I. Abstract

As part of the project, we have collected data about electric vehicles and conventional gas-powered vehicles (petrol cars) to determine which presents the better buying option. This includes data on environmental effects, purchasing and ownership costs, driving ranges for vehicles, consumer survey results, etc. These different factors were weighted according to our group member's individual preferences. Some affected our buying decision more than others. Electric vehicles and petrol cars each received an independent score for each of these factors based off of the data we collected. We then applied this data and our weighting factors to our decision making process by utilizing methods learned about in the Decision Analysis lectures. Overall, we *currently* find it a better option to purchase a gas-powered vehicle rather than an EV.

II. Introduction

Electric vehicles (EVs) have recently entered the auto market, and present a new option for American and international consumers. The main belief is that EVs are a more environmentally friendly option for car buyers. Many consumers have not done any in-depth research into whether or not this is the case. We made sure to do extensive research before we made any decisions. EVs do not release any direct emissions, but are certainly not 100% eco-friendly either. Electric cars differ from normal gasoline powered vehicles mainly because they run on a different power source. There are many other differences between the two vehicles though. We collected data on environmental impact differences between EVs and petrol cars, and on these other differences. This data was necessary to make an informed decision analysis.

We conducted a survey to get an idea of where many young consumers stand on the topic of electric vehicles. All surveyors were students from our Decision Analysis lecture. The survey showed where students stand on the topic of addressing environmental problems as well as what factors strongly impact their car buying decisions.

After gathering all relevant data, we applied this information to our ultimate decision of deciding whether or not to purchase an electric vehicle. We first constructed a decision tree and influence diagram to get a broad idea of the structure of our decision making process. We then utilized techniques like sensitivity analysis and creating a preference matrix to determine how factors affect our overall final decision. These methods allowed us to break down our decision into separate pieces and better fully comprehend what was most important in our decision making process. After exhausting all tools relevant to our decision making process, we came to a final decision. We outline the structure of this process throughout the rest of the report.

IV. Data collection

Gas vehicle exhaust emissions

The exhaust emitted from petrol cars includes:

1. Sulphur oxides
   A group of gases that has the ability to dissolve easily with water causing respiratory effects, increased probability of asthma, visual impairment, and acid rain. Acid rain causes damage to vegetative and water sources as well as aesthetic damage to metal related items such as statues.

2. Nitrogen oxides
   Nitrogen oxides when released into the air can react with other chemical compounds to form acid rain, which can cause harmful effects on the human body such as chronic bronchitis

3. Volatile organic compounds (VOCs)
   These organic compounds, when in the presence of light react together to form smog. Smog can be detrimental to human health especially the respiratory system, resulting in coughing, lung damages, and difficulty breathing

4. Carbon compounds
   The main greenhouse gas emitted into the environment, though it is naturally present in the air, human activities, particularly gas car combustions have upset the delicate balance of carbon dioxide in the atmosphere, causing an increase in temperature and influencing the unpredictable extreme weather conditions around the world.

Gas vehicle vs. EVs

EVs which use electricity from the grid to power the vehicle play a role in reducing greenhouse gases (GHG) from the transportation sector. The figure below shows the number of miles PHEV# (Plug-in Hybrid Electric Vehicles) can travel with a full charge. According to the figure, PHEVs emit lesser GHG as compared to gas powered vehicles (CV)

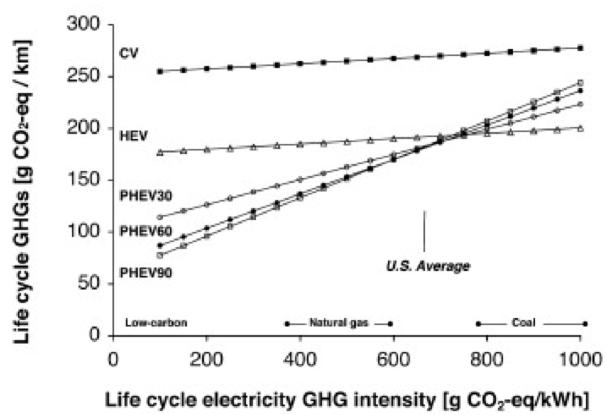


Figure: GHG emissions of different vehicles

Vehicle to Grid (V2G) Services

According to the U.S. Energy Information Administration (EIA), although there have been other alternate sources of fuel used to generate electricity such as solar, hydro, wind, etc., coal is still the main fuel source used to generate electricity within the United States of America (USA). Coal when burnt releases similar emissions to those emitted from a gas vehicle. In order to manage the generation of electricity through the burning of coal-sourced generators, V2G services is introduced

V2G is a system in which allows plug-in hybrids to communicate data to the power grid. This data would be utilized by the power grid management to ensure a more efficient delivery of electricity with respect to the demand required by specific periods. It promotes the charging of plug-in hybrids when the cost of generating electricity is low and discharging it when high, decreasing the use of low-efficiency, high-emissions peaking generators. As a result, power grid management would be able to anticipate the demand required and supply electricity using high-efficiency, low-emissions peaking generators, which in turn reduces the overall emissions level from generators. As can be seen from the table below, emission of harmful gases were reduced when using V2G services

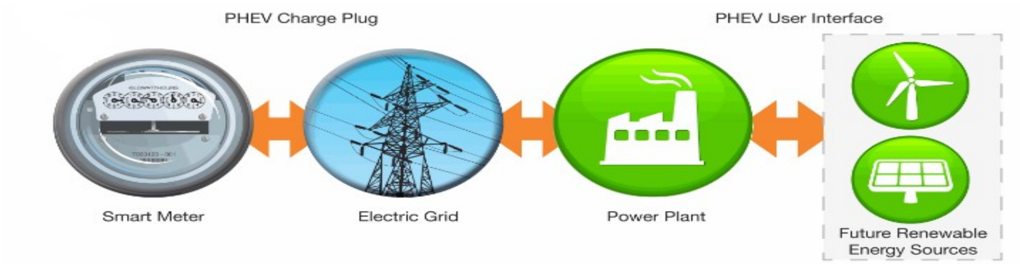


Figure: V2G process flow

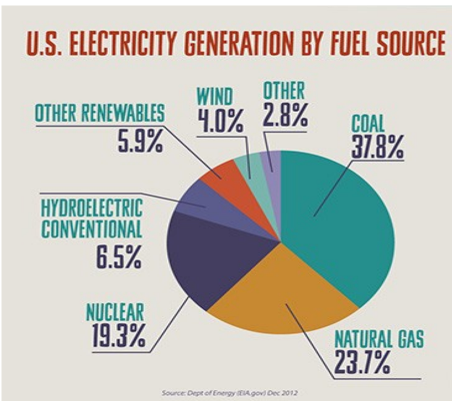


Figure: Percentage of fuel sources used in electricity generation in USA

TABLE 5. Reduction in PHEV Charging Emissions of CO_2, SO_2, and NO_x from V2G Services[a]

	generator emissions reductions			
			NO_x [%]	
PHEV penetration	CO_2 [%]	SO_2 [%]	ozone	non-ozone
1%	25.8	8.0	20.2	29.7
5%	30.5	4.6	34.5	76.6
10%	21.0	0.1	25.4	53.0
15%	19.2	−0.2	48.0	39.0

[a] Reductions are reported as a percentage of the increase in generator emissions from introducing the PHEV fleet, without V2G services. Estimates assume a fixed input emissions rate for CO_2, and a variable input emissions rate for SO_2 and NO_x, with a different NO_x emissions rate for ozone and non-ozone seasons.

Table: Reduction in emissions for Plug-in Hybrids utilizing V2G services

Effects of introduction EVs

It's believed that the introduction of EVs into the market will reduce carbon footprints. A study done by the University of Colorado department of Mechanical Engineering showed that compared to an area where with high concentration of gas powered vehicles, the same area with higher proportion of EVs has a lower proportion of carbon compounds emitted as seen from the figure below. The blue area represents the concentration of ozone. Ozone being formed in the atmosphere through the reaction of nitrogen oxides and volatile organic compounds, which are present in gas-car, exhaust emissions. Additionally, it causes a shift in the temporal and spatial distribution of local air pollutants, as these emissions are shifted to central electric generating units.

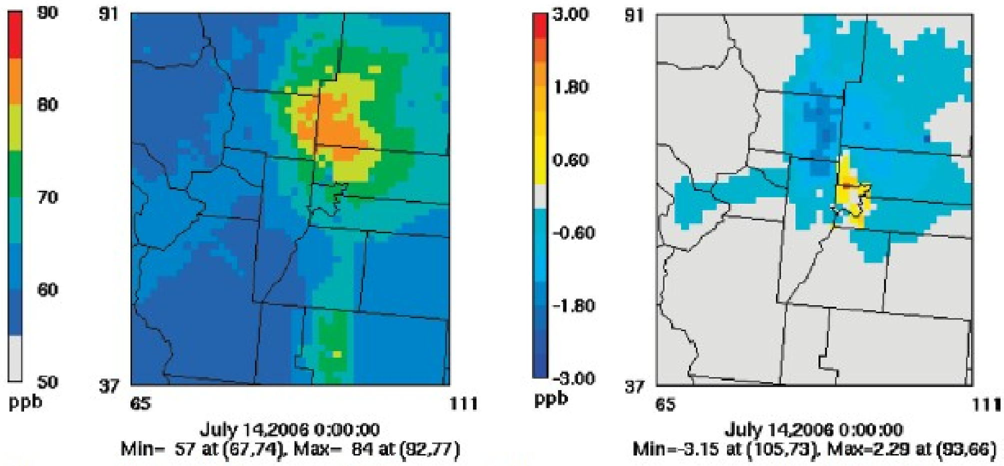


FIGURE 2. Base case (left) and difference in (right) maximum 8-h average ozone concentration for the 100% penetration V2G scenario for July 14.

Figure: Ozone concentration for high gas powered vehicle vs. High EVs

Lithium-ion (Li-ion) batteries

Li-ion is the lightest of all metals and offers the greatest electrochemical potential in order to provide for high power and energy density. Li-ion is used to power a wide variety of electronics such as laptop batteries and EVs as it requires little maintenance, has no memory effect, little self-discharge and no scheduled cycling is required to prolong the battery's life.

Production of anode/cathode batteries and battery packs dominate Li-ion usage, of which the major contributors to the environmental burden are caused by the supply of copper and aluminum. One study analyzed the use of lithium ion batteries in electric vehicles as an environmentally viable option and evaluates whether the burdens related to the battery are likely to offset the benefits related to the electric drive train, and found that the impact of Li-ion batteries in vehicles is relatively small.

Availability of EVs charging stations

EVs are powered by electricity as opposed to the traditional gasoline. Charging the EV's battery requires a source of the electricity that could come from residential source where the EV is plugged into a conventional electrical socket or it could come from a charging station such as those by Tesla. These are known as Tesla supercharging stations, and have the ability to charge 33% faster as opposed to conventional sockets.

Figure: EVs charging station

However, EVs are still in their early stages in the market, and because of this, there are only a few charging stations in the United States of America. Tesla is currently in cooperation with the U.S. Government, and plan to greatly increase the number of available stations, as see from the figures below.

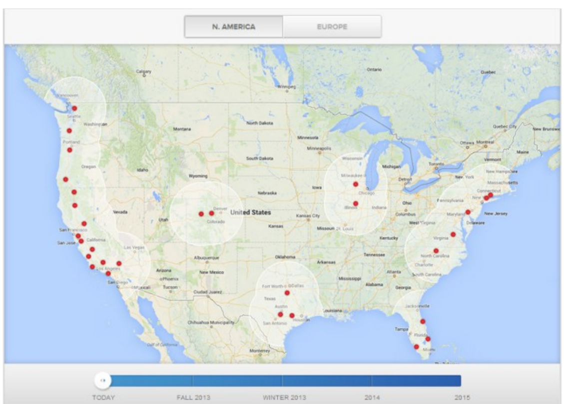


Figure: Number of Tesla charging stations today

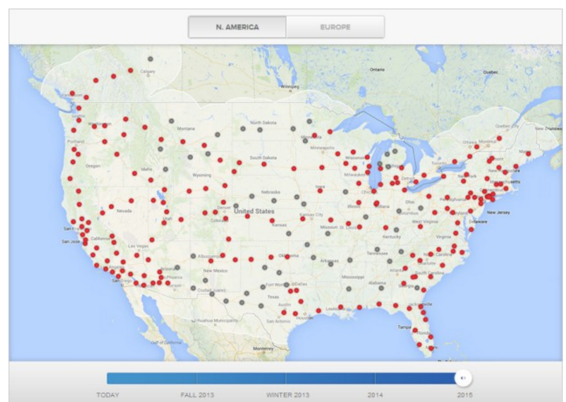


Figure: Number of Tesla charging stations by 2015

US government subsidies and benefits

In order to promote EVs successfully, the role of government is important. There are new initiatives to support advanced technology vehicles in the United States. President Obama is proposing three steps to address consumer demand and positioned the United States as a global leader in manufacturing and deploying next-generation vehicle technologies on February 09, 2011. His goal is to put one million electric vehicles on the road by year 2015. His 3 steps include:

1) Making electric vehicles more affordable with a rebate up to $7,500: The President is proposing to transform the existing $7,500 tax credit for electric vehicles into a rebate that will be available to all consumers immediately at the point of sale.

2) Advancing innovative technologies through new Research & Development (R&D) investments: Building on Recovery Act investments, the President's Budget proposes enhanced R&D investments in electric drive, batteries, and energy storage technologies.

3) Rewarding communities that invest in electric vehicle infrastructure through competitive grants: To provide an incentive for communities to invest in EV infrastructure and remove regulatory barriers, the President is proposing a new initiative that will provide grants to up to 30 communities that are prioritizing advanced technology vehicle deployment.

For different states in the US, there are different types and amounts of incentives to benefit consumers. They're based on those particular states policy incentives. Industry can achieve its planned production with the support of policies that encourage investment in manufacturing facilities, enable technology demonstration and deployment, and provide incentives to promote adoption and drive consumer demand. Most importantly, these incentives are to encourage consumers with a low budget to buy EVs.

For example, Florida provides $5000 incentives for limited conversion rebates. This rebate only allow for plug in hybrid vehicle (PHEV) conversion. Moreover, EVs are exempt from most insurance surcharges. New Jersey provides up to $4000 incentives for sales tax exemptions. However, the tax exemptions qualify only for BEVs (Battery Electric Vehicles), not PHEVs. Rebates on BEV purchases are also available for local governments. New Jersey State allows car pool lane access for EVs.

The US government also supports EVs by sponsoring research to encourage scientists to improve EVs to another stage. The President has announced that the Fiscal Year 2012 Budget will include enhanced R&D investments in battery and other electric drive technologies. Investments will support R&D initiatives through DOE's Vehicle Technologies Program, as well as a new Energy Innovation Hub devoted to developing better batteries and energy storage capacity to support electric vehicles and other technologies. This focus on continued innovation complements ongoing R&D to support the development of critical technologies needed for the widespread introduction of electric drive vehicles. These efforts include battery development, power electronics and electric motors, and electric drive vehicle systems.

Long-term assessment of EVs' energy

With the depletion of the earth's ozone layer and the shortage of our oil supply becoming an issue, we have had to look at alternative fueled vehicles that will not harm the environment, but will still provide us with a reliable source of transportation.

Compared to gasoline-powered vehicles, electric vehicles are considered to be 97 percent cleaner, producing absolutely no tailpipe emissions that can place particulate matter into the air. Particulate matter can increase asthma conditions, as well as irritate people's respiratory systems. Because EVs produce no emissions, there are no requirements for EV owners to ever take in their vehicle to DEQ for an emissions inspection. Another factor that makes these vehicles so clean is that since they don't use half of the parts that a gasoline powered vehicle does (including gasoline and oil), they are not at risk of shedding any worn out radiator hoses, fuel filters, etc, to be dumped in our overcrowded landfills, and leaking contaminated oil into our water supply, killing plant and animal life.

Although electric cars claim that they are zero carbon emission vehicles, electric cars have higher manufacturing emissions than normal cars. Electric cars also use electricity that has its own footprint. When these two factors put together, the benefits of EVs need to be reconsidered again. Hence, in order to fully assess the climate impact of an electric car we need to consider the scope of emissions that occur in both the electricity supply and in vehicle manufacturing.

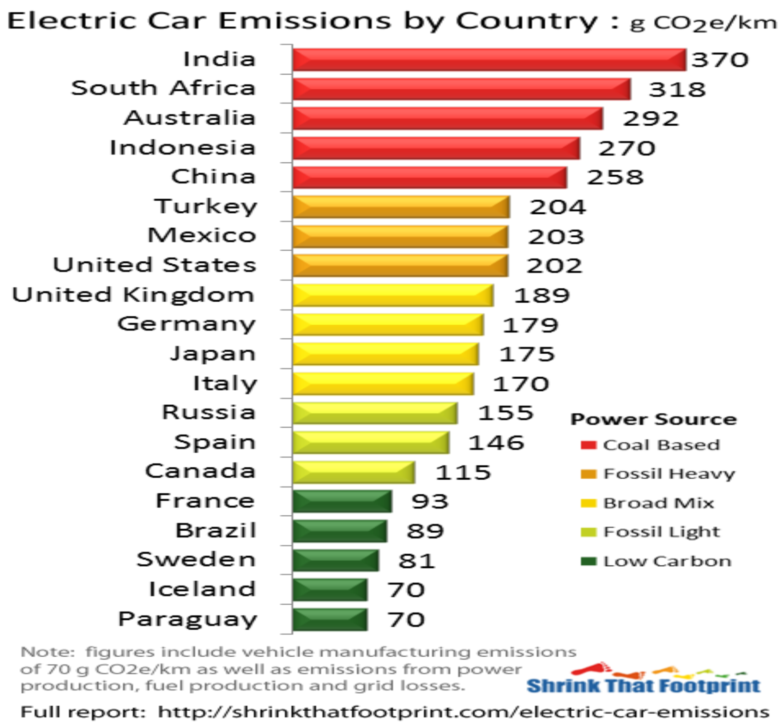


Figure: Electric car emissions by country

The figure above showed that the carbon emissions of grid powered electric vehicles are four times greater in countries with coal-dominated power generation than in those with low-carbon electricity. Due to the dominant share of coal generation in India, South Africa, Australia, Indonesia and China, grid powered electric cars produce emissions comparable to normal petrol vehicles. With emissions ranging from 258-370 g CO2e/km electric cars generate significant emissions, many multiples of those using low carbon sources. In these countries electric vehicles will have limited climate benefit. Paraguay is 'the greenest place on earth to drive an electric car'. Hydroelectric exporter Paraguay edges out Iceland to claim top spot with driving emissions of just 70 g CO2e/km.

The US dash for gas is driving down electric driving emissions. In the decade from 1999 to 2009 the carbon intensity of electricity in the US fell by 15%, due largely to the increased use of natural gas. Based on 2009 data, an electric vehicle using average US electricity generates 202 g CO2e/km. The fast moving changes in the US fuel mix means this figure is significantly higher than what will be the case for 2012 and that the footprint of driving an electric car continues to fall in regions using less coal.

Long-term assessment of battery

Conventional vehicles utilize a lead-acid battery, which is highly toxic and damaging to our environment. Even with its low value as scrap, the recycling rate for lead-acid batteries is reported to be approximately 98% in the United States. Most EVs use advanced battery chemistries with metals such as Nickel and Lithium ions. These metals are more valuable than lead, and since the batteries are quite large, the value of the spent battery packs will be such that the recycling rate is expected to approach 100%. This fact, combined with government regulation of battery disposal, will help ensure that EV batteries do not have a negative impact on our environment.

However, Lithium-ion batteries may suffer thermal runaway and cell rupture if overheated or overcharged, and in extreme cases this can lead to combustion. Several plug-in electric vehicle fire incidents have taken place since the introduction of mass-production plug-in electric vehicles in 2010. Most of them have been thermal runaway incidents related to their lithium-ion battery packs, and have involved the Zotye M300 EV, Chevrolet Volt, Fisker Karma,BYD e6, Dodge Ram 1500 Plug-in Hybrid, Toyota Prius Plug-in Hybrid, Mitsubishi i-MiEV and Outlander P-HEV, and Tesla Model S. As of October 2013, two fires after a crash have been reported associated with the batteries of plug-in electric cars.

The first modern crash-related fire was reported in China in May 2012, after a high-speed car crashed into a BYD e6 taxi in Shenzhen. The second reported incident occurred in the United States in October 2013, when a Tesla Model S caught fire after the electric car hit metal debris on a highway in Kent, Washington, and the debris punctured one of 16 modules within the battery pack.

In the United States, General Motors ran a training program in several cities for firefighters and first responders to demonstrate the sequence of tasks required to safely disable the Chevrolet Volt’s power train and its 12 volt electrical system, which controls its high-voltage components, and then proceed to extricate injured occupants. The Volt's high-voltage system is designed to shut down automatically in the event of an airbag deployment, and to detect a loss of communication from an airbag control module. GM also made available an Emergency Response Guide for the 2011 Volt for use by emergency responders. The guide also describes methods of disabling the high voltage system and identifies cut zone information. Nissan also published a guide for first responders that details procedures for handling a damaged 2011 Leaf at the scene of an accident, including a manual high-voltage system shutdown, rather than the automatic process built-in the car's safety systems.

Comparing the long term assessments of EVs and gas-powered cars

A concerning long term assessment of EVs is that their widespread deployment will lead to the need for more energy production facilities in the United States. However, according to the U.S. Department of Energy, America's power grid could accommodate converting approximately 84 percent of all conventional vehicles to EVs right now. This is because the primary time to charge EVs will be off peak, when there is excess capacity and waste in the electric grid. The U.S. Department of Energy study also excluded the contribution of renewable electricity production, which is growing rapidly and producing a higher percentage of electricity in the grid. Therefore, it is not expected that EVs will create a need for new or expanded energy facilities any time in the near future.

The long term assessment for gas powered cars is the rising price of gasoline. As the oil supply dwindles, prices will only continue to rise. In addition to this, gas engines are fairly inefficient; for every gallon of gas users put in your tank, only 1/5 produces mechanical energy that moves users’ car. The other 4/5 is lost as heat. It has parts to convert gas to energy, and more parts to manage the excessive heat. Therefore, the maintenance is going to add up if users plan on keeping their cars for a long time. However, the initial cost of a gas car is much lower than its electric equivalent. Hence, it is more suitable for limited income middle class families.

In conclusion, it depends on user's lifestyles. If car owners are looking for an everyday commuter car that will save money in the long run, an electric car might be worth the investment. However, users should not plan on embarking on a cross-country road trip unless they can find places to charge up before hand. It is also important that electric cars are a fairly new technology and are constantly improving; but if no one shows interest, the idea might be abandoned by manufacturers. Eventually it boils down to a higher initial cost with lower maintenance (for electric cars), or a lower initial cost with costly fuel and maintenance; car owners must choose which is most compatible with their financial situation.

Trends & Statistics of EVs in the market

North America's total EV car sales in 2012 reached about 53,000 units. This includes new models that arrived in 2012. 2010/2011 saw sales of similar vehicles at about 18,000 units. Total BEV sales in the past 5 years are over 200,000 units worldwide. Nissan has sold over 30,000 Leaf units in the USA and over 80,000 worldwide. In China (the biggest car market worldwide) battery and plugin EV sales reached only 5,889 units (5,114 BEV and 775 PHEV) in the first 6 months of 2013. We can assume that EVs are still new in China and the Chinese do not yet realize the advantages of EVs.

By the end of June 2013, nearly 41,000 plug-in EVs had been sold in the US and Canada. This compares to about 53,000 units in all of 2012. HEV Sales in 2012 - 2013 Hybrid electric sales are increasing as well. The HEV offers a lowered carbon footprint, increased fuel economy and a wider range of overall satisfaction at a moderately increased price. Total HEV sales have hit 6.3 million units worldwide, and are forecasted to reach 2.07 million units in 2013 alone. The Toyota Prius has been the best selling new car in California in 2012 (60,688 units), and 33,987 units in the first half of 2013.

Month	HEV	PHEV	BEV	TOTAL
January	21,778	603	824	23,205
February	36,222	1,023	639	37,884
March	48,206	3,200	961	52,367
April	39,901	3,116	775	43,792
May	37,184	2,766	612	40,562
June	34,558	2,455	863	37,876
July	31,610	2,537	479	34,626
August	38,369	3,878	837	42,216
September	34,835	4,503	1,306	40,644
October	33,290	4,994	2,040	40,324
November	35,002	4,544	2,211	41,757
December	43,690	4,965	2,704	51,359
2012 Total	434,645	38,584	14,251	486,612

2012 HEV, PHEV, and BEV sales in the USA
Data courtesy of electricdrive.org

Figure: Sales units of different vehicle category

However, there are some perceptions limiting the growth of EVs. Despite the positive experiences of EV owners and drivers, there are big bumps in the road to widespread EV adoption and sales. The main bumps are:

1. Price too high.

2. Design and looks. People connect electric car body types with bad curves. They are seen as ugly; like sheet metal experiments gone wrong.

3. Performance. This includes the dreaded range issue. Otherwise, electric cars can accelerate, stop, corner, and top out at speeds as well as any ICE.

V. Data analysis

Preference matrix

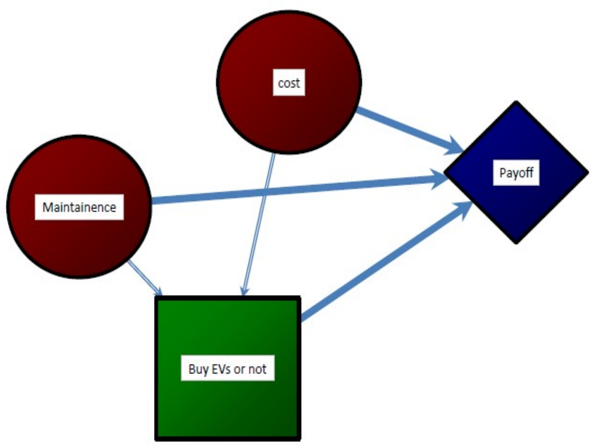
Factor	Weight	EV	Petrol car
Sustainability	65	0.68	0.38
Carbon Dioxide Release	78	0.47	0.23
Cost of Vehicle	80	0.3	0.7
Cost of fuel	70	0.7	0.5
Maintenance	45	0.37	0.47
Driving Range	57	0.32	0.82
Fuel Station Availability	38	0.12	0.95
Resource Extraction	66	0.29	0.28
Energy for Production	42	0.38	0.52

Harmful Substance Release	64	0.44	0.33
		232.57	243.07

Figure: Preference matrix

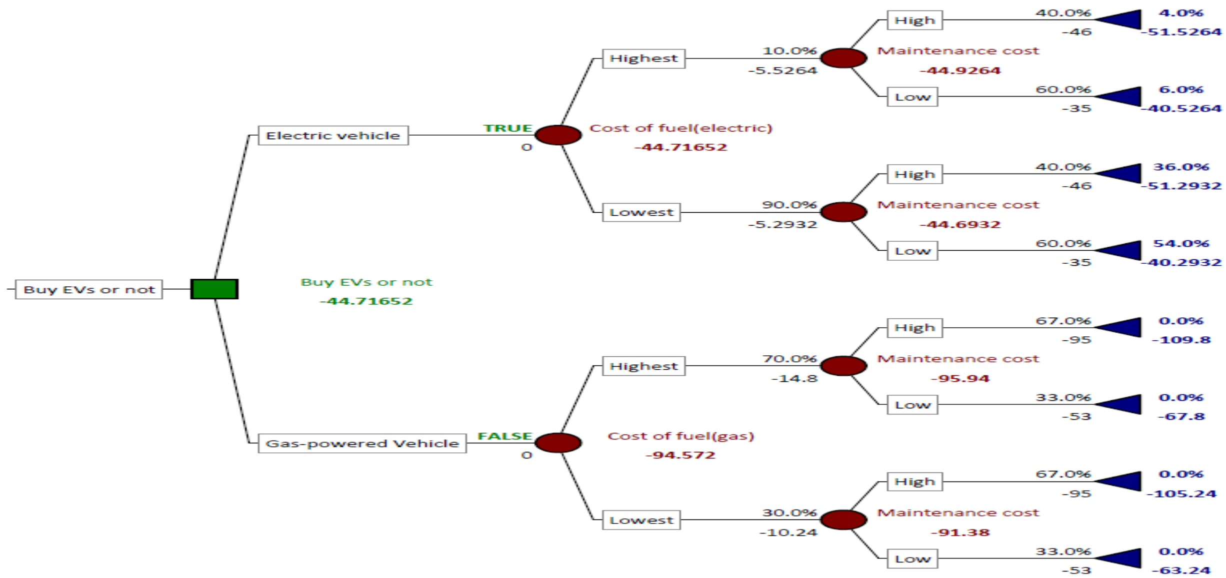
The preference matrix aided the initial decision making process. Weights are first assigned to each factors based on the weighted average of each team members subjective interpretation of priorities with regards to the factors. The values assigned to each type of vehicle factor are also a weighted average of each team members mostly objective scoring, where the higher the score the better it is.

Influence Diagram



There are two chance nodes in this diagram that will affect the decision node. The factors are cost of fuel and maintenance cost. However, the cost of fuel is independent to the maintenance cost, so there is no influence arc between these two chance nodes. These factors are also the uncertainties of the decision. Both nodes directly affect decision payoff.

Decision Tree



The above is the decision tree converted directly from our influence diagram. This decision tree will use Toyota RAV4 2012 as an example. The reason this model was chosen is because there are gasoline models and electric vehicle models for the RAV4. By comparing the same model, it can minimize the difference caused by other "control" factors. Since all the values assign are cost values, they will be negative. The higher the end expected value, the better.

The first stage is the cost of fuel for vehicles. It is divided into two parts, the cost of fuel for electric vehicle and the cost of fuel for gas power car. Both chance nodes are divided into two parts: highest and lowest. The highest part means that the highest value of cost of fuel from 2006 to 2012. The lowest part means that the lowest value of cost of fuel from 2006 to 2012. The cost will be based on the total cost of driving a RAV4 100 miles.

In order to drive 100 miles, RAV4 EV will consume 44kilowatthour. The highest residential electricity price value from 2006 to 2012 is 0.1256 cents per kilo-watt-hour during year 2009, while the lowest residential electricity price value from 2006 to 2012 is 0.1203 cents per kilowatthour during year 2007. According to the appendix 1, it is assumed that there will be 10 percent that the residential electricity rate can reach to the highest rate again; while there will be 90 percent that the residential electricity rate can reach to the lowest rate again.

For RAV4, which is gasoline car, it will consume 4 gallon in order to drive 100 miles. The highest regular gasoline retail price value from 2006 to 2012 is 14.8 dollar per gallon during year 2009, while the lowest value from 2006 to 2012 is 10.24 dollar per gallon during year 2007. According to the appendix 2, it is assumed that there will be 70 percent that the residential electricity rate can reach to the highest rate again; while there will be 30 percent that the residential electricity rate can reach to the lowest rate again.

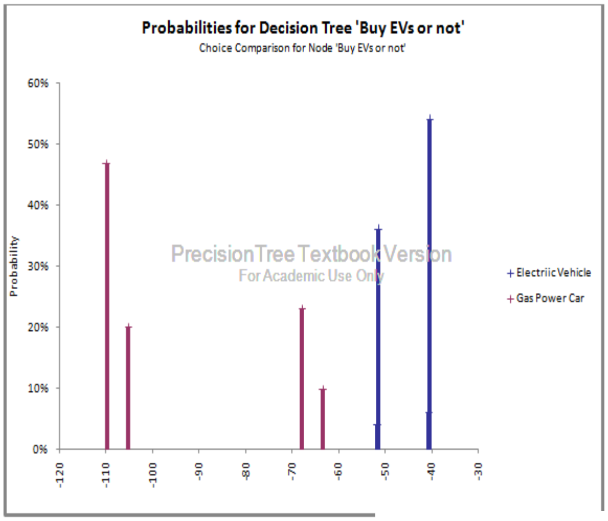
After that the first stage, the second stage is the maintenance cost for electric vehicles and gas power car. Four chance nodes are divided into two parts: highest and lowest. The highest part means that the highest value of maintenance cost to have 10,000 mile service in Buffalo. The lowest part means that the lowest value of maintenance cost to have 10,000 mile service in Buffalo All the maintenance costs are estimated according to website, Repairpal.com.

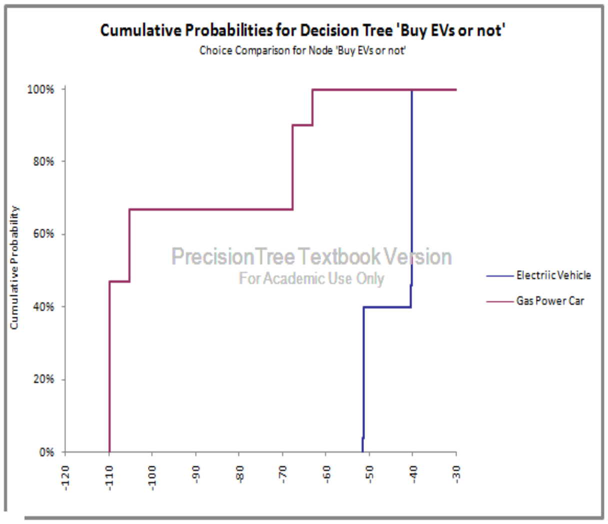
In Buffalo, the highest cost for RAV4 EV to have 10,000 mile service is 46 dollar; while the lowest cost for RAV4 to have 10,000 mile service is 35 dollar. There are total of 5 dealerships in Buffalo which offer this service. 3 out of the 5 dealerships will offer the price around 35 dollar to provide this service and 2 out of the 5 dealerships will offer the price around 35 dollar to provide 10,000 mile service. Hence, according to the number of dealerships which provide the 10,000 mile service, there is 60 percent that consumers will need to pay the price around 35 dollar to have 10,000 service; while there is 40 percent that consumers need to pay the price around 46 dollar to have 10,000 service.

The highest cost for RAV4 to have 10,000 mile service is 95 dollar in Buffalo; while the lowest cost for RAV4 to have 10,000 mile service is 53 dollar in Buffalo. There are total of 39 dealerships in Buffalo which offer this service. 26 out of the 39 dealerships will offer the price around 95 dollar to provide this service and 13 out of the 39 dealership will offer the price around 95 dollar to provide 10,000 mile service. Hence, according to the number of dealership which provide the 10,000 mile service, there is 67 percent that consumers will need to pay the price around 95 dollar to have 10,000 service; while there is 33 percent that consumers need to pay the price around 53 dollar to have 10,000 service.

Therefore, according to this decision tree, electric vehicles will have -44.71652of expected value; while gasoline car will have -94.572 of expected value. Based on the expected value, the decision will be buy electric vehicles since it has higher expected value.

Risk profile





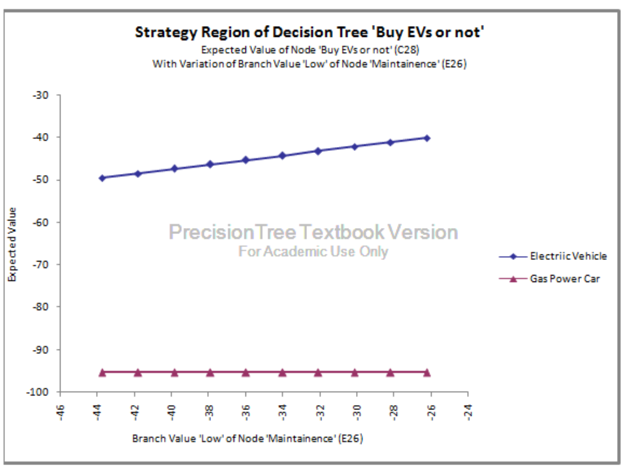
According to the probability chart, if the decision go to electric vehicle, there is 54 percent that consumer will need to spend around 5.2932 dollar for the fuel in order to drive 100 miles and around 35 dollar for the 10,000 mile service. The payoff of this path is 40.2932 and this path is the cheapest cost among the other 3 decision path of electric vehicles decision. There is also 4 percent that consumer will need to spend around 5.5264 dollar for the fuel in order to drive 100 miles and around 46 dollars for the 10,000 mile service. The payoff of this path is 51.5264 and this is the most expensive path among the other 3 decision path of electric vehicles.

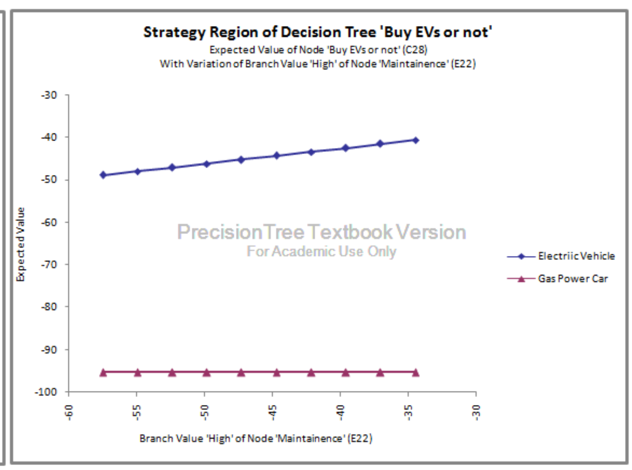
If the decision go to electric vehicle, there is 46 percent that consumer will need to spend around 14.8 dollar for the fuel in order to drive 100 miles and around 95 dollar for the 10,000 mile service. The payoff of this path is 109.8 and this path is the most expensive cost among the other 3 decision path of gas power car decision. There is also 9.9 percent that consumer will need to spend around 10.24 dollar for the fuel in order to drive 100 miles and around 536 dollars for the 10,000 mile service. The payoff of this path is 63.24 and this is the cheapest path among the other 3 decision path of electric vehicles.

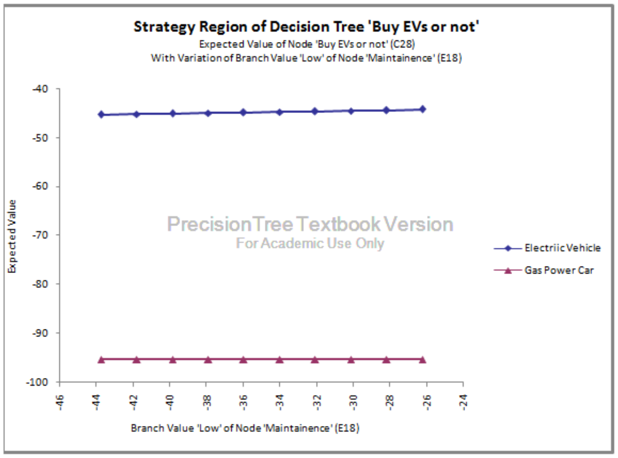
According to the cumulative chart, electric vehicles will always be the first choice regardless the cost of the fuel and maintenance cost. The highest cost for an electric vehicle to drive 100 miles is 5.5264 dollar. The lowest cost for a gas power car to drive 100 miles is 10.24 dollar. Hence, although compare the highest cost of fuel of EV to the lowest cost of fuel of gas power car, the fuel cost for EV is still less than the fuel cost for gas power car.

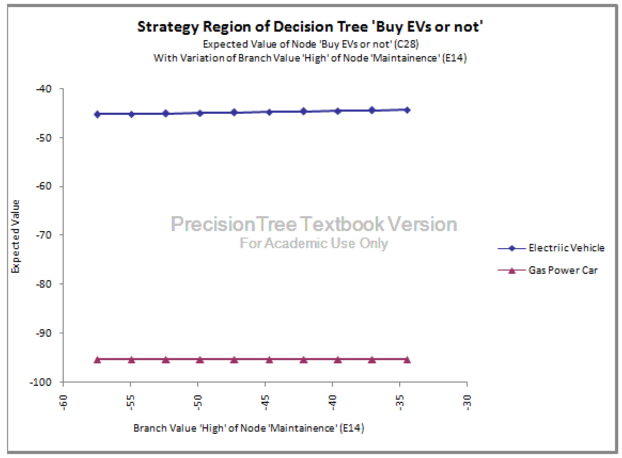
For the 10,000 mile service maintenance cost, the highest cost for an electric vehicle is 46 dollar, but the lowest cost for a gas power car is 53 dollar. Even compared the highest maintenance cost of EV to the lowest maintenance cost of gas power car, the maintenance cost for EV is still less than the maintenance cost of gas power car. Hence, regarding cost of fuel and maintenance cost, RAV4 EV is much cheaper to RAV4.

Sensitivity Analysis

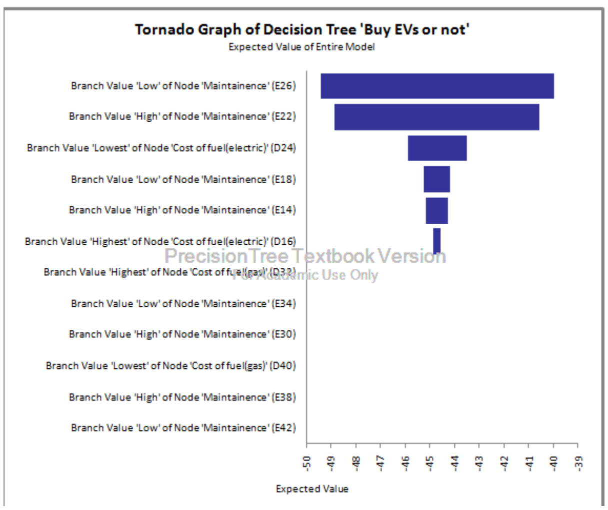


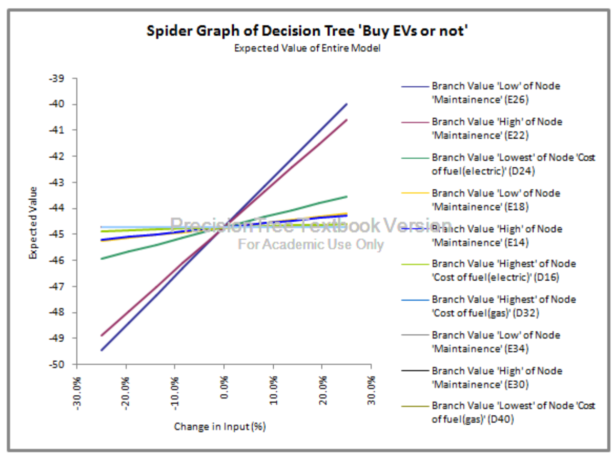






Based on the sensitivity analysis graph above, it is very obvious that EVs will always be the better choice for consumer if consider cost of fuel and maintenance cost. According to the graph, even the lowest maintenance cost of a gas power car still higher than the highest maintenance cost of an EV. This result also same as the cost of fuel. The lowest gasoline retail price of a gas power car to drive 100 mile is much more expensive than the highest residential electric price of an EV to drive 100 mile. Therefore, there is no breakeven point in all these graph.





The Tornado diagram displays the changes in the expected value of the "Buy EV or not" model for each input varied. Based on the graph, the expected value of this model is most sensitive to changes in low maintenance cost of EV, which has the largest bar. The expected value is least sensitive to changes in highest cost of fuel of gas power car.

The Spider Graph displays the percentage change in the expected value of this model as each input changes. There is a line for each input. Based on the graph above, the expected value of the model is most sensitive to changes of low maintenance cost of EVs. This is because the slope of the low maintenance cost of EVs is much steeper than others. This means that a smaller percentage change in the low maintenance cost of EVs leads to a larger change in the expected value of this model.

VI. Conclusion

Based off our data collection and data analysis we find the petrol car as the better option right now. The overall cost of the vehicle is less, and this is the most important factor impacting our final decision. Electric vehicles have a significant higher cost because of components like its battery. Going forward, the cost of EVs may go down as they become more main stream though. Other factors, like available charging stations and driving range, influencing our decision will most likely change going forward. We could rework our analysis in the future, and our final decision may change because of these changing factors. Therefore, this final decision may change due to dynamic effects on our decision. Therefore, we currently find it a better option to purchase a gas-powered vehicle, but realize that our decision may change in years to come.

VII. Appendix

Appendix 1

The entire survey and survey results are shown below:

For this survey, please circle the correct number to indicate your opinion of each statement.

1 = Definitely No
2 = Probably No
3 = Indifferent
4 = Probably Yes
5 = Definitely Yes

I. Tackling environmental problems represents a major problem for current and future generations

1 2 3 4 5 Average: 4.54

II. Electric vehicles are more environmentally friendly than gas powered cars

1 2 3 4 5 Average: 4.18

III. Electric vehicles are a more sustainable transportation option than gas powered cars

1 2 3 4 5 Average: 3.5

IV. Electric vehicles decrease overall carbon emissions into the atmosphere

1 2 3 4 5 Average: 3.89

V. Electric vehicles cost more than gas powered vehicles

1 2 3 4 5 Average: 4.14

VI. There are increased maintenance and energy costs for electric vehicles

1 2 3 4 5 Average: 3.43

VII. The driving range of electric vehicles meet the needs of drivers

1 2 3 4 5 Average: 2.57

VIII. The available public charging stations and battery recharge times meet the needs of EV drivers

1 2 3 4 5 Average: 2.18

IX. I would like to buy an electric vehicle (EV) in the future

1 2 3 4 5 Average: 3.14

Please indicate the main reason for your answer to question IX:

Most popular answers:

1. EV is currently too costly
2. EV is a more environmentally friendly option
3. It’s not easy to use/difficult to keep battery sufficiently charged/not enough charging stations

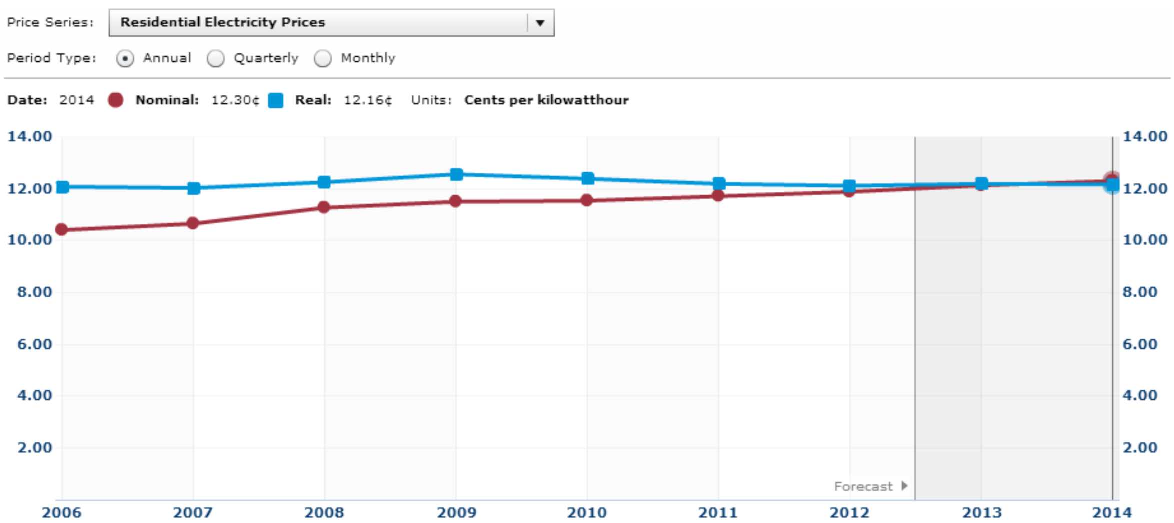
Please indicate the most important factor that goes into your car-buying decision:

Most Popular Answers:

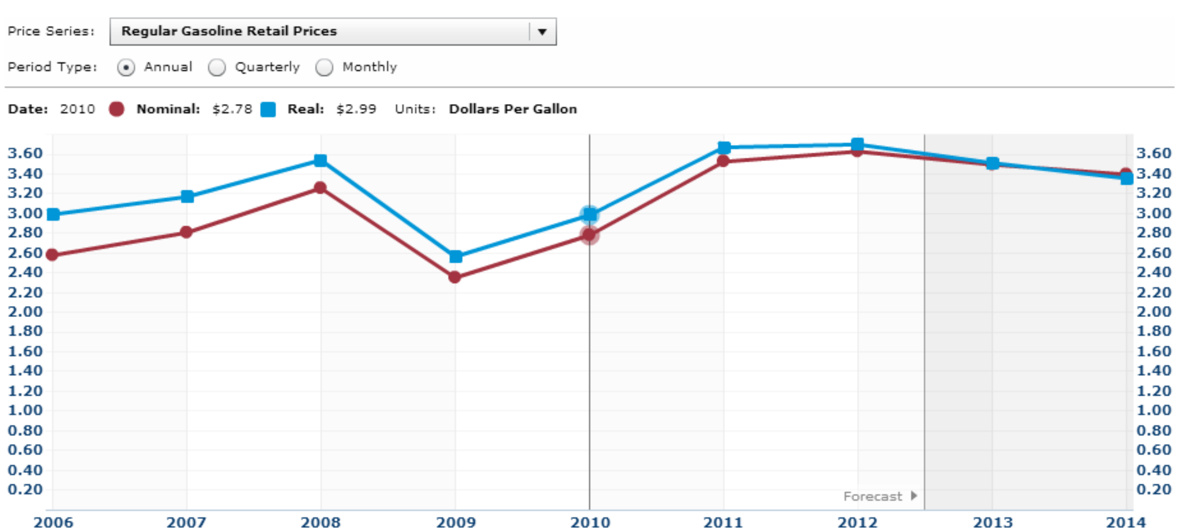
1. Price
2. Gas Mileage
3. Safety and Looks/Style

27 total respondents

Appendix 2


Price Series:
Residential Electricity Prices
Period Type: Annual Quarterly Monthly
Date: 2014 Nominal: 12.30¢ Real: 12.16¢ Units: Cents per kilowatthour
14.00
12.00
10.00
8.00
6.00
4.00
2.00
Forecast
2006
2007
2008
2009
2010
2011
2012
2013
2014

Appendix 3


Price Series:
Regular Gasoline Retail Prices
Period Type: Annual Quarterly Monthly
Date: 2010 Nominal: $2.78 Real: $2.99 Units: Dollars Per Gallon
3.60
3.40
3.20
3.00
2.80
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
Forecast
2006
2007
2008
2009
2010
2011
2012
2013
2014

Appendix 4

Statistical Summary:

Statistics	**Electric Vehicle**	**Gas Power Car**
Mean	-44.71652	-94.572
Minimum	-51.5264	-109.8
Maximum	-40.2932	-63.24
Mode	-40.2932	-109.8
Std. Deviation	5.389331536	19.85918065
Skewness	-0.4082	0.7121
Kurtosis	1.1673	1.5552

Spider Graph Data:

Spider Graph Data
Decision Tree 'Buy EVs or not' (Expected Value of Entire Model)

			Input Variation			**Output Variation**		
Input Name	**Cell**	**Step**	**Value**	**Change**	**Change (%)**	**Value**	**Change**	**Change (%)**
Branch Value 'Low' of Node 'Maintainence' (E26)	E26	1	-43.75	-8.75	-25.00%	-49.44152	-4.725	-10.57%
		2	-41.80555556	-6.80555556	-19.44%	-48.39152	-3.675	-8.22%
		3	-39.86111111	-4.86111111	-13.89%	-47.34152	-2.625	-5.87%
		4	-37.91666667	-2.91666667	-8.33%	-46.29152	-1.575	-3.52%
		5	-35.97222222	-0.97222222	-2.78%	-45.24152	-0.525	-1.17%
		6	-34.02777778	0.972222222	2.78%	-44.19152	0.525	1.17%
		7	-32.08333333	2.916666667	8.33%	-43.14152	1.575	3.52%
		8	-30.13888889	4.861111111	13.89%	-42.09152	2.625	5.87%
		9	-28.19444444	6.805555556	19.44%	-41.04152	3.675	8.22%
		10	-26.25	8.75	25.00%	-39.99152	4.725	10.57%
Branch Value 'High' of Node 'Maintainence' (E22)	E22	1	-57.5	-11.5	-25.00%	-48.85652	-4.14	-9.26%
		2	-54.94444444	-8.94444444	-19.44%	-47.93652	-3.22	-7.20%
		3	-52.38888889	-6.38888889	-13.89%	-47.01652	-2.3	-5.14%

		4	-49.83333333	-3.833333333	-8.33%	-46.09652	-1.38	-3.09%
		5	-47.27777778	-1.277777778	-2.78%	-45.17652	-0.46	-1.03%
		6	-44.72222222	1.277777778	2.78%	-44.25652	0.46	1.03%
		7	-42.16666667	3.833333333	8.33%	-43.33652	1.38	3.09%
		8	-39.61111111	6.388888889	13.89%	-42.41652	2.3	5.14%
		9	-37.05555556	8.944444444	19.44%	-41.49652	3.22	7.20%
		10	-34.5	11.5	25.00%	-40.57652	4.14	9.26%
Branch Value 'Lowest' of Node 'Cost of fuel(electric)' (D24)	D24	1	-6.6165	-1.3233	-25.00%	-45.90749	-1.19097	-2.66%
		2	-6.322433333	-1.029233333	-19.44%	-45.64283	-0.92631	-2.07%
		3	-6.028366667	-0.735166667	-13.89%	-45.37817	-0.66165	-1.48%
		4	-5.7343	-0.4411	-8.33%	-45.11351	-0.39699	-0.89%
		5	-5.440233333	-0.147033333	-2.78%	-44.84885	-0.13233	-0.30%
		6	-5.146166667	0.147033333	2.78%	-44.58419	0.13233	0.30%
		7	-4.8521	0.4411	8.33%	-44.31953	0.39699	0.89%
		8	-4.558033333	0.735166667	13.89%	-44.05487	0.66165	1.48%
		9	-4.263966667	1.029233333	19.44%	-43.79021	0.92631	2.07%
		10	-3.9699	1.3233	25.00%	-43.52555	1.19097	2.66%
Branch Value 'Low' of Node 'Maintainence' (E18)	E18	1	-43.75	-8.75	-25.00%	-45.24152	-0.525	-1.17%
		2	-41.80555556	-6.805555556	-19.44%	-45.12485333	-0.408333333	-0.91%
		3	-39.86111111	-4.861111111	-13.89%	-45.00818667	-0.291666667	-0.65%
		4	-37.91666667	-2.916666667	-8.33%	-44.89152	-0.175	-0.39%
		5	-35.97222222	-0.972222222	-2.78%	-44.77485333	-0.058333333	-0.13%
		6	-34.02777778	0.972222222	2.78%	-44.65818667	0.058333333	0.13%
		7	-32.08333333	2.916666667	8.33%	-44.54152	0.175	0.39%
		8	-30.13888889	4.861111111	13.89%	-44.42485333	0.291666667	0.65%

		9	-28.19444444	6.805555556	19.44%	-44.30818667	0.408333333	0.91%
		10	-26.25	8.75	25.00%	-44.19152	0.525	1.17%
Branch Value 'High' of Node 'Maintainence' (E14)	E14	1	-57.5	-11.5	-25.00%	-45.17652	-0.46	-1.03%
		2	-54.94444444	-8.94444444	-19.44%	-45.07429778	-0.357777778	-0.80%
		3	-52.38888889	-6.38888889	-13.89%	-44.97207556	-0.255555556	-0.57%
		4	-49.83333333	-3.83333333	-8.33%	-44.86985333	-0.153333333	-0.34%
		5	-47.27777778	-1.27777778	-2.78%	-44.76763111	-0.051111111	-0.11%
		6	-44.72222222	1.277777778	2.78%	-44.66540889	0.051111111	0.11%
		7	-42.16666667	3.833333333	8.33%	-44.56318667	0.153333333	0.34%
		8	-39.61111111	6.388888889	13.89%	-44.46096444	0.255555556	0.57%
		9	-37.05555556	8.944444444	19.44%	-44.35874222	0.357777778	0.80%
		10	-34.5	11.5	25.00%	-44.25652	0.46	1.03%
Branch Value 'Highest' of Node 'Cost of fuel(electric)' (D16)	D16	1	-6.908	-1.3816	-25.00%	-44.85468	-0.13816	-0.31%
		2	-6.600977778	-1.074577778	-19.44%	-44.82397778	-0.107457778	-0.24%
		3	-6.293955556	-0.767555556	-13.89%	-44.79327556	-0.076755556	-0.17%
		4	-5.986933333	-0.460533333	-8.33%	-44.76257333	-0.046053333	-0.10%
		5	-5.679911111	-0.153511111	-2.78%	-44.73187111	-0.015351111	-0.03%
		6	-5.372888889	0.153511111	2.78%	-44.70116889	0.015351111	0.03%
		7	-5.065866667	0.460533333	8.33%	-44.67046667	0.046053333	0.10%
		8	-4.758844444	0.767555556	13.89%	-44.63976444	0.076755556	0.17%
		9	-4.451822222	1.074577778	19.44%	-44.60906222	0.107457778	0.24%
		10	-4.1448	1.3816	25.00%	-44.57836	0.13816	0.31%
Branch Value 'Highest' of Node 'Cost of fuel(gas)' (D32)	D32	1	-20.475	-4.095	-25.00%	-44.71652	0	0.00%
		2	-19.565	-3.185	-19.44%	-44.71652	0	0.00%
		3	-18.655	-2.275	-13.89%	-44.71652	0	0.00%

		4	-17.745	-1.365	-8.33%	-44.71652	0	0.00%
		5	-16.835	-0.455	-2.78%	-44.71652	0	0.00%
		6	-15.925	0.455	2.78%	-44.71652	0	0.00%
		7	-15.015	1.365	8.33%	-44.71652	0	0.00%
		8	-14.105	2.275	13.89%	-44.71652	0	0.00%
		9	-13.195	3.185	19.44%	-44.71652	0	0.00%
		10	-12.285	4.095	25.00%	-44.71652	0	0.00%
Branch Value 'Low' of Node 'Maintainence' (E34)	E34	1	-66.25	-13.25	-25.00%	-44.71652	0	0.00%
		2	-63.30555556	-10.30555556	-19.44%	-44.71652	0	0.00%
		3	-60.36111111	-7.361111111	-13.89%	-44.71652	0	0.00%
		4	-57.41666667	-4.416666667	-8.33%	-44.71652	0	0.00%
		5	-54.47222222	-1.472222222	-2.78%	-44.71652	0	0.00%
		6	-51.52777778	1.472222222	2.78%	-44.71652	0	0.00%
		7	-48.58333333	4.416666667	8.33%	-44.71652	0	0.00%
		8	-45.63888889	7.361111111	13.89%	-44.71652	0	0.00%
		9	-42.69444444	10.30555556	19.44%	-44.71652	0	0.00%
		10	-39.75	13.25	25.00%	-44.71652	0	0.00%
Branch Value 'High' of Node 'Maintainence' (E30)	E30	1	-118.75	-23.75	-25.00%	-44.71652	0	0.00%
		2	-113.4722222	-18.47222222	-19.44%	-44.71652	0	0.00%
		3	-108.1944444	-13.19444444	-13.89%	-44.71652	0	0.00%
		4	-102.9166667	-7.916666667	-8.33%	-44.71652	0	0.00%
		5	-97.63888889	-2.638888889	-2.78%	-44.71652	0	0.00%
		6	-92.36111111	2.638888889	2.78%	-44.71652	0	0.00%
		7	-87.08333333	7.916666667	8.33%	-44.71652	0	0.00%
		8	-81.80555556	13.19444444	13.89%	-44.71652	0	0.00%
		9	-76.527777	18.4722222	19.44	-44.71652	0	0.00%

			78	2	%			
		10	-71.25	23.75	25.00%	-44.71652	0	0.00%
Branch Value 'Lowest' of Node 'Cost of fuel(gas)' (D40)	D40	1	-11.2	-2.24	-25.00%	-44.71652	0	0.00%
		2	-10.70222222	-1.74222222	-19.44%	-44.71652	0	0.00%
		3	-10.20444444	-1.24444444	-13.89%	-44.71652	0	0.00%
		4	-9.706666667	-0.746666667	-8.33%	-44.71652	0	0.00%
		5	-9.208888889	-0.248888889	-2.78%	-44.71652	0	0.00%
		6	-8.711111111	0.248888889	2.78%	-44.71652	0	0.00%
		7	-8.213333333	0.746666667	8.33%	-44.71652	0	0.00%
		8	-7.715555556	1.244444444	13.89%	-44.71652	0	0.00%
		9	-7.217777778	1.742222222	19.44%	-44.71652	0	0.00%
		10	-6.72	2.24	25.00%	-44.71652	0	0.00%
Branch Value 'High' of Node 'Maintainence' (E38)	E38	1	-118.75	-23.75	-25.00%	-44.71652	0	0.00%
		2	-113.4722222	-18.47222222	-19.44%	-44.71652	0	0.00%
		3	-108.1944444	-13.19444444	-13.89%	-44.71652	0	0.00%
		4	-102.9166667	-7.916666667	-8.33%	-44.71652	0	0.00%
		5	-97.63888889	-2.638888889	-2.78%	-44.71652	0	0.00%
		6	-92.36111111	2.638888889	2.78%	-44.71652	0	0.00%
		7	-87.08333333	7.916666667	8.33%	-44.71652	0	0.00%
		8	-81.80555556	13.19444444	13.89%	-44.71652	0	0.00%
		9	-76.52777778	18.47222222	19.44%	-44.71652	0	0.00%
		10	-71.25	23.75	25.00%	-44.71652	0	0.00%
Branch Value 'Low' of Node 'Maintainence' (E42)	E42	1	-66.25	-13.25	-25.00%	-44.71652	0	0.00%
		2	-63.30555556	-10.30555556	-19.44%	-44.71652	0	0.00%
		3	-60.36111111	-7.361111111	-13.89%	-44.71652	0	0.00%

	4	-57.41666667	-4.416666667	-8.33%	-44.71652	0	0.00%
	5	-54.47222222	-1.472222222	-2.78%	-44.71652	0	0.00%
	6	-51.52777778	1.472222222	2.78%	-44.71652	0	0.00%
	7	-48.58333333	4.416666667	8.33%	-44.71652	0	0.00%
	8	-45.63888889	7.361111111	13.89%	-44.71652	0	0.00%
	9	-42.69444444	10.30555556	19.44%	-44.71652	0	0.00%
	10	-39.75	13.25	25.00%	-44.71652	0	0.00%

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