**Appendix Code**

% EMTH171 // CaseStudy2

% Name: Menghao Zhan // Jiyao Zhu

clear

clc

close all

%====================--Constant Values--======================

g = 9.81; % Coeficience of Gravity(m/s^2)

tarray = 1:1:8760; % One year shown by array (hours)

Stand\_d = 1000; % Standard deviation (h)

Mean = 5000; % Mean of distribution with North Island Power demand (h)

density = 998; % (kg/m^3)

K = 1.55; % (m^0.5\*s^-1)

L = 300; % length of weir (m)

%-------------------Assume NI&SI wind capacity--------------------

%===================--Task1--==========================

wind\_geCA\_NI = 4130/2;%(MW)

wind\_geCA\_SI = 4130/2;%(MW)

%===================--Task1--==========================

%===================--Task3(abcd)--==========================

% wind\_geCA\_NI = Wind\_Capacity; % The value get from task2 after optimisation

% wind\_geCA\_NI = Wind\_Capacity; % The value get from task2 after optimisation

%===================--Task3(abcd)--==========================

%===================--Known Values--==========================

Area\_SI = 350e6; % Suface area of South Island(m^2)

Area\_NI = 620e6; % Suface area of North Island(m^2)

Minh\_SI = 402; % Minimum height of South Island(m)

Minh\_NI = 355.85; % Minimum height of North Island(m)

Maxh\_SI = 410; % Maximum height of South Island(m)

Maxh\_NI = 357.25; % Maximum height of North Island(m)

h\_ge\_SI = 0; % Height of generator of South Island(m)

h\_ge\_NI = 80; % Height of generator of North Island(m)

Av\_flow\_SI = 593; % Average flow of South Island(m^3/s)

Av\_flow\_NI = 345; % Average flow of North Island(m^3/s)

Maxge\_SI = 3590; % Maximum generation(MW)

Maxge\_NI = 1870; % Maximum generation(MW)

E\_NI\_ge = 1525; % Energy of geothermal capacity(MW)

%===================--Initial Values--========================

hSI(1) = (Maxh\_SI+Minh\_SI)/2 % Initial height of SI lake (m)

hNI(1) = (Maxh\_NI+Minh\_NI)/2 % Initial height of NI lake (m)

vNI(1) = 0; % Spillage of NI lake (m^3)

vSI(1) = 0; % Spillage of SI lake (m^3)

P\_SI\_demand = 1940; % SI power demand in MW(Eq14,15)

%=====================--For-loop--==========================

for n=2:tarray(end)

t = n;

% 1 ----------NI power demand in MW(Eq14,15)----------

P\_NI\_demand = 4065 + 1.4e6 \* normpdf(t, Mean, Stand\_d);

% 2 ----------Inlet flow rate into NI&SI lakes(Eq5,6)----------

F\_NI\_inlet = 345 + 73\* sin((2\*pi\*(t-3624))/8760);

F\_SI\_inlet = 593 - 183\* sin((2\*pi\*(t-2320))/8760);

%=====================--Task3-c--==========================

% F\_SI\_inlet = 0.9\*(593 - 183\* sin((2\*pi\*(t-2320))/8760));

%=====================--Task3-c--==========================

F\_NI\_ge = F\_NI\_inlet;

%=====================--Task3-a--==========================

% if t < 8760/4

% F\_NI\_ge = 0.9\*F\_NI\_inlet; %Reducing generation flow

% elseif t < 8760\*3/4

% F\_NI\_ge = 1.1\*F\_NI\_inlet;

% else

% F\_NI\_ge = 0.9\*F\_NI\_inlet;

% end

%=====================--Task3-a--==========================

%=====================--Task3-d--==========================

if t < 8760/6 || 8760\*(5/6)<t

% Reducing generation flow to 0.8 accln water

F\_NI\_ge = 0.8\*F\_NI\_inlet;

F\_SI\_ge = 0.8\*F\_SI\_inlet;

CF = CF / 2;

else

% The generation flow dose not change /the wind power capacity changed

F\_NI\_ge = 1\*F\_NI\_inlet;

F\_SI\_ge = 1\*F\_SI\_inlet;

CF = CF \* 1.3;

% F\_SI\_ge = 1.2\*F\_SI\_inlet;

end

%=====================--Task3-d--==========================

%=====================--Task3-b--==========================

% if t<=5088 && t>4344 % Reducing wind power capacity to 50%

% CF = CF/2;

% end

%=====================--Task3-b--==========================

%=====================--Equations--==========================

% 4 --------The hydro-electric generation in NI(Eq7)----------

P\_NI\_hydro = 0.9\*F\_NI\_ge\*density\*g\*(hNI(n-1)-h\_ge\_NI)/(1e6);

% 6 ---- Power of wind-------

P\_NI\_wind = wind\_geCA\_NI \* CF;

P\_SI\_wind = wind\_geCA\_SI \* CF;

%----Electrical power balances for each Island -------

P\_HVDC = P\_NI\_demand - E\_NI\_ge - P\_NI\_wind - P\_NI\_hydro;

% 4-1--------The hydro-electric generation in SI------------

P\_SI\_hydro = P\_SI\_demand + P\_HVDC - P\_SI\_wind;

% 3 ----------The generating flow for NI&SI(Eq8)----------

F\_SI\_ge = (P\_SI\_hydro\*1e6)/((0.9\*density\*g)\*(hSI(n-1)-h\_ge\_SI));

% 10 ---- Spillway flow for each lake(Eq9) -------

if hNI(n-1) > Maxh\_NI

F\_NI\_spill = K\*L\*(hNI(n-1)-Maxh\_NI)^1.5;

Spill\_NI\_dvdt = F\_NI\_spill\*3600;

% Derivative of NI spill water volume (m^3/h)

else

F\_NI\_spill = 0;

Spill\_NI\_dvdt = 0;

end

if hSI(n-1) > Maxh\_SI

F\_SI\_spill = K\*L\*(hSI(n-1)-Maxh\_SI)^1.5;

Spill\_SI\_dvdt = F\_SI\_spill\*3600;

% Derivative of SI spill water volume (m^3/h)

else

F\_SI\_spill = 0;

Spill\_SI\_dvdt = 0;

end

%-----------Main part----------

dhNIt = (F\_NI\_inlet - F\_NI\_ge - F\_NI\_spill) \* 3600/Area\_NI; % (m^3/h)

dhSIt = (F\_SI\_inlet - F\_SI\_ge - F\_SI\_spill) \* 3600/Area\_SI; % (m^3/h)

%-----------Euler's method-----

hNI(n) = hNI(n-1) + dhNIt; %Current lake level of North Island(m)

hSI(n) = hSI(n-1) + dhSIt; %Current lake level of South Island(m)

vNI(n) = vNI(n-1) + (Spill\_NI\_dvdt);%Current lake volume of NI lake (m^3)

vSI(n) = vSI(n-1) + (Spill\_SI\_dvdt);%Current lake volume of SI lake (m^3)

% Calculate money if the minimum criteria condition passed

%=====================--Task2---==========================

%----Find the optimised wind generated capacity of North Island-------

if check == 0;

Total\_cost = cost\_NI + cost\_SI;

if Total\_cost < A\_money

A\_money = Total\_cost;

Wind\_Capacity = wind\_geCA\_NI;

New\_H\_NI = hNI;

New\_H\_SI = hSI;

New\_spillNI = vNI;

New\_spillSI = vSI;

end

end

%=====================--Task2---==========================

end

%=====================--Task2/3---==========================

% Calculation of total cost from North & South Islands.

cost\_NI = 90\*density\*(vNI(tarray(end)))\*g\*(hNI(n)-h\_ge\_NI)/(3600\*1e6);

cost\_SI = 90\*density\*(vSI(tarray(end)))\*g\*(hSI(n)-h\_ge\_SI)/(3600\*1e6);

total = cost\_NI + cost\_SI

%=====================--Task2/3---==========================

%==============================ploting================================

% figure(1)

% plot(tarray,hNI)

% hold on

% plot(tarray,hSI)

% hold off

% xlabel('Time (h)')

% ylabel('Lake Level (m)')

% legend("North Island","South Island")

%==============================ploting================================

figure(1)

plot(tarray , hNI)

xlabel('Time(h)')

ylabel('North lake-level(m)')

figure(2)

plot(tarray , hSI)

xlabel('Time(h)')

ylabel('South lake-level(m)')

figure(3)

plot(tarray , vSI)

xlabel('Time(h)')

ylabel('South spill-volume(m^3)')

figure(4)

plot(tarray , vNI)

xlabel('Time(h)')

ylabel('North spill-volume(m^3)')

%=====================--Task2/b--==========================

E\_NI\_ge = 1605; % When calculating the cost the power from North Island geothermal is original one

Wind\_cost = (Wind\_Capacity-Extra\_wind)\*Cost\_wt\*trans;

Geo\_cost = (E\_NI\_ge-Extra\_geo)\*Cost\_Ngc\*trans;

Cost\_extra\_geo = (Wind\_cost + Geo\_cost)/1e6

%=====================--Task2/b--==========================