA, and our approach can then serve as a good reference for them.

On behalf of conventional fuel retailers, a remarkable fact is that in light of enhanced fuel efficiency (Figure 3)³, as well as stable economic and population growth (Figure 4)⁴, the traditional fuel retailing market is not likely to undergo significant escalation in the next twenty years. Notably, the situation could even be worse in the case that fierce competition between internal combustion engine-based cars and EVs squeezes the demand for traditional fuels.

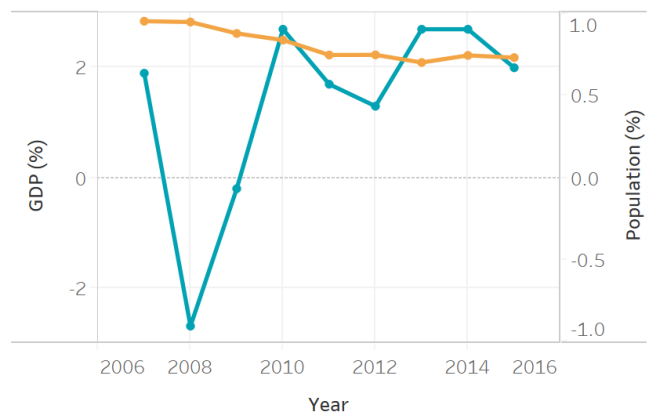
Fuel Efficiency Improvement



Measure Names
■ Average over All Vehicles (MPG)
■ New Vehicles (MPG)

Figure 3

GDP and Population Growth Trend



Measure Names
■ GDP (%)
■ Population (%)

Figure 4

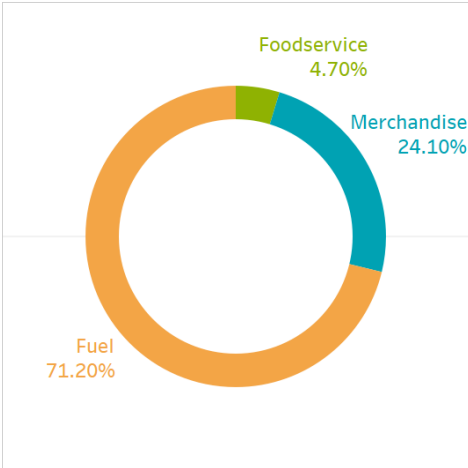
³https://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html

⁴ Population: <https://fred.stlouisfed.org/series/SPPOPGROWUSA#0>;
 GDP: <https://fred.stlouisfed.org/series/A191RL1Q225SBEA>

As price-takers at the endpoint of the supply chain, we, the fuel retailers, possess limited market influence; therefore, to maintain healthy future cash flow, we should adapt our fuel retailing business model to the evolution of the energy market.

In addition, considering the substantial share of sales and margin of food service as well as merchandise shown by figure 5 and 6, we plan to carry out in-store renovation in accordance with our business transformation which incorporates EV as another theme -complement to traditional fuel.

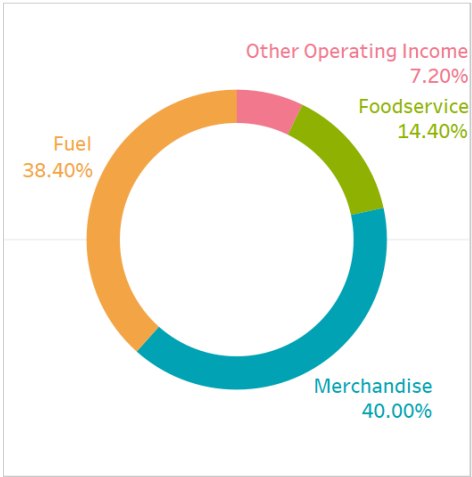
Fuel and Inside Sales Mix



- Foodservice
- Merchandise
- Fuel

Figure 5

Margin Contribution Mix



- Other Operating Income
- Foodservice
- Merchandise
- Fuel

Figure 6

Part 2. Market Analysis and Segmentation

1. WHO ARE THE CUSTOMERS?

As convenience store owners, we will run three types of stores (Table 1) from now on in light of our business shift: (1) pure convenience stores, (2) convenience stores that also sell traditional fuels, and (3) convenience stores that sell traditional fuels and provide battery swap services. For each class of stores defined above, we will categorize our customers according to two dimensions: store location and passenger type.

Class	Location	EV owners	Non EV owners -Students	Non EV owners -General Public
Class (1): Pure convenience store	College town /Metro	√ ⁵	√	√
	Highway/ Suburban	√		√
Class (2): Traditional Fuel + convenience store	College town/ Metro			√
	Highway/ Suburban			√
Class (3): Traditional Fuel + convenience store + EV product	College town/ Metro	√	√	√
	Highway/ suburban	√		√

Table 1

2. WHO ARE OUR PT/ST CUSTOMERS⁶?

Our PT/ST stores⁷ are mainly those of Class (1) and Class (3). On one hand, for the stores near the exit of highways, there is greater demand for battery swap service, so they belong to PT/ST stores. On the other hand, for people living in college areas, most of them are students who do not own an EV; however, they are also our PT/ST customers

⁵ If a customer falls into a particular checked cell, that means he/she enjoys the characteristics of living in or driving around the corresponding area and of the corresponding passenger type, and this customer belongs to the class on the leftmost column.

⁶ PT customers (resp., ST, TT) stand for primary target (resp., secondary, tertiary) customers.

⁷ PT stores (resp., ST, TT) are those in particular cities and areas that serve our PT (resp., ST, TT) customers.

since they are highly educated and are thus more willing to embrace our new in-store modifications. For stores in Class (2), most of them belong to TT stores, suggesting no major change in their business model will be implemented in the first 10 years.

The PT customers (reps., ST customers) are the individuals to whom it is (reps., less) easier either to promote EV-related business or the ones who are (reps., less) more inclined to accept our in-store updates. That said, our PT customers constitute EV owners and/or highly educated people who are not EV drivers in California.

3. WHAT ARE THOSE PT/ST CITIES⁸? HOW LARGE IS THE EV MARKET SIZE IN THESE CITIES?

While customers bearing these characteristics are all our potential PT customers, our limited 75 stores in California are not capable of serving all regions, so we constrain our PT customers to those in the selected PT cities where our business model transformation can be smoothly accomplished. Based on a range of screening conditions, we will conduct a two-stage selection process to decide in which cities our PT/ST stores should locate.

On stage 1, we consider city populations, average incomes, gas retailing prices, and price margins; however, the final decision is made only on the basis of population, income, and price margin. To be selected as a candidate PT/ST city, a city must be any one of the three: populous, affluent, or of low price margin.

- **[Population]** Densely inhabited cities have a large number of vehicles owned by households, leading to greater customer flow and implying more potential customers who may favor our new business.

⁸ PT/ST cities are those where PT/ST our stores operate

- **[Income]** For one thing, residents in wealthy cities are more likely to afford EVs, suggesting a higher proportion of EV owners compared with lower income cities. That said, it is easier for us to obtain more EV customers and sell EV products to people in these areas easily. For another thing, wealthier individuals are more inclined to spend more money on high-quality food.
- **[Margin]** On one side, albeit fuel acts as a substitute for our EV products, higher fuel margin does not cause rise in demand for EV-products, because customers focus only on the retail price, not the margin behind it. On the other side, a high price margin implies considerable opportunity cost, profit earned from gasoline sales, of switching from traditional fuel retailing to battery swap service. Simply speaking, the fuel price margin is inversely proportional to the difficulty of our business transformation.

A natural question is why gas retailing prices is not a decisive screening factor, given its evident connection to our revenue model. In fact, it is due to its confounding economic implication on our fresh business model.

- **[Retail price]** While substitution effect suggests that expensive gasoline leads to a rise in demand for electricity-based business, the high gasoline retail prices also implies tremendous opportunity cost, as in the case of high priced margins. In light of these two conflicting forces, the actual effect of high fuel price is ambiguous.

According to the aforementioned logic, 12 cities are selected as candidates (Figure 7⁹).

⁹ Gasoline Price and Margin Data are from NACS State of the Industry Report of 2016 Data
Population: <https://www.cacities.org/Resources/Learn-About-Cities/2011Cities-by-Population.asp>
Income: <https://statisticalatlas.com/state/California/Household-Income>

Distribution of Candidate Cities

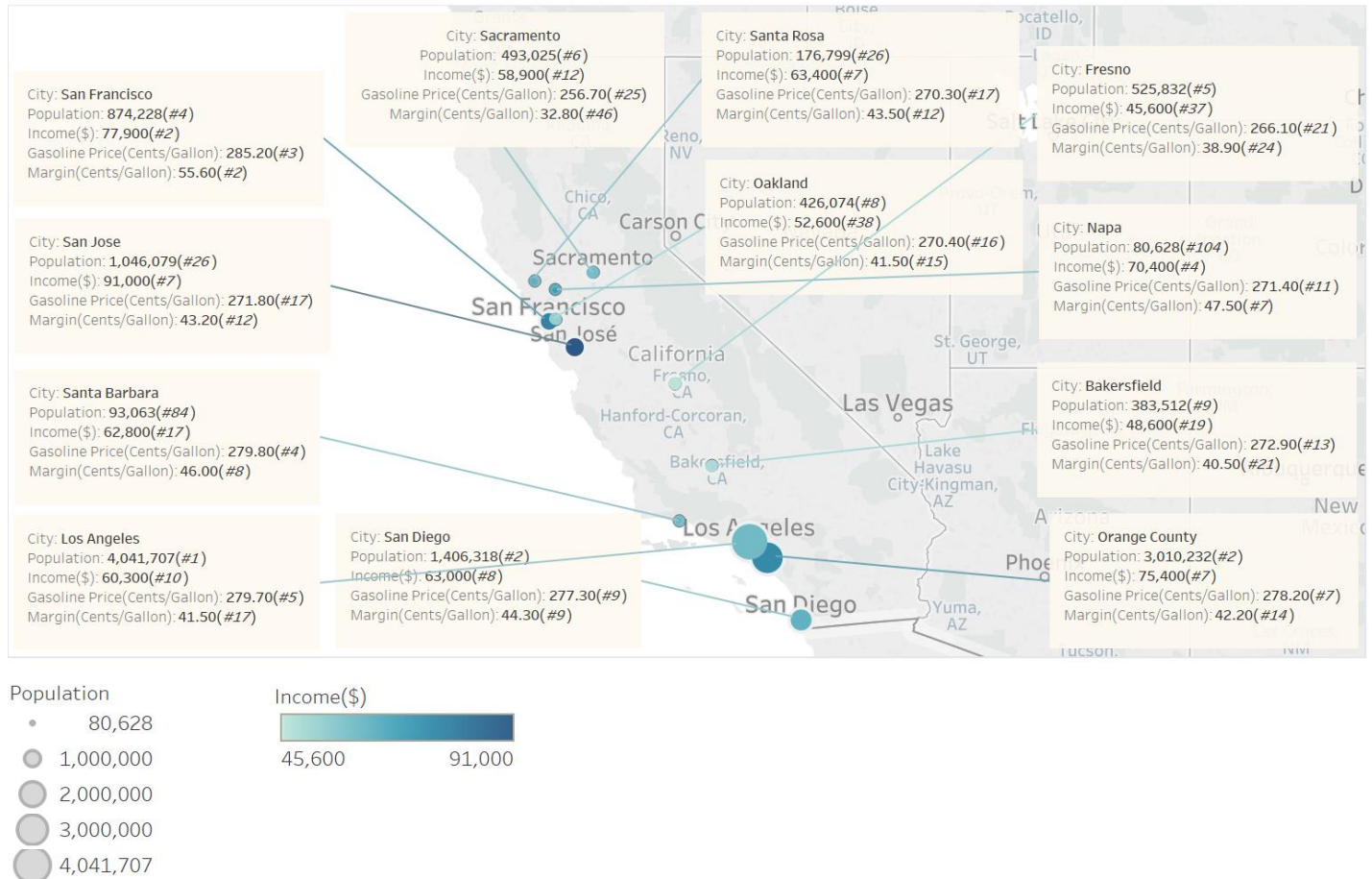


Figure 7

To further extract PT/ST cities from the candidates, we impose two more conditions on previous screening criteria: ideally (1) the city should have *both* high population and high income, and (2) there is a college town or an exit from a major highway in the city.

- **[Education]** Highly educated people such as college students are more concerned about food quality and environmental issues, so they tend to be more willing to buy non-GMO and organic foods.
- **[Travelling Distance]** Imagining a vehicle just traveled for a long distance and stopped at our store near the exit of highway, we think that the driver is likely to

consume groceries or require vehicle refueling. Especially for the EV drivers, they may be eager to recharge their vehicles since batteries are likely to run out. This stimulates greater demand for the recharging service, which makes it easier for us to sell EV related products to them.

Selected PT and ST Cities with EV Market Size

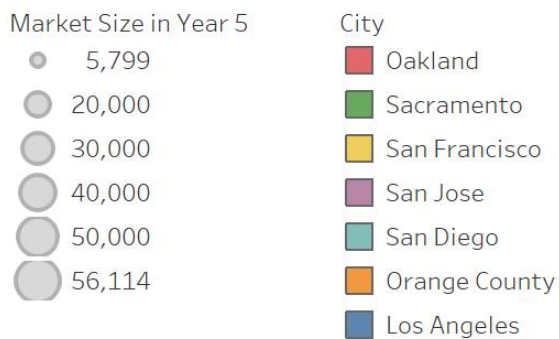
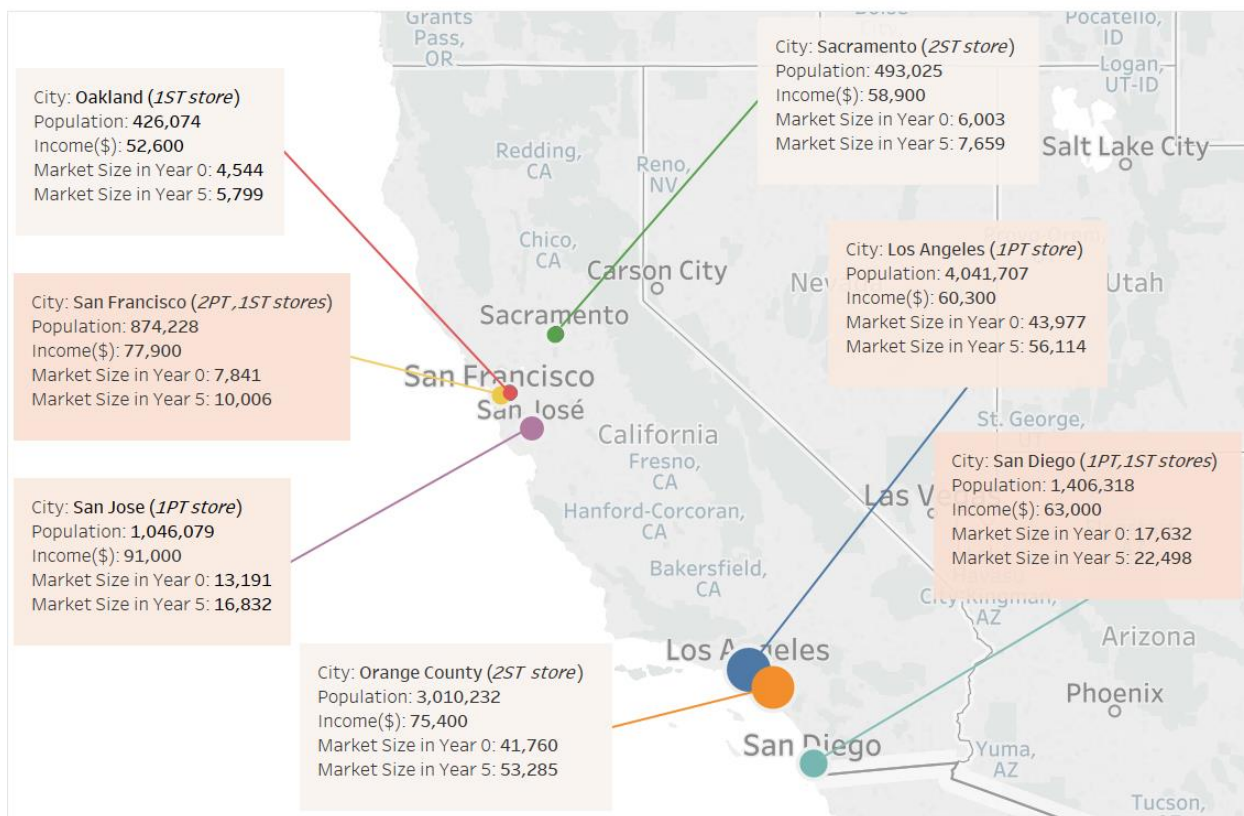


Figure 8

As a result, we will remove Fresno, Napa, Bakersfield, Santa Barbara, Santa Rosa and choose 4 cities (San Francisco, San Jose, San Diego, and Los Angeles) with 5 PT stores in them. By mildly relaxing the screening conditions, we will incorporate 3 more areas (Oakland, Sacramento, and Orange County) into the category of ST cities. In total, there are 7 selected PT/ST cities and 12 selected PT/ST stores (Figure 8). Through this approach, we can take into account variants across the selected cities. In addition, we also consider variants within a city by assigning some stores in that city to targeting PT customers and assigning other stores to ST audience.

We plan to roll out our B2B battery swap business model in the selected PT stores in the first five years, and then extend the business to ST stores in the following five years.

We can predict the average EV annual growth rate in the 7 selected PT/ST cities by fitting a simple linear regression model on previous 5-year historical data¹⁰. Assuming total vehicle annual growth rate is 1.15%¹¹, then we can expect that the percentage of the EV market share (total EV number out of the total light duty vehicle number) takes up to 4% 20 years later in our 7 cities (Figure 9).

7 Selected Cities EV Average Annual Growth Rate and Market Share

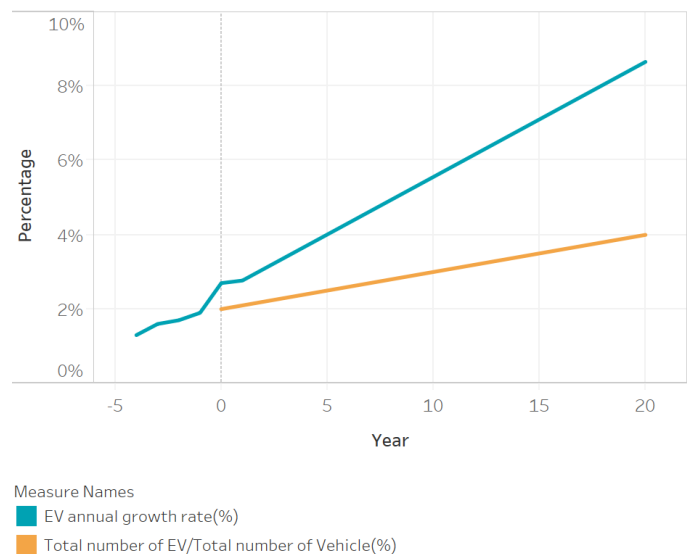


Figure 9

¹⁰ <http://www.latimes.com/business/autos/la-fi-hy-electric-vehicles-20170517-story.html>

¹¹ Calculate from the 5-year average annual total vehicle growth rate in California from 2012 to 2016 https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_16_1YR_B08201&prodType=table

Part 3. Alternative Analysis

ELECTRICITY AS FUEL: HOW WILL IT BE CONSUMED?

Based on the predicted market share of electric vehicles, we claim that electricity will be the most plausible second fuel alternatives to liquid fuels. Although the growth of electric vehicle will not overturn the traditional fuel retailing market, fuel retailers can still benefit from the raise of the electric vehicles. There are new profit potentials for fuel retailers to provide electricity, service and commodities to the EV owners.

The first question is: how the electricity would be consumed as a fuel for the electric vehicle? For light-duty cars and personal electric car owners, the cheapest and the most convenient way will always be charging by a slow AC power plug-in charger under the standard residential voltage (110V) at the spare time slot (at home during the night or at workplace parking lot during the day). The role of commercial electricity suppliers will be satisfying the demands of long-distance travel, frequent usage, and other urgent situations. Also, having these facilities in the market will release the range anxiety of EV owners, which is the fear that a vehicle has insufficient range to reach its destination.

There are only two kinds of feasible options being considered for commercial electricity supply: the fast plug-in charging stations like Tesla Supercharger and the battery swapping services like Better Place. We noticed that the fast-in-fast-out business style of battery swapping can easily cater current consumer habits of fuel retailing stores. Nowadays convenience stores contribute significant profit margin to fuel retailers. From the aspect of a fuel retailer, if we can incorporate battery swapping services into our business, we will create a new profit point for providing services to electric car owners and attract more consumers to our convenience stores. However, after Better Place lost

\$812 million and went bankrupt in 2012, it has been said that the battery swapping concept was dead. And Tesla closed its pilot battery swapping station in 2015 and now bet on its supercharger as a key element of widespread electric car adoption. However, a new patent of Tesla released on September 2017 shows that Tesla is still working on battery swap technology¹².

The technology of electric cars battery swapping is not really difficult and has minor technical barriers if we want to go in. The technology has long history in heavy-duty vehicles: it was first implemented in early 1900's for electric trucks and battery swapping stations for electric buses are all over China today¹³. For the light-duty vehicle, battery swapping is not applied widely as they are not intensively used as trucks and buses. Also, permission or license is not an obstacle. The barrier to scale adoption by personal automobile drivers is in the business model.

Better Place bet that all EV drivers would prefer to swap their batteries rather than charge them. The fact that Better Place put its beta stations in major cities as they supposed that city drivers would prefer battery swapping rather than charging in regular usage. It turned out that the assumption does not come true. However, compared to single home charger on a low voltage charge, battery swapping does not have significant economic advantages. As we have stated above, any commercial charging services for electric vehicles will be supplemental options rather than a mainstream charging alternative.

¹² <http://mashable.com/2017/09/18/tesla-patent-battery-pack-swapping/#B0qtk9yfaqqP>

¹³ http://www.cse.anl.gov/us-china-workshop-2012/pdfs/session3b_demos_standards/hua_3B-4-HUA-Tsinghua%20Univ-Progress%20in%20Battery%20Swapping%20Technolo.pdf

Also, Better Place designed its business model to face a market with standardized batteries, which is impossible as battery technology is the key competitive field of EV producers. It turns out that Better Place had to prepare their stations for all kinds of EVs. This is a nightmare for inventory control and management of battery warranty offers and claims. Although providing services to all electric car brands and models will expand increase its customer base, it is not realistic to do that. We believe that any success of battery swapping business model should build on a deep cooperation between the service suppliers and the electric car producers, or it is even an extension of after-sales service of electric car producers¹⁴.

By contrast, Tesla's battery swapping pilot station is located at the midway between Los Angeles and San Francisco, already a spot popular with carnivorous travelers. Drivers are given a choice: charge at a fast charging station for half to one hour for free or pay a little less than the cost of a tank of gas for a battery swap. In this case, battery swapping is considered an emergency solution for drivers who don't want to waste 20 minutes waiting on the road to their destination. Tesla closed this pilot station in 2015 because of the low usage of the battery swap station. According the Elon Musk, the CEO of Tesla, in the middle of a long-distance travel, people might want to take a rest and do not care additional waiting time. More importantly, in our opinion, Tesla requires appointment for their services in order to release the stress of inventory control, which affects the function of "emergency" function of battery swapping¹⁵.

From the failures of Better Place and Tesla in battery swapping business model, it seems that the user scenarios of battery swapping are poorly defined in the industry. And

¹⁴ <https://cleantechnica.com/2015/01/08/battery-swapping-can-now-scaled/>

¹⁵ <http://www.roadandtrack.com/new-cars/car-technology/news/a25872/elon-musk-tesla-battery-swap/>

many studies and business reports have stated that the capital investment of battery swapping business is too high to bear for business owners. As the batteries in the inventory can cost a lot, the high percentage of fixed assets might lead to unhealthy cash flow of the business. This is the problem we are aiming to solve by propose our business model for the fuel retailers.

Will "Supercharger" be a better option for fuel retailers to expand its business? If battery swapping is not going to work for them, should fuel retailers consider to build fast plug-in charging stations—just like the Tesla "supercharger"—in order to profit from electric vehicle owners?

Time will be the primary problem that plug-in charging stations alternatives might face nowadays. Even the most advanced fast charging technology—the Tesla Supercharger would take at least 20 min to charge sufficient electricity for the car to run more 100 miles. Under current technology, the most common plug-in charging time should be at least half-hour. This is way more than the average time for a consumer would stay in a fuel station and convenience store. If the business owner does not want the 30 minutes waiting time to be a torture for the consumers and wants to make benefits from them, extra commercial facilities should be added to the business besides the conventional fast-in-fast-out additional services like car washing and convenience store. This will create a conflict in the current business model of fuel retailers, increase the burden of investment and decrease the space of the business, and the charging station will have already occupied significant space.

Even when the fuel retailers can figure out a way to solve the conflict, the fast charging stations still do not have competitive advantages in cost and profits compared

to battery swapping stations¹⁶. One fast direct-current high-voltage plug-in charging installation can easily take \$50,000 to \$100,000 capital cost including infrastructure, equipment and permitting as well as \$2,000 to \$5,000 maintenance cost per year. Considering a charging station can service capacity per day of plug-in charging stations is much less than battery swapping stations. Fast charging stations do not have significant advantages in cost. Also, the profit margin of plug-in charging will be trivial. Service suppliers will not have any pricing power for the charging as the electricity is actually produced and provided by the utilities. However, battery swapping will have an advantage as electricity prices are variant in the different time slots. A battery swapping station with battery inventory connecting to the grid is a perfect buffer of the grid that local utilities will prefer and a natural implement of the "smart grid" concept—battery swapping station can earn profit from charging at low-price time slot of electricity and even sell spare electricity back to the grid at higher prices when it is needed.

The market is changing. Since Batter Place ended up with bankrupt in five years ago, the market environment has changed a lot. New start-up electric cars producers are springing up like rain, and multiple traditional automakers (such as BMW, Nissan, Chevrolet and Volkswagen) have planned or already produced electric cars under their brands. Several especially forward-thinking utilities are exploring additional actions, such as offering preferential rates for electric vehicle charging, electric vehicle or EVSE financial incentives, and direct deployment of or investment in public charging infrastructure. And the concept of "smart grid" we just mentioned became to be mature in these years and people start to realize the value of battery inventory itself.

¹⁶ <https://www.greenbiz.com/blog/2014/05/07/rmi-whats-true-cost-ev-charging-stations>

Although battery chemistry is still too limited and battery capacity is the common issue that electric vehicle industry is facing, the price of battery packs for low-range electric cars (less than 200-mile) significantly dropped in the past years. People are still looking for cheaper batteries while having longer mile ranges, but the batteries that can support 100 to 200 mileage travel have already been pretty affordable now. The price of a 24kWh battery of Nissan LEAF is now \$5,500, at about \$200/kWh¹⁷. In five years the price can decrease to \$150/kWh. Many batteries will have significant degradation after certain years, but the EV industry should have mature scenarios prepared for the demand of battery replacement and recycling¹⁸. Most of the electric car producers can provide battery warranty or rental programs at a cheap price and a good value. After learning the current market trend, we made some assumptions about the future of the electric car industry. And we will introduce our new business model to help fuel retailers to benefit from the growth of electric cars based on these reasonable assumptions:

- Electric cars are designed for both plug-in charging and battery swapping options.
- For light duty vehicles, home charging will be the mainstream method as it is cheap and convenient. Any commercial alternatives, including fast plug-in charger and battery swapping, will be considered only as the solution to the "worst case scenario" and supplement to the demands of long distance travel, frequent usage and urgent situations, rather normal user habits.
- Most of the electric vehicles will have mileage range below 200 miles, as a result of balancing the prices of the battery and the convenience of usage. Batteries will

¹⁷ <https://www.edmunds.com/car-news/nissan-prices-leaf-battery-replacement-at-5500.html>

¹⁸ <https://electrek.co/2016/12/07/gm-chevy-bolt-ev-battery-degradation-up-to-40-warranty/>

not be standardized, as the battery technology is the key competitive field of the electric car producers.

- The price of battery pack will continue to drop. And electric cars producers will offer affordable battery warranty and rental programs. Electric car industry will have strong competitions and electric cars producers are eager to cooperate to extend their market influence.

In our business model, we will expand selected stations with battery swapping equipments in order to serve electric car owners. For the new battery swapping business, we will seek to build business-to-business (B2B) cooperation with electric cars producers. The purposes of the cooperation with electric vehicle companies are: (1). to rent battery swapping equipments and batteries from producers with favorable prices instead of purchasing them with large capital investment, (2). to reduce the battery types and configurations in our inventory in order to release the pressure of inventory management and battery renewal, and (3). In return, we can serve as an extension of the after-sales services of the EV companies and help our partners to capture more market share in the area. Besides the battery swapping business, we are also planning to update our convenience store rack with to fit the lifestyles of electric car drivers. For our new business model, we will have some pilot stations based on our market analysis and the applicability of specific stations. Once we confirm that the new business is profitable and gain more experiences, we could easily extend our business to more applicable stations.

Part 4. Operation

TIMELINE

In the next twenty years, we will roll out our business plan in three phases (Figure 10). In Phase 1 (year 0 through year 4), the selected five PT stores will start upgrading immediately, while the ST and TT stores will keep their current business unchanged. At the outset of Phase 2 (year 5 through year 10), ST stores will employ the business model transformation, following what the PT stores have accomplished. Depending on the performance of the PT and ST stores in the first ten years as well as the evolution of fuel energy market, we will then decide whether TT stores will shift their business model in phase 3 (year 11 through year 20), if any. We will update some of our PT/ST stores with new in-store business and modify others both new in-store and EV-related business based on the market segmentation analysis previously.

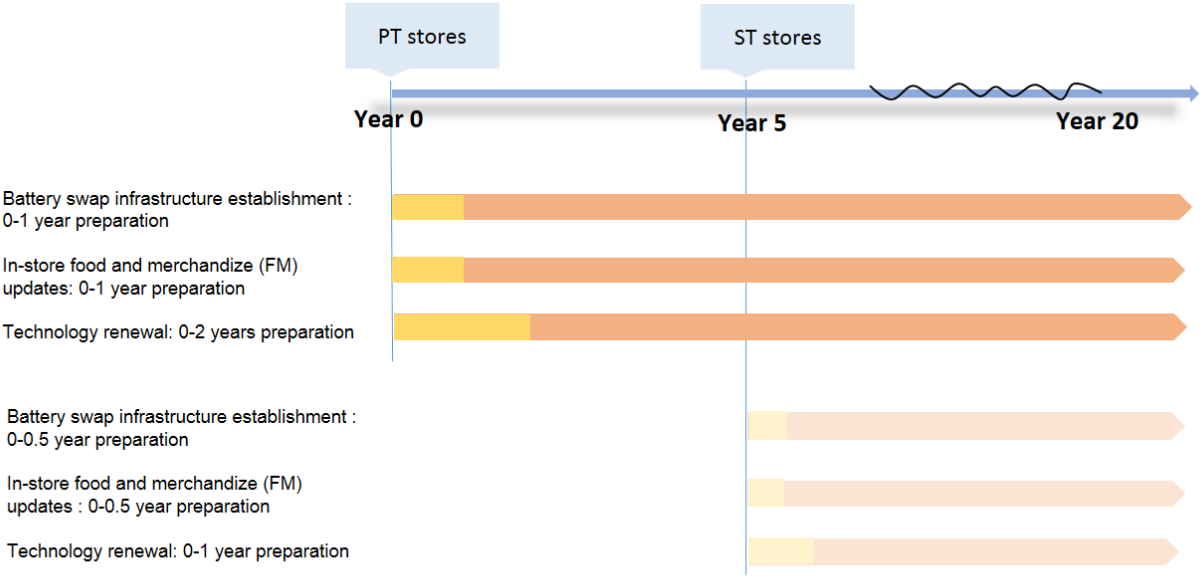


Figure 10

The implementation of business transformation constitutes three components: (1) infrastructure establishment, (2) update on in-store food and merchandize (FM) options, and (3) technology renewal. Regarding (1), we posit that there is enough spare space in each PT store so that the battery swap station and underground battery inventory can be installed without removing any of the existing fuel equipment (e.g. dispensers and underground oil tanks). Such assumption implies there would be no cannibalization involved when battery swap service is added as a supplement to our fuel retail business. We will defer the discussion of (2) and (3) to the next two sections, for the renovation of FM and technological gadgets are closely linked with our competition and marketing strategy. Figure 11¹⁹ and 12²⁰ show an automated battery swap station and the vehicle battery swap process.

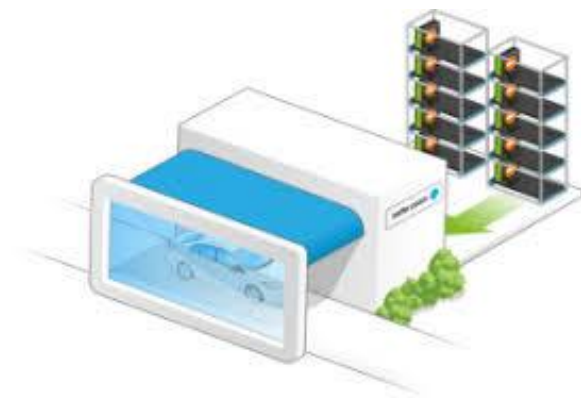


Figure 11

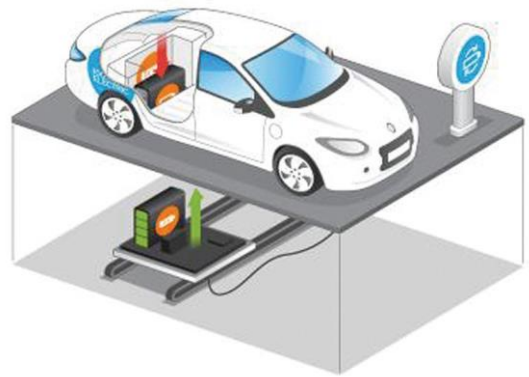


Figure 12

¹⁹https://www.google.com/search?q=better+place+battery+swap&rlz=1C1CHMO_enUS585US585&source=lnms&tbm=isch&sa=X&ved=0ahUKEwiY87Wmv6HYAhWpRt8KHdo8As8Q_AUICygC&biw=1280&bih=592#imgdii=q0VoA0B_WmRMbAM:&imgcr=UQM39xGQB4Zx4M:

²⁰<https://media2.fdncms.com/sfexaminer/imager/a-7-million-electric-taxi-network-plan-included-four-battery-swapping-stat/u/original/2322386/battery-car.0214.jpg>

COMPETITION STRATEGY

Per Michael Porter²¹, the two dominant atoms of sustainable competitive power for a business are (i) comparative advantage and (ii) differential advantage. The former means our ability to provide service at a lower price than competitors and the latter underlines that our services differ from competitors and are deemed better by customers.

- **(i) Comparative advantage**

From the finance perspective, we can charge our battery swap service (assuming designed for a battery capacity of 60 kWh) to be as low as \$20/unit in order to maintain a NPV of \$39,984 in 5 years. In comparison, a battery swap for Tesla Model S (battery capacity of 100 kWh) and Chevrolet Impala would cost drivers \$60 to \$80²² and \$44 to \$56²³ respectively, let alone the tedious appointment process. Comparing with Tesla and Chevrolet, we enjoy comparative advantage on the battery swap price.

- **(ii) Differential advantage**

In the context of our business, we harness the power of differentiation by offering high-quality products that are pertinent to the theme of our new business and meeting the same needs in a novel way.

- a. The Core Value

To distinguish our updated business from the past one, we not only refresh the services but also define and deliver new core values at the selected stores.

²¹ *Competitive Advantage*, Michael Porter, 1985

²² <http://www.businessinsider.com/teslas-battery-swapping-plan-isnt-working-out-2015-6>

²³ <https://repairpal.com/estimator/chevrolet/impala/battery-replacement-cost>

To illustrate, for those stores who provide battery swap service and target at EV drivers, the core value consists of the consumption of organic products and the promotion of healthy lifestyle. In detail, starting from year 0, we plan to replace 30% of the old FM on the shelves by organic fresh fruits, foods that are raised humanely, and packaged goods containing all-natural ingredients. In the snack aisle, the new offerings will be low-calorie, gluten-free and non-preservative products. We will adjust the proportion of new FM according to their sales in the following years.

To promote these products, we will (1) offer combo options bundling old goods with new ones at an attractive discounted price and (2) alter the in-store adornments in order to cohere with the green and healthy concept.

Admittedly, the gas station is often the last place a customer would think of to look for natural and organic goods. Nevertheless, we believe that there is high probability that our customers will embrace the FM renovations for two reasons. First, EV owners are generally more concerned about health and environment. Second, as we did in the market analysis, the stores which will implementing the aforementioned changes are selected in the regions where the educated and/or the affluent are concentrated.

For the remaining PT and ST stores who serve the individuals with no EVs or traditional autos, we plan to create a family style shopping and resting environment inside the stores. While a warm, secure, sharing, and family-oriented atmosphere will be fostered, the featured products are toys, gifts for kids, locally grown foods etc. Shelves with low-margin products will be removed to make room for the resting area.

b. Technology Improvement

How to allure fuel-refilling-only customers to shop inside the stores is a problem almost as antique as the fuel retail business itself. In contrast to the widely held belief that money is the major factor keeping passengers from shopping inside, a recent study²⁴ shows that it is the weak demand for the in-store goods and the limited shopping time that indeed play the most significant role. To solve such a conundrum, we realize that it is also necessary to solve a presupposed problem: how to inform our customers about the in-store renovations. The solution is the technological innovation, meaning we meet the needs from customers in a better manner.

To wit, we will equip each fuel dispenser with a tablet on which a well-designed app provides an integrated portal for the in-store shopping and checking out. With the artistry of user interface design, the featured and recommended products will stand out, a process engineered by the internal recommending system. This one-stop-serves-all-needs type of application best demonstrates the principle of convenience at its finest. Normally, after the transaction is completed on the tablet, it will only take an individual at most 2 minutes to walk into the store to fetch his/her order. In this light, consumers could efficiently utilize their waiting time and we would benefit from the rising sales.

²⁴ <http://www.cspdailynews.com/industry-news-analysis/marketing-strategies/articles/one-retailer-s-pump-store-strategy>

MARKETING STRATEGY- CUSTOMER AWARENESS

We will design a loyalty program offering special prices on our products for the membership owners. On one side, the discounted prices will be best applied to high-margin in-store FM items, such as coffee and fountain drinks. On the other side, the stamp scheme on the battery swap business is one stamp accumulated for each paid battery replacement and 10 recorded stamps for 1 free swap. Besides, we will also carry out a referral program aiming at raising customer awareness of our updated business. Every loyalty member will be provided a personal invitation code (promotion code) that he/she can share with other EV drivers/friends interested in creating a loyalty account. The referee will receive rewards when a new referral signs up using the invitation code and completes the first consumption. In this way, we can achieve a win-win outcome with our old clients and also allure potential new customers.

Part 5. Policy Support

The U.S. Government seeks to remove barriers²⁵, expand the mainstream EV market while continuing to strive to reach many of prospective EV consumers. We summarize actions and rationale focusing on growing the EV market (see Table 2 for actions taken by state (mainly chosen in CA), city, and utility levels).

Most of the actions benefit us; they specifically target easing consumer difficulties of EV purchases and usage and relieving financial stress firms shoulder in R&D. On the consumers' side, these strategies promote their incentives to owning EVs, accelerating the growth of EV demand. On the automakers' side, these actions encourage investment in research and production of EVs, scaling up EV manufacturing. Consequently, the EV market is projected to hit a new equilibrium with stable pricing as well as magnified sales.

Nonetheless, these policies, to some degree, intensify the competition we face, as they foster the development of public charging services, a substitute for our battery swap business. When the availability of substitute's rises, or its price falls, the demand for our battery swap drops.

Admittedly, the increasing competition may exert a negative impact on our business; nevertheless, the influence is limited (public charging stations can hardly meet the demand for EV recharging in all cities) and we will enjoy a sharp advantage over the substitutes, for the service we offer is not just a battery swap, but a comprehensive service encompassing all routine EV maintenance.

²⁵For consumers, the major barriers are the high expenditure on EV purchases and the maintenance as well as battery charging. For producers who desire to enter the EV market, the market entrance barriers are both the huge early-stage R&D investment on EV-related technology and the current oligopolistic market structure. Additionally, there are latent social barriers: customer awareness and education of accepting and investing on EVs.

	Policy Action	Rationale
State Level	1. State ZEV program -- Zero Emission Vehicle program (CA)	1. Aiming at cutting emissions from automobiles, the program motivates EV manufactures to expand zero emission vehicle production by building ZEV infrastructure like EV charging stations
	2. State manufacturing incentive -- Sales and Use Tax Exclusion Program (CA)	2. Through tax exclusion to cutting-edge companies who conduct clean energy research, technological support for improvements of EV can be sustained
	3. State increased BEV incentive for low-income -- Clean Vehicle Rebate (CA)	3. Spur demand for EVs via subsidizing qualified low-income applicants
	4. State BEV Purchase Incentive -- Innovative Motor Vehicle Tax Credit (CO)	4. By offering cheap credit to EV purchasers, upfront cost barrier is lowered, helping to expand EV market
City Level	1. City vehicle purchase subsidy -- Alternative Fuel Vehicle Rebate Program (Riverside, CA)	1. The subsidy acts as a relief in the purchasing cost of a new EV, leading to a strong dent in the family budget, therefore stimulating EV consumption
	2. City electric vehicle strategy -- 2017 City of Portland Electric Vehicle Strategy (Portland, OR)	2. With the actions such as broadening access to used EVs and launching outreach programs in the city, the strategy increases awareness about the performance and functionality of EVs
	3. City parking benefit -- Free Parking for All-Electric Vehicles (Cincinnati, OH)	3. With the offers of free parking to all-electric vehicles, the program can help to reduce parking inconvenience (e.g. provide more parking space for EV drivers and save them parking fee)
Utility Level	1. Utility public charging infrastructure for low-income communities -- SDG&E to install thousands of EV chargers (San Diego, CA)	1. By expanding charging infrastructure to underserved area, spread of EVs can reach a further extent
	2. Utility-deployed public charging infrastructure -- Clean Charge Network (KS)	2. With the establishment of more charging spots, consumers will enjoy greater convenience during their use of EVs
	3. Utility-preferred EV rates -- Georgia Power Plug-in Electric Vehicle Rate (Atlanta, GA)	3. With preferential charging rates tailored for EVs, cost of using EV is lowered to encourage EV purchases

Table 2

Part 6. Financial Analysis

INTRODUCTION

To determine whether the project is financially desirable, we must conduct a project evaluation, namely estimating the project's net present value (NPV²⁶). We first forecasted the project's revenues and costs, and from them estimated the expected future free cash flows (FCF). Next, due to the intrinsic uncertainty contained in the cash flow forecasts, we demonstrated the sensitivity of the NPV to the assorted uncertainties through break-even analysis, sensitivity analysis, and scenario analysis.

UNLEVERED PROJECT EVALUATION

We posit the following reasonable assumptions in order to simplify the capital budgeting process:

1. All cash are received at the year ends²⁷
2. The unit sale of battery swap services increase yearly, specifically the 2nd year sale is 20 units more than the 1st year, the 3rd, 4nd, 5nd are 40 units more than the 2nd year
3. No liquidation or salvage value for discarded equipment
4. Twenty-year straight-line depreciation
5. Cannibalization happens only when updated FM replace the original ones²⁸
6. Constant tax ratio. No tax loss carryforwards or carrybacks²⁹
7. B2B with cooperating automakers reduce the initial capital expense to \$500K.

²⁶ NPV is the present value of the cash flows at the required rate of return. It measures the project's contribution to the shareholder value. In corporate finance, managers typically utilize NPV rule to make investment decision: (1) negative NPV implies financial inapplicability and (2) choose the project with highest NPV among alternatives.

²⁷ In reality, cash will be collected on a daily basis after each transaction is completed.

²⁸ Since we did not uninstall existing gasoline pumps to make space for battery swap station, we can assume our fuel retail business is unaffected; therefore, no cannibalization in this respect.

²⁹ These are two special tax code features enabling companies to take income losses during a current year and offset them against positive pretax incomes in nearby years. Suffering from negative pretax income, a firm can *carry back* current losses by obtaining a refund for taxes paid in previous two years. If no tax expense happened in the last two years, the firm can *carry forward* the loss by using it to offset future taxable income.

The initial settings of the key parameters are summarized below (Table 3).

Variable	Initial
Price\$/Unit	25.00
Unit	10.00
Tax Ratio	0.20
Cost of Capital	0.08
Depreciation	20.00

Table 3

Under the assumptions given above, we conducted the project evaluation as follows (Figure 13). The project has a NPV of \$252K and its IRR is 20.68%.

PT Store Capital Budgeting (\$)						
For the period ended in	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
<i>Revenue</i>						
Battery Swap Revenue	0.00	91,250.00	273,750.00	456,250.00	456,250.00	456,250.00
New Food & Merchandise Sales	42,912.30	42,912.30	42,912.30	64,368.45	64,368.45	64,368.45
Loss in Fuel Sales	0.00	0.00	0.00	0.00	0.00	0.00
Loss in F&M Sales	32,435.60	32,435.60	32,435.60	48,653.40	48,653.40	48,653.40
Total Sales	10,476.70	101,726.70	284,226.70	471,965.05	471,965.05	471,965.05
<i>Production Costs</i>						
Battery Charging Costs	0.00	6,858.35	20,575.05	20,575.05	34,291.75	34,291.75
Others (e.g. F&M Costs)	1,443.94	1,443.94	1,443.94	2,165.90	2,165.90	2,165.90
Total Costs	1,443.94	8,302.29	22,018.99	22,740.95	36,457.65	36,457.65
<i>Gross Profit</i>						
Battery Swap	0.00	84,391.65	253,174.95	435,674.95	421,958.25	421,958.25
New In-store Business	9,032.76	9,032.76	9,032.76	13,549.14	13,549.14	13,549.14
Total Gross Profit	9,032.76	93,424.41	262,207.71	449,224.09	435,507.39	435,507.39
<i>Operating Expenses</i>						
Permitting, inventory mobilization	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Maintenance	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00	1,500.00
Market Advising and Promotion	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00	2,000.00
Overhead Costs	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00	20,000.00
Total Operating Expenses	25,500.00	25,500.00	25,500.00	25,500.00	25,500.00	25,500.00
EBITDA	(16,467.24)	67,924.41	236,707.71	423,724.09	410,007.39	410,007.39
Depreciation	25,000.00	25,000.00	25,000.00	25,000.00	25,000.00	25,000.00
EBIT	(41,467.24)	42,924.41	211,707.71	398,724.09	385,007.39	385,007.39
Interest Expense	0.00	0.00	0.00	0.00	0.00	0.00
Tax Expense	(8,293.45)	8,584.88	42,341.54	79,744.82	77,001.48	77,001.48
Unlevered Net Income	(33,173.79)	34,339.53	169,366.17	318,979.28	308,005.92	308,005.92
Depreciation	25,000.00	25,000.00	25,000.00	25,000.00	25,000.00	25,000.00
Capital Expenditure	500,000.00	0.00	0.00	0.00	0.00	0.00
Increase in Net Working Capital	0.00	50,000.00	100,000.00	0.00	100,000.00	0.00
Free Cash Flow	(508,173.79)	9,339.53	94,366.17	343,979.28	233,005.92	333,005.92
Net Present Value (NPV)	252,344.08					
Internal Rate of Return (IRR)	20.68%					

Figure 13

BREAKEVEN ANALYSIS

In light of the uncertainties in the parameters, we calculated the break-even level of the most crucial inputs, whereby revealing the level for which the investment has a NPV of zero.

Based on the initial assumptions, in the first year, our project will break even with daily sales of 1.3 units when price is \$19.05 per unit. Alternatively, when daily sales are 1.3 units, the project will break even if we charge \$19.05 per unit.

Furthermore, the internal rate of return (IRR³⁰) is 20.68%, suggesting the required rate of return³¹ could be as high as 20.68%.

Additionally, the breakeven tax ratio implies that we can bear up to 44.23% on our pre-tax income and the breakeven net working capital (NWC) indicates that we can afford up to \$22,277.54 on each battery we purchased.

SENSITIVITY ANALYSIS

To learn which assumptions play the most vital role in calculating NPV, we disentangled the NPV computation into its components, demonstrating the variation of NPV as the underlying assumptions change.

Table 4 shows the base-case assumptions, together with the optimistic and bearish cases, for several key aspects of the project.

³⁰ IRR is the level of cost of capital at which the project's NPV would equal zero.

³¹ RRR is the minimal acceptable rate of return that the project must earn in order to be worthwhile.

Variable	Initial	Initial NPV	Worst	Worst NPV	Best	Best NPV
Price\$/Unit	25.00	252344.08	20.00	39,984.61	30.00	464,703.54
Unit	10.00	252344.08	5.00	106,610.16	15.00	398,077.99
Tax Rate	20%	252344.08	30%	148,211.64	10%	356,476.51
Cost of Capital	8%	252344.08	25%	59,631.83	5%	336069.52
Depreciation	20.00	252344.08	30.00	244022.89	10.00	277307.63

Table 4

To see the order of importance of uncertainties embedded, we recalculated the project's NPV under the best and worst situations for each parameter. For instance, in the worst case, the sale price is assumed to be \$20 per unit, corresponding to a decrease in NPV by \$212k. Repeating the calculation in each circumstances, we plot the change in NPV in the two extreme cases in Figure 14.

Sensitivity Analysis I - Change in NPV

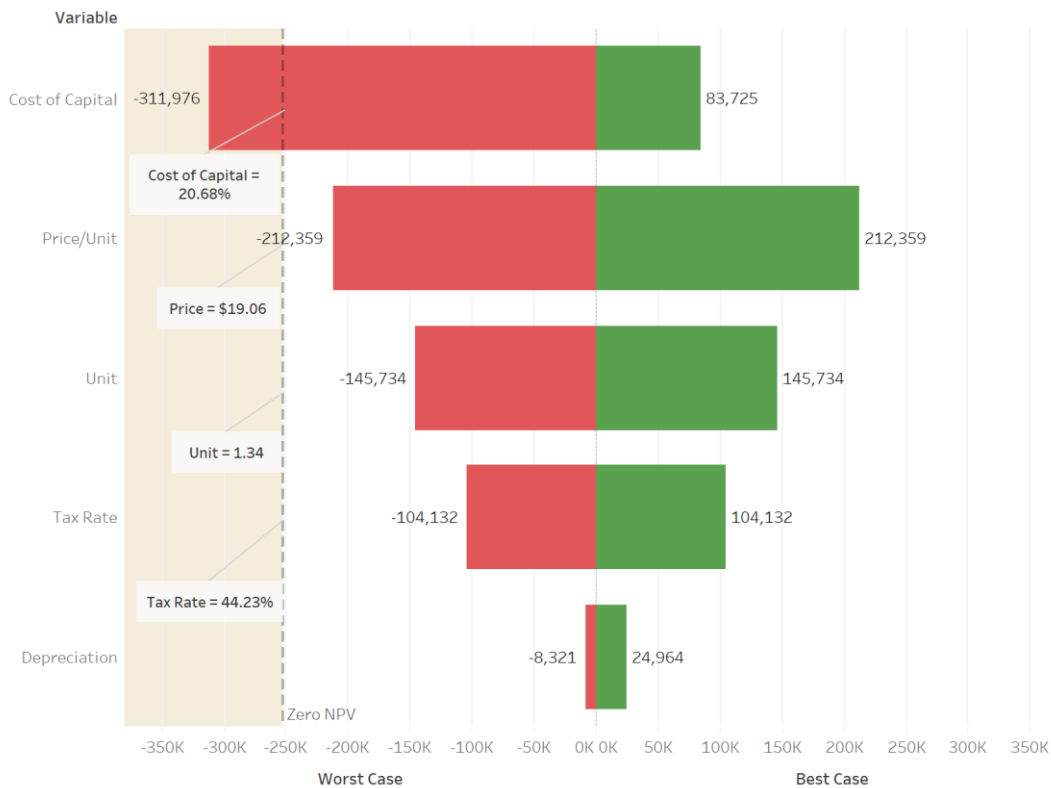
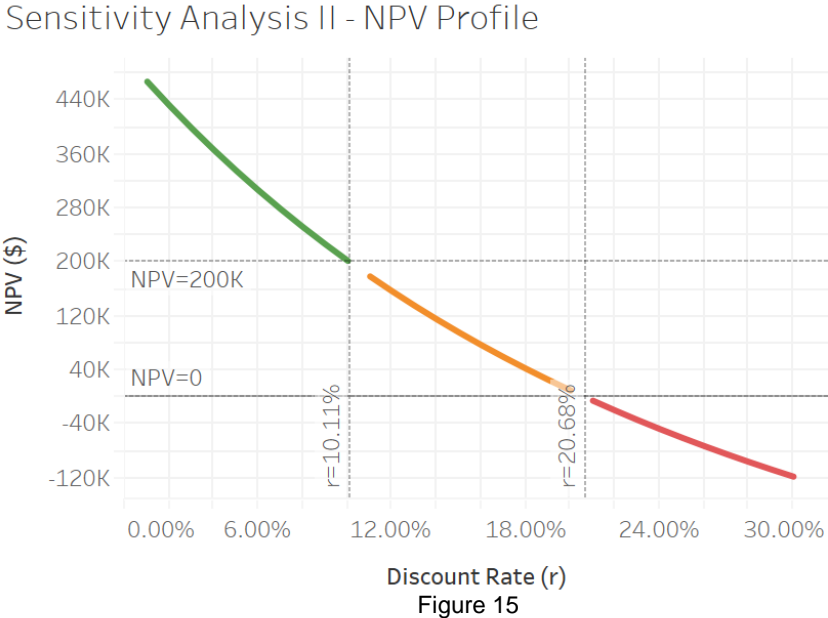


Figure 14

To illustrate, the green (respectively, red) bars display the deviation of NPV from its initial value under the best-case (respectively, worst-case) circumstance. The width of the bar gauges the influence of that parameter: the wider, the stronger. That said, the most consequential parameter is cost of capital, followed by price/unit and unit. Note that due to depreciation tax shield³², even in the worst case, depreciation would not drive the NPV to be negative; therefore, no breakeven value is associated with depreciation. The shaded area and the cut-off value on the left show the breakeven threshold for each parameter, under which the NPV would fall below zero.

Next, we drew the so-called NPV profile (Figure 15) to take a closer look at the behavior of NPV against various discount rates. The graph is split into three panels: the left(segment line in green) (respectively, right(segment line in red)) one indicates the range of cost of capital that would generate a NPV of more (respectively, less) than \$200K (respectively, \$0). The middle panel exhibits the neutral case (segment line in orange) where the NPV would lie between \$0 and \$200K.



³² Depreciation tax shield means the tax savings resulted from the deduction of depreciation from pre-tax net income. In that light, depreciation expenses always exert a positive impact on FCF.

SCENARIO ANALYSIS

As yet we have only considered the *ceteris paribus* consequences of varying only one parameter at a time, we now extend our analysis to study how the simultaneous change of multiple parameters would affect the NPV. In Figure 16, we drew three iso-NPV curves, each of which shows alternative combinations of price and units that would yield a certain NPV level. The figure also exhibits the required daily units sold in order to achieve the three prescribed NPV levels under the base price assumption (\$25).

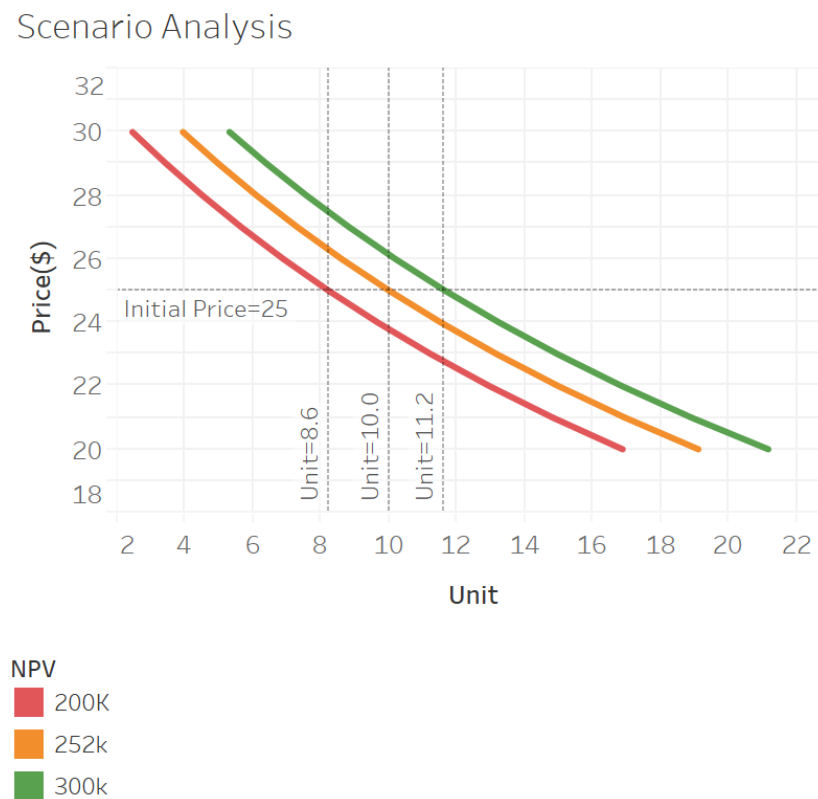


Figure 16

Part 7. Conclusion

While modern technology has been experiencing an exponential growth in the past several decades following the Moore's law, the fast-paced evolution in almost all business realms poses a serious and inevitable question to each forward-looking business manager: how I should adapt my current business to the mercurial and developing market?

In the situation of our problem, we argue that the EV will be the most vibrant entrant into the light-duty vehicle market, a prophecy backed by the study of alternatives. Then, the market and competition analysis inform us when, where, and how to transform our business. Finally, crucially relying on the B2B assumption, the finance projection validates the feasibility of the shift under assorted uncertainties.

In light of our conservative assumptions and actions in plan together with the flexibility in the operation, our proposed business model would be robust against market fluctuation as well as the unexpectations.

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. By bringing together diverse stakeholders of the transportation and fuels markets, the 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.

The Fuels Institute commissions and publishes comprehensive, fact-based research projects that address the interests of the affected stakeholders.

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PMCI | RINAlliance, Inc.

Renewable Fuels Association

STI/SPFA

Texas Food & Fuel Association

Washington Oil Marketers
Association

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