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# Smart Distribution Systems

## Neural Networks for Day Ahead Price Prediction

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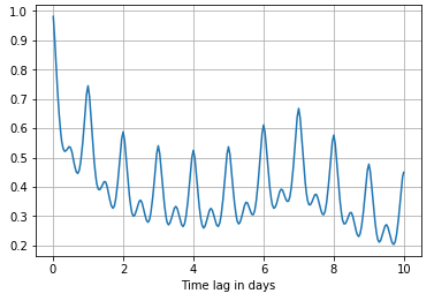
## Pre Processing

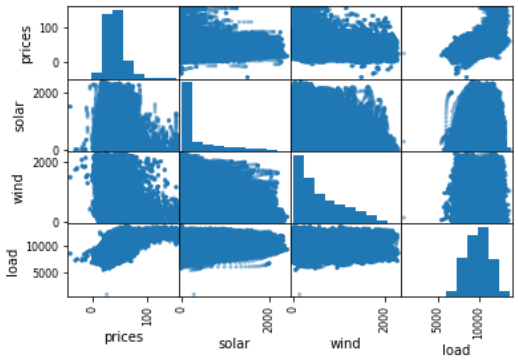
During the exercise session, the dataset from 2015 to 2017 was fetched using the “Datafetcher” package in python working space.

Prior to the neural network analysis a number of steps and practices were performed to make sure the data that we fetch from the Elias database is in the correct format and usable for our neural network prediction. Since the “Belpex Prices” are provided in an hourly period and the other data from the “Solar” and “Wind” are on a scale of 15 minutes, the price dataset was resampled to match the other available data.

To capture null data “NA” from the database a command function “isnull” is used to check for the empty cells and reassigned value from the previous hour. Also to avoid the possibility of outliers corrupting the dataset, outliers were detected using custom made standard deviation functions and outliers were removed from the database. After cleaning the data all the data from the three sources was combined into one vector matrix called “d”.

Autocorrelation was performed to judge the randomness of the data correlation with the delayed samples of itself and a scatter matrix was plotted to observe the trends of correlation among different features of the dataset.



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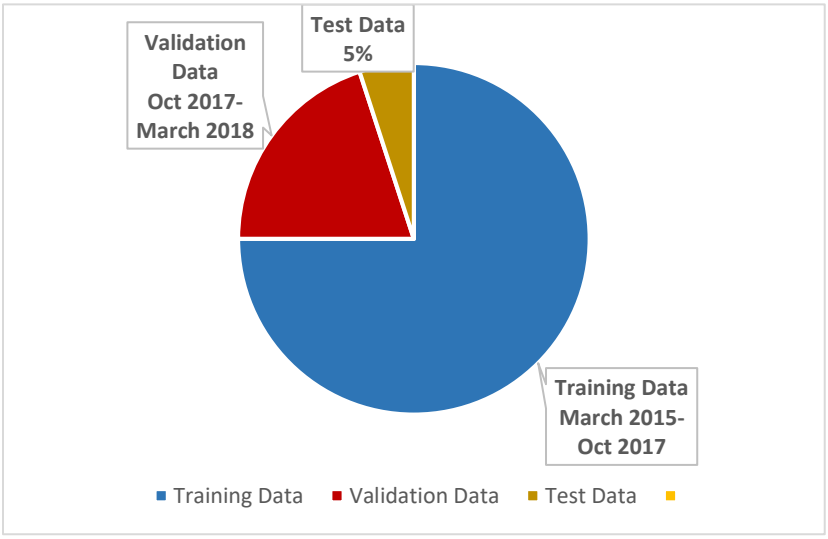
## Neural Networks

For price prediction neural network analysis, the data provided is divided into three sections as shown in the following figure:




We used data from March 2015 to Oct 2017 as our training data and from Oct 2017 to March 2018 as our validation data, the rest was used as test data.

### a) Model Architecture

For our neural network model we experimented with a different number of hidden layers together with one input and one output layer and we achieved the minimum errors in result for

**1 Input Layer: 5 Hidden Layers: 1 Output Layer**

In choosing our inputs as to the number of neurons in the input layer and output layer, since we input 24 hours of data, the input and output neurons were set to 24. Again with the hidden layers we tried some different combinations and chose 120 neurons in our hidden layers.

**24 Input Neurons: 120 Hidden Neurons: 24 Output Neurons**

Relu, Linear and Sigmoid functions were used as our activation functions for input, hidden and output layers respectively.

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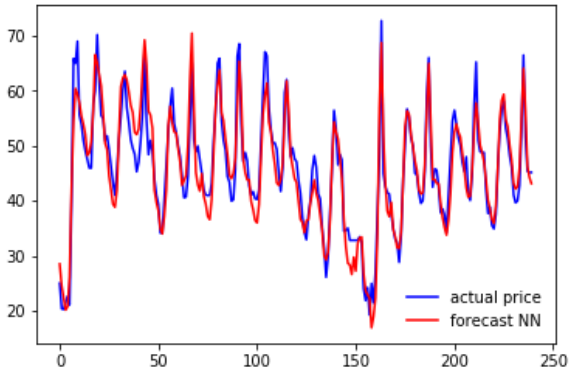
### b) Training Set and Validation Set

Training of the model was performed using the data from March 2015 to October and for validation, the data onwards from October 2015 till March 2018 was used and MSE was calculated as guided in the exercise session. The following graph shows the predicted prices and the actual prices of the validation set used, which shows the correct working of the neural network model. One interesting observation was that the more iterations of training were performed on the model, the lesser the MSE became. But care was taken to avoid over fitting and not to make the results much optimistic.




## Test Set Day Ahead Forecast

Different experiments were tried out with the day ahead prediction of prices. One general observation was that our model was able to predict the weekday prices quite well but failed to give a good MSE reduction when calculating for the Weekend prices. The following graphs show the MSE, the comparison with predicted prices with the actual prices of two selected dates.

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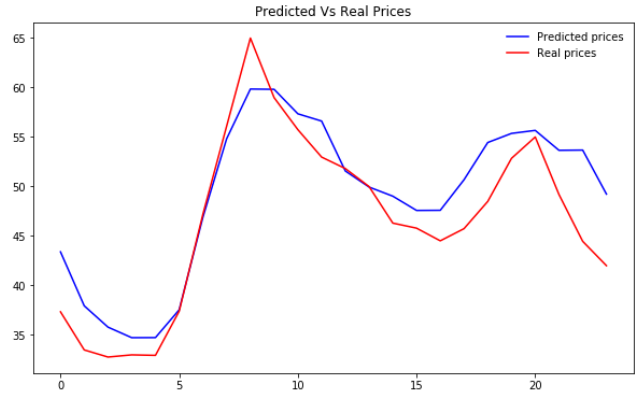
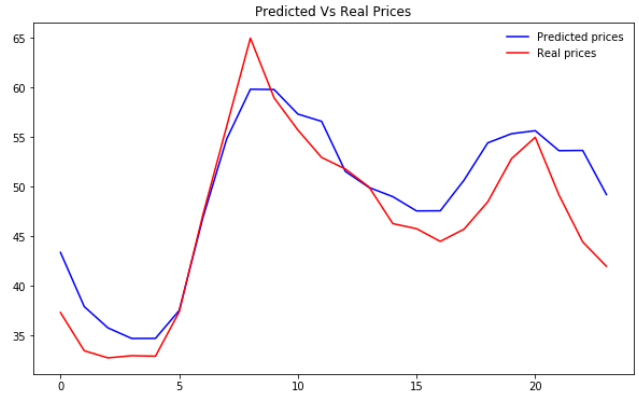
## 16th April 2018




15.02416345706296

**MSE=15.0241**

## 27th April 2018




15.02416345706296

**MSE=XXXX**