TEXAS STATE UNIVERSITY

QMST 5336 ANALYTICS PROJECT

ELECTRIC VEHICLES

08.05.2022

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Objective

- There were two primary reasons for us on selecting this particular topic:-
- Firstly, with increasing gasoline prices, accruing miles behind the wheel every day is also becoming more expensive.
- Secondly, with the increase in the environmental impact of vehicle carbon emissions, electric cars can be beneficial for improving air quality in towns and cities.
- In recent decades, Alternative vehicle technologies, such as full electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs), have dramatically increased as a strategy to fight the transportation sector's reliance on fossil fuels, and also to focus on preserving the environment.

Problem Statements

- Predictive analytics: Forecast expected electricity/gasoline prices in the next 3-5 years.
- Prescriptive analytics:

  Given uncertainties in the future 5-10 years, e.g., work-from-home policy, green energy, subsidies, which to choose: Tesla (or other electric vehicles) versus a specific fuel vehicle for a specific traveler? [Decision analysis].

Goal

- To help a consumer decide which car he should buy: Fuel based or Electric based.

Data Collection

- For predicting prices for the next 5 years, data related to Gasoline and Electricity prices for 30 years in a particular city Dallas, Texas State is taken from US Energy Information Administration (EIA). (Links in the reference)
- Assumption & Uncertainties:

  a. Gathered Data on the work from home percentages for a time period.: 30% and 70% from the Forbes website.

  b. Different vehicle Subsidies are available.

The dataset collected consists of electricity and fuel prices for 30 years ranging from 1992 to 2021 for a particular city Dallas in Texas state. Below are the associated Images:

Electricity Data

Series Title: Electricity per KWH in Dallas-Fort Worth-Arlington, TX
Area: Dallas-Fort Worth-Arlington, TX
Item: Electricity per KWH

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	0.062	0.062	0.062	0.062	0.079	0.079	0.079	0.079	0.079	0.079	0.063	0.062
1993	0.062	0.062	0.062	0.062	0.079	0.079	0.079	0.079	0.092	0.092	0.073	0.072
1994	0.073	0.074	0.073	0.074	0.073	0.086	0.086	0.086	0.074	0.086	0.073	0.072
1995	0.075	0.074	0.075	0.075	0.074	0.088	0.086	0.086	0.077	0.086	0.072	0.072
1996	0.072	0.062	0.072	0.072	0.072	0.086	0.087	0.087	0.087	0.086	0.072	0.072
1997	0.072	0.072	0.072	0.072	0.072	0.087	0.087	0.072	0.087	0.087	0.072	0.072
1998	0.070	0.071	0.070	0.070	0.070	0.084	0.084	0.084	0.084	0.084	0.070	0.070
1999	0.070	0.070	0.070	0.070	0.071	0.072	0.083	0.083	0.078	0.083	0.069	0.069
2000	0.069	0.069	0.069	0.069	0.069	0.083	0.083	0.083	0.085	0.086	0.075	0.075
2001	0.075	0.080	0.080	0.080	0.079	0.100	0.102	0.093	0.093	0.092	0.087	0.086
2002	0.081	0.080	0.081	0.080	0.078	0.086	0.086	0.086	0.088	0.087	0.079	0.079
2003	0.079	0.080	0.084	0.089	0.089	0.096	0.095	0.096	0.099	0.099	0.089	0.089
2004	0.090	0.090	0.090	0.091	0.094	0.105	0.105	0.110	0.110	0.108	0.099	0.099
2005	0.099	0.099	0.099	0.100	0.106	0.118	0.119	0.119	0.119	0.119	0.123	0.122
2006	0.134	0.134	0.131	0.131	0.130	0.140	0.140	0.140	0.138	0.135	0.122	0.122
2007	0.124	0.125	0.126	0.122	0.125	0.135	0.135	0.134	0.134	0.134	0.123	0.123
2008	0.124	0.123	0.129	0.130	0.140	0.147	0.154	0.154	0.152	0.146	0.140	0.139
2009	0.139	0.134	0.134	0.133	0.128	0.132	0.128	0.126	0.125	0.125	0.120	0.121
2010	0.121	0.116	0.116	0.116	0.117	0.120	0.118	0.118	0.118	0.115	0.108	0.108
2011	0.109	0.112	0.112	0.112	0.113	0.117	0.117	0.117	0.118	0.120	0.114	0.113
2012	0.112	0.112	0.113	0.113	0.115	0.118	0.116	0.116	0.115	0.114	0.114	0.115
2013	0.117	0.117	0.119	0.119	0.123	0.127	0.126	0.126	0.126	0.128	0.123	0.118
2014	0.119	0.124	0.123	0.123	0.130	0.134	0.132	0.133	0.133	0.130	0.125	0.127
2015	0.127	0.127	0.127	0.126	0.126	0.129	0.130	0.125	0.124	0.122	0.116	0.116
2016	0.116	0.116	0.111	0.111	0.112	0.116	0.116	0.119	0.117	0.117	0.112	0.112
2017	0.112	0.112	0.112	0.112	0.128	0.128	0.128	0.128	0.128	0.128	0.127	0.126
2018	0.126	0.126	0.124	0.132	0.133	0.142	0.142	0.142	0.136	0.136	0.136	0.136
2019	0.141	0.141	0.142	0.142	0.142	0.142	0.142	0.142	0.143	0.143	0.142	0.142
2020	0.141	0.137	0.134	0.134	0.136	0.136	0.135	0.133	0.132	0.132	0.130	0.130
2021	0.131	0.131	0.128	0.127	0.128	0.129	0.133	0.144	0.152	0.153	0.153	0.154

Fuel Data

Series Title: Gasoline, all types, per gallon/3.785 liters in Dallas-Fort Worth-Arlington, TX,
Area: Dallas-Fort Worth-Arlington, TX
Item: Gasoline, all types, per gallon/3.785 liters

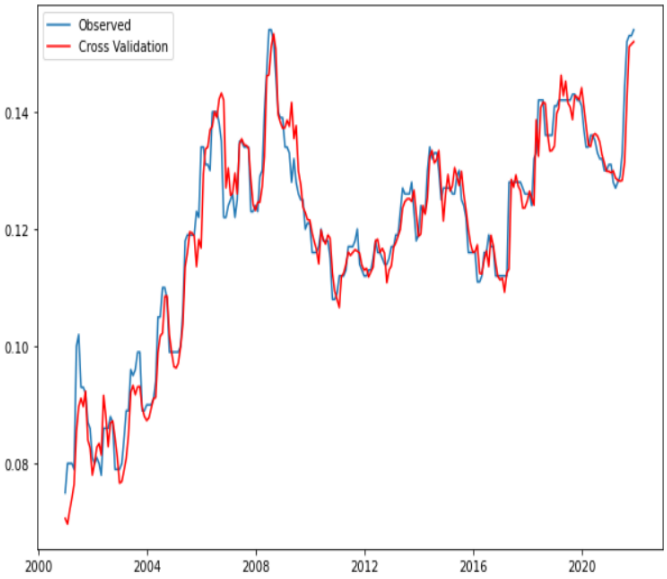
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1992	1.122	1.086	1.089	1.115	1.159	1.205	1.210	1.204	1.190	1.180	1.176	1.167
1993	1.137	1.112	1.119	1.120	1.144	1.158	1.148	1.145	1.122	1.153	1.123	1.103
1994	1.069	1.063	1.055	1.078	1.090	1.106	1.127	1.193	1.210	1.202	1.205	1.225
1995	1.221	1.206	1.192	1.186	1.224	1.257	1.240	1.201	1.173	1.147	1.086	1.087
1996	1.113	1.105	1.151	1.283	1.314	1.295	1.246	1.210	1.214	1.207	1.219	1.229
1997	1.226	1.229	1.217	1.209	1.201	1.202	1.184	1.217	1.240	1.218	1.184	1.161
1998	1.119	1.079	1.051	1.049	1.052	1.051	1.046	1.033	1.013	1.023	1.025	1.002
1999	0.971	0.959	0.965	1.086	1.121	1.119	1.137	1.200	1.235	1.275	1.261	1.297
2000	1.297	1.351	1.516	1.521	1.490	1.562	1.606	1.518	1.517	1.506	1.494	1.443
2001	1.403	1.459	1.416	1.555	1.693	1.657	1.450	1.364	1.437	1.333	1.168	1.067
2002	1.094	1.110	1.214	1.418	1.430	1.405	1.395	1.400	1.408	1.463	1.432	1.390
2003	1.495	1.632	1.658	1.542	1.456	1.456	1.497	1.583	1.561	1.479	1.436	1.425
2004	1.580	1.622	1.674	1.747	1.947	1.930	1.864	1.853	1.854	1.902	1.921	1.818
2005	1.741	1.860	1.934	2.196	2.158	2.100	2.245	2.393	2.933	2.943	2.311	2.116
2006	2.299	2.300	2.334	2.767	2.950	2.858	2.926	2.934	2.473	2.111	2.119	2.214
2007	2.167	2.097	2.402	2.737	2.953	2.990	2.905	2.743	2.676	2.681	2.955	2.876
2008	2.948	2.908	3.190	3.354	3.685	3.962	4.004	3.689	3.610	3.176	2.015	1.618
2009	1.663	1.801	1.849	2.013	2.123	2.520	2.392	2.497	2.372	2.374	2.509	2.498
2010	2.570	2.486	2.674	2.766	2.821	2.606	2.591	2.583	2.523	2.682	2.663	2.842
2011	2.957	2.991	3.450	3.741	3.853	3.576	3.580	3.577	3.403	3.215	3.212	3.070
2012	3.236	3.525	3.766	3.860	3.593	3.329	3.306	3.524	3.650	3.499	3.162	3.096
2013	3.258	3.605	3.673	3.516	3.509	3.507	3.578	3.524	3.329	3.226	3.080	3.135
2014	3.207	3.274	3.429	3.595	3.530	3.598	3.529	3.344	3.261	3.012	2.708	2.286
2015	1.926	2.173	2.290	2.403	2.614	2.742	2.593	2.391	2.101	2.085	1.981	1.907
2016	1.773	1.631	1.913	2.001	2.112	2.223	2.101	2.045	2.010	2.052	2.015	2.037
2017	2.165	2.066	2.136	2.290	2.207	2.214	2.133	2.247	2.537	2.256	2.310	2.210
2018	2.273	2.235	2.332	2.509	2.721	2.762	2.623	2.601	2.636	2.621	2.267	1.961
2019	1.892	2.031	2.332	2.602	2.604	2.399	2.549	2.335	2.348	2.249	2.286	2.214
2020	2.235	2.054	1.919	1.417	1.406	1.722	1.903	1.869	1.893	1.833	1.766	1.885
2021	2.065	2.196	2.533	2.485	2.737	2.836	2.882	2.894	2.910	3.033	3.137	3.015

Visualization:

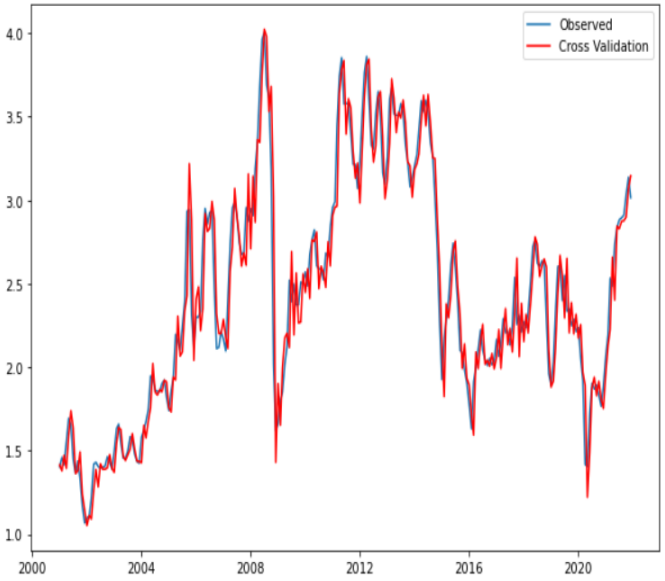
Cross-Validation of Data:

Cross-validation of data helps to check the accuracy of the dataset collected with the test data and is an important feature that helps to develop and fine-tune a dataset.

Electricity prices



Fuel prices



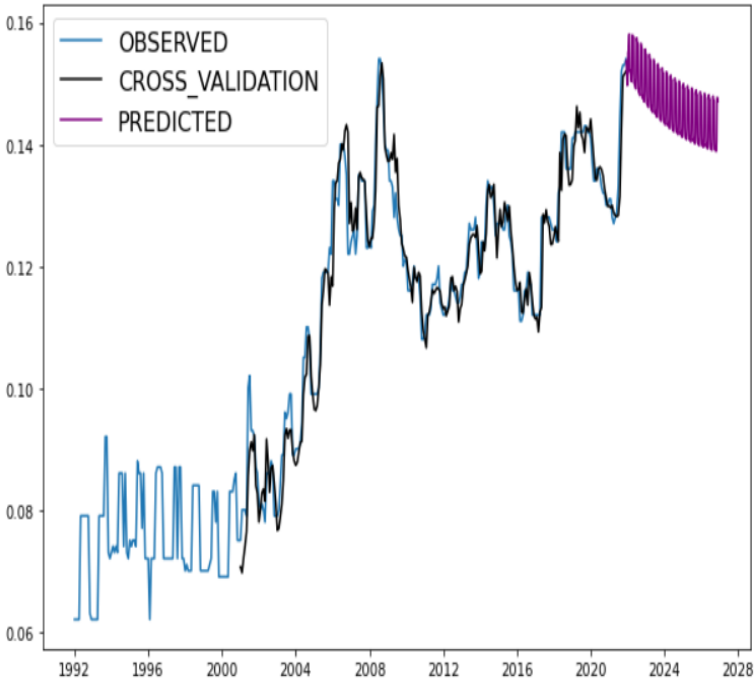
- In both of the above Illustrated Graphs: the X-axis represents years and the Y-axis represents prices.
- The above cross-validations are Visible from the two graphs the dataset we collected is accurate.

We planned to predict electricity and fuel prices for the next 5 years from 2021 to 2026 through *Time-series Analysis.*

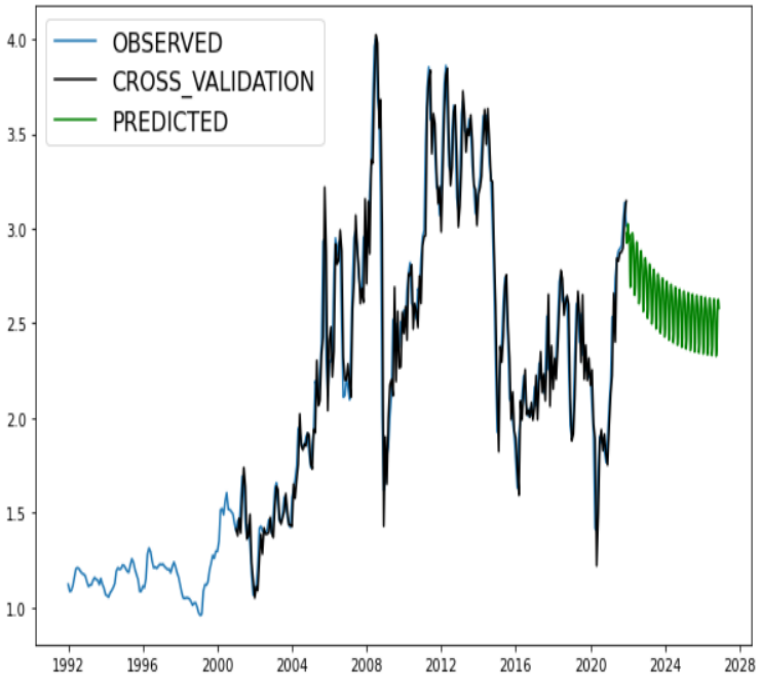
Time-series Analysis: Time series analysis is a statistical method in which we analyze the pattern of the data set collected and this analysis is used to predict future prices.

Forecasting Prices for the Next 5 Years:

Electricity prices



Fuel Prices



- In both of the above Illustrated Graphs: the X-axis represents years and the Y-axis represents prices.
- There is a steady decrease in both electricity and fuel prices for the next 5 years from 2022 to 2026.

Analysis:

Descriptive Analysis:

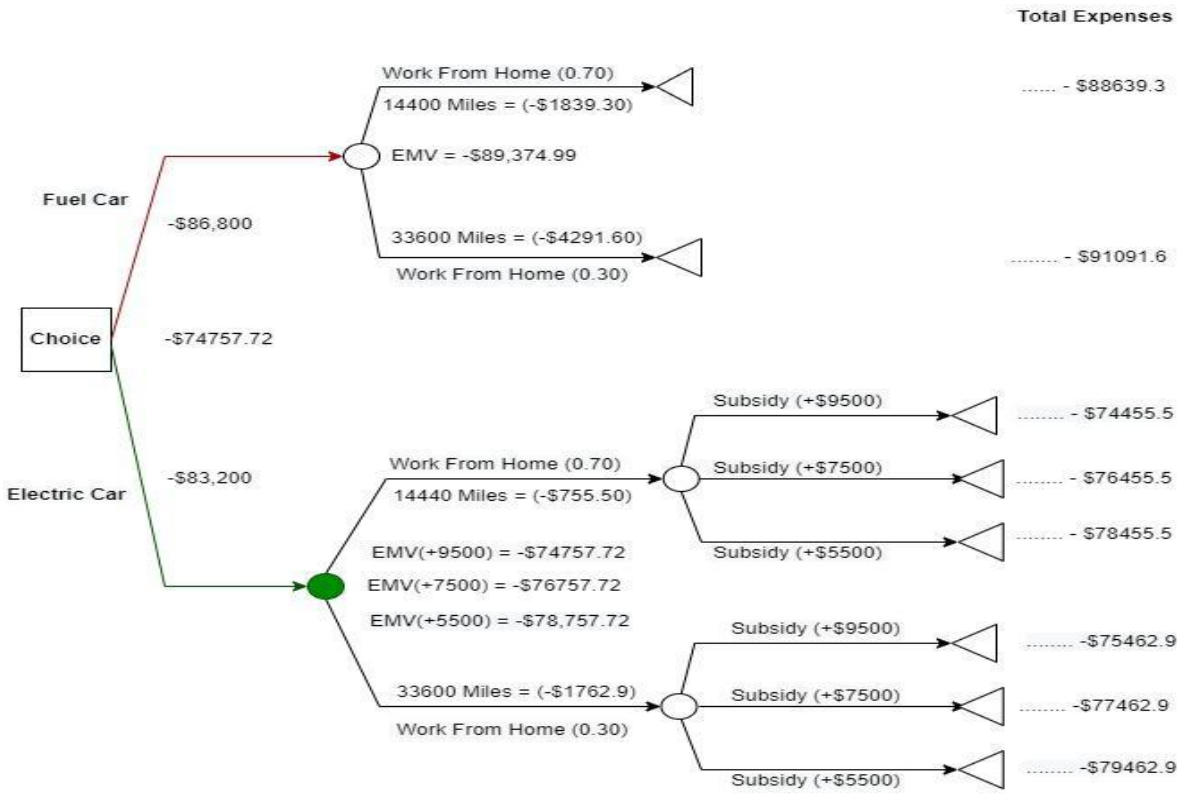
- We have taken a dataset that was without outliers or missing data and it just contains historical data. so there was no need for any further refinements to the dataset we have taken. So there was no need for any descriptive analysis.

Predictive Analysis:

- For the predictive analysis, We developed a TestSet for cross-validation and then we cross-validated the data we have extracted from the previously mentioned sections. After cross-validation, we have predicted the Electricity and Gasoline prices for the Next 5 years.

Prescriptive Analysis (Decision Analysis): The following two cars were considered for the analysis. Since both are of the same segment, approximately the same price range, and are from the same manufacturer.

- BMW 7 Series 2022(Fuel-based)
- BMW iX 2022 (Electric-based)



- From above we have the price of both fuel-based and electric cars which are $86800 and $83200 respectively.
- We are considering the WFH uncertainties and the green energy subsidies and also calculating the distance the customer is going to travel and the expense for the next 5 years.
- Since the customer travels 9600 Miles a year for the next 5 years the Total distance he/she would travel is 48000 miles.
- Considering WFH, we have the values on how much a person is going to spend if WFH is 30% or 70% each for the next 5 years based on the predicted fuel and gas price.
- Electric Vehicles have Green Energy - for now, Tax Credits are $7500 but even Green Energy Subsidies are still uncertain so we took 2 other values of Tax Credits into consideration into branches.
- In the decision tree, we have the total expenses based on how much a customer has to spend for the given miles and the price of the car, and subsidiary benefits that a customer can have.

Calculating EMV:

- After calculating the total expenses we backtrack the tree to find the Expected Monetary Value(EMV),
- In the Fuel car here we take the Total expense of the 1st branch which is 88639.3, and Multiply it with the probability of that branch which is 0.70 and add up these 2 branch values which will give us the EMV for the fuel car node we do this similar process for the Electric Car Node and find the EMV.
- We have both the EMV values from the decision tree which are 89,374.9 for the fuel-based vehicle and 76757.72 for the electric vehicle. The least EMV value i.e, Electric Vehicle will be the best to choose.

The predicted gas and fuel price for the next 5 years, i.e 2022 to 2026 inclusive are shown in the below table.

Year	Predicted Electricity Price ($) per kWh	Predicted Fuel Price ($) per Gallon	MPGE	MPG	Cost to commute 9600 miles ($) Electric Vehicles	Cost to commute 9600 miles ($) Fuel Vehicles
2022	0.1537	2.93	55.4	22	502.49	1265.23
2023	0.1537	2.85	53.9	22	502.49	1230.68
2024	0.1527	2.8	53.3	22	499.22	1209.09
2025	0.1516	2.75	52.7	22	495.62	1187.5
2026	0.1506	2.72	52.5	22	492.36	1174.55

Cost to commute with WFH uncertainity			
Electric Vehicles		Fuel Vehicles	
70% WFH	30% WFH	70% WFH	30% WFH
150.75	351.74	379.57	885.66
150.75	351.74	369.2	861.48
149.77	349.45	362.73	846.36
148.69	346.93	356.25	831.25
147.71	344.65	352.36	822.18

The assumptions inspired by real instances are as follows:

- A person commutes 40 miles a daily to and from work/school.
- Considering 5 workdays a week, it will be 200 miles a week, 800 miles a month, and 9600 miles in a year.

Calculations are made for the total expenditure for commuting 9600 miles a year for both electric and fuel cars using the predicted values of the gas and fuel prices for the next 5 years.

<u>The calculation for the year 2022:</u>

As per the company website, BMW 7 Series has got 22 MPG and BMW iX has got MPGE of 86. But these numbers on BMW iX will hold good only when the current fuel and gas prices are considered. Gas Price per Gallon: $2.93 and Electricity Price per kWh: $0.1537.

BMW 7 Series has got MPG of 22, i.e, for every gallon of fuel, the car does 22 miles.
The mileage on the electric cars is given in MPGE units which is Miles per gallon equivalent.
So, for the same amount i.e, $2.93 we are calculating the number of miles BMW iX does.
As mentioned in the table above, for every 1kWh the price is $0.1537 and for $2.93, we will have 19.03 kWh.

- BMW iX has got a battery size of 111.5 kWh.
- With the full charge of 111.5 kWh, the range that the vehicle travels is 324 miles.
- So, with the charge of 19.03 kWh, the range the vehicle travels is 55.4 miles.
- For every $ 2.93, BMW iX makes 55.4 miles whereas BMW 7 Series makes 22 miles.

Conclusion:

- The expenses on fuel vehicles to travel the same number of miles when compared to the electric vehicle is more than half of the expenses made on the electric vehicles. In addition, in the last year, gas prices have risen dramatically.
- Electric vehicles are cheaper than petrol vehicles. According to our estimates, for the same $2.93, the MPG for a gasoline vehicle is 22 MPG and for an electric vehicle is 55 MPGE. Compared to a gasoline vehicle, driving an electric vehicle saves approximately $3,500 per 48,000 miles.
- Fuel-based engines have several parts that can wear out and fail over time. EVs have fewer moving parts and do not require regular engine oil changes, new coils, or oil/air/fuel filter changes like traditional vehicles.
- The transport sector contributes significantly to CO2 emissions. The vehicle under consideration, the BMW 7 Series, emits 7.1 tons per 25,000 km. The CO2 emissions of an electric vehicle are 0. Driving an electric vehicle reduces CO2 emissions, which helps mitigate the effects of climate change. Air quality improves when pollution is reduced, and breathing cleaner air is better for your health.

Critical Thinking:

- The above analysis and calculations could have been more accurate, if maintenance, repair cost, and depreciation would have been taken into account for both the cars.
- The shortcoming of the given decision analysis is the considered work from policy percentages. As there is a possibility of these percentages changing in the coming years.
- Aligning consumer perception of EVs in regards to affordability, availability, and familiarity existing in the market would have been useful in understanding the consumer behavior and further in the decision-making process.
- The consumer's convenience data of refilling and recharging of fuel cars and EV cars respectively would have been beneficial in understanding the buying preference prevailing in the market.

References:

- Electricity prices: https://www.eia.gov/electricity/data/browser/
- Gasoline prices: https://www.bls.gov/regions/midwest/data/averageenergyprices_selectedareas_table.htm
- Work from home predicted percentage: https://www.forbes.com/sites/bryanrobinson/2022/02/01/remote-work-is-here-to-stay-and-will-increase-into-2023-experts-say/
- Subsidies data: https://www.nber.org/digest/jun19/assessing-federal-subsidies-purchases-electric-vehicles