Melbourne Datathon 2020: Energy Demand Forecasting during a Pandemic

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October 17, 2020

Introduction

The year 2020 has been a challenging year for the humankind. As a result of the COVID19 restriction measures (working from home, social distancing), the everyday energy consumption patterns have been disrupted. In this study, I made an effort to visualise this impact using the *Australian Energy Market Operator, half-hourly energy demand dataset (for the state of Victoria)*, which is publicly available from [1].

Aggregated Energy Consmption Analysis

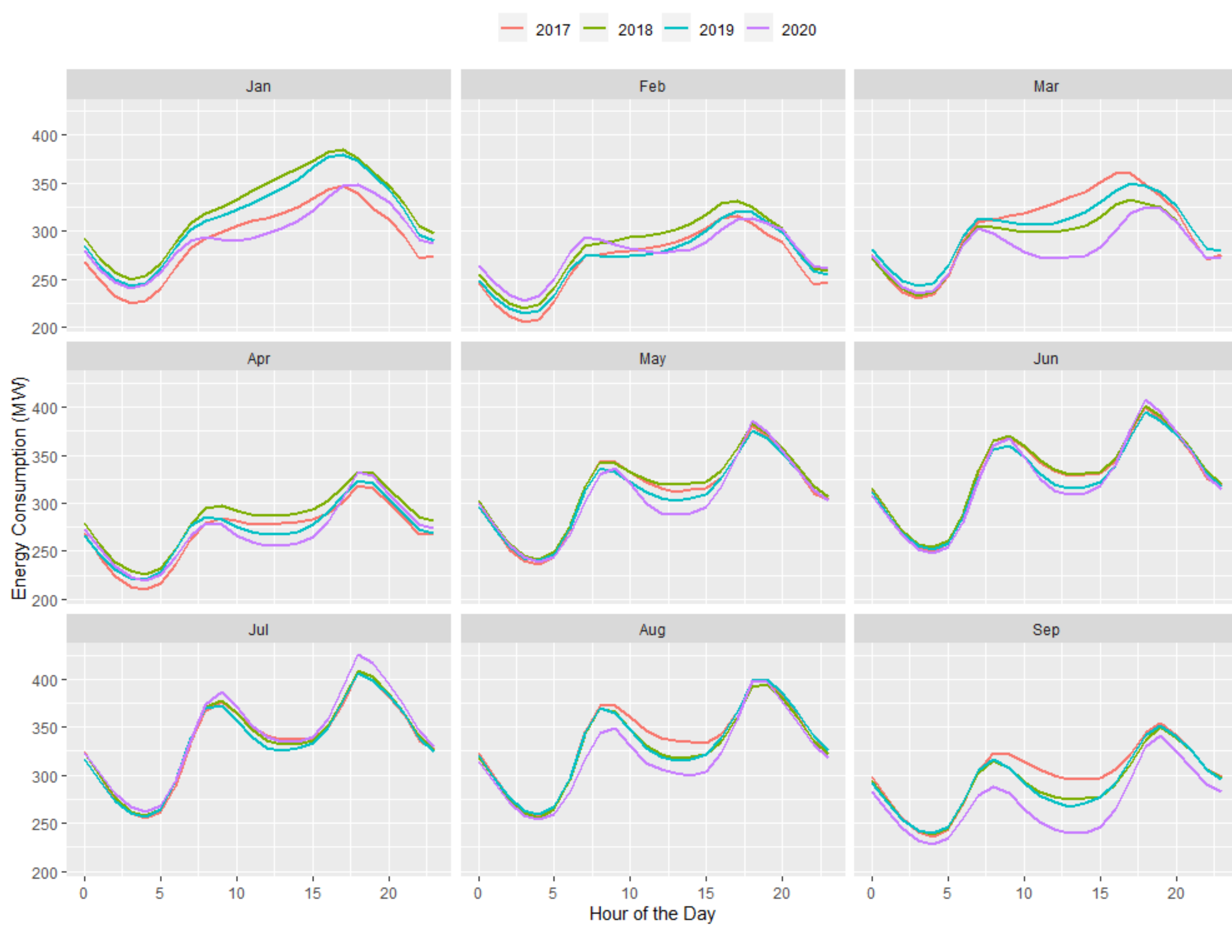

Figure 1: The aggregated hourly energy consumption in the state of Victoria

The Figure 1 demostrates the hourly aggregated energy consumption for each month from year 2017. Following are the main observations:

- The presence of daily seasonality (one peak in the morning, and other peak in the evening) across all the years.
- In year 2020, from the month of April (with COVID restrictions), the hourly energy consumption levels are starting to get increased, overlapping with the consumption levels of previous years.
- In year 2020, for the month of **July** (more tougher restrictions imposed in Victoria), the total hourly energy consumption (including the daily peaks) is much higher compared to previous years.
- As a result of the COVID19 restrictions, more people were enforced to stay at home, leading to higher daily energy consumption levels.

Seasonal Consumption Analysis

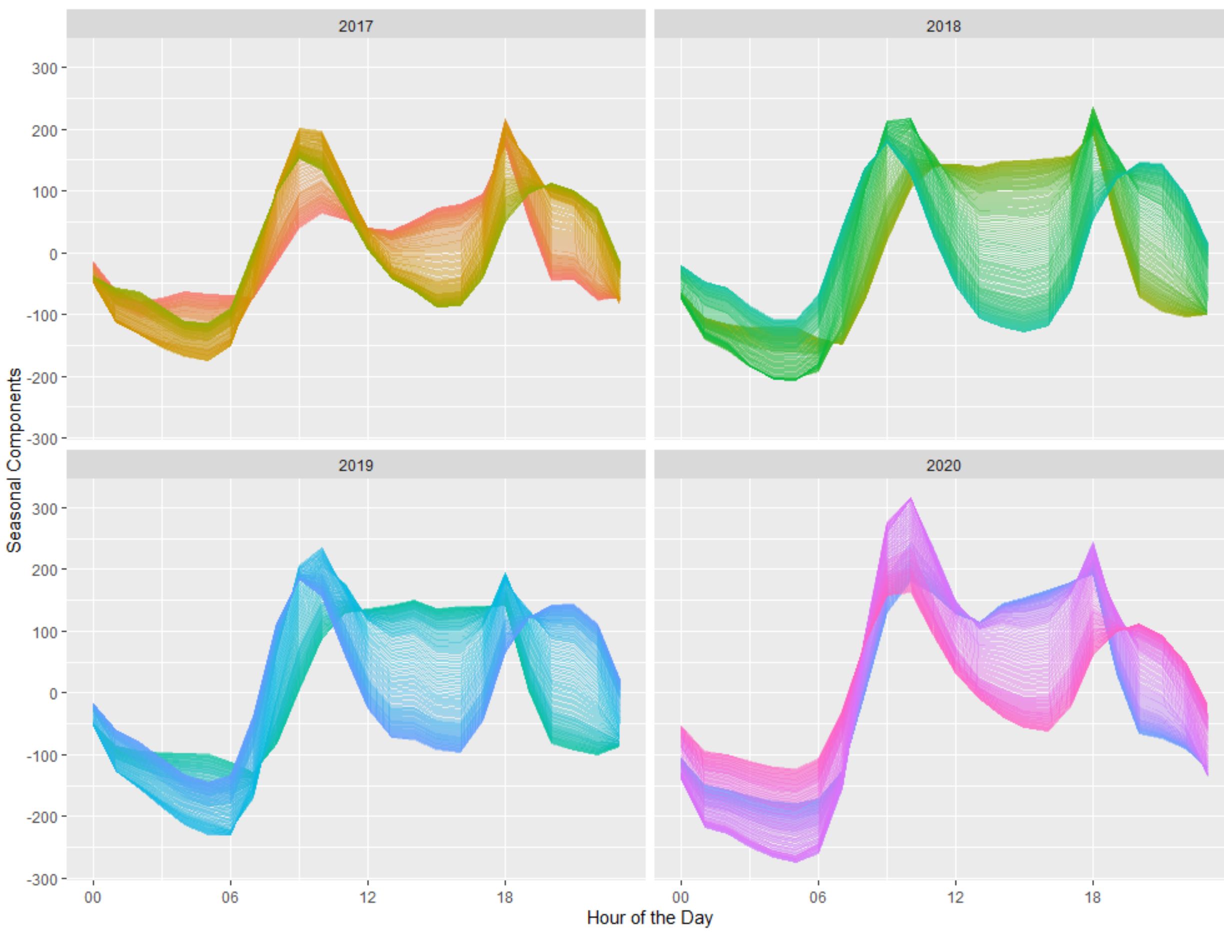

Figure 2: The daily seasonal energy consumption distribution from April to September

The Figure 2 illustrates the daily seasonal energy consumption components over the years (from April to September, focusing on COVID19 restriction period in Victoria). The *STL decomposition* method [2] is used to extract the daily seasonality. Following are the main observations:

- It is evident that the morning energy consumption peak (around 9 A.M - 10 A.M) is much higher in the year 2020, compared to previous years.
- The average energy consumption during the off-peak (11 A.M to 4 P.M) is comparatively higher in the year 2020 (more people staying at home).

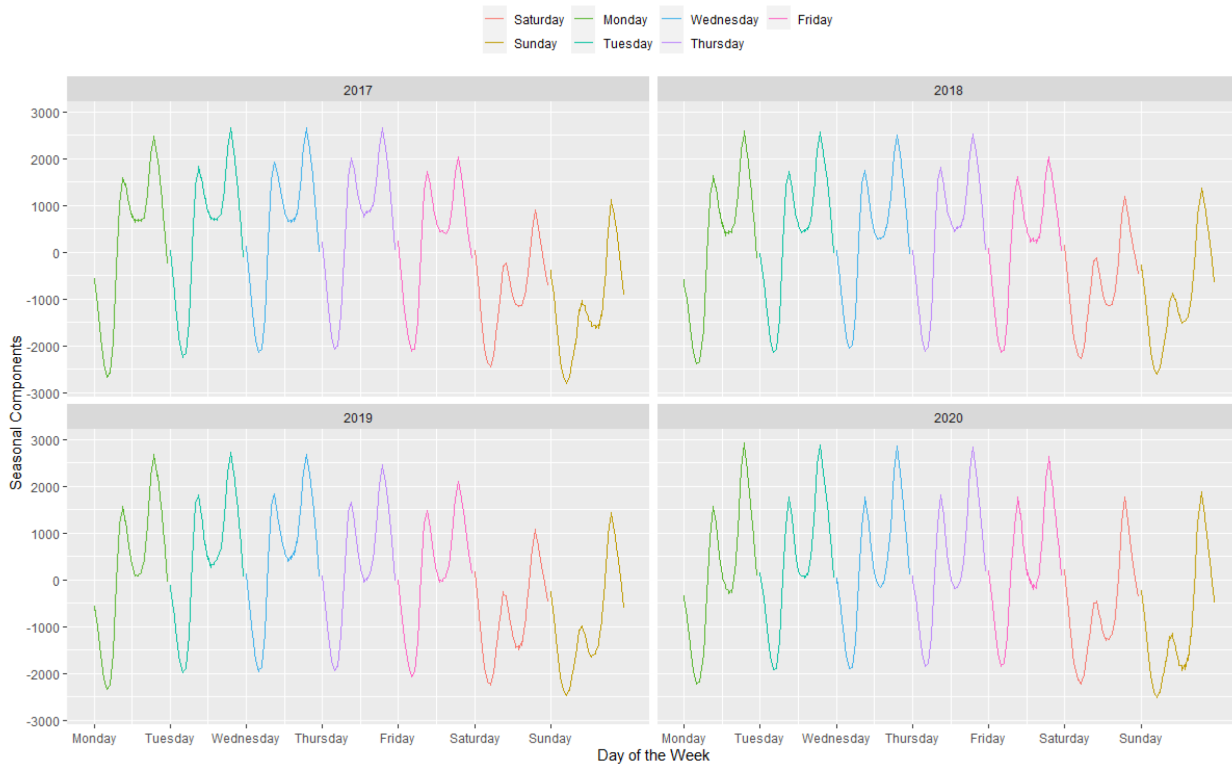

Figure 3: The weekly seasonal energy consumption distribution from April to September

The Figure 3 demostrates the weekly seasonal energy consumption components over the years. Following are the main observations:

- The average energy consumption in the weekdays is higher compared to weekend (The presence of weekly seasonality).
- In year 2020, we observe a higher energy consumption peak levels on Fridays, Saturdays, and Sundays, compared to other years. This indicates lesser outdoor activities in the weekends during the pandamic.

Energy Consumption Variations in July

As identified from Figure 1, compared to previous years, the month of July in year 2020 shows higher levels of energy consumptions. The Figure 4 further investigates the energy consumption in July across past few years. Following are the main observations:

- The energy consumption differences between the weekdays and weekend in July are minimal for the year of 2020.
- Due to COVID19 restrictions, even in the weekends, people are enforced to stay at home, leading to consumption patterns similar to weekdays.

Daily Energy vs Daily Temperature

The Figure 5 shows the relationship between the daily aggregated energy consumption and the average temperature, faceted by the type of the day: a Weekday, a Weekend, or a Holiday. The daily temperature data is collected from [3], whereas [4] is used as the official source to combine the victorian holidays.

- There exist a non-linear relationship between the energy consumption and the average temperature.
- The temperature around 20°C can be considered as the optimal temperature that minimises the overall energy consumption.

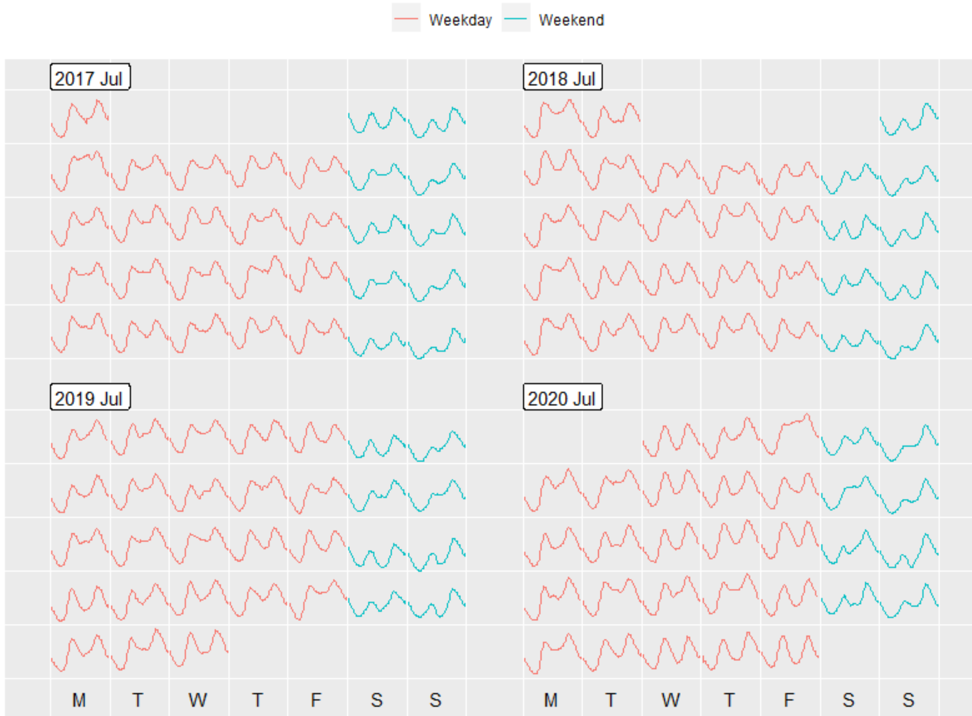

Figure 4: The variations of energy consumption in the month of July

Figure 5: The daily aggregated energy consumption against the daily average temperature, from Jan 2017 to Sep 2020

Table 1: Forecasting Error Summary

Method	RMSE	MASE
ARIMA.COVID	19.6	0.970
ARIMA.NORMAL	19.6	0.971
TSLM.COVID	18.4	0.906
TSLM.NORMAL	19.6	0.978
NAIVE_SEASONAL	30.7	1.410

Energy Forecasting

Based on the previous findings, I fit a host of forecasting models to predict future energy consumption using [2]. The proposed models are, the ARIMA model without the COVID19 dummy variable (*ARIMA.NORMAL*), the ARIMA model with the COVID19 dummy variable (*ARIMA.COVID*), the Time series Regression model without the COVID19 dummy variable (*TSLM.NORMAL*), the Time series Regression model with the COVID19 dummy variable (*TSLM.COVID*), and the Naive Seasonal model without any exogenous variable (*NAIVE_SEASONAL*). The **COVID restriction dummy variable** is introduced for the period from Apr 2020 to Sep 2020 to represent the COVID19 restrictions.

Training period: **2017 Jan - 2020 Aug**, Test period: **2020 Sept** , and *Mean Absolute Scaled Error (MASE)*, *Root Mean Square Error (RMSE)* are used as the primary evaluation metrices. Please refer to [5] or [7] for the detailed explaination of the experimental setup (external variables, model selection, residual analysis)

Table 1 summarises the results of the proposed forecasting benhmarks. The **TSLM.COVID** performs the best, recording the lowest *RMSE* and *MASE*. Also, among ARIMA varaints, the **ARIMA.COVID** variant outperforms the *ARIMA.NORMAL*. This indicates the importance of accounting for the COVID19 restriction factor when forecasting energy consumption under current circumstances. The Figure 6 illustrates the predictions for each forecast model.

Figure 6: The model forecasts vs actual observations for September 2020

References

[1] AEMO Energy Consumption Dataset

[2] fable Package

[3] BOM Weather Data

[4] Australian Holidays

[5] Detailed Analysis (PDF)

[6] feasts Package

[7] Detailed Analysis (HTML)