Intelligent Data Analytics for Energy Producing and Energy Consuming Systems

by Khivishta Boodhoo

Supervisors: Nicholas Watson, Isaac Triguero Velazquez, Josh Plumbly

The University of Nottingham

Intelligent Plant — Inform, Enhance, Grow. Intelligently.

Background of project

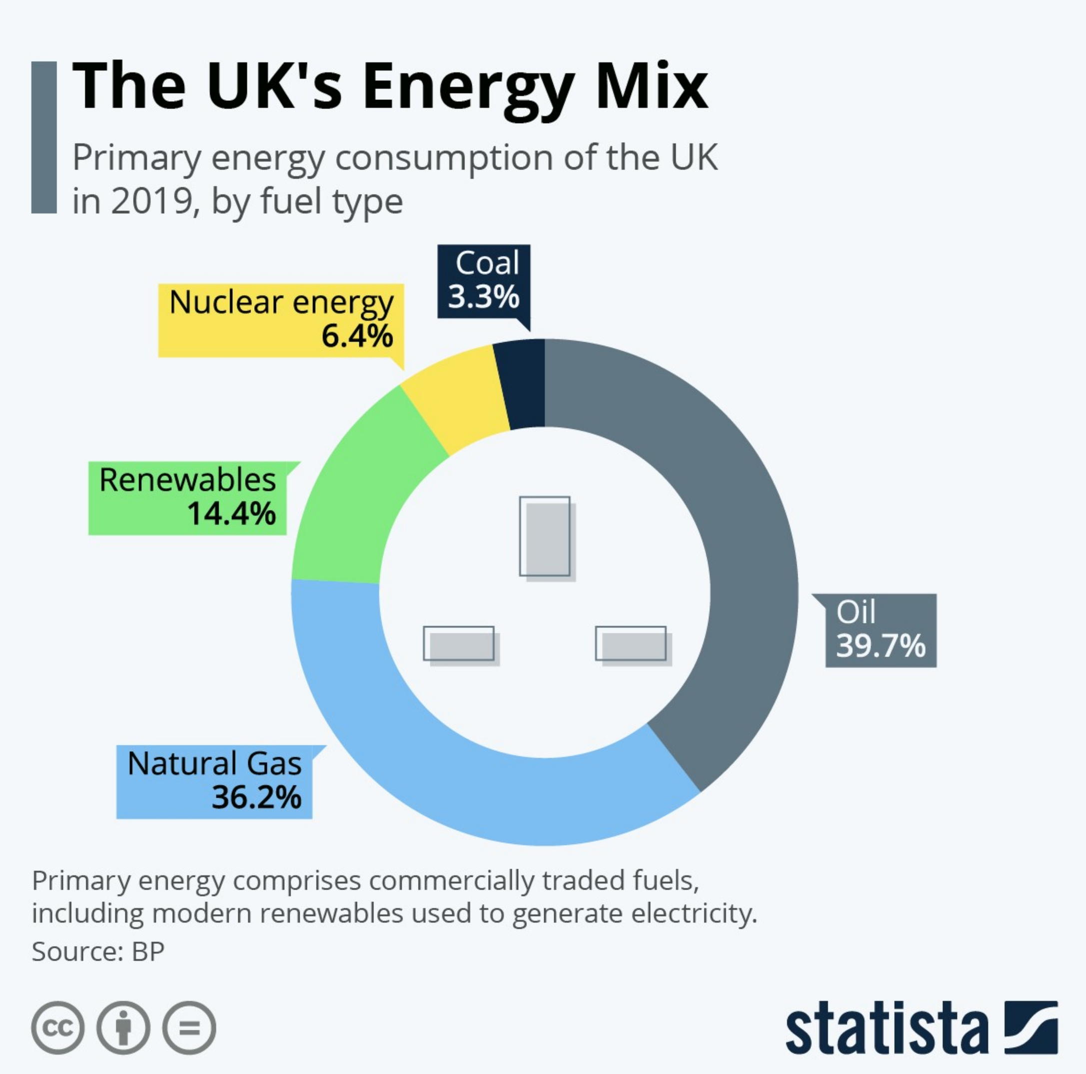

Figure 1. UK total primary energy consumption in 2019.(Source:BP)

- UK energy mix still comprises of a significant amount of oil and gas. Therefore it makes sense to optimise the energy produced/ used in this area
- There is an upcoming growth in renewable energy particularly wind turbines and therefore optimizing energy produced is very

The renewable energy mix for the UK in 2019

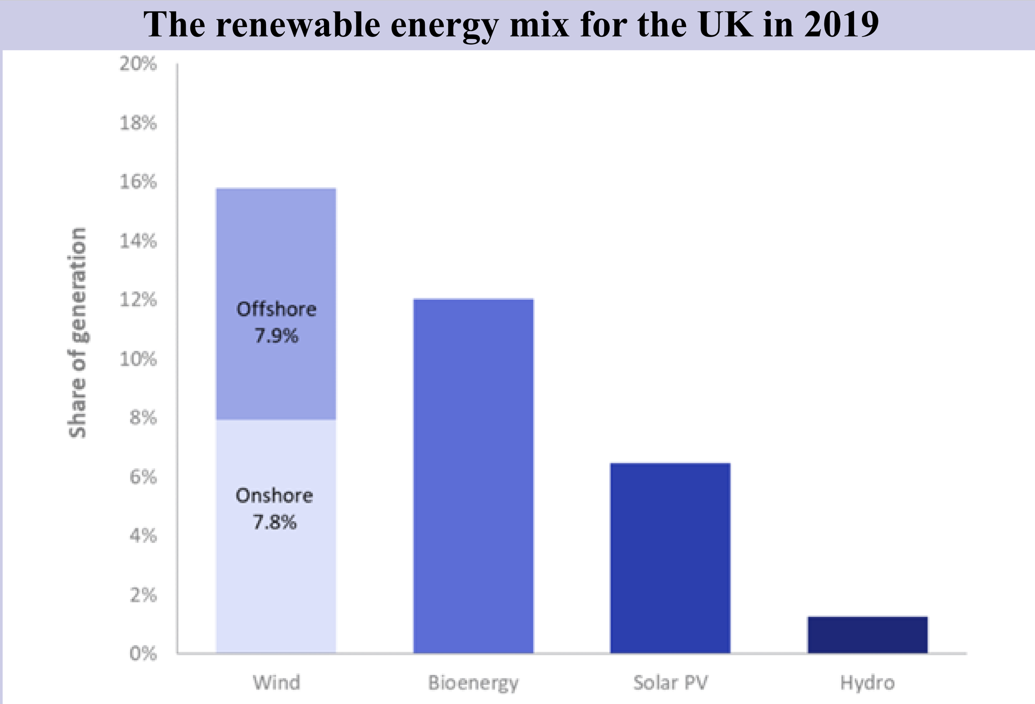

Figure 2.GOV.UK. 2019. Energy Trends: September 2019 - GOV.UK . [ONLINE] Available at: https://www.gov.uk/government/statistics/energy-trends-september-2019. [Accessed 31 Mar 2022].

Case Study 1 Overview

Figure 3. Offshore ORE catapult wind turbine in FIFE (Source: https://ore.catapult.org.uk/) [Accessed :31-Mar-2022]

- Optimise the production of energy from the offshore wind turbine.
- More efficient operation.
- Project in line with UK goal to decarbonize the UK by 2050.

Expected Outcome of this study

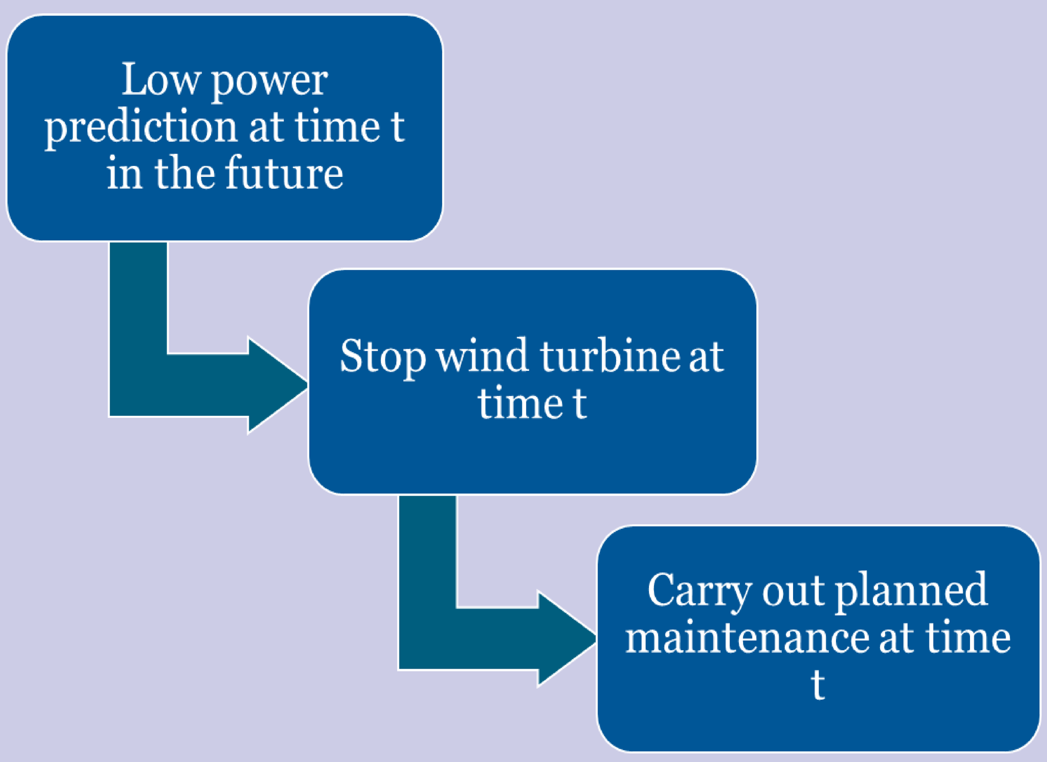

Figure 4. Schematic Representation of the purpose of the case study

Artificial Intelligence

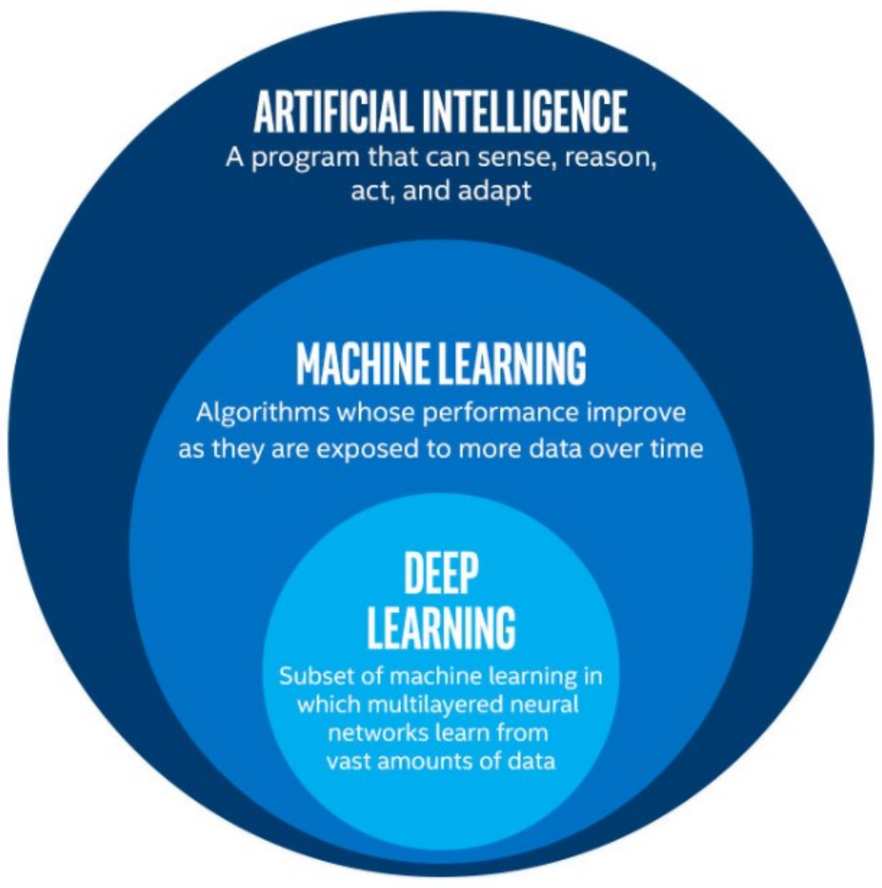

Figure 5. S.Srivastav (2020). Artificial Intelligence, Machine Learning, and Deep Learning. What's the Real Difference? Available at: https://medium.com/swlh/artificial-intelligence-machine-learning-and-deep-learning-whats-the-real-difference-94fe7e528097[Accessed on: 31Mar. 2022].

Machine Learning

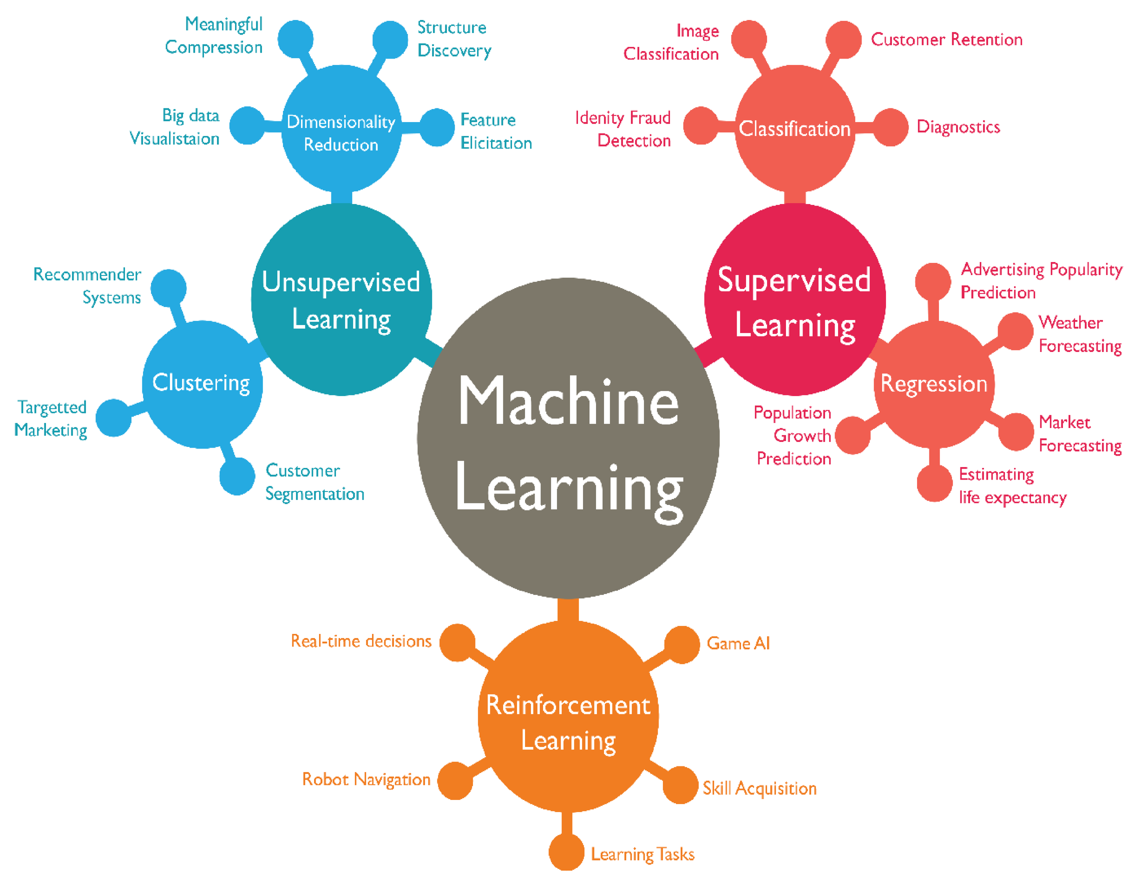

Figure 6. D.Shewan(2021).[Online]. Available:https://www.wordstream.com/blog/ws/2017/07/28/machine-learning-applications. [Accessed: 30– Mar- 2022]

Deep Learning

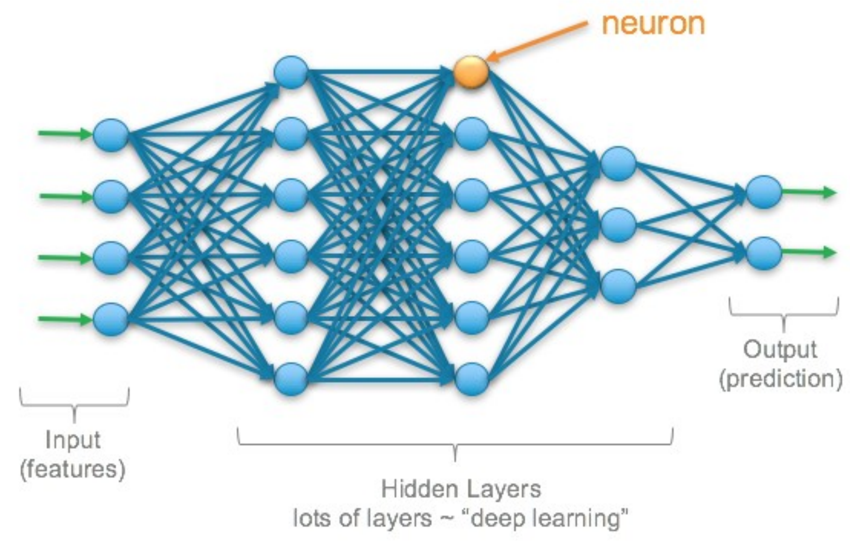

Figure 7. S.Ronaghan (2018).[Online]. Available at :https://srnghn.medium.com/introduction-to-deep-learning-what-do-i-need-to-know-75794ebc4a62[Accessed: 30– Mar- 2022]

Case Study 1 Methodology-Preprocessing

Preprocessing of datasets and datapoints leftover at each stage

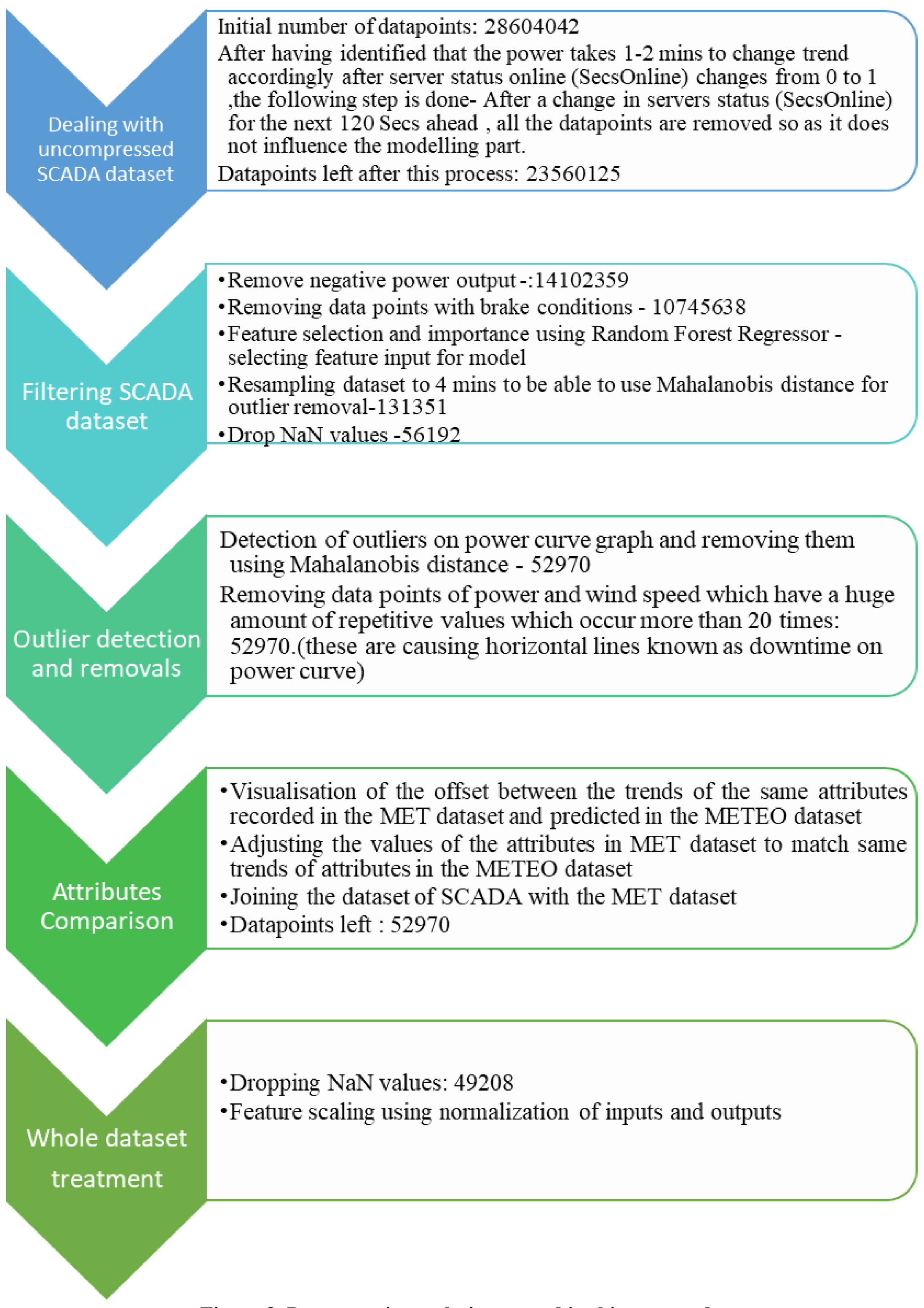

Figure 8 .Preprocessing techniques used in this case study

Case Study 1 Model Development and Deployment

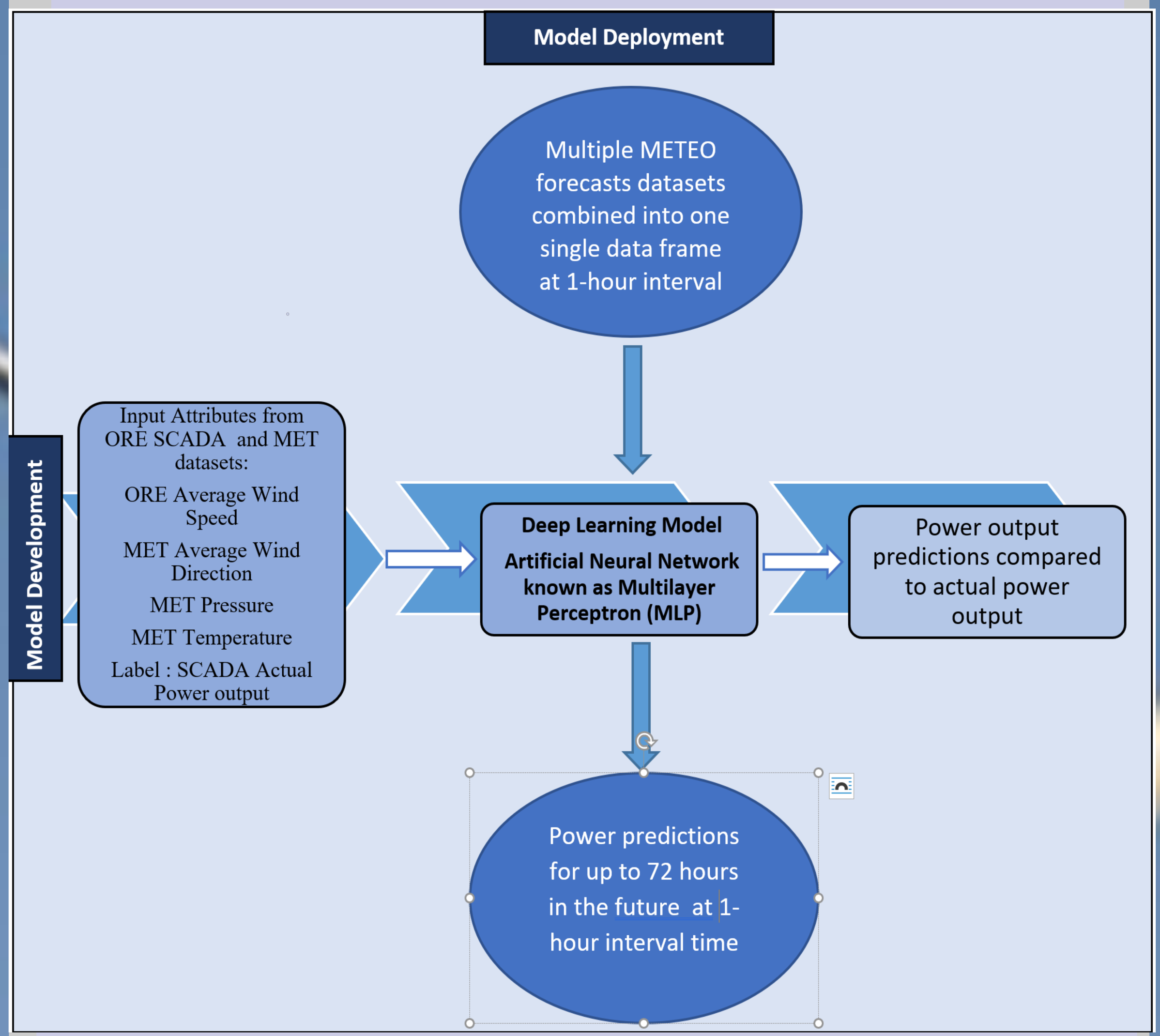

Figure 9.Modelling method

Case Study 1 Results and Discussion

The MLP model developed in this case study is compared to a baseline model developed and deployed on the same dataset. From the metric results ,it can be seen that the combination of preprocessing techniques together with a deep learning algorithm work the best. The amount of data to train/test the model also improved the metric results.

Models	Inputs	Pre-processing techniques	Metric results
The MLP Neural Network	Wind speed Wind direction Temperature Pressure	-Datapoints removed where there is a gap between server online change and changing power -Negative power removed -Brake conditions removed -METEO and MET trends attributes adjusted -Mahalanobis distance for outlier removal -Excessive repetitive values removed	R_2: 0.98 MAE:194.14 RMSE:283.7 NRMSE:0.11 MAE between the power from SCADA and Power predicted using METEO forecasts:1462.16
Linear regression	Wind speed	-Datapoints removed where there is a gap between server online change and changing power -Negative power removed -Brake conditions removed -METEO and MET trends attributes adjusted -Mahalanobis distance for outlier removal -Excessive repetitive values removed	R_2 score:0.94 MAE: 441.1 RMSE:544.7 NMRSE:0.22 MAE between the power from SCADA and power predicted using METEO forecasts:2072.99
Linear regression	Wind Speed	None	R_2:0.31 MAE:1202.9 RMSE:1663

Figure 10. Metric results of model developed compared to baseline model developed using same dataset

Maintenance Scheduling

The energy output of the wind turbine in 4 hours blocks for up to 72 hours in the future is calculated so as to give enough time for the maintenance team to plan and do the maintenance needed.

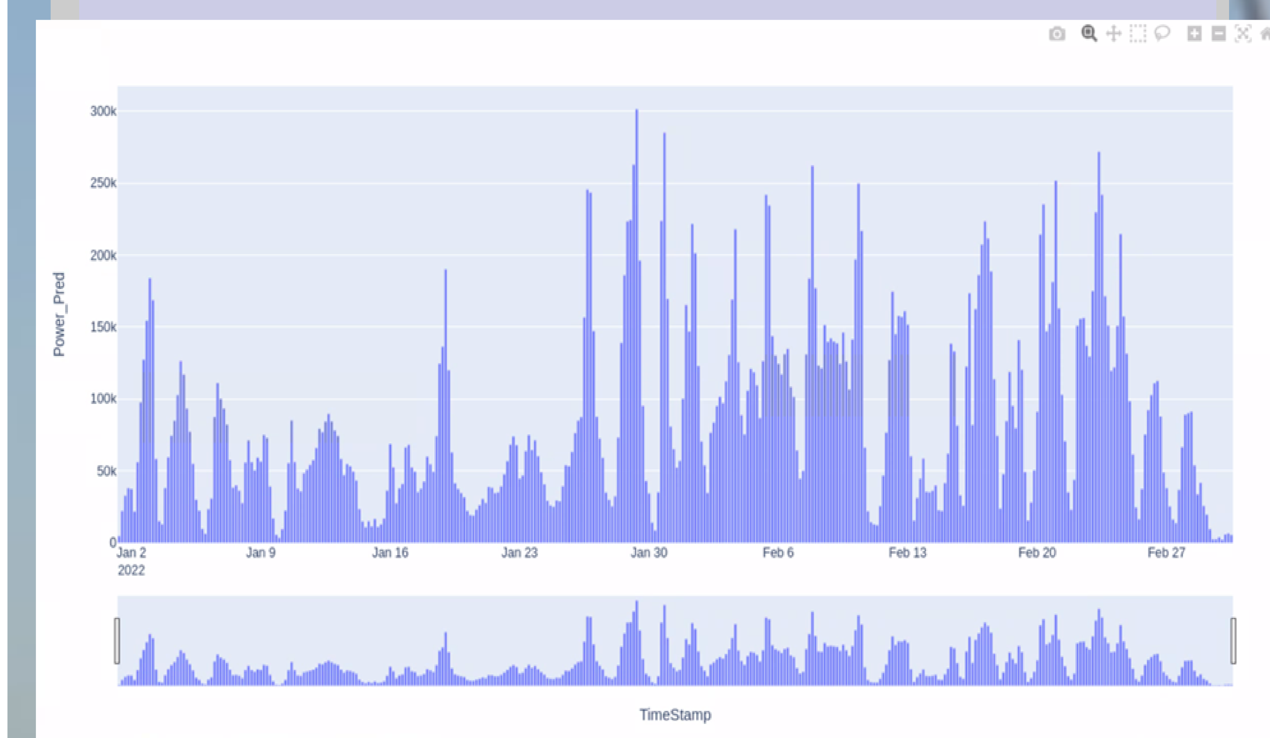

Figure 11. Energy output for up to 72 hours in the future in 4 hours bars

Next Case Study Optimisation of diesel usage in oil platforms

Current Status

- Description and operation of oil platform
- Exploratory data analysis:
  - Features that affect usage of diesel
  - Label (output) attribute
  - Type of model to use

Figure 12. Ithaca Energy (2022)[Online]. Available at :https://www.ithacaenergy.com/our-operations/ithaca-operated-assets/captain[Accessed: 30– Mar- 2022]