BUSINESS ANALYTICS PROJECT (BUSA8031)

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MACQUARIE
University

CLIENT REPORT

Submitted to: STEFAN TRUECK

SUBMITTED BY

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Executive Summary

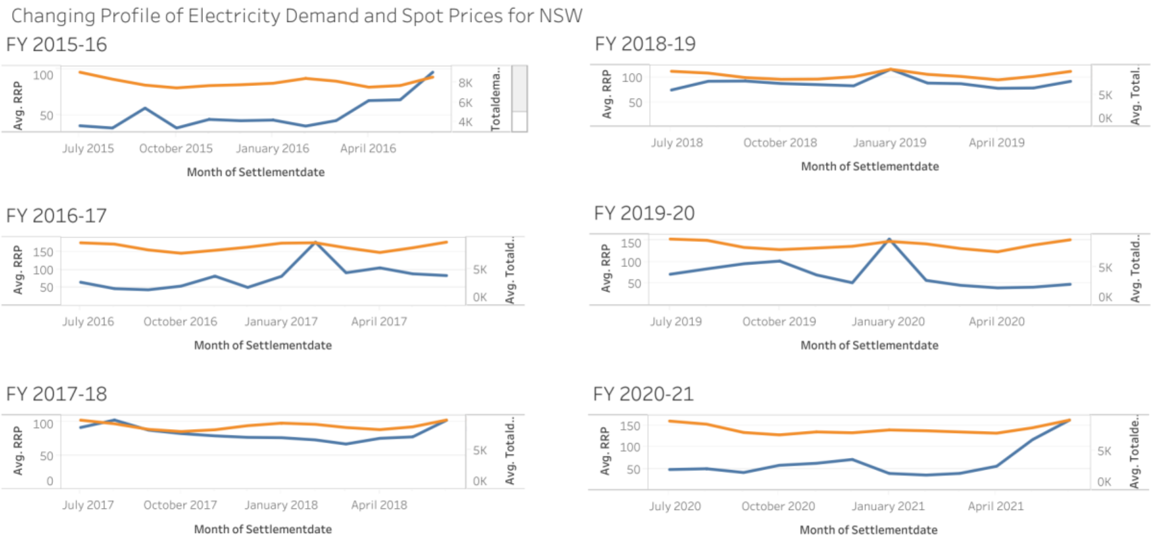
In this report the consulting team is providing advice to the Australian government with regards to electricity, price and demand of NSW and SA. In the Descriptive part of the report, we have shown the Changing Profile of Electricity Demand and Spot Prices for NSW for 2015-2016 as well as the same for SA. The report aims to visualise demand and price for NSW. One thing additional to it is its relationship to solar PV installations. The report has also given a clear comparison of Changes in Price Levels, Volatility and Extreme price outcomes for NSW and SA. The graphs in the report have clearly described the Half Hourly Demands and Prices in South Australia and New South Wales in four main seasons of Australia and its Half Hourly Negative price trends in New South Wales and Australia. In discussion to the Predictive part, We have developed a prediction model for the upcoming half-hourly behaviour of current power prices and demand. By using the two data sets, price and demand forecasts of electricity will be created by using a programming approach. Factors and variables used in making the prediction are discussed briefly. The prediction also covers up the heat map by which we can identify the relationships and correlation between variables Demand, RRP and Pv installed. All the factors such as NSW Trends, Seasonality, NSW Price correlation between AND PVC installed AND RRP and South Australia Correlation between RRP - PVC installed and total demand have been clearly discussed by using the graphs. The report also describes the models used to predict demand. The models are Linear Regression and Tableau. In order to control the extreme price of electricity, which steps companies should take that will help to track the energy consumption and price charges per unit of energy are discussed as well. The report sums up with the Limitation and Assumptions taken to analyse the data.

So, the whole report provides the overview of AEMO data from July 2015 to June 2021.

Descriptive Analytics:

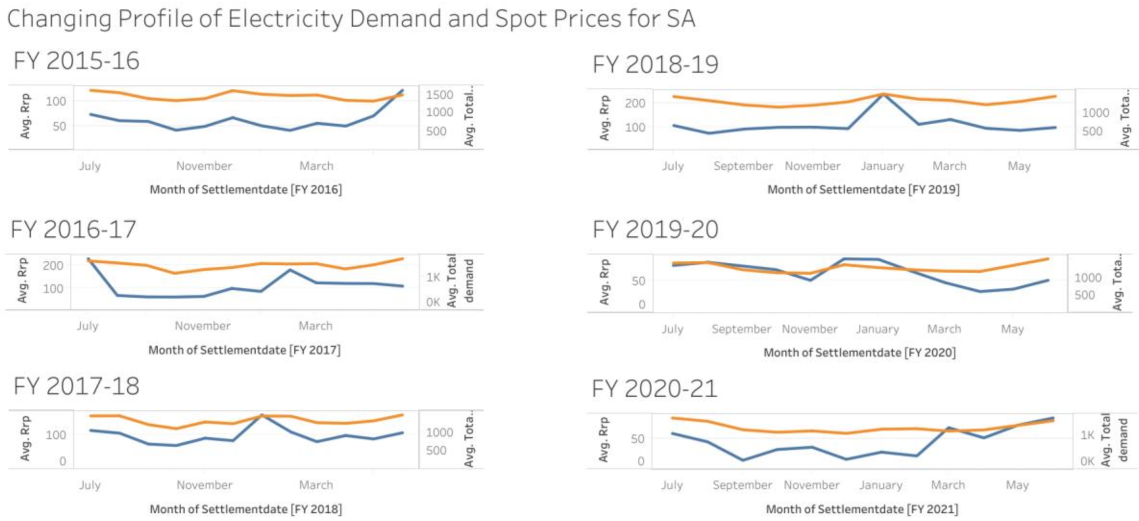
Changing Profile of Electricity Demand and Spot Prices:

Orange line indicates demand and blue line indicates price.



Electricity demand for NSW stayed at an average of 8k throughout the years 2016-2021. Although, if we look in depth for small changes, the demand seemed to be the highest in the months June and July which is winter season and lowest in the months October and April which are Autumn and Spring season. The highest reach throughout the years 2016-2021 was around 9k in July and the lowest reach was around 7k-7.4k in October and April.

Spot prices for NSW has seen many spikes throughout the years 2016-2021. The highest it reached was in FY 2016-17, 178.6 in the month of February and the lowest it reached was in FY 2015-16, 36.75 in August and October. That was the lowest price NSW has seen until in FY 2020-21 during COVID when prices dropped again to 35-39 in January-March. After March 2021, there was a spike again from 55 to 163 in June 2021 (in just two-month time).



Electricity demand for SA stayed at an average of 1.5k throughout the years 2016-2021. Although, if we look in depth for small changes, the demand seemed to be the highest in the months June and July which is winter season and lowest in the month October which is Autumn season. The highest reach throughout the years 2016-2021 was 1,556.6 in July and the lowest reach was around 1k in October and December. We cannot compare this with that of NSW because of the population gap.

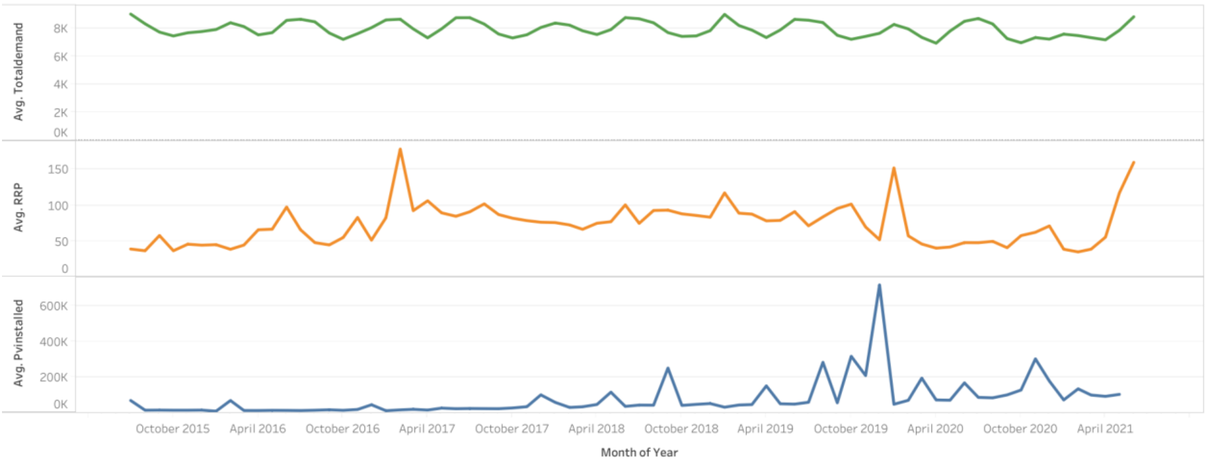
Spot prices for SA, on the contrary has seen bigger spikes than that of NSW with almost 229.5 reach in July FY 2016-17 and 241 in January FY 2018-19. The lowest it reached before its first spike was in February 2016 with 40.72. After that it stayed on an average of 100-200 until FY 2019-2020 and FY 2020-21 when COVID hits. During COVID, SA has seen a drop in prices almost as low as 15 in September 2020, lower than that of NSW. The next rise was of 70 in March 2021 to 85 in June 2021.

One interesting thing to note here was, even though the demand in NSW is four times more than that of SA, the prices in SA were higher than that of NSW. Yet during the time of pandemic, SA has seen a bigger fall in price than NSW.

Changes in Half Hourly Patterns of Electricity Demand, Spot Prices, and PV installations

Green line indicates demand, orange line indicates price and blue line indicates PV installations.

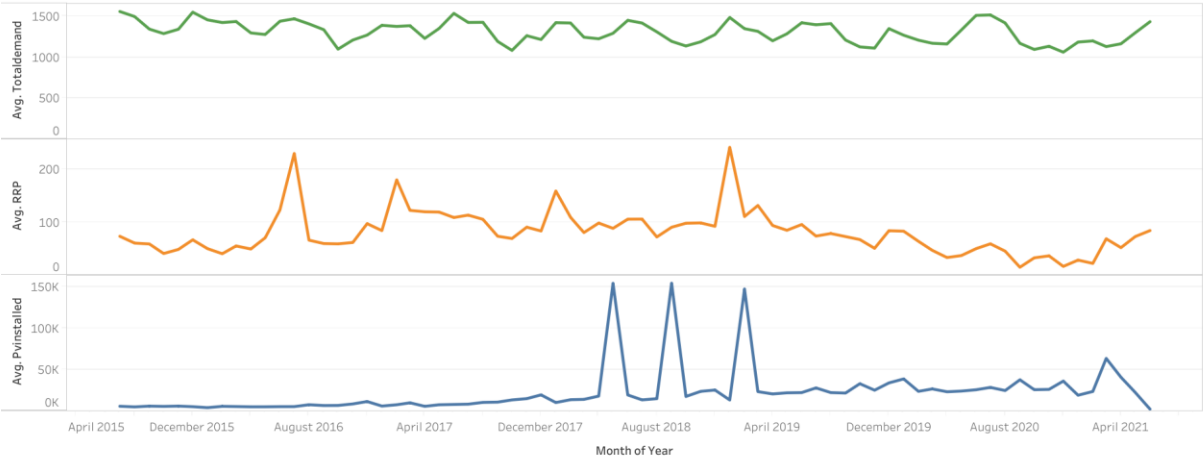
Changes in Half Hourly Patterns of Electricity Demand, Spot Prices, and PV Installations for NSW.



The above visualisation is a half-hourly view of demand and price for NSW, similar to our discussion before. One thing additional is its relationship to solar PV installations.

The average trend of PV installations in NSW over the year 2016-2019 was around 10k with some spikes touching 100k. In FY 2020, it saw the biggest spike of 720k and then the sudden drop to 50k in that same year. After that, it stayed at an average of 200k with just one spike touching 300k in FY 2020-21 November.

Changes in Half Hourly Patterns of Electricity Demand, Spot Prices, and PV Installations for SA.



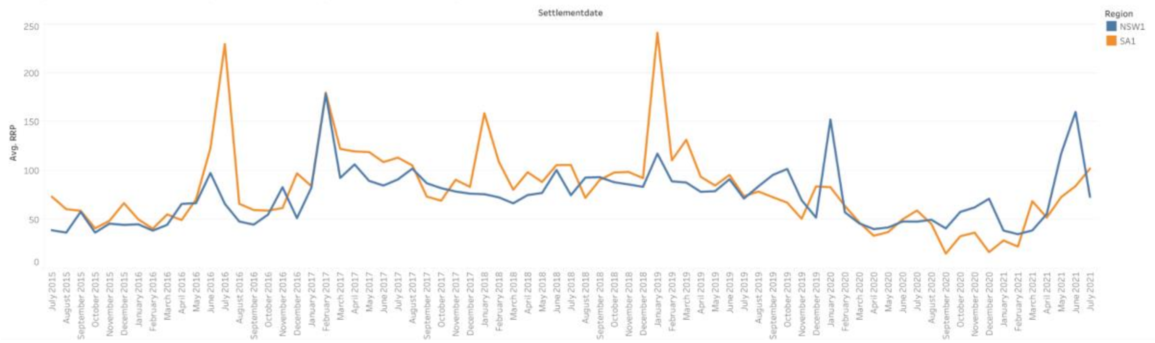
The above visualisation is a half-hourly view of demand and price for SA, similar to the discussion before with an addition of solar PV installations.

The average trend of PV installations in SA, from FY 2015-16 was around 5k-10k until its first spike of 155k in May FY 2017-18 dropping back to an average of 15k in just one month. The second spike of 155k was in September FY 2018-19, dropping back to an average of 20k in the next month. The third spike was of 150k in February of same year, dropping back again to 20k in one month time. It then stayed at an average of 20k with just one (not so big) spike of 64k in March 2021 and then dropping to as low as 2.5k in June 2021.

SA has seen three notable spikes throughout FY 2015-21. However, NSW has only seen one but rather big spike of 720k.

Changes in Price Levels, Volatility and Extreme Price Outcomes

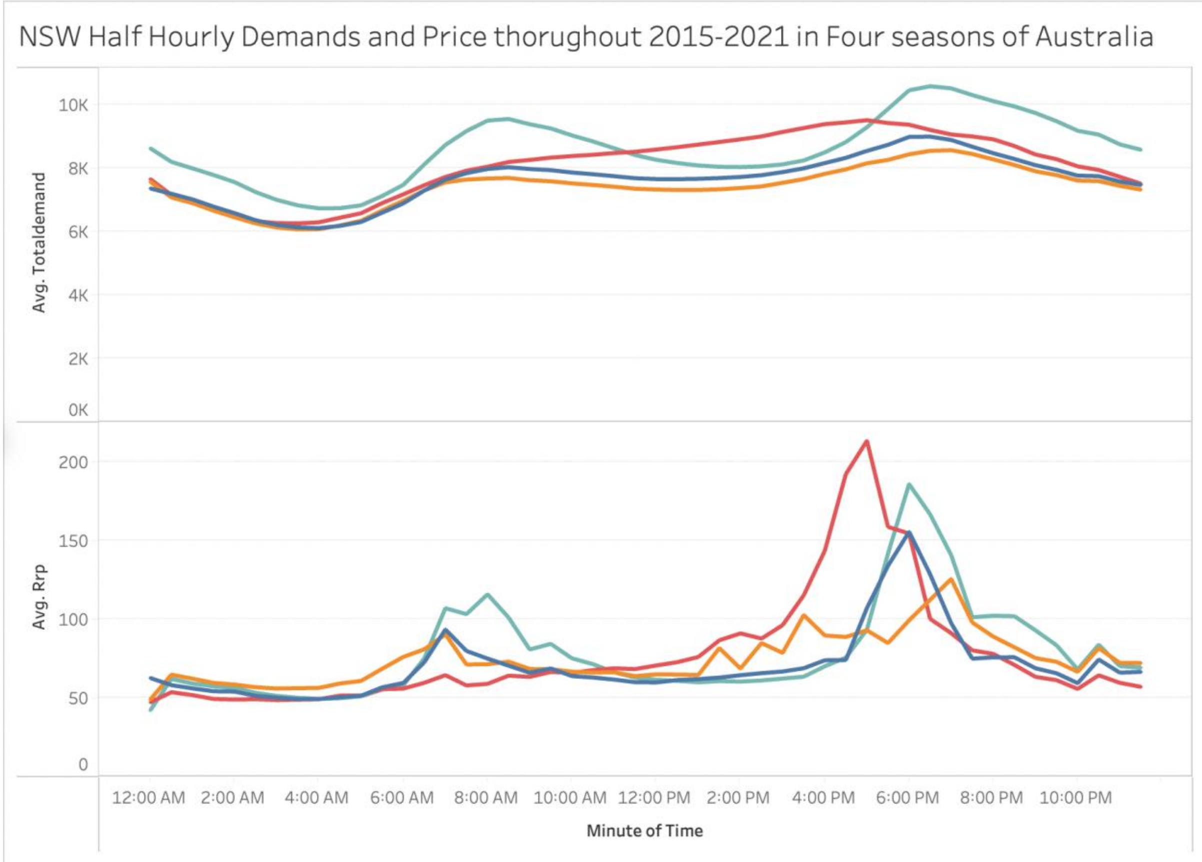
Changes in prices levels through time and changes in price volatility and extreme price outcomes for NSW and SA

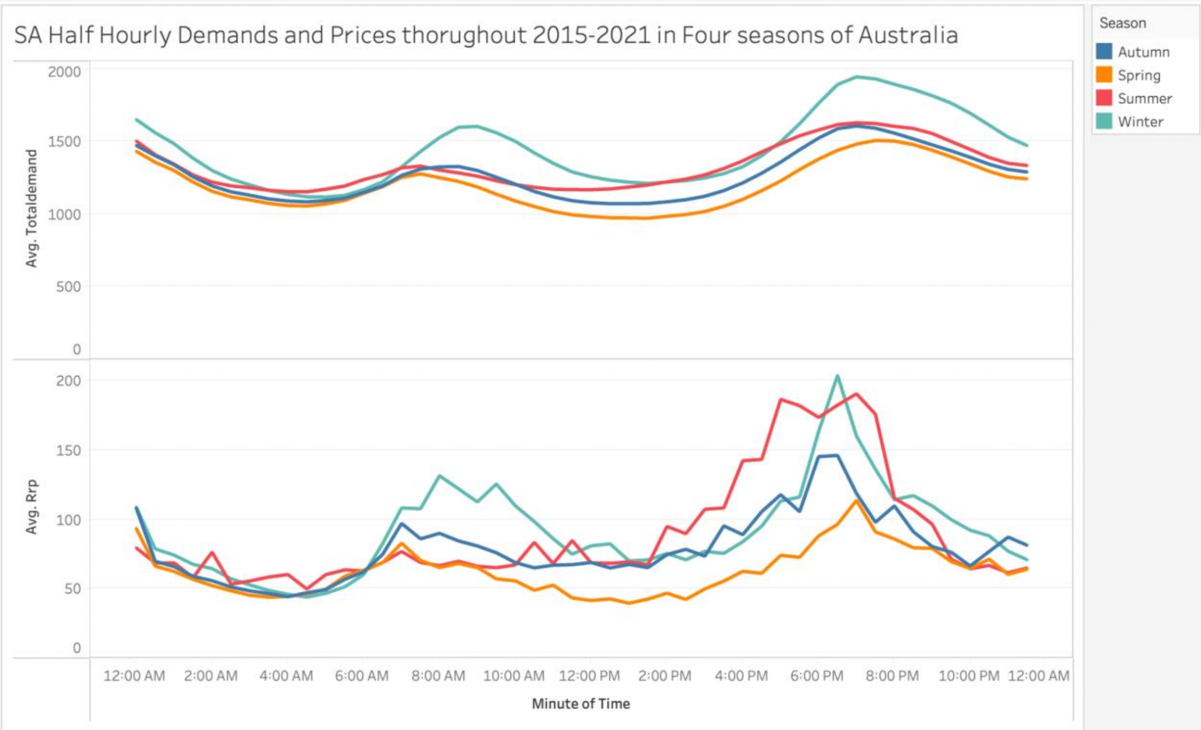


A clear comparison of price shows that SA has seen two rather big spikes of 229 and 241 and two medium spikes of 179 and 159 throughout the FY 2015-21. Whereas NSW has only seen a maximum spike of 180 which was side by side to the 2017 spike of SA in February.

Here, an interesting thing to note is that the price of NSW has always been lower than SA until August 2019. From August FY 2018-19 to January FY 2020-21 (including COVID time), NSW has had higher prices than SA. However, the ending price for FY 2020-21 (start of recovery from pandemic) is 73.3 for NSW and 102.2 for SA.

Half hourly Demands and Prices in South Australia and New South Wales in four main seasons of Australia

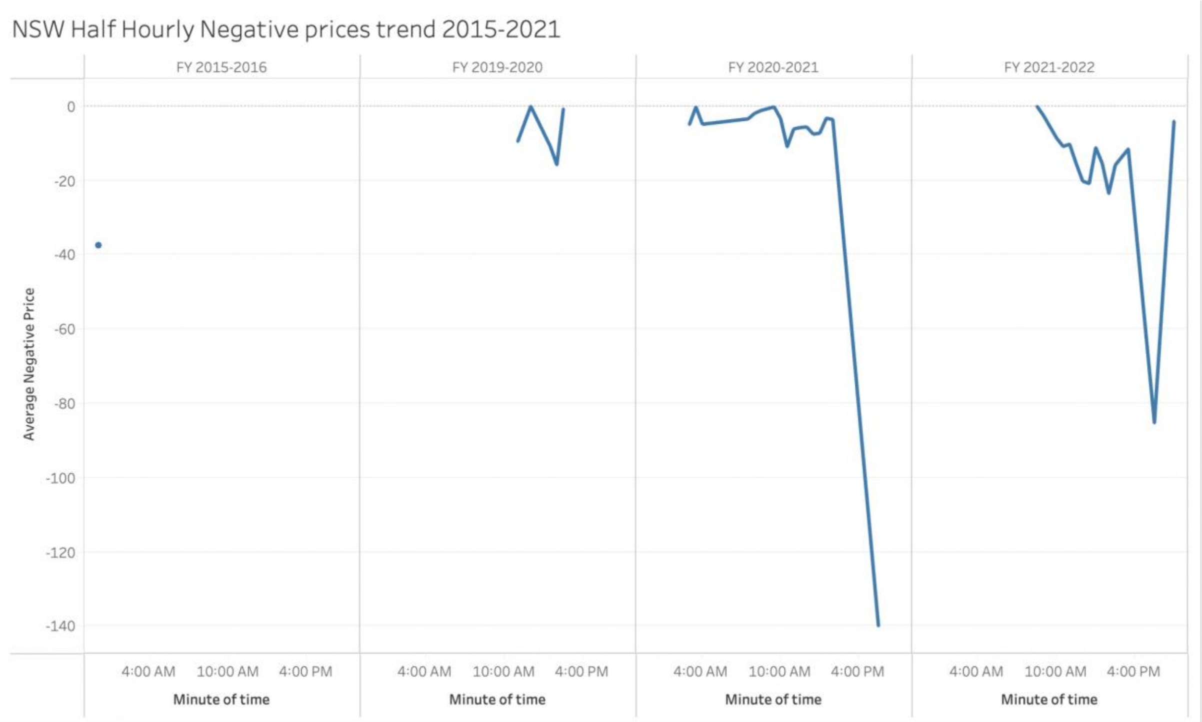


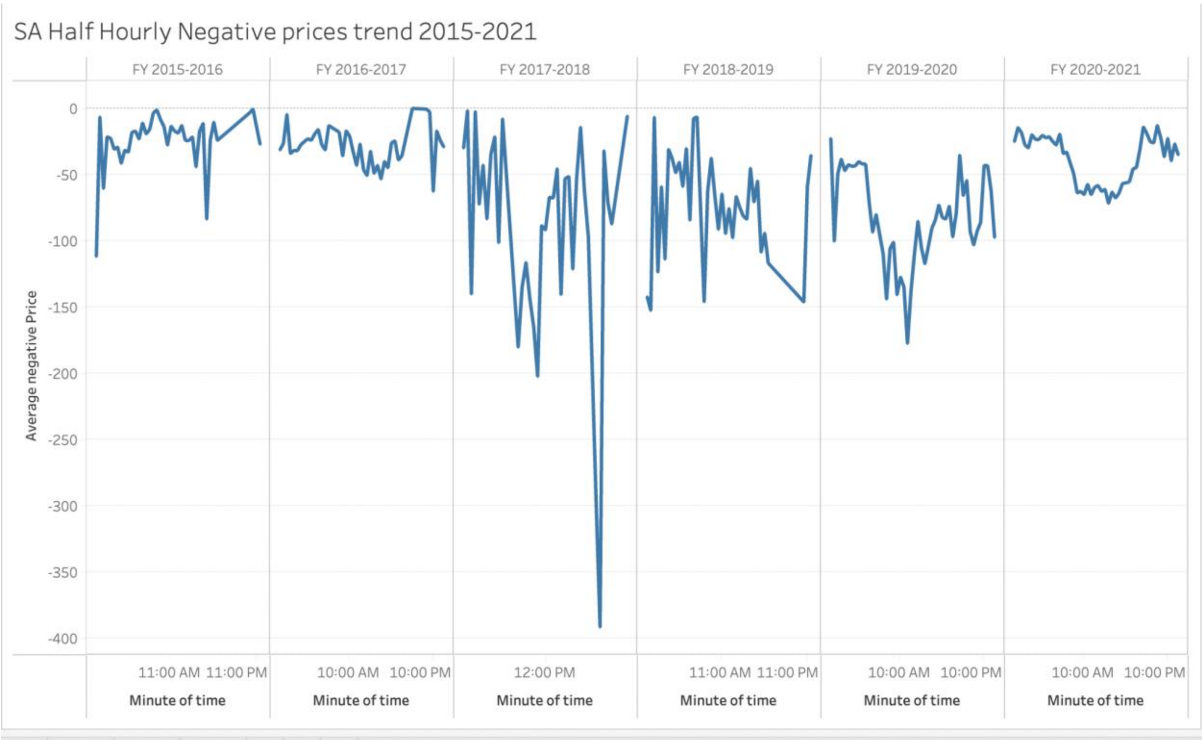


The first above graph is the half hourly prices throughout the day in NSW through 2015-2021 during 4 seasons of Australia. It can be concluded that the overall trend for the prices of electricity through 2015-2021 is increasing and decreasing throughout the day. It can be concluded from the trend is:
The price is low around 4:00 am in all seasons because people in the household are sleeping, not much demand for electricity. When demand increases, price also increases. The price is a bit higher around 9:00 am, because people get up from sleep. The price is the highest around 6:00 pm because the electricity markets need to turn on the expensive generators to meet the increased demand. The demand/consumption is also highest at this point because people in the household are turning on their electrical appliances after coming back home from the office. In the winter season, the electricity consumption is currently the highest because people turn on their heaters at home. Then after 10:00 pm, the electricity consumption is lower because everyone goes to sleep so the price also goes down in all 4 seasons.

On the other hand, in the second graph, South Australia, people are using more solar panels to produce electricity throughout the day which they use at night. (Mountain & Szuster, 2015). The prices are low around 10:00 pm because demand is lower as people are using electricity produced from the solar panel. At night around 12:00 am, the electricity generators and providers are increasing the prices to compensate for that.

Half Hourly Negative price trends in New South Wales and Australia

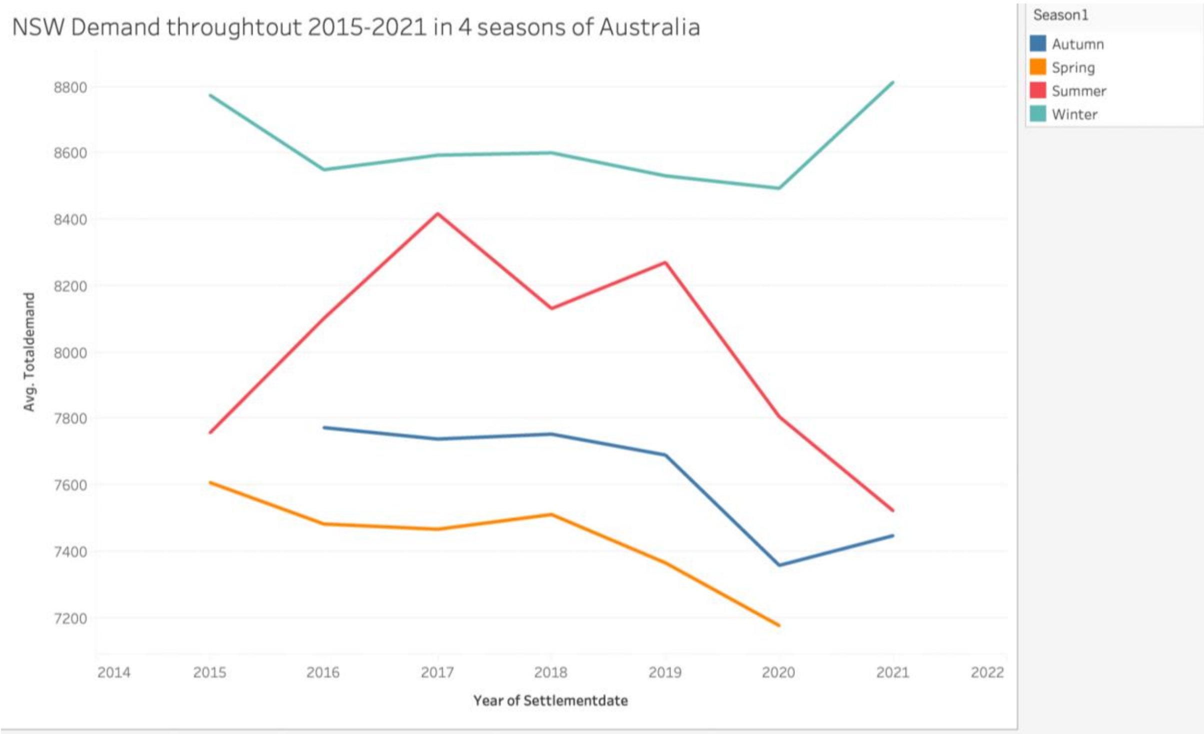




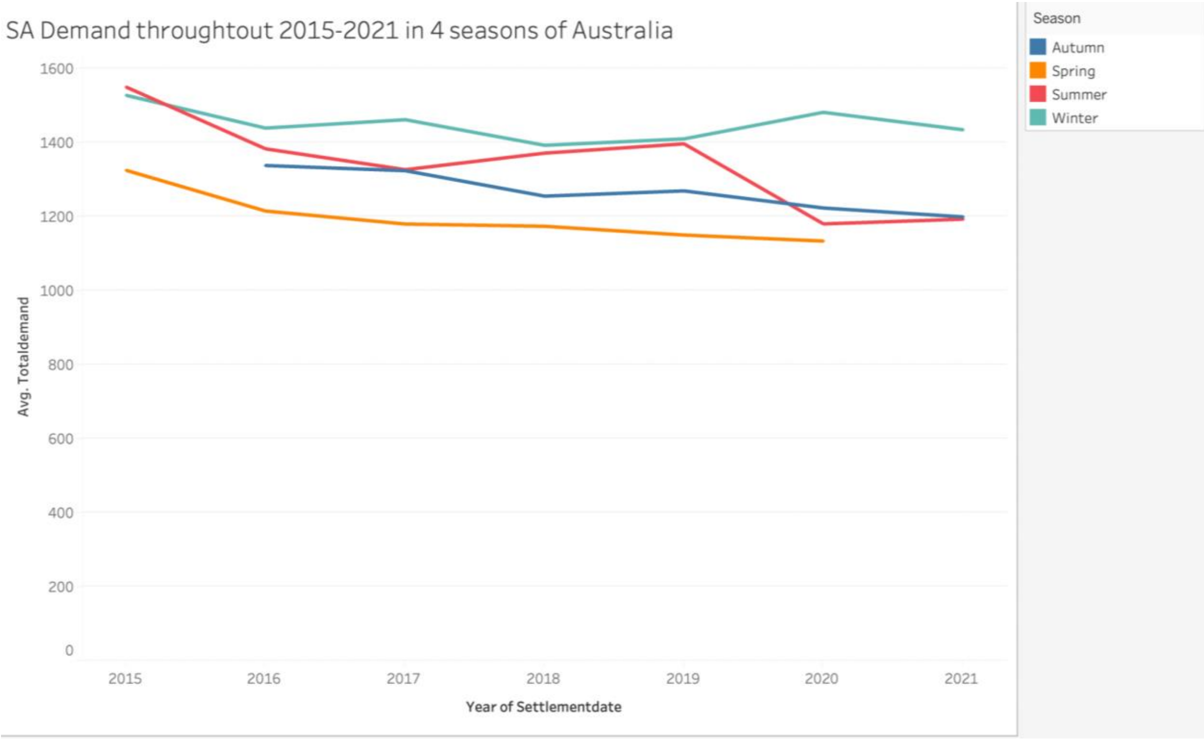
The above graphs, it can be concluded that there are not many negative prices for the entire six years in NSW. There was a sharp negative price at 5:00 pm, this means all the offices were closed around this time, people were consuming less electricity, weather conditions are

good for wind energy generation, so the electricity stock prices had to be sold at negative prices.
On the other hand, in South Australia, it has more negative electricity prices because in South Australia there are more renewable energy generation sources like wind farms and solar. (Teitzel, Haque & Inwood, 2015). In South Australia, people are using solar during the midday which reduces the demand for electricity, hence, reducing electricity markets must sell electricity at a negative price instead of shutting down their generators which will cost them more.

Electricity demand in New South Wales and South Australia in Four main seasons of Australia

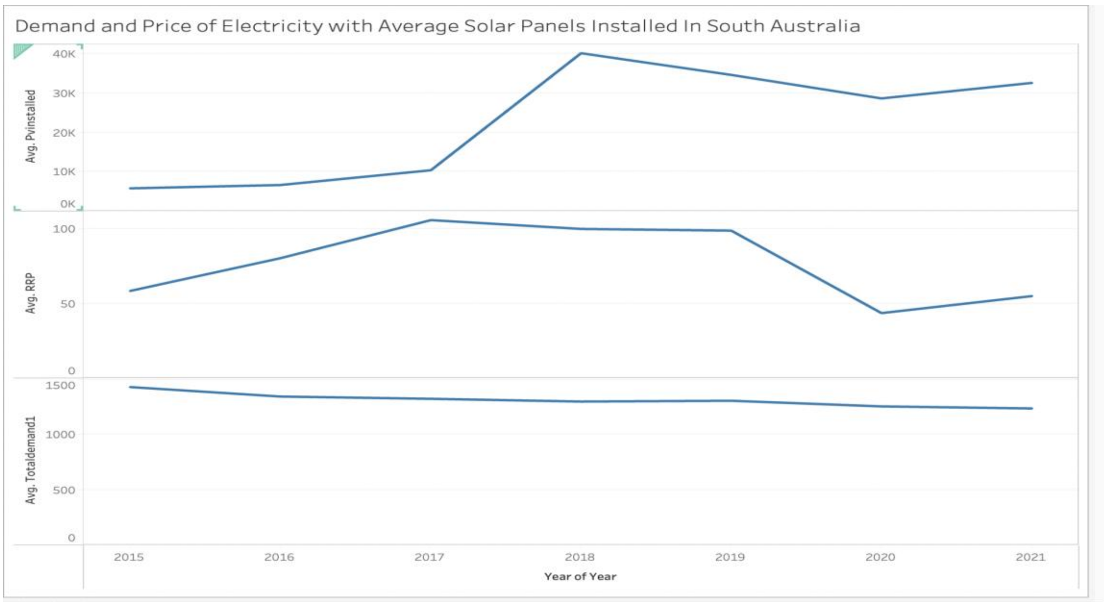


From the above demand against year graph for NSW for 4 different seasons, it can be concluded that the demand of electricity is the highest in the winter as more people are turning on their heaters during the day and night, then the second highest demand is in the summer season because people are turning on their air conditioners more. The demand went down in 2020 and 2021 summer because of milder temperatures and a 2500 MW of solar rooftop capacity in NSW. (Muampashi, et al.,2021).



The above demand graph of South Australia is not showing many changes throughout the six years because South Australia is increasingly using solar PV panels at rooftops and other renewable energy sources to produce electricity which is exceeding the demands for electricity. Nevertheless, the highest electricity demands are in the winter because some people are using heaters in their homes.

To support my arguments regarding the price and demand going down as more solar panels are installed, I have visualized the below graph:



As it can be seen, the demand of electricity is slowly going down throughout 2015 to 2022 as more and more solar panels are being installed on rooftops of houses. The price is also decreasing as the demand goes down.

Predictive Analysis

Introduction

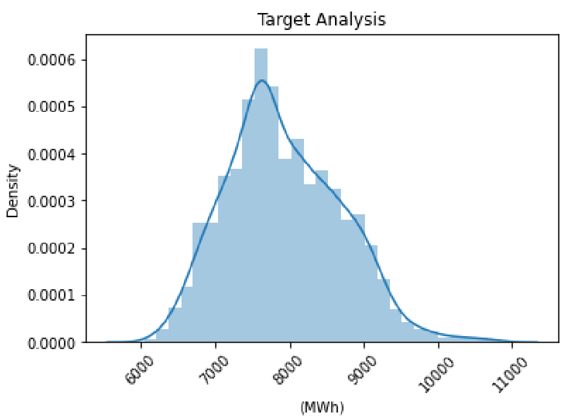
In this report, the predictive analysis is to develop a prediction model for the upcoming half-hourly behaviour of current power prices and demand. Here, as both a member of a data as well as for analytics implementation team, users will be expected to deliver meaningful analysis by considering the two regions that are South Australia and New South Wales. By using the two data sets, price and demand forecast of electricity will be created by using programming approach.

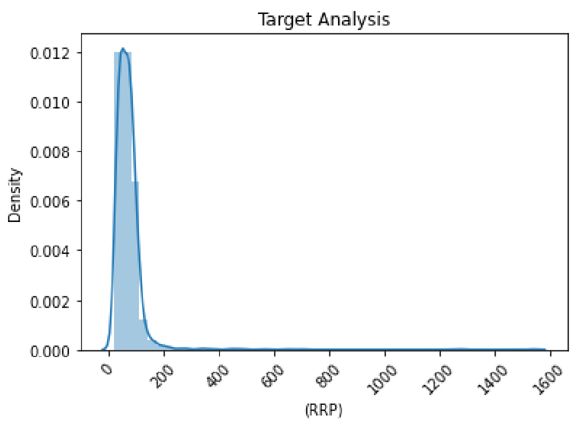
Factors and variables are used in making the prediction

In this dataset, the factors and variables are used for making the prediction to predict electricity demands Forecasting power consumption is becoming increasingly crucial as the demand for power rises (van Smeden *et al.* 2019). Electricity forecasting is governed by a set of different variables such as climate, weather, and socio-economic activities. We used PV installed monthly data as an important independent variable correlating with demand and price. Understanding how much power will be required in advance has a substantial influence on carbon production, energy costs, as well as policy decisions.

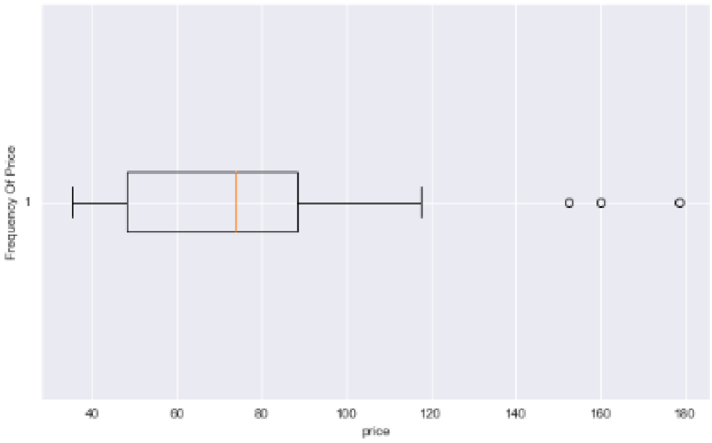
Predictive analysis of both demand and electricity prices

<u>NSW Demand and Price distribution.</u>



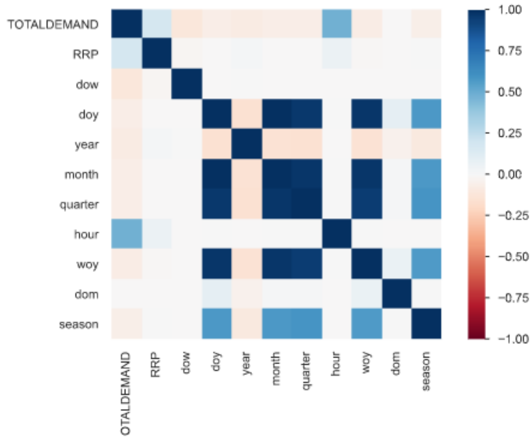


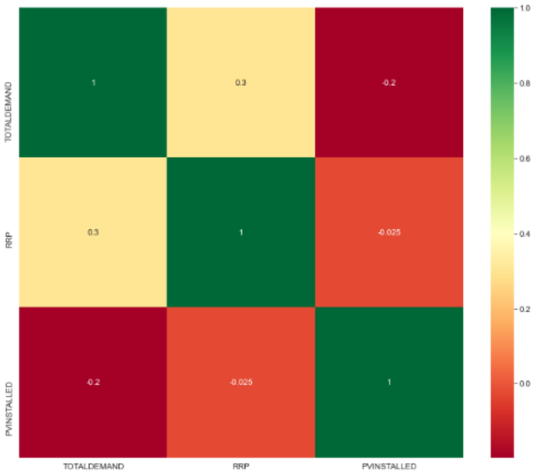
As seeing the distribution of Demand, Demand distribution is slightly skewed towards the left but still comes under stationary series. Whereas Price distribution is left-skewed meaning that every price has different statistical properties that are changing through time.



By fixing a boxplot, we can identify the outliers in the data. Therefore, we see some unusual prices in NSW that is going between AUD 140-180.

NSW DEMAND AND PRICE HEATMAP

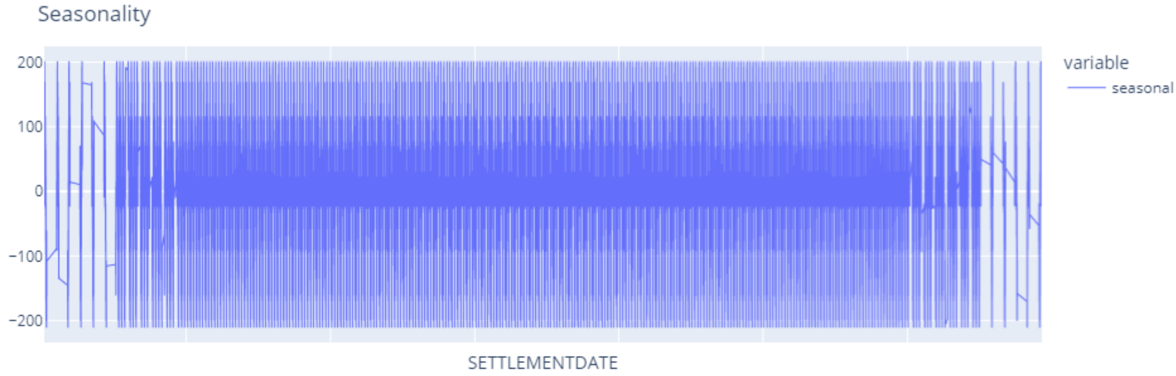


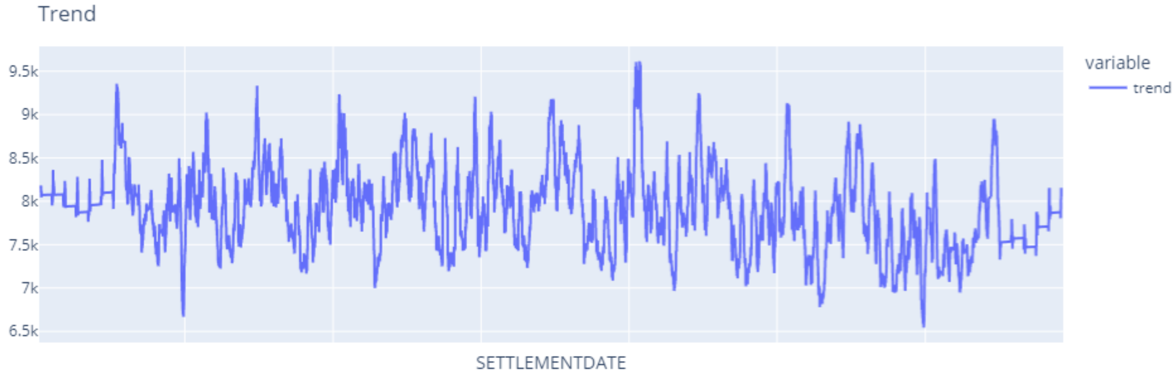


In the heat map, we can identify the relationships and correlation between variables Demand, RRP and Pv installed.

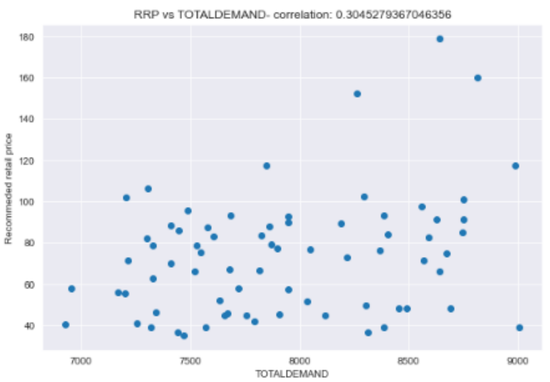
NSW TREND, SEASONALITY

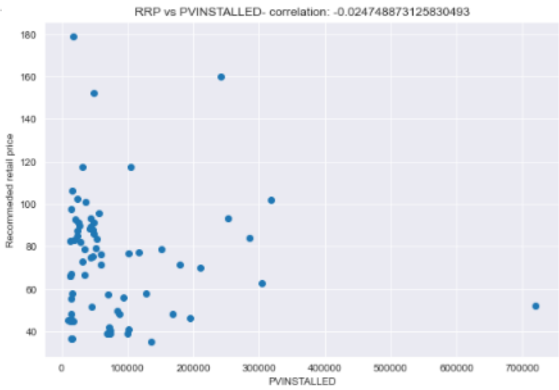
Data points over time can be interesting in the sense that their patterns are complemented by a trend (upward or downward) and/or seasonality.





NSW PRICE CORRELATION BETWEEN AND PVC INSTALLED AND RRP

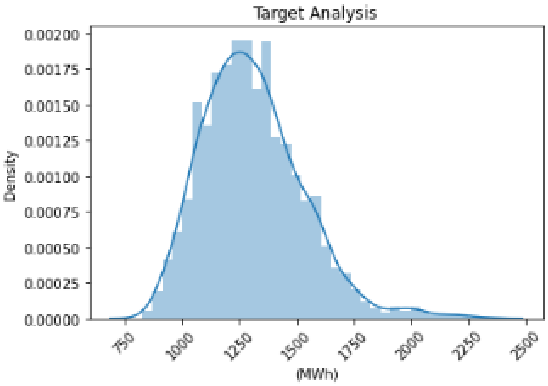


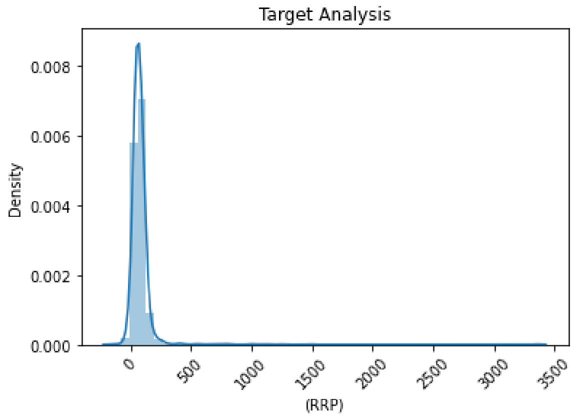


RRP and Total Demand shows a positive relation as Price is increasing with increase in Demand

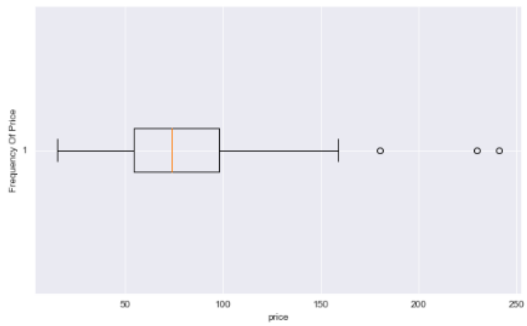
RRP and Pv Installed shows a negative relation where increase In PV installed decrease the price.

SOUTH AUSTRALIA demand and price DISTRIBUTION



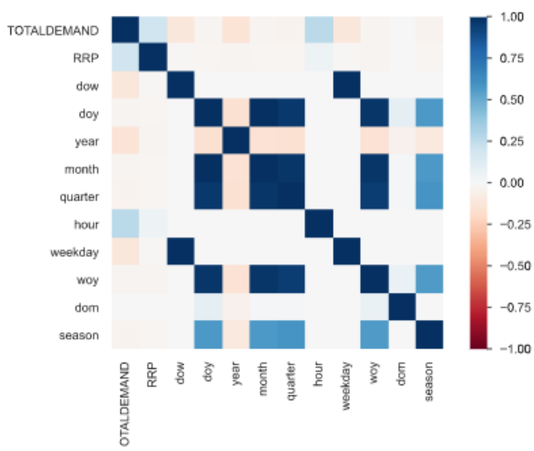


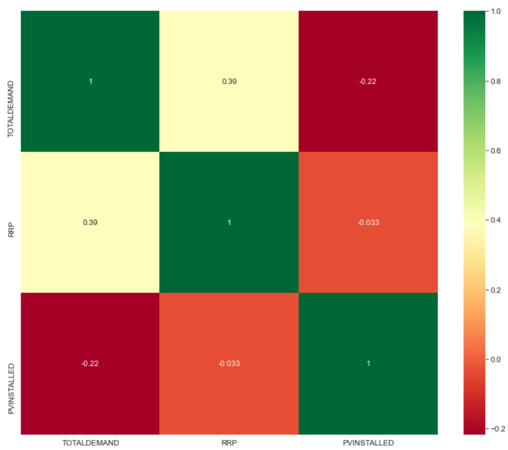
As seeing the distribution of Demand, Demand distribution is slightly skewed towards left but still comes under stationary series. Whereas, Price distribution is left skewed meaning the every price has different statistical properties are changing through time.



By fixing a boxplot, we can identify the outliers in the data. Therefore, we see some unusual prices in SA that is going between AUD 200-250 which is more than NSW RRP.

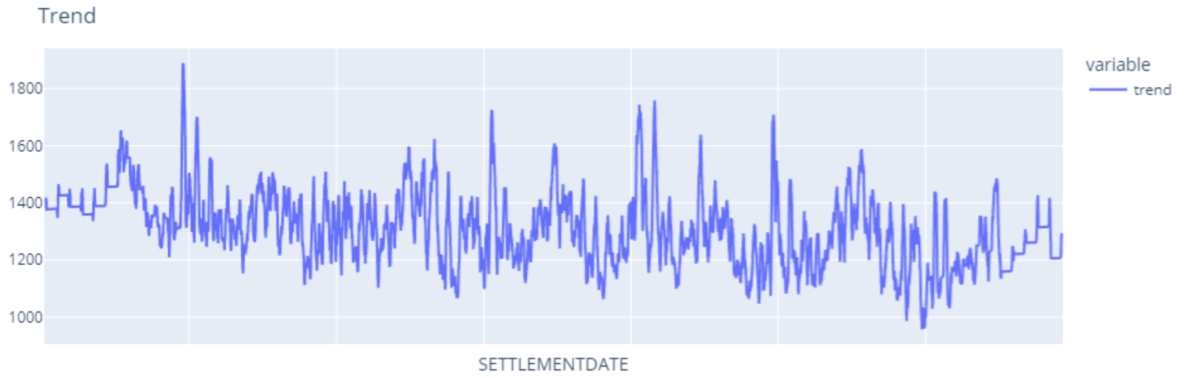
SOUTH AUSTRALIA DEMAND AND PRICE HEATMAP

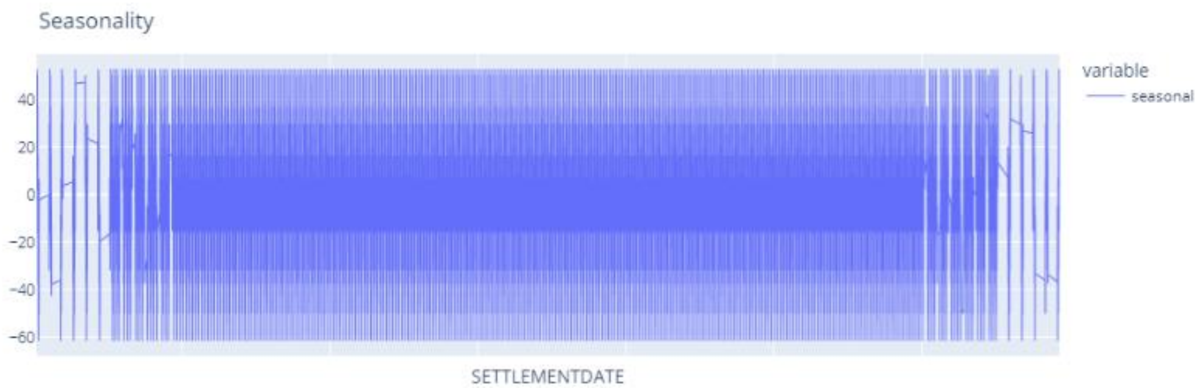




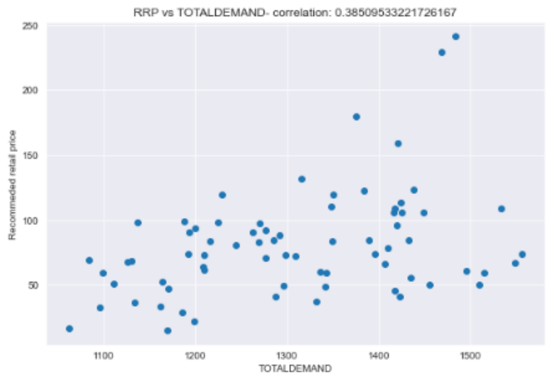
In the heat map, we can identify the relationships and correlation between variables Demand, RRP and Pv installed.

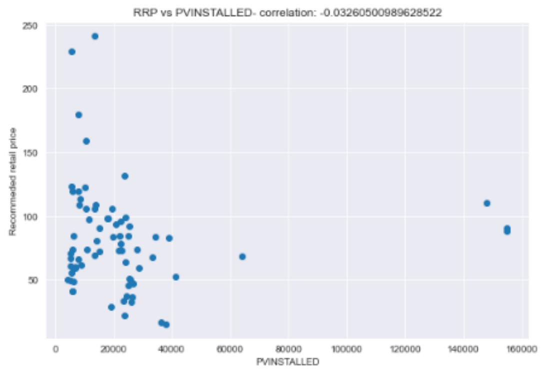
SOUTH AUSTRALIA TREND, SEASONALITY





SOUTH AUSTRALIA CORRELATION BETWEEN RRP - PVCINSTALLED AND TOTALDEMAND



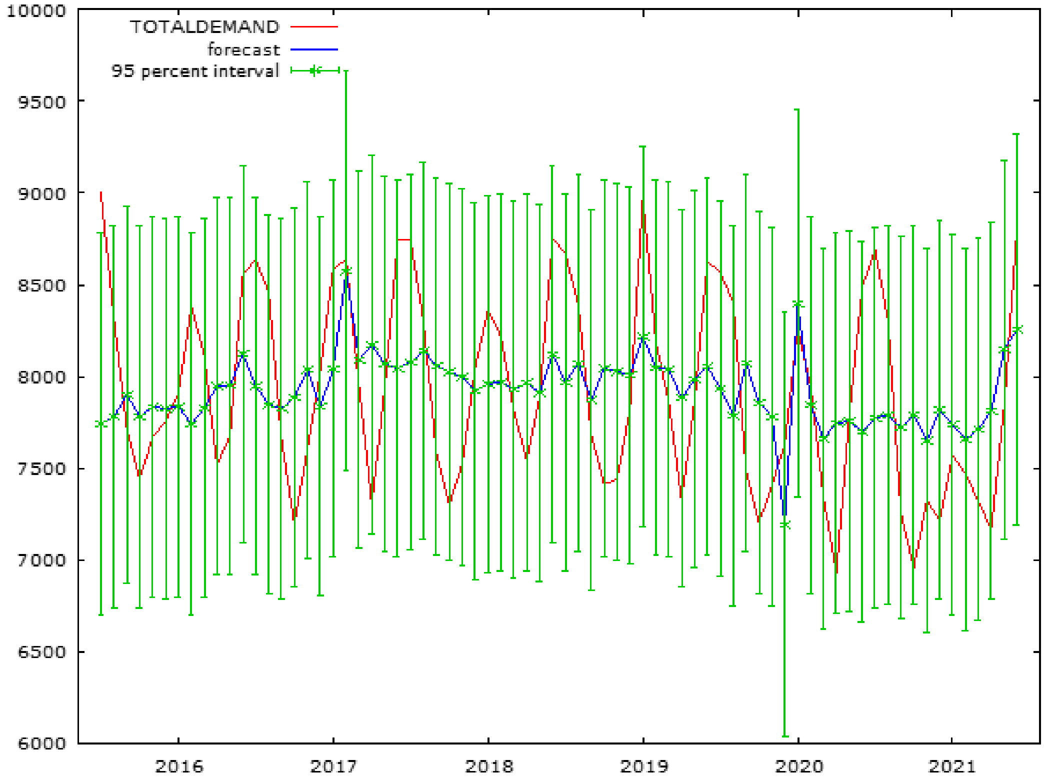


RRP and Total Demand shows a positive relation as Price is increasing with increase in Demand.	RRP and Pv Installed shows a no relation.

MODELS USED TO PREDICT DEMAND

NEW SOUTH WALES -

LINEAR REGRESSION



$$TD = const + 5.60467\beta_1 - 0.000959506\beta_2$$

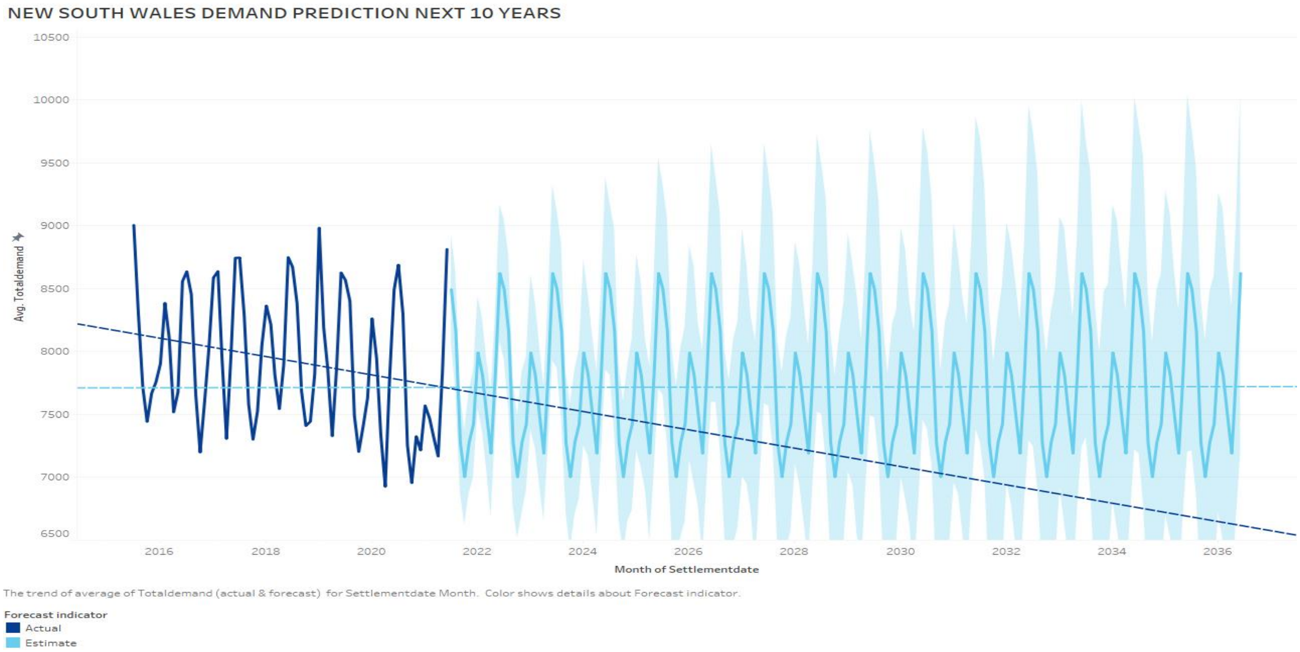
Model 1: OLS, using observations 2015:07-2021:06 (T = 72)
Dependent variable: TOTALDEMAND
HAC standard errors, bandwidth 3 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	7590.87	167.407	45.34	<0.0001	***
RRP	5.60467	1.89620	2.956	0.0043	***
PVINSTALLED	−0.000959506	0.000401317	−2.391	0.0195	**

Mean dependent var	7924.645	S.D. dependent var	538.7420
Sum squared resid	17959349	S.E. of regression	510.1768
R-squared	0.128494	Adjusted R-squared	0.103232

An increase in 1 PV installed would decrease the demand by -000959506 . Whereas, an increase in 1 RRP would lead to an increase of 5.60467 demand. As you can see, The model is overfitting with $R^2 = 0.128494$ and RSS 1959349 which is quite high with a Mean of 7924.645.

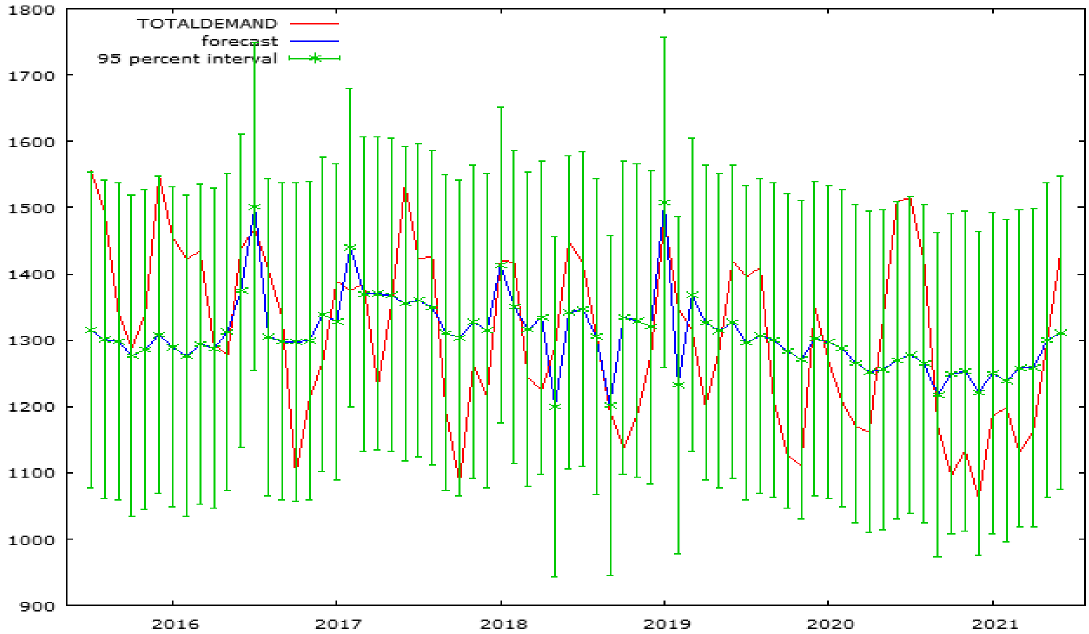
Tableau



This future demand is predicted using Tableau and it shows that price remain constant over the period with a downward trend. With increase in population, This can be interpreted as the demand increased in future, PV installed also increased during the same span of time. Making price of RRP stable and consistent.

SOUTH AUSTRALIA

Linear Regression



$$TD = const + 1.18929\beta_1 - 0.000895768\beta_2$$

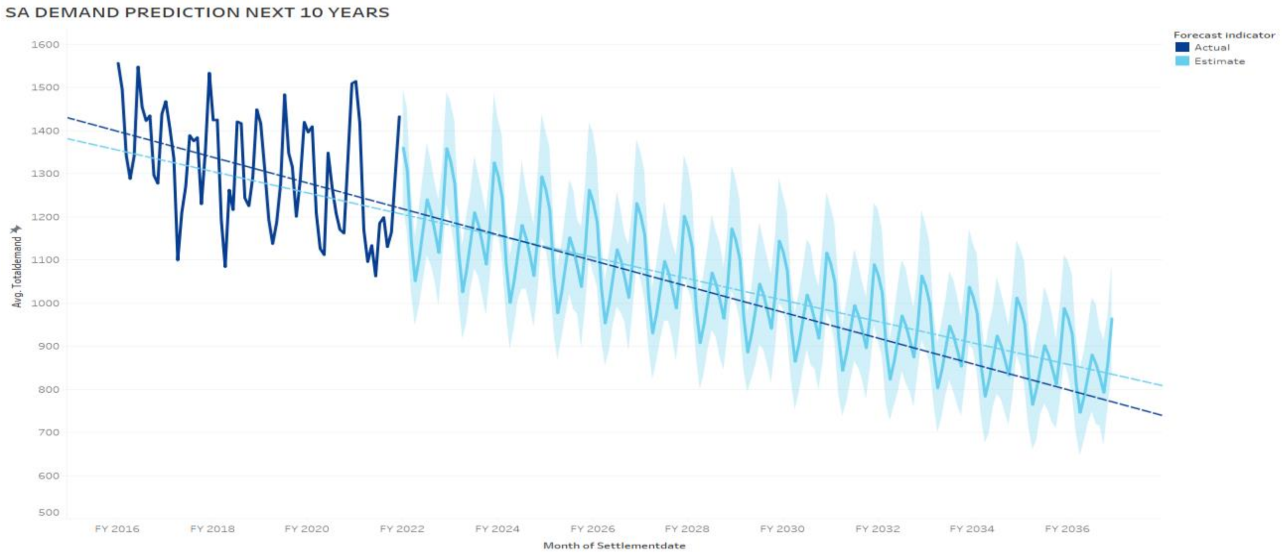
Model 1: OLS, using observations 2015:07-2021:06 (T = 72)
Dependent variable: TOTALDEMAND
HAC standard errors, bandwidth 3 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	1233.43	42.9633	28.71	<0.0001	***
RRP	1.18929	0.319426	3.723	0.0004	***
PVINSTALLED	−0.000895768	0.000415680	−2.155	0.0347	**

Mean dependent var	1308.694	S.D. dependent var	128.6902
Sum squared resid	952407.6	S.E. of regression	117.4862
R-squared	0.190021	Adjusted R-squared	0.166544

An increase in 1 PV installed would decrease the demand by -0.000895768 . Whereas, an increase in 1 RRP would lead to an increase of 1.18929 demand. As you can see, The model is overfitting with R^2 = 0. 190021 and RSS 952407.6 which is quite high with a Mean of 1308.694

Tableau



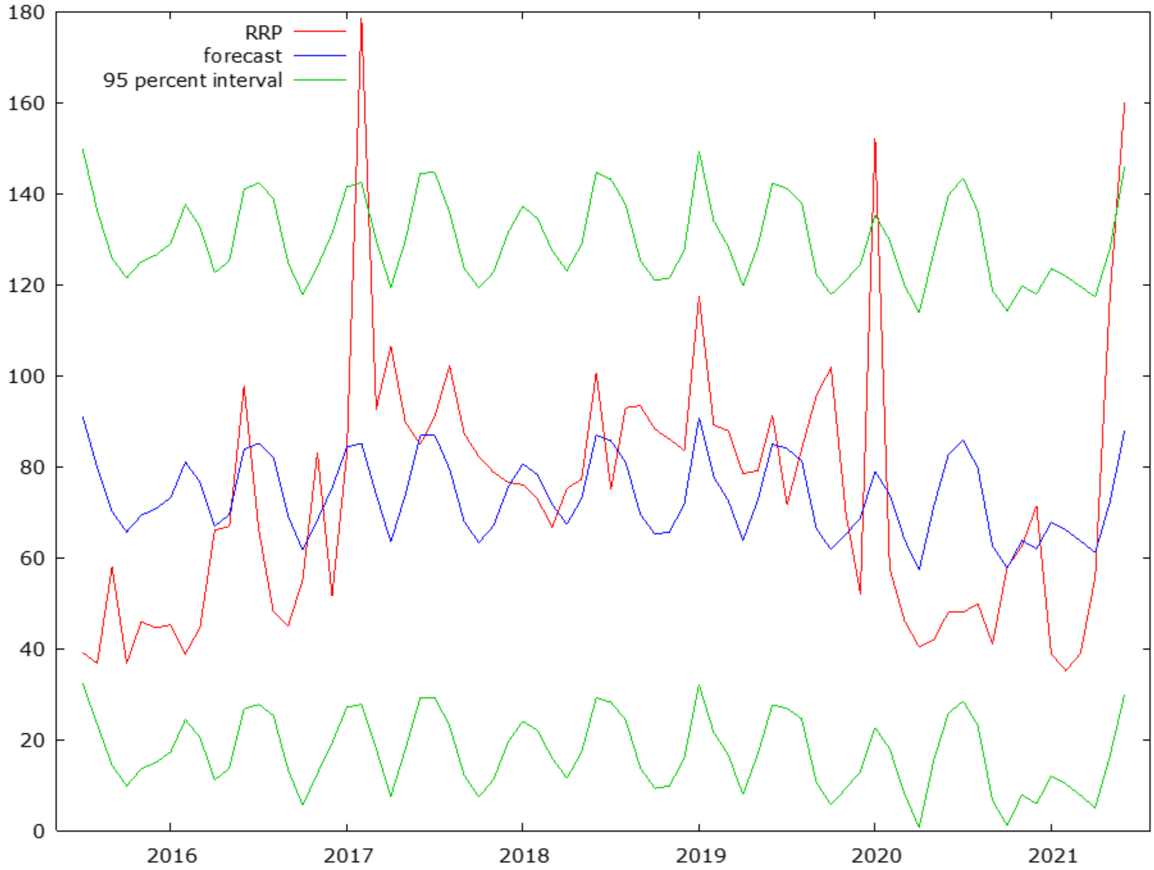
The trend of average of Totaldemand (actual & forecast) for Settlementdate Month. Color shows details about Forecast indicator.

This future demand is predicted using Tableau and it shows that price decreases over the period with a downward trend. With less population, This can be interpreted as the demand increased in future, PV installed also increased during the same span of time. Making price of RRP in decreasing trend.

MODELS USED TO PREDICT PRICE

NEW SOUTH WALES

LINEAR REGRESSION



Model 1: OLS, using observations 2015:07-2021:06 (T = 72)
Dependent variable: RRP
HAC standard errors, bandwidth 3 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−55.6105	52.5178	−1.059	0.2933	
TOTALDEMAND	0.0162921	0.00684230	2.381	0.0200	**

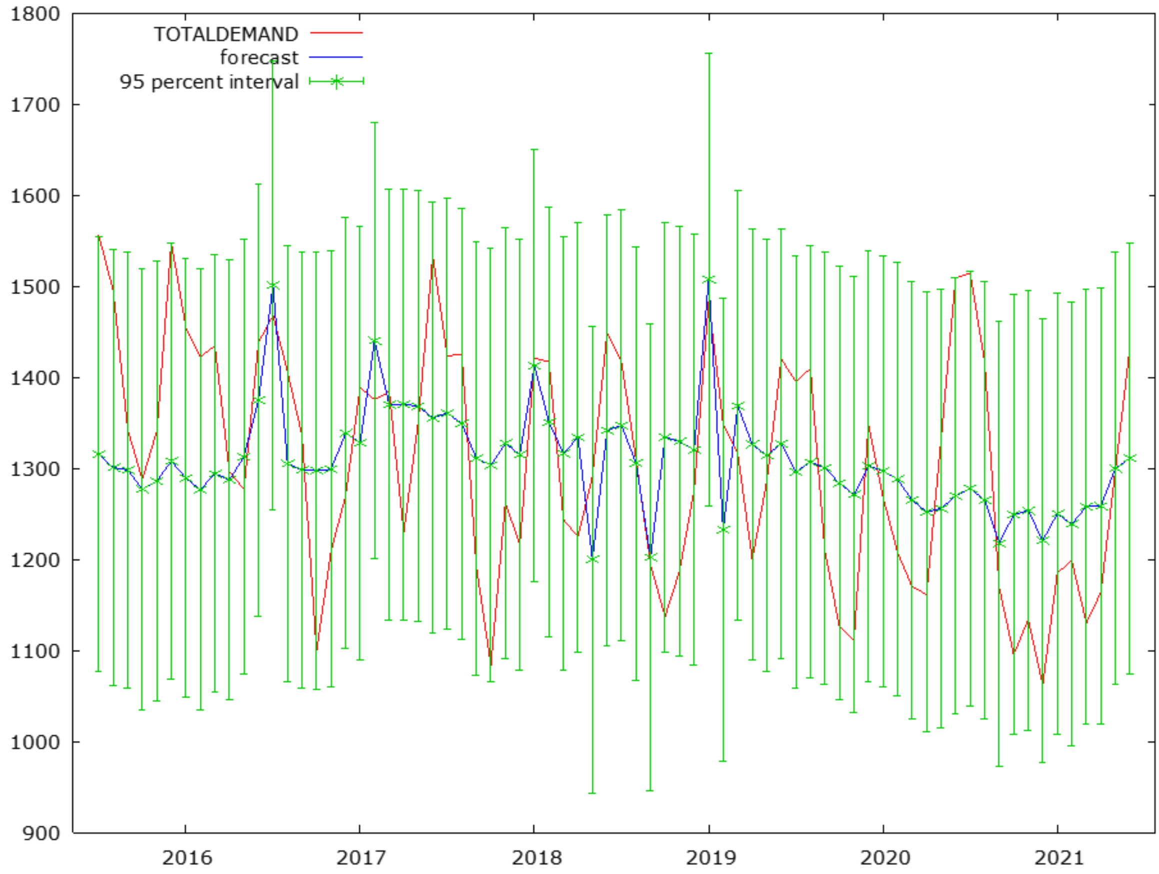
Mean dependent var	73.49826	S.D. dependent var	28.82237
Sum squared resid	53511.94	S.E. of regression	27.64880
R-squared	0.092737	Adjusted R-squared	0.079776

$$TD = -55.6105 + 0.0162921\beta_1$$

An increase in 1 unit of Total demand would increase the RRP by 0.0162921. As you can see, The model is overfitting with $R^2 = 0.092737$ and RSS 53511.94 which is quite high with a Mean 73.49826

South Australia

LINEAR REGRESSION



Model 3: OLS, using observations 2015:07-2021:06 (T = 72)
Dependent variable: RRP
HAC standard errors, bandwidth 3 (Bartlett kernel)

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−79.5257	56.0287	−1.419	0.1602	
TOTALDEMAND	0.122537	0.0453976	2.699	0.0087	***

Mean dependent var	80.83809	S.D. dependent var	40.94921
Sum squared resid	101399.7	S.E. of regression	38.06005
R-squared	0.148298	Adjusted R-squared	0.136131

$$TD = -79.5257 + 0.122537\beta_1$$

An increase in 1 unit of Total demand would increase the RRP by 0.148298. As you can see, The model is overfitting with R^2 = 0.148298 and RSS 101399.7 which is quite high with a Mean 80.83809.

Alter solution to energy crisis

In order to control the extreme price of electricity, companies should take some vital steps that will help to track the energy consumption and price charges per unit of energy. Artificial intelligence (AI) and supervised learning systems have the potential to improve practically everything else element on this category. Machine learning techniques have the potential to drastically transform how we use electricity in our residences and companies by monitoring consumer behaviours and offering new techniques, or by automatically managing aspects (Fachrizal et al. 2020). To be established, all innovations require time, investment, and sensory quality. Furthermore, an increasing number of consumers are interested in learning new strategies to reduce overall energy cost and use and effect to the environment. Tools to make alternative energy and require less energy in the first spot must have a significant positive influence on the environment if companies going to invest.

Limitation and Assumptions

1) Data was on half hourly, for PV installed converted the data from half-hourly to Monthly
2) used another independent variable PV installed for better demand prediction.
3) It’s assumed the Total demand column is the demand received by the energy company during the span of time, not the actual total demand

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