UNIVERSITIES MAKING AN IMPACT

EACH YEAR STUDENTS, on MSc programmes in analytical subjects at several UK universities spend their last few months undertaking a project, often for an organisation. These projects can make a significant impact. This issue features reports of projects recently carried out at two of our universities: Strathclyde and Lancaster. If you are interested in availing yourself of such an opportunity, please contact the Operational Research Society at email@theorsociety.com

REDUCING UNCERTAINTY IN EMISSIONS FOR DOOSAN BABCOCK'S CLEAN COMBUSTION TEST FACILITY

(Connor Wilson, University of Strathclyde, MSc Business Analysis and Consulting)

Doosan Babcock is an engineering firm which provides services in the energy sector, including the upgrade and replacement of burners used in Combustion Power Plants. The burner is a highly engineered component, responsible for combining fuel and oxygen for ignition in a power plant furnace. The furnace heats water into steam that then turns a turbine to generate electricity. Doosan Babcock designs, manufactures, tests, and implements burners which are designed to reduce the emissions of noxious and greenhouse gases. To aide in the burner design and implementation process, Doosan constructed a Clean Combustion Test Facility (CCTF) which operates as a full-scale power plant and allows Doosan engineers to test burners under controlled conditions. The CCTF is fitted with sensors which measure parameters such as air flow, fuel flow, temperatures, and emissions. This real-time data is then used to calculate Burner Zone Stochiometry (BZS) and Nitric Oxide emissions. The BZS is the molar ratio of fuel to oxygen at the ignition point of the burner, and is correlated to the magnitude of Nitric Oxide emissions. Doosan adjusts air flows and fuel flows in the CCTF to test burners at different BZS points which they then compare to the Nitric Oxide emissions. This allows them to find the ideal operating point for each burner which reduces emissions.

Each of the sensors in the CCTF has some measurement uncertainty associated with it, and Connor's project involved understanding how this uncertainty propagates through to the calculations of BZS and Nitric Oxide emissions. The first project objective was to help Doosan Babcock engineers define uncertainties for the various instruments, and the second objective was to develop a model that could calculate the uncertainty of the BZS and Nitric Oxide parameters based on the uncertainty of the input sensor data. Using Python, a Monte Carlo Simulation involving more than 20000 iterations was developed to randomize previously collected sensor data before passing the data into the calculations for BZS and Nitric Oxide. The BZS and Nitric Oxide values were collected with each iteration, and the uncertainty was then calculated using population statistics. Once Doosan Babcock was aware of the magnitude of uncertainty in their BZS and Nitric Oxide calculations, they were interested in identifying the sensors which contributed the most uncertainty to the BZS and Nitric Oxide outputs. Final recommendations from the project included possible methods that could be used to reduce the uncertainty of those sensors which were resulting in the greatest uncertainty in BZS and Nitric Oxide calculations.

Dr Stuart C Mitchell, Head of T&E Product and Technology Development, says that "Connor's work supported the combustion team to better understand test facility instrumentation errors and how we determine measurement uncertainty during our test campaigns. Based on Connor's dissertation Doosan Babcock is currently considering modifications to the existing plant duct work to improve measurement accuracy."

FORECASTING ELECTRICITY DEMAND AT BUSINESS ENERGY SOLUTIONS

(Dmitrii Ishutin, Lancaster University, MSc Management Science and Marketing Analytics)

Lancaster University Management School

BES Utilities

Business Energy Solutions (BES) is a UK-based utilities supplier located on the Fylde coast in Lancashire. Established by prominent entrepreneur Andy Pilley in 2002, it has grown to a successful enterprise with more than 300 staff. BES supplies electricity and gas to business customers across the UK; Dmitrii's project focussed on the electricity domain.

The UK electricity industry is highly competitive and complex, especially for smaller suppliers, which have to compete against the traditional Big Six - British Gas, E.ON, npower, SSE, Scottish Power, and EDF Energy. In addition, there are numerous regulation and compliance policies that suppliers must sign up to and stick to. To be a successful supplier, BES must:

- win customers on a competitive retail market
- forecast customers' consumption accurately
- buy electricity on the wholesale market at the best prices
- bill customers and respond to their queries effectively.

Accurate electricity demand forecasting has always been a critical success factor. Precise knowledge of customers' demand allows buying enough energy in advance and prevents additional expenses incurred in the case of surplus or shortage of energy. In short, accurate demand forecasting saves a lot of money.

Dmitrii's objective as part of his MSc project was to develop a statistical predictive model that would achieve forecast accuracy of at least 90% on a 5-week-ahead forecast horizon. Since electricity demand is half-hourly metered, there are three seasonal cycles, namely daily, weekly and yearly cycles, that had to be analysed and modelled. Dmitrii tested and assessed forecasting methods such as exponential smoothing and autoregressive integrated moving averages (ARIMA), but eventually a regression-based model proved to be the most accurate. This model considered a consecutive time-series of historic demand, its lagged observations and various dummy variables that modelled daily, weekly and yearly seasonal patterns. Dmitrii also developed a forecasting algorithm that could be used by BES independently and produced reliable and up to 93% accurate forecasts.

Upon successful completion of his MSc, Dmitrii was offered a Statistical Analyst position at BES. Since joining BES, Dmitrii has upgraded his regression-based model by introducing weather factors such as temperature and wind speed. Pursuing higher accuracy, Dmitrii tested two other forecasting approaches with deseasonalised time series. The first approach eliminated the daily period in a way that the original consecutive time series was split into half-hourly time series. Hence, a separate forecasting model was computed for each half-hour, amounting to 48 different models. The second approach eliminated daily and weekly periods in a way that a separate forecasting model was developed for each half-hour for each day type, amounting to 336 different models. In both cases all forecasted half-hours are assembled together and thus the original time series is restored. Regarding practical outcomes, the 48-half-hourly demand forecasting model demonstrated the highest accuracy of 96% and is about to be implemented by the business.

David Ballantyne, BES Commercial Director and sponsor of the project, stated that "Business Energy Solutions saw a real practical benefit in Dmitrii's demand forecasting model as it could help to reduce day-to-day trading costs, which was a primary objective of the whole project. It also provided valuable insight that forecasting disaggregated half-hourly data can be more accurate than forecasting original continuous time-series. We are happy to see Dmitrii among our staff upon his successful completion of this project."