Exploring the seasonal variation in electric vehicle charging in New Zealand

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Data Exploration

Flip the Fleet Data Exploration

Distance traveled and vehicle efficiency (km/kWh) by month, as well as the region of the vehicle was collected from the on-board computers of 1259 vehicles between 2017 and 2021 as part of the 'Flip the Fleet' project.

A monthly weighted average was calculated for the whole of New Zealand and then for each region of NZ. The monthly averages were weighted using the distance traveled to give more weighting to vehicles with higher km traveled in that month. this was done using the formula

$$\bar{x} = \frac{\sum_i^n (d_i \times x_i)}{(\sum_i^n d_i) \times n}$$

Power consumption (Wh/km) was calculated using the efficiency (km/kWh). This will be used instead of efficiency in the modeling for reasons that will become apparent later in the analysis.

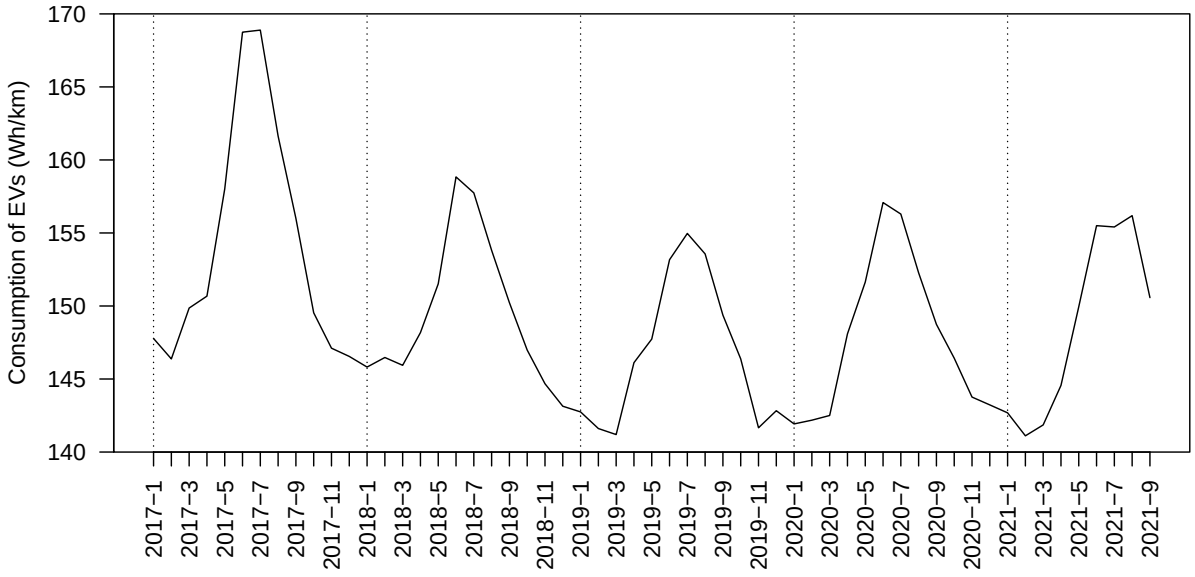

Figure 1: Time series of EVs weighted mean consumption using Flip the Fleet data from all NZ regions

Figure **??** shows there is a clear seasonal trend in the monthly average consumption of Flip the Fleets vehicles from all regions of NZ.

A time series Decomposition is used to isolated the seasonal trend in consumption from the overall trend. This can be done for all regions of NZ combined and also for each region independently.

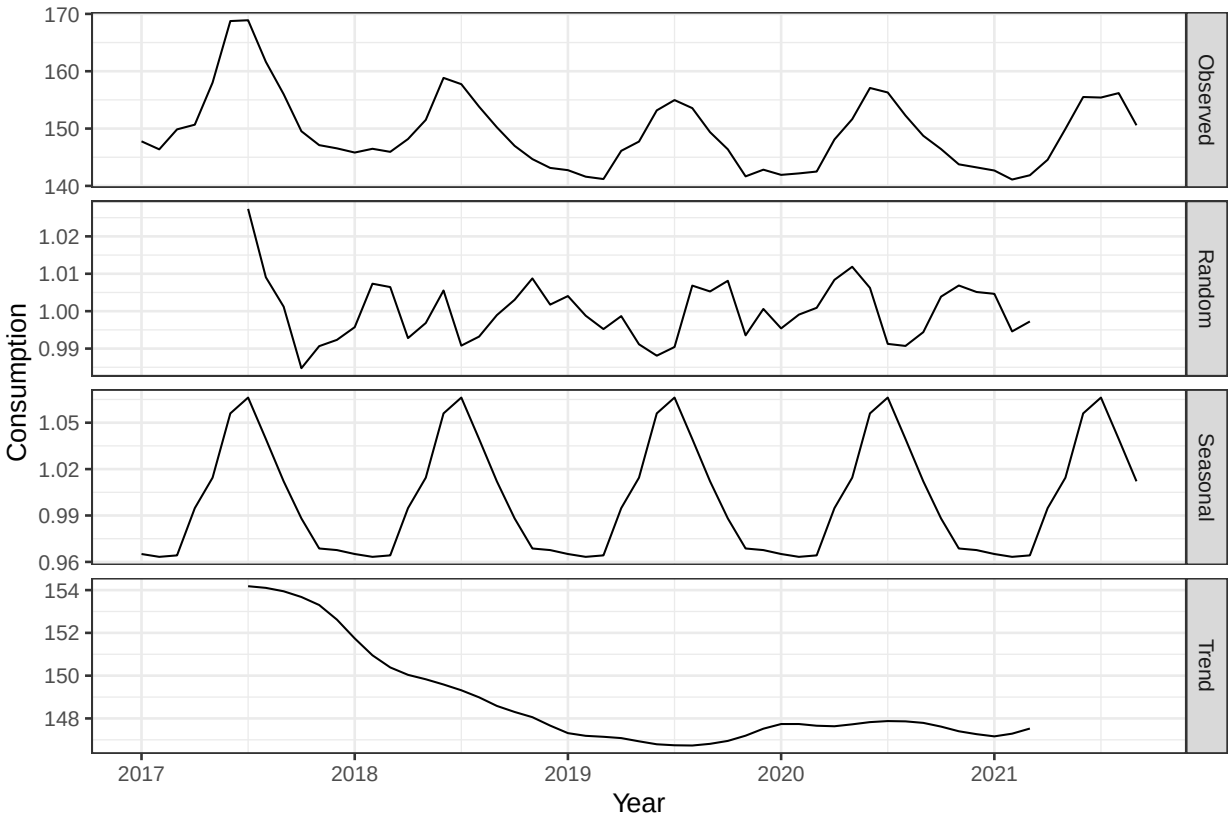

Figure 2: Multiplicative time series decomposition of flip the fleet average consumption for all of NZ

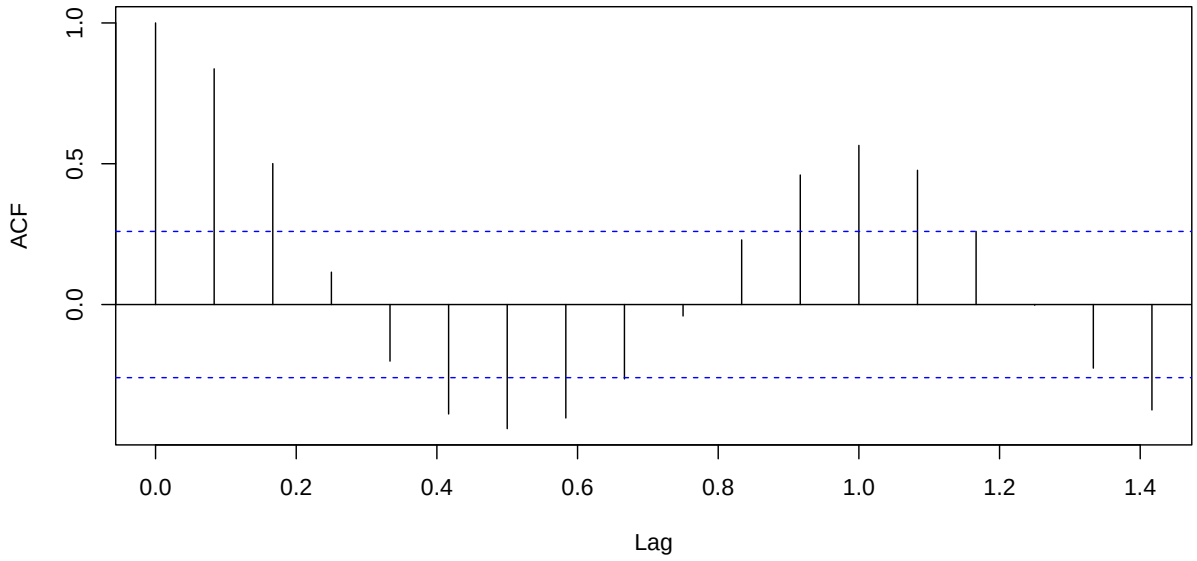

Figure 3: Autocorrelation plot of flip the fleet average consumption for all of NZ

The time series decomposition (Figure 2) shows a very clear seasonal trend. The autocorrelation plot (Figure 3) shows that this yearly trend is significant. This seasonal trend going from 0.96 times the mean consumption in February to 1.07 times the mean consumption in February, A peak to peak difference of 10.7%.

As NZ weather differs significantly by region, to test the hypothesis that EV consumption is correlated with heating degree days we must limit the comparison to a single region of Flip the Fleet data and compare it to that regions weather at the same period of time.

In order to do this hourly weather data from 2017 to 2021 was collected from the NIWA national climate Database for 14 regions around New Zealand that best correspond to the regions of the Flip the Fleet vehicles. The base temperatures were selected to represent the range of comfortable temperatures for most people, as research shows that a majority of the seasonal variation in EV efficiency is due to cabin temperature control[1]. Using the regional hourly temperatures, monthly heating degree days (HDD) and cooling degree days (CDD) were imputed using base temperatures of 16°C and 22°C respectively. Monthly average temperature was also calculated.

The HDD and CDD was then divided by the length of the month so that HDD and CDD corresponds to average heating degrees days per day for the month. This is so that when comparing to other statistics such as efficiency that are averaged out rather than summed so there is less bias.

The calculated monthly weather statistics by region was then added to the monthly EV data based on the regions of vehicle. This assumes that vehicle stays in it's own region for a majority of the time.

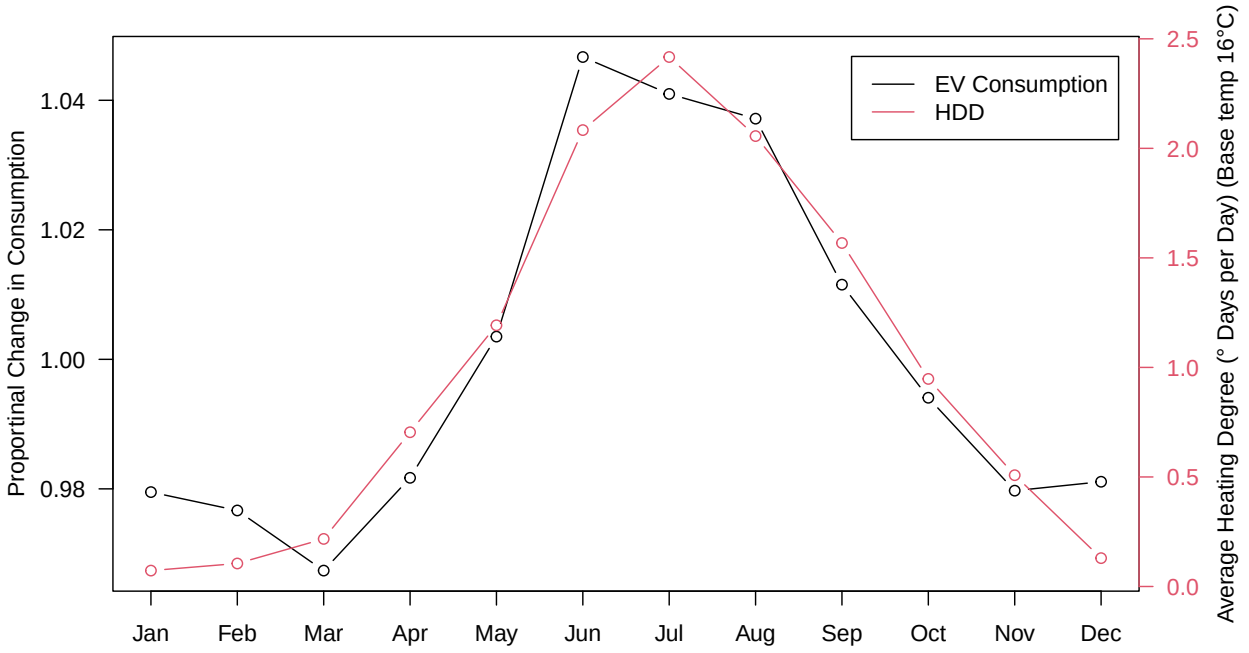

Figure 4: Auckland seasonal HDD and EV Consumption decompostions

Auckland is used as an example to compare correlation between HDD and consumption as it has the largest amount of data and is of most interest to Vector. Within Auckland Figure 4 shows very clearly that HDD and consumption of EVs are highly correlated. There is a slight increase in consumption in January and February and it can be questioned if that is due to AC usage which would decrease range [1] or other factors such as holiday travel which could involve highway driving which EVs are generally less efficient at [2]. This effect is not obvious in the overall trend this could be as Auckland for the most part is a warmer climate than the rest of NZ.

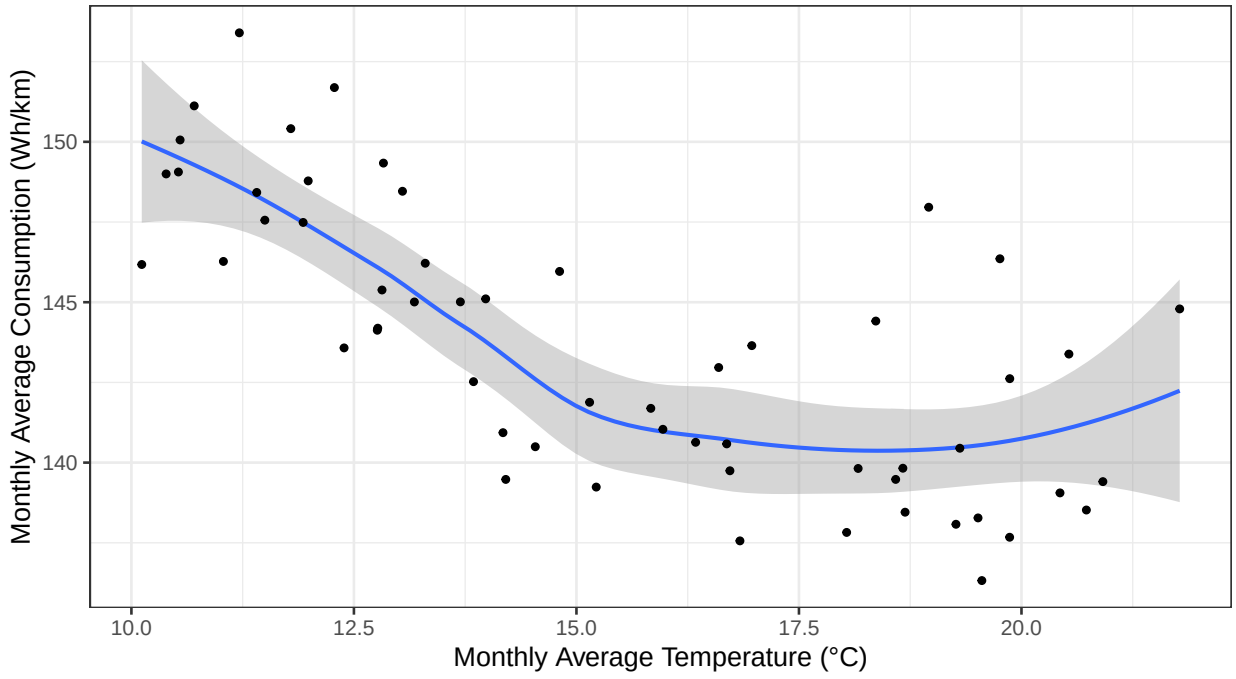

Figure 5: Auckland monthly average consumption by avg temperature

Further looking into Auckland consumption by weather Figure 5 shows a decreasing consumption up to around a monthly average temperature of 17.5°C. However, increasing monthly average temperature past this there appears to be a trend towards increasing EV consumption.As stated previously research [1] suggested AC also increases consumption of the EV. This suggest it may be worth including cooling degree days and heating degree days in analysis. This could also be useful to explain the points well above the trend line that may be from a month where there was both cold and warm days contributing to a high usage of cabin temperature control increasing consumption but average temperature would not be able to show this.

NZ VKT Data Exploration

If we know EV consumption has a seasonal trend in order to see how this will affect the grid we need to see how this correlates with NZ populations driving pattern.

To find if a seasonal trend in fuel usage in NZ fuel trade data [3] from the Ministry of Business, Innovation and Employment (MBIE) is used. This data set quarterly data in broken down by fuel type and sector. This allows the isolation of petrol usage in domestic land transport which should be an accurate representation of the fuel usage by light passenger vehicles. Fuel trade data from 2020 was excluded as lockdowns were not an accurate representation of the general driving patterns of the NZ population.

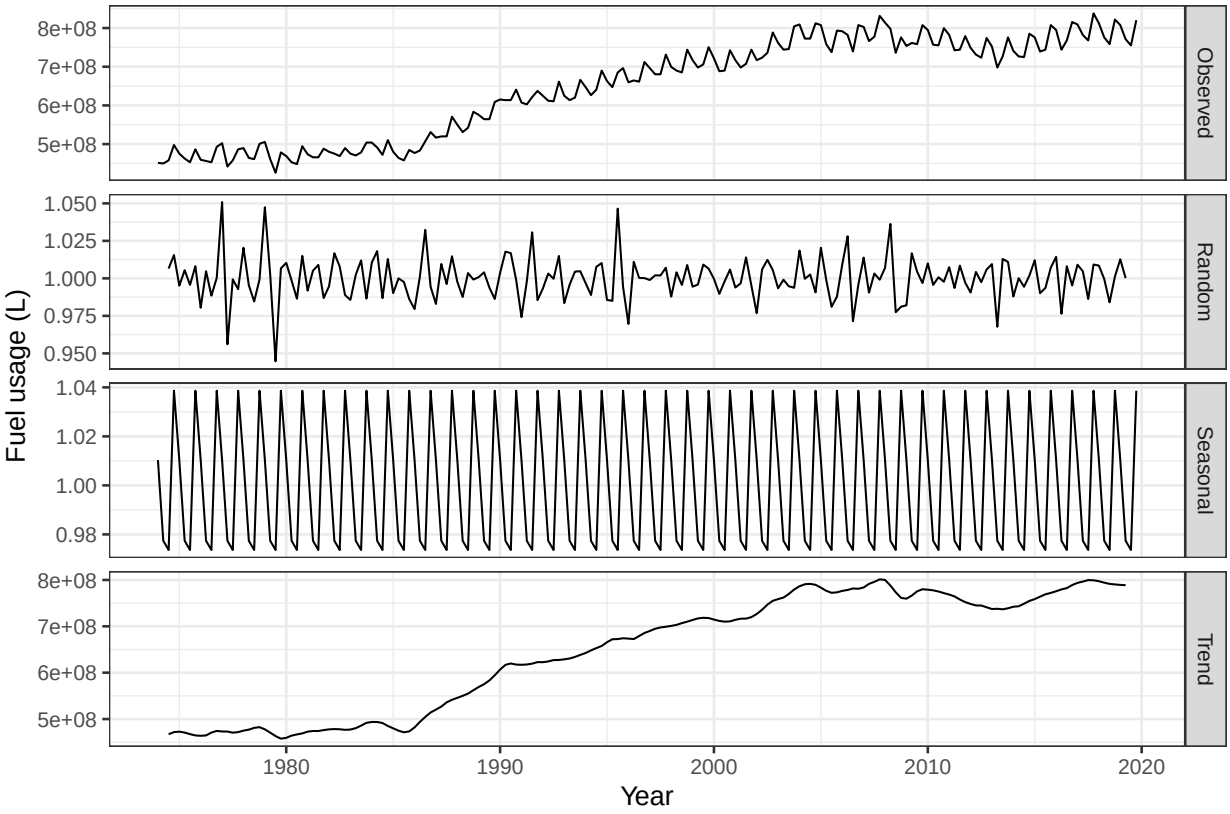

Figure 6: Multiplicative time series decomposition of petrol usage in domestic land transport

Figure 6 decomposition shows a seasonal trend, however, it is of relatively small magnitude compared to the random variations suggesting this trend may not be significant.

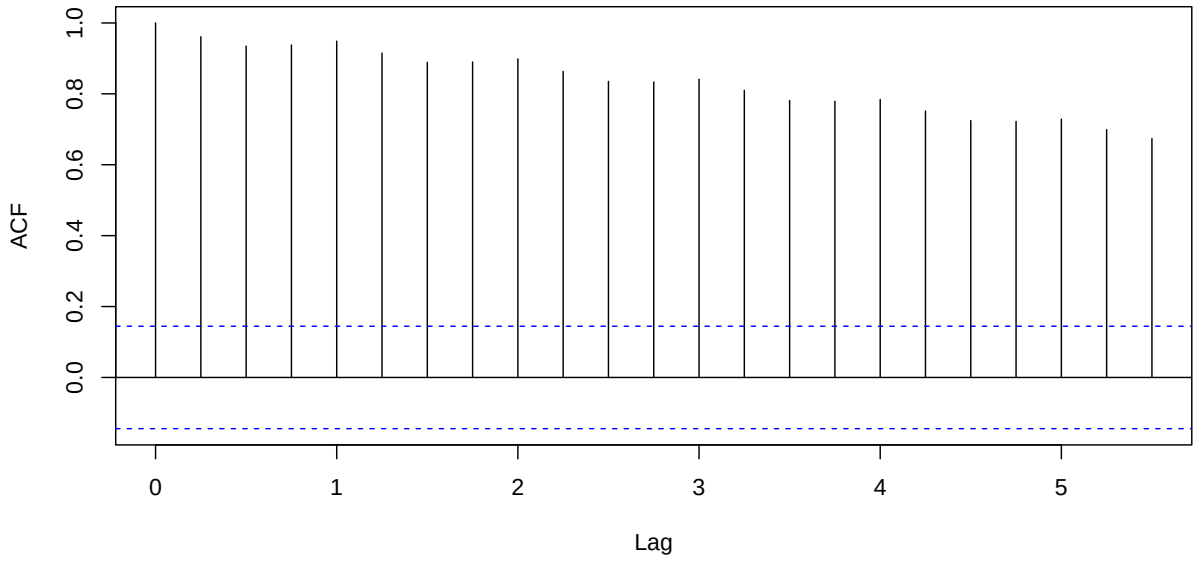

Figure 7: Autocorrelation of petrol usage in domestic land transport

Model

References

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[2] *Why is the range of an EV less on the freeway than the city?*
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[3] *MBIE oil trade statistics*
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