**Energy Analytics Risk and Hedging Assignment: 2023**

**Individual Assignment**

In this assignment you are asked to make trading decisions for a gas fired generation plant called Drango using CCGT technology with a capacity of 700 MW, made up from two 350 MW units.

You believe that the prices for both gas and electricity for November 2023 will be approximately the same as the prices in November 2019 (prior to Covid and the Ukraine war). The Figure and Table below show average electricity price over the peak period 8 am to 8 pm in GBP per MWh, and a daily gas price in pence per therm. Usually Drango generates only during the peak period of 8 am to 8 pm.

|  |  |  |
| --- | --- | --- |
| Day | gas price (pence per therm) | electricity price (GBP per MWh) |
| 1 | 43.07 | 53.71 |
| 2 | 43.06 | 47.69 |
| 3 | 43.78 | 54.5 |
| 4 | 43.50 | 58.77 |
| 5 | 43.74 | 50.00 |
| 6 | 44.76 | 50.20 |
| 7 | 45.78 | 51.40 |
| 8 | 46.01 | 50.22 |
| 9 | 46.08 | 54.16 |
| 10 | 47.66 | 54.21 |
| 11 | 47.71 | 49.78 |
| 12 | 46.36 | 52.29 |
| 13 | 46.38 | 49.16 |
| 14 | 46.21 | 54.44 |
| 15 | 45.97 | 52.85 |
| 16 | 46.10 | 49.37 |
| 17 | 46.85 | 54.50 |
| 18 | 45.05 | 56.60 |
| 19 | 44.19 | 50.74 |
| 20 | 43.41 | 44.76 |
| 21 | 42.19 | 44.10 |
| 22 | 39.98 | 42.64 |
| 23 | 39.80 | 36.88 |
| 24 | 40.30 | 45.55 |
| 25 | 39.84 | 43.77 |
| 26 | 39.14 | 45.67 |
| 27 | 39.16 | 45.66 |
| 28 | 38.97 | 42.83 |
| 29 | 37.82 | 40.99 |
| 30 | 37.66 | 42.59 |

Drango runs at an efficiency of 55% in conversion of energy from gas to electricity. The result is that a therm of gas (which is 29.30711 kWh) will produce 16.11891 kWh of energy and when operating normally Drango consumes 43427.254 therms per hour. Drango has an existing contract for gas supply at 50 pence per therm for an average of of 250,000 therms per day, with the requirement to take that amount when averaged over a month. Additional gas required will be purchased at the market price.

In addition to fuel costs, the plant costs 150,000 GBP per day to run in operating and financing costs.

The Assignment is in 4 parts:

**Part 1 (20%)**

Estimate the average daily profit over the 30-day period, assuming that market prices for gas and electricity are exactly the same as the data from November 2019.

You should assume that each day there is the same draw down of 250,000 therms from the fixed price contract, rather than a more complicated arrangement where the generator tries to use this fixed price gas on days when buying at the spot price would be more expensive. Be careful with units (e.g. pence and pounds) and you can assume that Drango generates for exactly 12 hours each day. You will find that there are large differences in the profits for individual days with quite a number where losses are made. Nevertheless, there is an average daily profit.

**Part 2 (20%)**

Assuming that wholesale market prices for gas and electricity have the same means, and covariances as the data from November 2019 use a bivariate normal distribution to take a large sample and use this to estimate the 95% expected shortfall for daily profit (or you can do this analytically using properties of the normal distribution).

With the spreadsheet that gives the data you will also find a method for producing samples from a bivariate normal distribution with given means and covariance structure. There are also functions to do this in both R and Python.

You need to start by estimating the means, standard deviations and correlation from the data. At the next stage you will simulate the process. You may want to check the average daily profit for this simulated data – you will find that it varies a lot depending on the particular set of random numbers drawn. Thus there is an advantage in using a large number of random draws from the bivariate normal to reduce this. A set of 10,000 of these is a good number to have. In any case make a fixed sample of gas and electricity prices (paste values if you are using a spreadsheet). Then find the worst 5% of the daily profits to calculate VaR and ES. You need to explain how you got these numbers (so either include code or attach a spreadsheet). Just reporting the numbers is not enough because each person will have generated a different set of simulated data – and the influence of randomness is considerable.

**Part 3 (20%)**

Now suppose that each day there is a 4% chance that one of the generation units is unavailable (an “outage”), so that for roughly 2 weeks each year the plant is reduced to operating just one unit. On these days the plant running costs are the same as before, generation is reduced to 350 MW and fuel consumption is correspondingly halved. Assuming that outages are independent of price, estimate the 95% expected shortfall for daily profit. You should use a simulation approach with a fixed number (the right proportion) of the sample with failures, and then the rest of the sample which does not have failures.

**Part 4 (40%)**

Suppose it is desired to minimize expected shortfall and the current market price for a futures contract (CFD) are £49 per MWh for peak electricity (i.e. in the period 8 am to 8 pm), and 43.5 pence per therm for gas. What quantities of these two contracts would you recommend buying (or selling) in order to minimize the 95% expected shortfall for daily profit? (Assume the same pattern of outages as in part 3.) You need to explain the method you have used to obtain your answer.

This will involve a minimization over three parameters, the quantity of contracts for gas , the quantity of contracts for electricity , and a parameter , which we can think of as the trial Value at Risk. Then we use the minimization form of the expression for expected shortfall. We work out, for each of the simulated days, the value , where the loss depends both on the operation and prices as in part 3, and also on the money gained or lost on the two contracts, and hence on the values of and . Then we minimize the expression

over choices of , , and . We need to pay attention to the sign of the quantities which will determine whether the generator is buying or selling the contracts.

Take care over the optimization here, it needs to be carried out to a reasonable accuracy to find the right solution, and you will want to look at starting from different points. If you are using Solver you are recommended to start with the evolutionary optimization setting using wide ranges for the variables (ensuring that the optimal solution does not get constrained by the ranges set), before refining the solution.

I expect your answer to this assignment will be around three pages long. You also need to hand in a separate file giving the spreadsheet or code that you have used for the calculations. Please keep the code and report separate (rather than e.g. submitting a Jupyter notebook)