Abstract

Since 1998 the East Coast Australian Energy Market has been driven by the National Energy Market (NEM). This is an organisation that since 2005 has rules set by the Australian Energy Market Commission (AEMC) and since 2009 the operational day to day management of the NEM has been managed by Australian Energy Market Operator (AEMO).

The NEM consists of 5 regions Queensland, New South Wales (including the Australian Capital Territory), Victoria, South Australia, and Tasmania. It has 40,000km of transmission cables with the longest distance of any electricity grid in the world traversing from Port Douglas QLD through to Port Lincoln in SA. IT produces around 200 terrawatt hours of electricity and provides 80% of the Australian Electricity market.

The NEM is accountable for matching the supply and demand of the Electricity market, it does this through 2 main mechanisms, a spot market that ensures electricity in real time, and sends signals to the electricity suppliers to power up and down generators, and contract market that provides surety in electrical supply in the long term.

The ability to predict the electrical demand has real financial benefits for both of these markets. It enables Electricity supplies to negotiate successful long term contracts removing the risk and variance in the spot market, As the modelling improves it also means that Electrical suppliers are able to best manage their systems and have successful bids in the spot market.

The demand for electricity is driven by several factors, these can be categorised into 2 main categories

Long term drivers are components such as (could make long/short term into a table?)

1. Climate Change

2. Expansion of Renewable Energy supplies

3. Expansion of rooftop solar

4. Increase of Electrical cars, which move users of petrol energy to electrical energy

5. Increase in Electrical Storage systems such as Batteries and Pumped Hydro

The increase in electrical storage systems has an interesting effect, pumped hydro for example has a round trip efficiency of around 80%, this means that the total demand for electricity is increased, however the ability to “flatten” the electrical demand, and makes it easier to supply renewable energy during peak periods.

Short Term drivers of electrical demand are

1. The time of Day

2. If a day is work day or non work day

3. The temperature (people heating or cooling)

4. Wind speeds (where people are spending their time)

5. Cloud cover (the efficiency of local rooftop solar)

From a geographical point of view, the location of electrical demand is proportional to the population of locations. This becomes important when modelling electrical demand, as it helps with understanding the granularity of the data available to build the modelling. For example, based on the Australian Building Codes Board climate zones definitions, and the close proximity to each other the temperature at Bankstown Airport is representative of the geographical regions of Sydney, Wollongong and Newcastle which accounts for a large percentage of the NSW total demand, where as the temperature of Canberra is representative of the ACT and other Central tablelands cities (roughly 10% of the population of the NSW region). (https://www.abcb.gov.au/Resources/Tools-Calculators/Climate-Zone-Map-NSW-and-ACT)

Wind and Cloud cover require much greater granularity in measuring as the wind and cloud cover significantly change over a geographical area, for this type of data it would require more accurate modelling of locations of Rooftop solar, and the associated cloud cover.

The current NEM spot markets operate on supply of electricity over 5 minute intervals, with the demand modelling done over 30 minute periods. The focus of this study is to improve the accuracy of the forecast modelling, this would enable greater reliability in electrical supply for the community, better ability for matching supply and demand in the electrical market, and provide stability and planning for Electricity supplies to participate in the energy market.

**Part 1 - Introduction & Motivation**

We aim to create a model that can predict the demand for electricity, to a higher degree of accuracy that the current methods used for forecasting demand. We believe that the gap between forecasted and true demand can be solved by accounting for solar panels and their usage throughout the day. Thus using temperature data, as well as other external datasets such as cloud coverage, we intend on using a Neural Network to fill-in the gaps between the current forecasted and true demand. Given that the current RMSE between forecasted and true electricity demand is roughly 85.87, the measure of success for this project is to build a more accurate model with an RMSE of at most 75. By taking into account solar panel usage, we intend on building a model that can predict electricity demand with more certainty.

**Part 2 - Literature Review**

Since 1998 the East Coast Australian Energy Market has been driven by the National Energy Market (NEM). This is an organisation that since 2005 has rules set by the Australian Energy Market Commission (AEMC) and since 2009 the operational day to day management of the NEM has been managed by Australian Energy Market Operator (AEMO).

The NEM is accountable for matching the supply and demand of the Electricity market, it does this through 2 main mechanisms, a spot market that ensures electricity in real time, and sends signals to the electricity suppliers to power up and down generators, and contract market that provides surety in electrical supply in the long term.

Roof top solar has been on the increase throughout NSW since << date>> and is expected to be one of the largest impacts to energy demand, Roof top solar provides individual houses with their electricity needs during high solar periods, as such they are not putting load on the grid <<cite>> . The current forecast models that are created by the AEMO do not include the rooftop solar as part of their demand, as it is not required to be included in either the contract or spot markets.Whilst Modeling has been done in other locations that include rooftop solar, it has not been included in the NEM data todate. Techniques such as linear regressions, neural networks have been used to model Energy Demand Data in the past, however to date the inclusion of solar information has not been included in the NSW modeling. Our investigation intends to use either synthetic solar information based on the bankstown latitude and longitude as being representative of the solar profile of NSW (based on the current population density of people in NSW). This data would then be used to increase the accuracy of the current AEMO predicted demand calculations, providing a more accurate RMSE.

**Part 3 - Data, Software & Methods**

In terms of the data, we intend on using Cloud coverage and Wind speeract or spot electricity markets.d datasets, as well as NSW Public Holiday data, in addition to the three datasets originally provided. Whilst we are aware that getting more accurate measurements of wind & cloud coverage will require much greater granularity and that these features do significantly change over a geographical area, this level of granular data would also require collecting information about the locations of rooftop solar panels, which is not possible. Thus, we are making the assumption that the external datasets reflect the true wind & cloud coverage rates of a region at a given point in time.

Since the location of electrical demand is proportional to the population of locations, we would like our model to reflect as much of the population as possible. Based on the Australian Building Codes Board climate zones definitions, and their close proximity to each other, we will be making the assumption that the temperature data collected from Bankstown Airport is representative of the geographical regions of Sydney, Wollongong and Newcastle which accounts for a large percentage of the NSW total demand, where as the temperature of Canberra is representative of the ACT and other Central tablelands cities (roughly 10% of the population of the NSW region). (Abcb.gov.au, 2015)

For this project, we plan on using Python as the main language for data preparation, analysis and modelling. Python was selected over R due to the common familiarity amongst the entire team, and it is well established amongst the Data Science community that Python is the language-of-choice for machine learning. For our presentation, we intend on using Powerpoint, a Google collab notebook, and a Rshiny/Power BI dashboard for interactive analysis.

Neural Networks are known to handle noisy data well compared to other models, and given the noisy nature of the electricity demand & temperature data, this seems appropriate to use a Neural Network for modelling. Additionally, since electricity demand & temperature data appears to have some form of seasonality, we would like to build a model that can capture patterns in the data, which would be possible with Neural Networks. As the data is time-based, we are inclined to use an LSTM or GRU form of a Neural Network (both will be built & tested), as these models retain information from the past when predicting future values. Finally, deep learning algorithms like Neural Networks have the computational capacity to process large datasets, and given the large volume of data we have for this project, it suggests that a Neural Network is suitable.

**Part 4 - Activities, Roles & Timeline**

Our Project team has chosen to use an agile methodology for managing the project, for this we are using the Jira tool. Due to the nature of the team members schedules, and geographical dispersion, the work is being managed via a wall of work with all team members “pulling” work as they are able. To ensure that the work is being completed the team has daily communications via whatsapp in the form of a daily standup, with a tuesday night checkpoint meeting, and a saturday sprint planning and retrospective.

Due to the aggressive timeframe of the project the work has been structured as a single epic, with larger components being managed as a story but the majority of the elements being managed as tasks.

We have chosen to load many of the tasks into the initial sprint, while recognising that the majority of this will spill over into future sprints, the due dates being managed by the scrum manager. The Scrum manager role is being performed by Nee, however, this is likely to rotate based on individuals workloads through out the project.

Task allocation is often being priotised for people wanting to learn the skills, with people with the current skills acting as reviewers, for instance James is performing the Rmarkdown to gain the skills whereas Peter is reviewing as he already has the skills. This way we ensure the team is able to provide backup for each other throughout the project.

The following table highlights the sprints and due date of the tasks.

<<insert>>

<< List out main takes >>

<< Create table of main roles for each member >>

<< Discuss timeline + gantt chart >>

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Final Reprot Literature Review

In 1879 it was released that the construction of the Garden Palace in the domain in Sydney was unlikely to be completed in time, as such the Govt. at the time decided to work at night. Arc lighting was chosen to illuminate the site (Brady). The demand forecasting process was slow, as was the supply as several electrical generators needed to be procured and shipped from England (Jobson). As noted by Brady significant events in australian history have been as a result of Electricty Demand, these include metallurgical industry in 1914, The snowy Hydro scheme beginning in 1949 (Brady).

Bently describes how the oil crisis in 1971 led to the need for better and more accurate energy forecasting (Bentley). It was also around this time that it was recognised that the speed of forecasting was important to manage not just the long term demand, but also the change in demand across the duration of a day.

In 1997 NSW opted to privatise the energy industry (Smith)

<< more on NEM >>

<< more on models used >>

<< more on gaps >>

<< industry expert - talk about gap in daytime predictions>>

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