PART II – Stochastic Model

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######### GAS MARKETING - PART 2 ####################
######### MATHS MODEL (STOCHASTIC) ####################
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SETS

Cust	Customer 1 to 3
Days	Days: Day 1 … Day 30
Loc	Loc: City A … City G
FBC	FB Contract 1 to 6
Pipes	Pipe P1 … P9
****Scenarios**	Scenarios A, B and C

PARAMETERS

****ScenarioProbablity{ Scenarios}**
****Customer4Demand{ Days, Scenarios}**

Demand{Cust, Days}	Customer Daily Demand.
CustomerLoc {Cust,Loc}	Customer Location
PreviousDay{d1 in Days,d2 in Days}	Parameter to represent days with previous days having stock. This parameter is 1 if d2 is the previous day to d1 param
FBDeliveryRange {FBC, Days}	Days that Flat Band Contract delivers gas.
FBMaxQuantity {FBC}	Maximum Daily delivery of Flat Band Contract.
FBPrice {FBC}	Price paid for Flat Band Contract.
DaysInContract {fb in FBC}	Number of days in a Flat Band Contract
SWCMaxTotalQuantity	Maximum Total MWh delivered by use of swing contract.
SWCTotalContractedCost	Cost for Total contracted MWh.
SWCDailyUseCost	Cost of daily use of swing contract.
PipeConn {Pipe, l1 in Loc, l2 in Loc}	Correspondence of Pipe connection (ex: P1 connects City A to City B).
PipeMaximumCapacity {Pipe}	Maximum Pipeline capacity.

PipeCapacityCost{Pipe}	Cost (in GBP/MWh) for contracted capacity.
PipeUseCost {Pipe}	Cost for volume use (in GBP/MWh).
StockWithdrawCapacityCost	Withdraw capacity cost.
StockInjectionCapacityCost	Injection capacity cost.
StockCapacityCost	Stock capacity cost.

VARIABLES

GasDeliveredToCustomer{Cust, Day} >= 0 Quantity of gas delivered to customer each day

****GasDeliveryCustomer4{ Days, Scenarios} >= 0;**

ContractedFB {FBC} >= 0	Quantity of MWh negotiated for flat band contract
TotalContractedSWC >= 0	Total MWh contracted for Swing Contracts
****DailyUseSWC {Days,Scenarios} >= 0**	Quantity of MWh is being used on a daily
****DailySWCCost {Scenarios} >= 0**	Daily cost due to use of Swing Contract
PipeContractedCapacity {Pipe} >= 0	Contracted capacity for Pipe during month
****TransportGas {I1, I2, d, Scenarios} >=0**	Quantity of gas transported from one city to another (represented by I1 to I2) in a day.
ContractedMaxStock >=0	Maximum contracted stock
MaxStockInject >=0	Maximum daily injection into stock
MaxStockWithdraw >=0	Maximum daily withdrawal from stock.
Stock{Days,Scenarios} >=0	Total gas stocked at the end of day 'd' at Location 'City C'
****BalanceSheet{Days, Scenarios}**	If positive represents that the network has been injected with more gas than withdrawn, if negative represents there has been more withdrawals than injections
BalancingCapacity >=0	How much gas can be withdrawn or injected in excess each day

OBJECTIVE FUNCTION:

Minimize Total_Cost:

$$\left[\sum_{fb\ in\ FBC} (ContractedFB[fb] * FBPrice[fb] * DaysInContract[fb]) \right]$$

$$+ \quad [TotalContractedSWC * SWCTotalContractedCost]$$

$$+ \quad \left[\sum_{s\ in\ Scenarios} (DailySWCCost[s] * ScenarioProbability[s]) \right]$$

$$+ \quad \left[\sum_{(p\ in\ Pipes)} PipeContractedCapacity[p] * PipeCapacityCost[p] \right]$$

$$+ \quad \left[\sum_{(l1,l2:PipeConn[p,l1,l2]=1)} (TransportGas[l1,l2,d,s] \ * PipeUseCost[p] * ScenarioProbability[s]) \right],$$

$$\forall \ p\ in\ Pipes, l1\ in\ Loc, l2\ in\ Loc, d\ in\ Days, s\ in\ Scenarios$$

$$+ \quad [\ ContractedMaxStock * StockCapacityCost]$$

$$+ \quad [MaxstockInject * StockInjectionCapacityCost]$$

$$+ \quad [MaxStockWithdraw * StockWithdrawCapacityCost]$$

CONSTRAINTS:

Gas delivery: Demand for Customers 1, 2 and 3

$$GasDeliveredToCustomer[c,d] \ = \ Demand[c,d], \ \forall \ c\ in\ Cust, d\ in\ Days$$

****Gas delivery: Demand for Customer 4**

$$GasDeliveryCustomer4[d,s] \ = \ Customer4Demand[d,s], \ \forall \ d\ in\ Days, s\ in\ Scenarios$$

Maximum Pipe Capacity Contract

$$PipeContractedCapacity[p] \ \leq \ PipeMaximumCapacity[p], \forall \ p\ in\ Pipes$$

****Maximum Gas Transport Pipe:**

$$\sum_{(l1,l2:PipeConn[l1,l2,p]=1)} TransportGas[l1,l2,d,s] \ \leq \ PipeContractedCapacity[p],$$

$$\forall \ p\ in\ Pipes, d\ in\ Days, s\ in\ Scenarios$$

Prohibit transport between cities without Pipe

$$TransportGas[l1,l2,d,s] \ = \ 0, \forall \ d\ in\ Days, s\ in\ Scenarios, \ l1 \text{ in Loc}, l2 \text{ in Loc}:$$

$$(p\ in\ (l1,l2) \notin (p\ and\ PipeConn[l1,l2,p] = 0)$$

Inflow and outflow Constraints

$$\left[\sum_{l2\ in\ Loc} 0.99 * TransportGas[l2,l1,d,s]\right] - \left[\sum_{l2\ in\ Loc} TransportGas[l1,l2,d,s]\right]$$

$$+ \left[\sum_{fb\ in\ FBC:\ l1='City\_A'\ and\ FBDeliveryRange[fb,d]=1} ContractedFB[fb]\right] + \left[\sum_{d2\ in\ Days:\ d=d2\ and\ l1='City\_A'} DailyUseSWC[d,s]\right]$$

$$+ \left[\sum_{d2\ in\ Days: l1='City\_C'\ and\ PreviousDay[d,d2]=1} Stock[d2,s]\right] + \left[\sum_{d2\ in\ Days: l1='City\_A'\ and\ PreviousDay[d,d2]=1} Balancesheet[d2,s]\right]$$

$$=$$

$$\sum_{c\ in\ Cust:\ CustomerLoc[c,l1]=1} GasDeliveredToCustomer[c,d,s] + \left[\sum_{d2\ in\ Days:\ d=d2\ and\ l1='City\_C'} Stock[d2,s]\right]$$

$$+ \left[\sum_{d2\ in\ Days:\ d=d2\ and\ l1='City\_A'} Balancesheet[d2,s]\right]$$

$$\forall\ d\ in\ Days, l1\ in\ Loc,\ s\ in\ Scenarios$$

Flat Band Contract maximum Quantity

$$ContractedFB[fb] \le FBMaxQuantity[fb],\ \forall\ fb\ in\ FBC$$

Swing Contract Maximum Daily Use

$$DailyUseSWC[d,s] \le \frac{TotalContractedSWC}{30},\ \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

Swing Contract Minimal Daily Use

$$DailyUseSWC[d,s] \ge (0.6) * \frac{TotalContractedSWC}{30},\ \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

Swing Contract Daily Cost

$$DailySWCCost[s] \ge \left[\sum_{d\ in\ Days} DailyUseSWC[d,s]\right] * SWCDailyUseCost\ ,\ \forall\ s\ in\ Scenarios$$

Swing Contract Minimal Daily Cost

$$DailySWCCost[s] \ge (0.8) * \frac{TotalContractedSWC}{30} * SWCDailyUseCost,\ \forall\ s\ in\ Scenarios$$

Swing Contract Maximum Total Cost

$$TotalContractedSWC \le SWCMaxTotalQuantity$$

****Limited Stock Capacity**

$$Stock[d,s] \le ContractedMaxStock,\ \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

****Limited Stock Injection (minus Day 1)**

$$\sum_{d2\ in\ Days:\ PreviousDay[d,d2]=1} Stock\ [d2,s] \le MaxStockInject,\ \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

****Limited Stock Withdraw (minus Day 1)**

$$\sum_{d2\ in\ Days:\ PreviousDay[d,d2]=1} Stock\,[d2,s] - Stock[d,s] \ \le\ MaxStockWithdraw, \quad \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

Maximum daily withdrawal from stock

$$MaxStockWithdrawn \ \le\ \frac{ContractedMaxStock}{25}$$

Maximum Balance Capacity (if under 2000 MWh distribution capacity_

$$BalanceCapacity \ \le\ 0.1 * \left[\sum_{p\ in\ Pipes:\ p='P1'\ or\ p=''P6} PipeContractedCapacity[p] \right]$$

Maximum Balance Capacity (if over 2000 MWh distribution capacity)

$$BalanceCapacity \ \le\ (0.1*2000) + 0.05 * \left[\sum_{p\ in\ Pipes:\ p='P1'\ or\ p=''P6} PipeContractedCapacity[p] \ - \ 2000 \right]$$

****Maximum Daily injection Balance**

$$BalanceSheet[d,s] \ - \sum_{d2\ in\ Days:\ PreviousDay[d,d2]=1} BalanceSheet\,[d2,s] \ \le\ BalanceCapacity, \quad \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

****Maximum Daily Withdraw Balance**

$$\sum_{d2\ in\ Days:\ PreviousDay[d,d2]=1} BalanceSheet\,[d2,s] - BalanceSheet[d,s] \ \le BalanceCapacity, \quad \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

****Maximum Overall Balanace:**

$$BalanceSheet[d,s] \ \le\ 0 \ + \sum_{d2\ in\ Days:\ d\ =\ d2\ and\ d2<>30} (3 * BalanceCapacity) \ + 0, \quad \forall\ d\ in\ Days,\ s\ in\ Scenarios$$

****Minimum Overall Balanace:**

$$BalanceSheet[d,s] \ \ge\ 0 \ - \sum_{d2\ in\ Days:\ d\ =\ d2\ and\ d2<>30} (3 * BalanceCapacity) \ + 0, \quad \forall\ d\ in\ Days,\ s\ in\ Scenarios$$