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Fuel Efficiency Comparison Between Shell Regular Unleaded Gasoline and Shell V-Power Gasoline

- **Objective of The Study:**

Oil and gas companies offer a variety of fuel grades to their customers when it comes to gasoline and diesel fuels. For Shell gas stations in Tunisia, they offer gasoline vehicles two types of gasoline: regular unleaded gasoline distinguished by its green colored pump and a premium version of gasoline called Shell V-Power known by its red colored pump.

Premium gasoline fuels are claimed to be more efficient when it comes to fuel consumption and are known to offer a better engine protection compared to regular unleaded gasoline. This is due to the additives that these premium fuels contain which are not found, or found in smaller portions, in regular unleaded gasoline. Given these advantages of premium gasoline, it comes with a higher price.

This study aims to test whether Shell V-Power actually offers a better a fuel efficiency when compared to Shell regular unleaded gasoline and to verify if the fuel economy benefits of Shell V-Power, if they exist, actually offset its extra cost.

For this test, I will be using my car as a test subject and driving through multiple driving and environmental conditions to see the different effects of these conditions on the fuel efficiency returned by the two Shell fuel types.

  - **Questions to be answered in this analysis:**

    The main question that I am trying to find an answer for in this study is the following:

    – *Taking my car as a test subject, does Shell V-Power Gasoline provide an overall better fuel efficiency than Shell Regular Unleaded Gasoline?*

    Other questions that I will try to answer as well are:

    – *What is the impact of temperature and humidity on car fuel consumption? In addition, which fuel type provides a better fuel efficiency at severe conditions (high temperatures and high humidity)?*

– *How much does driving on bumpy roads and/or driving aggressively affect fuel consumption? Which fuel type performs better in these conditions?*
– *For each type of gasoline, what is the driving speed sweet spot that provides the best fuel consumption?*

- ## Collecting the Data:

To collect the data required for this study, I had to make sure that my car is well-maintained and will have a stable condition throughout the data collection phase. For this, I did an oil change, replaced air and oil filters, greased the battery poles, checked my tires pressure, coolant level, brake fluid quality and level, tires and brake pads conditions. I kept checking these areas as long as I was collecting the data points to ensure that the MPG values returned after each trip are mostly a result of the fuel type, driving and environmental conditions and not my car condition.

In addition, when filling up on gas, I made sure that the gas tank level at the time of the fill-up is at the ¼ level or less and that I alternate between the two types of Shell gasoline with each fill-up operation. I made sure this condition is present so the tank contains at least 75% of one of the fuels after each fill-up.

- **The Dataset:**

  After the collection of 106 data points in Excel, I now have a dataset that is ready for cleaning and analysis:

	A	B	C	D	E	F	G	H	I	J
1	date	road_class	fuel_type	L_100km	avg_speed	trip_duarti	driving_sty	road_conc	temperatu	humidity
2	1/31/2023	hwy	V-Power	7.6	60	30	Normal	Normal	15	54
3	1/31/2023	city	V-power	13.6	30	20	Normal	Normal	13	56
4	2/1/2023	hwy	V-Power	5.9	80	95	Normal	Normal	7	85
5	2/3/2023	hwy	V-Power	6.4	85	100	Normal	Normal	15	62
6	2/3/2023	city	V-Power	9.6	30	15	Normal	Normal	15	59
7	2/3/2023	city	V-Power	10.4	45	10	Agressive	Normal	12	54
8	2/4/2023	city	V-Power	12	30	35	Normal	Normal	15	60
9	2/5/2023	city	Regular	7.4	40	30	Normal	Bumpy	17	55
10	2/5/2023	city	Regular	7.2	45	25	Normal	Bumpy	17	55
11	2/5/2023	city	Regular	8.4	30	10	Normal	Normal	17	53
12	2/5/2023	city	Regular	8.7	30	10	Normal	Normal	17	46
13	2/6/2023	hwy	Regular	6.1	70	100	Normal	Normal	8	87
14	2/7/2023	city	Regular	10.6	30	10	Normal	Normal	14	68
15	2/7/2023	city	Regular	8.4	25	10	Normal	Normal	14	68
16	2/10/2023	hwy	Regular	6.9	65	110	Agressive	Normal	11	82
17	2/11/2023	city	Regular	6.8	40	40	Normal	Normal	11	82
18	2/11/2023	city	Regular	9.5	40	20	Normal	Normal	14	85
19	2/11/2023	city	Regular	7.6	45	20	Normal	Normal	14	84
20	2/12/2023	city	Regular	14.1	25	45	Normal	Bumpy	7	82
21	2/12/2023	city	Regular	12.9	30	10	Normal	Normal	10	87
22	2/12/2023	city	Regular	7	45	35	Normal	Normal	12	61

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90	3/13/2023	City	V power	5.4	50	25	Normal	Normal	12	77
91	3/16/2023	City	Vpower	7.1	40	25	Normal	Normal	16	60
92	3/16/2023	Hwy	V power	7	80	55	Normal	Normal	14	59
93	3/16/2023	City	V power	6.8	50	30	Agressive	Bumpy	14	61
94	3/17/2023	City	V power	11.2	20	15	Notmal	Normal	16	54
95	3/17/2023	City	V power	11.6	15	15	Normal	Normal	18	50
96	3/17/2023	City	V power	8.6	20	25	Normal	Normal	16	57
97	3/18/2023	City	V power	9.4	20	45	Normal	Normal	14	74
98	3/18/2023	City	V power	8.4	25	20	Normal	Normal	21	48
99	3/18/2023	City	V power	5.9	20	20	Normal	Bumpy	22	47
100	3/18/2023	City	V power	7.8	30	30	Normal	Normal	21	51
101	3/18/2023	City	V power	10.3	35	10	Normal	Normal	20	55
102	3/18/2023	City	V power	8.4	25	30	Normal	Normal	17	69
103	3/19/2023	City	V power	7	40	35	Normal	Normal	17	68
104	3/19/2023	City	V power	6.5	40	35	Normal	Normal	17	67
105	3/19/2023	City	V power	7.6	35	20	Normal	Bumpy	18	68
106	3/21/2023	City	Regular	6.3	80	50	Normal	Normal	12	83
107	3/21/2023	City	Regular	6.4	50	30	Normal	Normal	13	79

- **About the Dataset:**
  This dataset contains 10 columns, namely:

- **Date:** represents the date the data point was collected.
- **Road_Class:** specifies if the drive at the time of the data collection is in the city or on the highway.
- **Fuel_Type:** specifies the type of the fuel used at the time of the data point collection.
- **L_100km:** represents the car fuel consumption in liters per 100 kilometers during each drive.
- **Avg_Speed:** represents the average speed of the trip in miles per hour.
- **Trip_Duration:** represents the duration of the trip in minutes.
- **Driving_Style:** specifies the style of driving for each trip: Normal or Aggressive.
- **Road_Condition:** specifies the road condition for each drive: Normal or Bumpy.
- **Temperature:** represents the outside temperature at the time of the drive in Celsius.
- **Humidity:** represents the percentage point of the outside humidity at the time of the drive.

- **Exporting to PostgreSQL:**

After the data has been collected and stored in an Excel sheet, it is now time to export it to PostgreSQL for cleaning and analysis. For this, I used PostgreSQL on pgAdmin. Before importing the Excel file, I converted it into a CSV file and created a table in PostgreSQL with the same column names and data types as found in the Excel sheet. The SQL code that I wrote to create the table that I called “Fuel_Consumption” was as follow:

```sql
CREATE TABLE Fuel_Consumption (
date date,
road_class varchar(50),
fuel_type varchar(50),
l_100km float,
avg_speed float,
trip_duration int,
drive_style varchar(50),
road_condition varchar(50),
temperature float,
humidity decimal(5,2)
)
;
```

After the table creation in SQL, the data was imported from CSV file using the Import/Export Data command in PostgreSQL. I now have a populated SQL table with my collected data. A simple SELECT statement in PostgreSQL helps visualize what this table looks like:

```sql
SELECT * FROM Fuel_Consumption
```

And the result was as expected, a table containing the same columns with the same data type and containing 106 data points:

	date date	road_class character varying (50)	fuel_type character varying (50)	l_100km double precision	avg_speed double precision	trip_duration integer	drive_style character varying (50)	road_condition character varying (50)	temperature double precision	humidity numeric (5,2)
1	2023-01-31	hwy	V-Power	7.6	60	30	Normal	Normal	15	54.00
2	2023-01-31	city	V-power	13.6	30	20	Normal	Normal	13	56.00
3	2023-02-01	hwy	V-Power	5.9	80	95	Normal	Normal	7	85.00
4	2023-02-03	hwy	V-Power	6.4	85	100	Normal	Normal	15	62.00
5	2023-02-03	city	V-Power	9.6	30	15	Normal	Normal	15	59.00
6	2023-02-03	city	V-Power	10.4	45	10	Agressive	Normal	12	54.00
7	2023-02-04	city	V-Power	12	30	35	Normal	Normal	15	60.00
8	2023-02-05	city	Regular	7.4	40	30	Normal	Bumpy	17	55.00

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	date date	road_class character varying (50)	fuel_type character varying (50)	l_100km double precision	avg_speed double precision	trip_duration integer	drive_style character varying (50)	road_condition character varying (50)	temperature double precision	humidity numeric (5,2)
99	2023-03-18	City	V power	7.8	30	30	Normal	Normal	21	51.00
100	2023-03-18	City	V power	10.3	35	10	Normal	Normal	20	55.00
101	2023-03-18	City	V power	8.4	25	30	Normal	Normal	17	69.00
102	2023-03-19	City	V power	7	40	35	Normal	Normal	17	68.00
103	2023-03-19	City	V power	6.5	40	35	Normal	Normal	17	67.00
104	2023-03-19	City	V power	7.6	35	20	Normal	Bumpy	18	68.00
105	2023-03-21	City	Regular	6.3	80	50	Normal	Normal	12	83.00
106	2023-03-21	City	Regular	6.4	50	30	Normal	Normal	13	79.00

- **Cleaning the Data:**

  Before beginning the analysis phase of the data, we, first, need to make sure our collected data is cleaned. A clean data will help generate accurate and reliable results which in turn will help create valuable insights and make efficient data-driven decisions.

  This section will deal with NULLS, typos, unwanted characters (i.e extra spaces), data readability, outliers, and inconsistent data format.

  - **NULLS:**

    To check for any NULL values that may be present in the dataset, I run the following command in PostgreSQL:

```
SELECT * FROM fuel_consumption
WHERE fuel_consumption IS NULL
```

	date date	road_class character varying (50)	fuel_type character varying (50)	l_100km double precision	avg_speed_mph double precision	trip_duration_min integer	driving_style character varying (50)	road_conditio character vary

As it can be seen, the returned table is empty meaning that there is no field in the table that contains NULL values.

- **Inconsistent Date Format:**

  Close investigation in the “date” column will help us realize that the dates are not stored in a consistent, standardized format. To make readability and analysis easier, it is wise to make all the dates follow the same format.
  I chose to set the dates to follow the “MM-DD-YYYY” Format.
  The PostgreSQL command that wrote for this was:

```sql
SELECT TO_CHAR(date, 'MM-DD-YYYY') AS date FROM fuel_consumption
;
```

  The result was as follows:

	date text
1	01-31-2023
2	01-31-2023
3	02-01-2023
4	02-03-2023
5	02-03-2023
6	02-03-2023
7	02-04-2023
8	02-05-2023
9	02-05-2023

- **Typos / Unwanted Characters:**

  After making sure that the date column is standardized, correct and clean from errors, it is time to check for discrepancies in the next columns. Skimming through “road_class” column, we can detect some typos and inconsistent values, as shown below:

road_class character varying (50)	fu ch
City	V
HWY	V
Hwy	V
Cuty	V
City	V

  I want to standardize all the city drives by returning the same word “City”, and highway drives by returning the same word “Highway”.
  For this, I wrote the following SQL code:

```sql
UPDATE fuel_consumption
SET road_class = 'City'
WHERE road_class ILIKE 'c%' or road_class ILIKE '%t%'
```

```sql
UPDATE fuel_consumption
SET road_class = 'Highway'
WHERE road_class ILIKE 'h%' or road_class ILIKE '%w%'
```

In the WHERE statement, I chose to use the ILIKE command so it accounts for all the values meeting the specified conditions without accounting for case sensitivity. The results were as follow:

road_class character varying (50)
Highway
Highway
Highway
Highway
Highway
Highway
Highway

road_class character varying (50)
City
City
City
City
City
City

And to verify that I have good results in the "road_class" column, I run a SELECT statement with GROUP BY command to check for the data groups that I have in this column, and as expected the column only contains values of "City" drives (89 data points) and "Highway" drives (17 data points):

```sql
SELECT COUNT(road_class), road_class FROM fuel_consumption
GROUP BY road_class
```

count bigint	road_class character varying (50)
89	City
17	Highway

Next is the "fuel_type" column. This column is supposed to have two distinct values across all its data points: "Regular" for drives using regular fuel and "V-Power" for drive using V-Power fuel. However, quite a few cells do not exactly reflect one of these two values. To check for possible typos and unwanted characters, the following SQL code should be of help:

```sql
SELECT COUNT(fuel_type), fuel_type, length(fuel_type) FROM fuel_consumption
GROUP BY fuel_type
```

	count bigint	fuel_type character varying (50)	length integer
1	1	V-power	7
2	18	V-Power	7
3	3	Regular	8
4	1	Regualr	7
5	8	Vpower	6
6	48	Regular	7
7	26	V power	7
8	1	V pwier	7

As it can be seen from the returned table, there is a lot more than two groups of values. To fix these discrepancies, we can run the same UPDATE query with ILIKE statement, that I run earlier:

```sql
UPDATE fuel_consumption
SET fuel_type = 'V-Power'
WHERE fuel_type ILIKE 'v%'

UPDATE fuel_consumption
SET fuel_type = 'Regular'
WHERE fuel_type ILIKE 'reg%'
```

Notice that in the previous table, there are values that looks the same but are grouped separately. This definitely means that there is an extra space or maybe multiple spaces at the end of one of these identical values. The UPDATE clause should help with eliminating these extra unwanted characters.

After running the necessary changes to the column, we can run a SELECT clause with a GROUP BY command to check for the data groups that we have. There should be two: “Regular” and “V-Power”. The code below is similar to the one used earlier and the returned table prove that our column is now clean and as expected:

```sql
SELECT COUNT(fuel_type), fuel_type, length(fuel_type) FROM fuel_consumption
GROUP BY fuel_type
```

	count bigint	fuel_type character varying (50)	length integer
1	52	Regular	7
2	54	V-Power	7

This same cleaning process was done to detect typos and unwanted characters in the "driving_style" column and correct the data in the column to return only two groups of values: "Normal" and "Aggressive".

	driving_style character varying (50)
1	Normal
2	Aggressive

- **Improving Data Readability:**
  Some columns, especially those that contain numerical values, may convey confusing information if the column name is not clear or does not precise the units of the values, in some of the cases. For our table, I wanted to make it clear what units are used in the columns containing numerical values, even though it is all explained in the data dictionary at the beginning of this report.
  Taking for example the "trip_duration" column, the unit used to store the values is minutes. To indicate this, I decided to rename the column to "trip_duration_min". In PostgreSQL, this was done as following:

```
ALTER TABLE fuel_consumption
RENAME COLUMN trip_duration TO trip_duration_min
```

  The same process was done to rename "avg_speed", "temperature" and "humidity" columns to specify for units used. The results are as shown:

avg_speed_mph double precision	trip_duration_min integer	temperature_degc double precision	humidity_perc integer
60	30	15	54

- **Outlier DATA Points Elimination:**
  Some data points were reflecting some conditions (low humidity, high temperature, etc) for only one of the two types of the fuels and not the other. This error of incomplete data points generated outliers

when creating visuals, which will be presented in a later section, which tend to skew the data and give inaccurate results. For this reason, these points were removed during the analysis and visuals creation.

- **Preparing the Data:**

  After cleaning the data, it is time to prepare the data by creating any additional necessary columns and making sure that our dataset is ready for analysis.

  - **Data Columns Addition:**

    The “l_100km” represents the fuel consumption of the car during each drive in liters per 100 kilometers. But I want an additional column that return car fuel consumption in miles per gallon or MPG. Same goes for “avg_speed_mph” and “temperature_degc” columns. I want a column that returns the average speed for each trip in kilometers per hour and another that returns temperature in degrees Fahrenheit.

    For this, I used the ALTER TABLE clause to create new columns and the UPDATE clause to populate the new columns. For each unit conversion, I used the appropriate conversion equation for each case in the UPDATE statement. The syntax and results can be seen below:

```sql
ALTER TABLE fuel_consumption
ADD COLUMN MPG DECIMAL(10,2)
```

```sql
UPDATE fuel_consumption
SET MPG = 235.215 / L_100km
```

mpg numeric (10,2)
34.59
31.36
25.29
39.20
39.20
22.62
37.34
36.75

```sql
ALTER TABLE fuel_consumption
ADD avg_speed_kmh float

UPDATE fuel_consumption
SET avg_speed_kmh = avg_speed_mph * 1.6
;
```

avg_speed_kmh double precision
144
136
128
64
104
72
96
128

```sql
UPDATE fuel_consumption
SET temperature_degF = (temperature_degC *1.8) + 32
```

temperature_degf double precision
57.2
73.4
71.6
64.4
51.8
53.6
59
44.6

- **Improving Data Readability:**
  In the "temperature_degf" column, I noticed an unusual value:

temperature_degf double precision
55.400000000000006

To fix the number of digits after the decimal point, I wrote the following code using the CAST clause to transform the data type of the entire column to DECIMAL(). DECIMAL() transforms all the input values to decimal while specifying, in the first digit between the parentheses, the precision level, or in other words the total number of digits in the numeric value on both sides of the decimal point (10) and, in the second digit, the number of digits (2) after the decimal point.

```sql
UPDATE fuel_consumption
SET temperature_degf = CAST(temperature_degf AS DECIMAL(10,2));
```

temperature_degf double precision
55.4

And with that, our data is now cleaned and prepared for analysis.

- **PostgreSQL Preliminary Analysis:**

  A quick analysis in PostgreSQL, using AVG function coupled with partitioning rows into groups using GROUP BY clause, gives a quick overview that regular unleaded gasoline seems to be more efficient than V-Power premium gasoline when it comes to car fuel consumption on both city and highway roads:

```sql
SELECT fuel_type, road_class, CAST(AVG(l_100km) AS DECIMAL(10,2)) AS l_100km,
ROUND(AVG(mpg),2) AS mpg, COUNT(fuel_type) AS data_points
FROM Fuel_Consumption
GROUP BY fuel_type, road_class
ORDER BY road_class, l_100km, mpg DESC
```

	fuel_type character varying (50)	road_class character varying (50)	l_100km numeric (10,2)	mpg numeric	data_points bigint
1	Regular	City	7.89	31.17	46
2	V-Power	City	8.57	29.07	43
3	Regular	Highway	6.50	36.48	6
4	V-Power	Highway	7.00	34.30	11

Another analysis shows that regular unleaded gasoline provides better fuel efficiency than that of V-Power for both aggressive and normal driving styles:

```sql
SELECT fuel_type, driving_style, CAST(AVG(l_100km) AS DECIMAL(10,2)) AS l_100km,
ROUND(AVG(mpg),2) AS mpg, COUNT(fuel_type) AS data_points
FROM Fuel_Consumption
GROUP BY fuel_type, driving_style
ORDER BY driving_style, l_100km, mpg DESC
```

	fuel_type character varying (50)	driving_style character varying (50)	l_100km numeric (10,2)	mpg numeric	data_points bigint
1	Regular	Aggressive	7.16	32.99	7
2	V-Power	Aggressive	8.02	29.92	10
3	Regular	Normal	7.82	31.59	45
4	V-Power	Normal	8.31	30.19	44

One additional analysis shows that regular unleaded gasoline returns a better fuel efficiency than V-Power gasoline on roads with normal conditions. On the other hand, Shell V-Power gasoline seems to provide a better fuel efficiency than regular unleaded gasoline on bumpy roads. However, this result might not be very accurate as I only collected one data point reflecting driving with regular unleaded gasoline on bumpy roads. I will need to collect more data points for these conditions to improve the results accuracy.

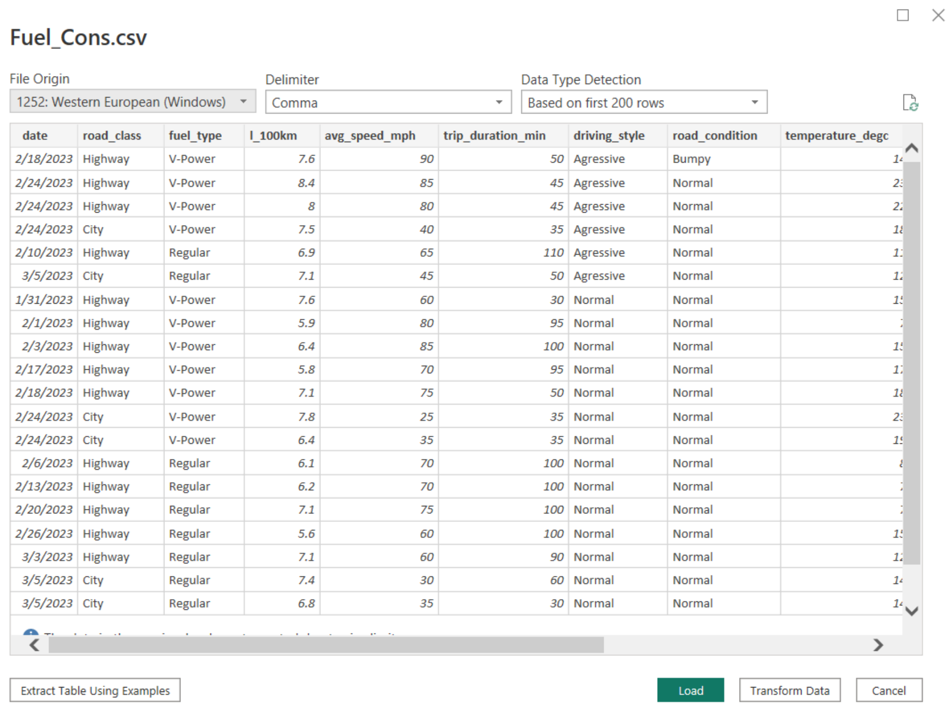
```
SELECT fuel_type, road_condition, CAST(AVG(l_100km) AS DECIMAL(10,2)) AS l_100km,
ROUND(AVG(mpg),2) AS mpg, COUNT(fuel_type) AS data_points
FROM Fuel_Consumption
GROUP BY fuel_type, road_condition
ORDER BY road_condition, l_100km, mpg DESC
```

	fuel_type character varying (50)	road_condition character varying (50)	l_100km numeric (10,2)	mpg numeric	data_points bigint
1	V-Power	Bumpy	7.18	33.13	4
2	Regular	Bumpy	8.00	29.40	1
3	Regular	Normal	7.73	31.83	51
4	V-Power	Normal	8.34	29.90	50

These preliminary results give a good idea on the general direction of the answers to the questions of this study. Now, I will be further exploring and visualizing these results through charts and graphs in Power BI.

- **Importing the Data to Power BI:**

  We now have our CSV file, named “Fuel_Cons” ready for further analysis and visualization in Power BI. To import this file to PBI, I chose Text/CSV option in the “Get Data” command under the “Section” of the Home Tab. I then chose the "Transform Data" option to verify the table headers titles, data types and to rearrange the columns so that the columns conveying similar info are stacked next to each other.



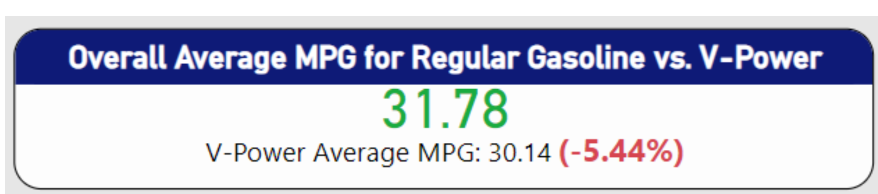
date	road_class	fuel_type	l_100km	avg_speed_mph	trip_duration_min	driving_style	road_condition	temperature_degc
2/18/2023	Highway	V-Power	7.6	90	50	Agressive	Bumpy	[illegible]
2/24/2023	Highway	V-Power	8.4	85	45	Agressive	Normal	[illegible]
2/24/2023	Highway	V-Power	8	80	45	Agressive	Normal	[illegible]
2/24/2023	City	V-Power	7.5	40	35	Agressive	Normal	[illegible]
2/10/2023	Highway	Regular	6.9	65	110	Agressive	Normal	[illegible]
3/5/2023	City	Regular	7.1	45	50	Agressive	Normal	[illegible]
1/31/2023	Highway	V-Power	7.6	60	30	Normal	Normal	[illegible]
2/1/2023	Highway	V-Power	5.9	80	95	Normal	Normal	[illegible]
2/3/2023	Highway	V-Power	6.4	85	100	Normal	Normal	[illegible]
2/17/2023	Highway	V-Power	5.8	70	95	Normal	Normal	[illegible]
2/18/2023	Highway	V-Power	7.1	75	50	Normal	Normal	[illegible]
2/24/2023	City	V-Power	7.8	25	35	Normal	Normal	[illegible]
2/24/2023	City	V-Power	6.4	35	35	Normal	Normal	[illegible]
2/6/2023	Highway	Regular	6.1	70	100	Normal	Normal	[illegible]
2/13/2023	Highway	Regular	6.2	70	100	Normal	Normal	[illegible]
2/20/2023	Highway	Regular	7.1	75	100	Normal	Normal	[illegible]
2/26/2023	Highway	Regular	5.6	60	100	Normal	Normal	[illegible]
3/3/2023	Highway	Regular	7.1	60	90	Normal	Normal	[illegible]
3/5/2023	City	Regular	7.4	30	60	Normal	Normal	[illegible]
3/5/2023	City	Regular	6.8	35	30	Normal	Normal	[illegible]

After this, I am now ready to start creating visuals and exploring my data on deeper levels.

- ## Creating Visuals and Gathering Insights:

  - ### Overall Average MPG Comparison

For the dashboard, I started by creating a KPI card, taking into account all driving and environmental conditions, that compares overall average MPG for Shell Regular Unleaded Gasoline to the overall average MPG for V-Power Gasoline. It turns out that regular gasoline gives a better overall MPG of 31.78 compared to 30.14 for V-Power, giving the regular gasoline a better overall efficiency of 5.44%.



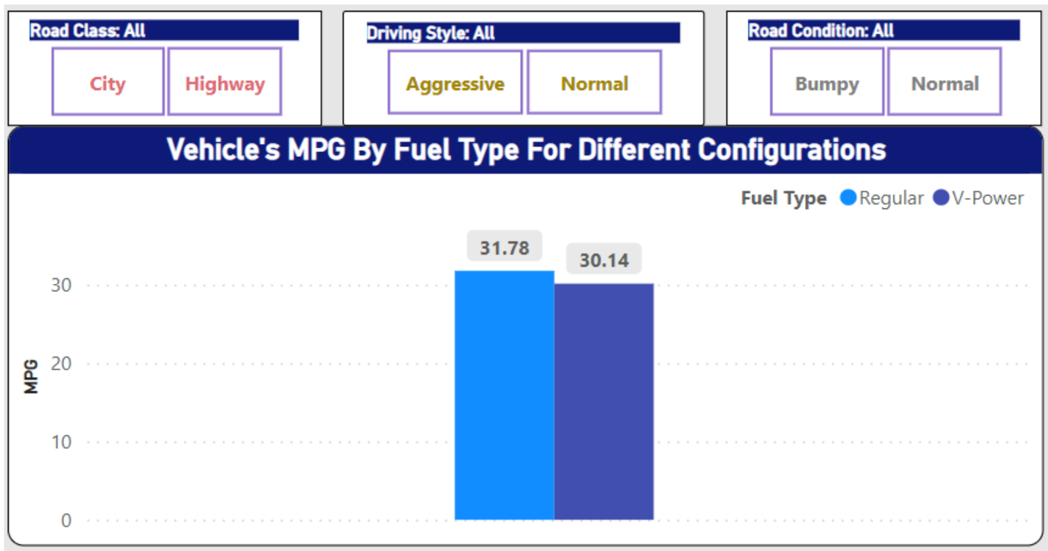
- **MPG By Fuel Type for Different Driving Configurations:**

To show the average MPG for both fuel types at different driving conditions, I created a stacked column chart showing regular and V-Power gasoline MPG values coupled with slicers giving possibility to see both fuel types MPGs at these different configurations. Generally, regular gasoline gave a better MPG than V-Power. In city driving, on normal roads with normal driving style, regular gasoline gave an MPG of **31.27** compared to **29.01** for V-Power, which returns a percent difference of **7.5%.** On highway, for the same road condition and driving style configurations, regular gasoline MPG was also better than V-Power gasoline MPG with **37.91** compared to **35.15** respectively, with a percent difference of **7.56%**. Moreover, regular gasoline gave better results on trips on highways with aggressive driving style and normal road condition returning an MPG of **34.09** compared to only **29.40** for V-Power gasoline, showing a percent difference of **14.77%**. Regular gasoline also gave better results for aggressive driving on city roads as well with normal road condition with an MPG of **34.38** compared to **27.26** for V-Power gasoline, which returns a percent difference of **23.1%**. This shows that in the majority of driving conditions that were considered in the data collection and analysis, Shell regular unleaded gasoline tend to be more efficient than Shell V-Power gasoline.

* For aggressive driving on bumpy roads for both city and highway, the data points collected for the two fuel types were not enough to generate reliable insights, so for now, they won't be considered in the analysis, until more data points reflecting these conditions will be collected.

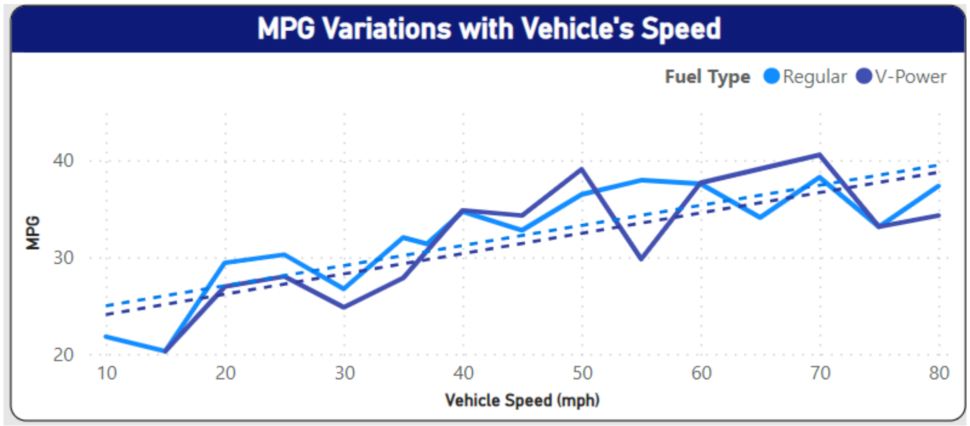
For highway driving on bumpy roads with normal driving style, V-Power had a better MPG of **36.84** compared to **33.13** for regular gasoline, showing a percent difference of **10.6%**. For the same configuration but for city driving, V-Power also returned a better MPG of **35.32** compared to **28.65** for regular gasoline, showing a percent difference of **20.85%**. This shows, with the data points collected, that V-Power gasoline is more efficient on bumpy roads than regular unleaded gasoline. However, there were only few data points in the dataset to show this.

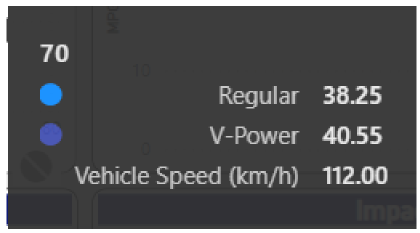
More data points that reflect driving on bumpy roads with aggressive driving style for both city and highway may provide results that are more accurate.



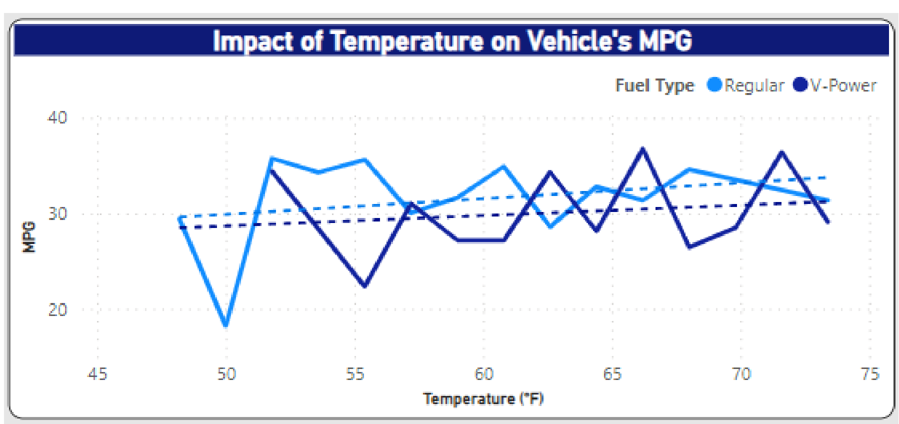
- **MPG Variation with Vehicle's Speed:**

  MPG Variation for both fuel types seem to have an <u>upward trend</u> as vehicle's speed increases, which makes sense since the fuel efficiency will increase until the vehicle hits a certain speed than MPG will start to decline, which also can be seen at the very end of the graph.
  <u>The trend axis shows that regular unleaded gasoline tend to have a slightly better MPG than V-Power across different ranges of speed, varying from 10 mph to 80 mph</u>. <u>My car's speed for best MPG for both fuel types</u> seems to be around **70 mph** as both fuel types return their best MPG values at that speed.
  To see the trend of MPG variation at higher speeds in a better way, collection of more data points reflecting higher speeds that are greater than 80 mph is advised.

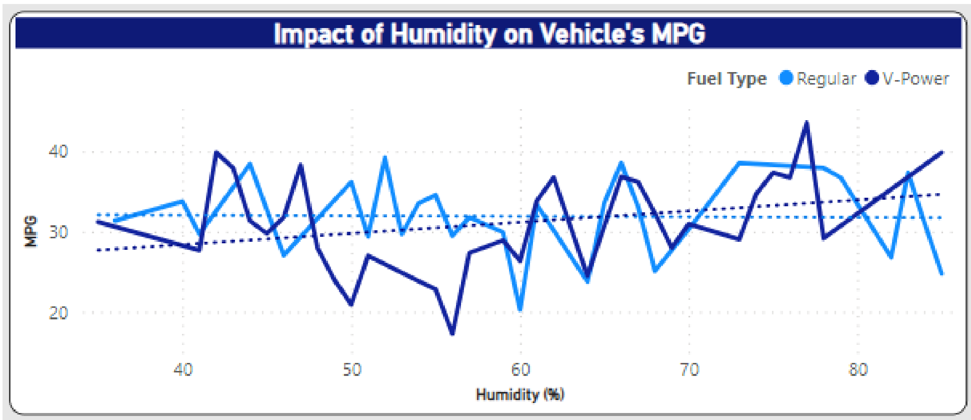




- **Impact of Temperature on Vehicle's MPG:**
  The MPG variation with temperature for both fuel types seem to follow an upward trend as temperature increases, which is reasonable, since engines are be more efficient in hot weather as they tend to warm up faster hence consuming less fuel.
  Regular gasoline, however, seems to have a better overall MPG values across the different temperature variations compared to V-Power gasoline. More data points reflecting hotter temperatures can help draw more conclusions regarding the behavior of the engine fuel efficiency in very hot climates.



- **Impact of Humidity on Vehicle's MPG:**
  Both fuel types show values of MPG that seem to increase with increasing humidity with V-Power gasoline MPGs having a higher rate of increase than that of regular gasoline MPGs. At lower humidity levels, regular gasoline is more efficient; however, as humidity levels keep increasing V-Power gasoline tend to be more efficient. This can be explained with the additives (i.e demulsifiers) that more present in the V-Power gasoline.



• Insights Summary:

- Shell Regular Unleaded Gasoline returned a higher overall average MPG of 31.78 compared to the overall average MPG of 30.14 for Shell V-Power Gasoline, making regular gasoline 5.44% more efficient than V-Power gasoline across all the driving and environmental conditions that my car was put through during the data collection phase.
- Regular Unleaded Gasoline proved to be more efficient in most driving conditions (on city and highway roads with aggressive and normal driving styles and on normal road conditions), however, V-Power Gasoline seems to return better MPG values when driving on bumpy roads with a normal driving style.
- MPG values for both gasoline types seemed to increase as temperature increases, which is reasonable, as engines tend to warm up faster hence consuming less fuel in hotter weathers. Regular gasoline, however,

returned higher MPG values than those of V-Power across all the temperature range.

- Regular gasoline was more efficient in lower humidity levels, however, V-Power gasoline returned better MPG values in higher humidity levels, which can be explained by the impact of additives (such as demulsifiers) that are more present in V-Power gasoline than in regular unleaded gasoline.

- Overall, the fuel efficiency offered by the V-Power gasoline is not worth the extra cost that comes with it when compared to its regular gasoline counterpart. However, I will be still using V-Power gasoline every now and then to take advantage of the additives it contains that can help clean the engine components, prolong its life and get better fuel efficiency in humid climates.

- **What I could have done better:**

  - Despite collecting trip duration data for each trip, the MPG correlation with trip duration for both types of fuel was not shown in the dashboard. This is due to the lack of data points that reflect trip durations for highway drives for the two types of fuel, which caused an inaccurate depiction of the impact of trip duration on MPG. Moreover, trip duration does directly impact MPG more than it is the case with road condition, driving style and road class. For these reasons, the trip duration graph was not shown.

  - Data points for trips on bumpy roads, especially trips with aggressive driving on bumpy roads for both city and highway for the two fuel types were not enough to help create valuable and reliable conclusions and insights. For this reason, further data points collection will be conducted to be able to form reliable insights regarding the impact of these driving conditions on the fuel efficiency of both gasoline types. Same observation goes for trips on highway with aggressive driving style and normal road condition.

*** Any feedback on this work is greatly appreciated. Thanks!**