PART I – Linear Model

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######### GAS MARKETING - PART I ####################
######### MATHS MODEL (LINEAR) ####################
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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

PARAMETERS

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
ContractedFB {FBC} >= 0	Quantity of MWh negotiated for flat band contract
TotalContractedSWC >= 0	Total MWh contracted for Swing Contracts
DailyUseSWC {Days} >= 0	Quantity of MWh is being used on a daily
DailySWCCost >= 0	Daily cost due to use of Swing Contract
PipeContractedCapacity {Pipe} >= 0	Contracted capacity for Pipe during month
TransportGas {l1, l2, d } >=0	Quantity of gas transported from one city to another (represented by l1 to l2) in a day.
ContractedMaxStock >=0	Maximum contracted stock
MaxStockInject >=0	Maximum daily injection into stock
MaxStockWithdraw >=0	Maximum daily withdrawal from stock.
Stock{Days} >=0	Total gas stocked at the end of day 'd' at Location 'City C'
BalanceSheet{Days}	If positive represents that the network has been injected with more gas than withdrawn, if negative represents there has been more withdrawals than injections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=0	How much gas can be withdrawn or injected in excess each day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:

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

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

$$+ \quad [DailySWCCost]$$

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

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

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

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

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

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

CONSTRAINTS:

Gas delivery: guarantee's that the customer is delivered with the demand quantity

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

Maximum Pipe Capacity Contract

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

Maximum Gas Transport Pipe:

$$\sum_{(l1,l2:PipeConn[l1,l2,p]=1)} TransportGas[l1,l2,d] \;\leq\; PipeContractedCapacity[p], \forall\; p\; in\; Pipes,\; d\; in\; Days$$

Prohibit transport between cities without Pipe

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

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

Inflow and outflow Constraints

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

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

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

$$=$$

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

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

$$\forall\; d\; in\; Days, l1\; in\; Loc$$

Flat Band Contract maximum Quantity

$$ContractedFB[fb] \;\leq\; FBMaxQuantity[fb], \forall\; fb\; in\; FBC$$

Swing Contract Maximum Daily Use

$$DailyUseSWC[d] \;\leq\; \frac{TotalContractedSWC}{30}, \forall\; d\; in\; Days$$

Swing Contract Minimal Daily Use

$$DailyUseSWC[d] \;\geq\; (0.6) * \frac{TotalContractedSWC}{30}, \forall\; d\; in\; Days$$

Swing Contract Daily Cost

$$DailySWCCost \ \geq \ \left[\sum_{d \ in \ Days} DailyUseSWC[d] \right] * SWCDailyUseCost$$

Swing Contract Minimal Daily Cost

$$DailySWCCost \ \geq \ (0.8) * \frac{TotalContractedSWC}{30} * SWCDailyUseCost$$

Swing Contract Maximum Total Cost

$$TotalContractedSWC \ \leq \ SWCMaxTotalQuantity$$

Limited Stock Capacity

$$Stock[d] \ \leq \ ContractedMaxStock, \ \forall \ d \ in \ Days$$

Limited Stock Injection (minus Day 1)

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

Limited Stock Withdraw (minus Day 1)

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

Maximum daily withdrawal from stock

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

Maximum Balance Capacity (if under 2000 MWh distribution capacity_

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

Maximum Balance Capacity (if over 2000 MWh distribution capacity)

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

Maximum Daily injection Balance

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

Maximum Daily Withdraw Balance

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

Maximum Overall Balanace:

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

Minimum Overall Balanace:

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