Power plants sizing/scheduling using Cplex - Python

Overview

- Disclaimer : do not take into account the following figures. They have been chosen to build this application without exact physical sense.
- Several power plants are available in terms of power type (nuclear, gas, biomass) and numbers (3 nuclear units, 5 gas and 26 biomass ones).
- Each power plant has a pattern in terms of power, duration and cost :
  - Power : 2500 MW for nuclear power plant during its effective power production time.
  - Duration : before and after this production period, maintenance/settings must be done. For the nuclear p.p. example, the starting up maintenance lasts 4 days and no effective power is available. Then it can produce 2500 MW during 30 days and afterwards it does not produce power during turning off maintenance which lasts 2 days.
  - Cost : each period costs an certain amount of money. For the previous example, let's say it costs k$ 20 for the starting-up maintenance then 180 during effective production and 10 during turning-off maintenance.
- We would like to determine :
  - the number of power plants needed to ensure a certain continuous power over a fixed time at a minimum cost. It can be expressed as an mixed integer linear problem (problem 1).
  - the optimal dispatching including timelines of all power plants and total/individual energy produced by power plants. It can be expressed as a scheduling/decision problem (problem 2).

Issue

- I would like to compute these problems using Cplex under Python (functional prefered rather than OOP).
- Apparently it is not possible to mix problems 1 and 2 in a single Cplex script… I guess I have to split them into pb 1 and 2 as presented previously.
- But problem 1 does take into account maintenance periods during which no effective power is available… And I can not plot timeline in this MILP… Furthermore problem 2 can not handle with unknowns like number of power plants : it takes it as fixed inputs to tackle with dispatching and timeline plots.

Problem presentation

- **Objective : ensure 10 000 MW continuously during 30 days at minimum cost**

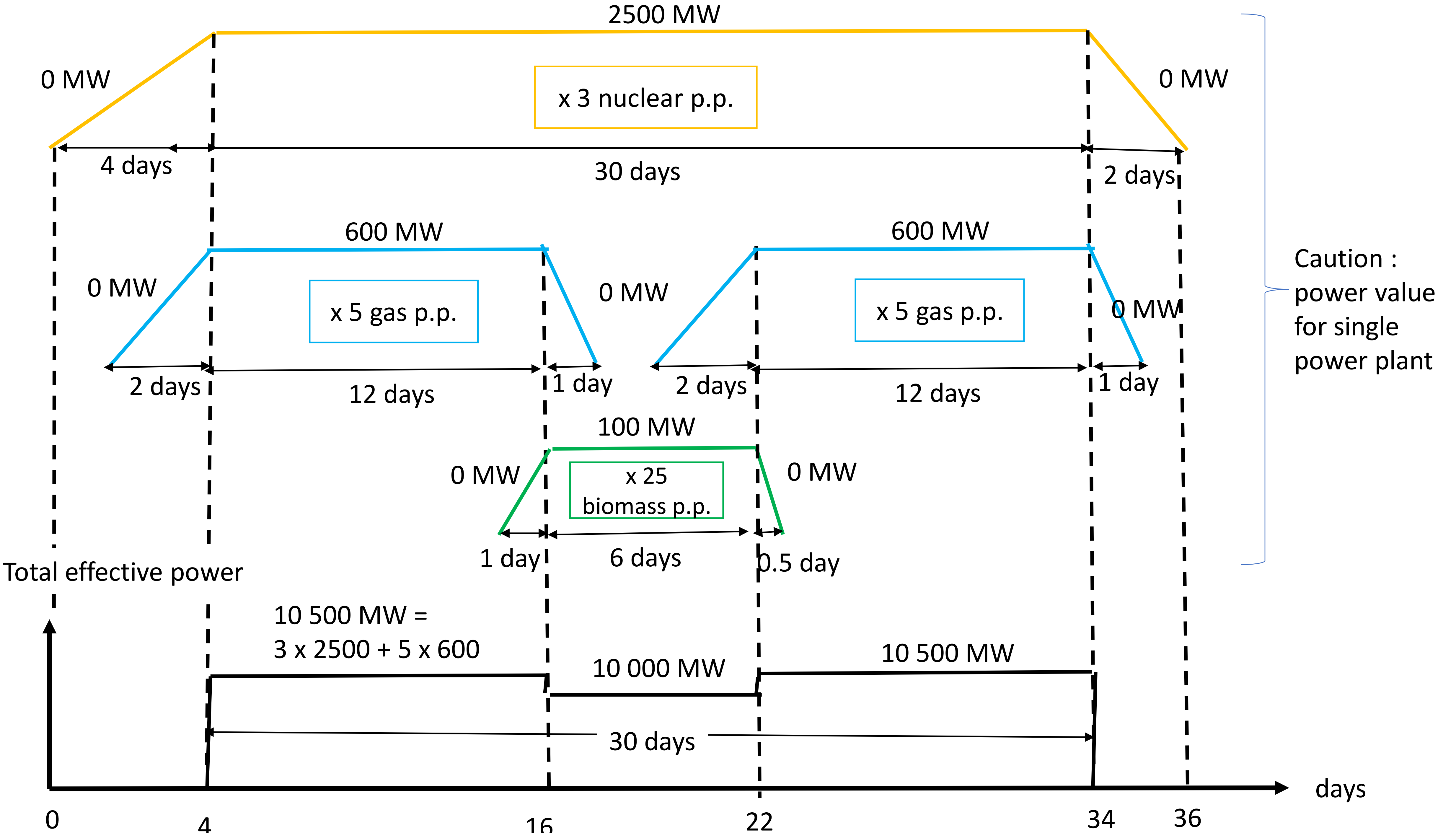
- Min (Total_cost) including :
  - Total_cost_nuclear_pp = nb_nuclear_pp * cost_single_nuclear_pp * using_time(including maintenance)
  - Same formula type for gas and biomass power plants
  - Total_cost = total_cost_nuclear_pp + total_cost_gas_pp pp + total_cost_biomass_pp
- Subject to following constraints :
  - nb_nuclear_pp $\leq$ 3 and nb_gas_pp $\leq$ 5 and and nb_biomass_pp $\leq$ 26
  - Total effective continuous power produced over the period : 10 000 MW
    - Total_power_nuclear_pp = nb_nuclear_pp * power_single_nuclear_pp (at a given time)
    - Same formula type for gas and biomass power plants
    - Total_power = total_power_nuclear_pp + total_power_gas_pp + total_power_biomass_pp (at a given time)
  - Continuous power required period : 30 days
- Given patterns :
  - Single nuclear p.p. power (MW) ; duration (days) ; cost (k$) : [0,2500,0] ; [4,30,2] ; [20,180,10]
  - Single gas p.p. power (MW) ; duration (days) ; cost (k$) : [0,600,0] ; [2,12,1] ; [4,40,2]
  - Single biomass p.p. power (MW) ; duration (days) ; cost (k$) : [0,100,0] ; [1,6,0.5] ; [1,5,0.5]

Ideal solution

- I would expect something like this :
  - Nb_nuclear_pp : 3 out of 3
  - Nb_gas_pp : 5 out of 3
  - Nb_biomass_pp : 25 out of 26
  - Total_cost on operating period ie 36 days (min operating value closest to fixed 30 days) : k$ 1252.5
    - Nuclear : (20+180+10)*3 = k$ 630
    - Gas : (4+40+2)*2*5 = k$ 460
    - Biomass : (1+5+0.5)*25 = k$ 162.5

- Some explanations about the following schedule I expect to have : max nuclear power plants as a base because of their power. Max gas p.p. to increase the scheme but they do not last enough time to ensure a complete production. Thus biomass p.p. can fill the gap between two gas p.p. patterns.

- And the following timeline including total energy evolution over time (see next).


2500 MW
0 MW
x 3 nuclear p.p.
0 MW
4 days
30 days
2 days
600 MW
0 MW
x 5 gas p.p.
0 MW
600 MW
x 5 gas p.p.
0 MW
2 days
12 days
1 day
2 days
12 days
1 day
Caution :
power value
for single
power plant
100 MW
0 MW
x 25
biomass p.p.
0 MW
1 day
6 days
0.5 day
Total effective power
10 500 MW =
3 x 2500 + 5 x 600
10 000 MW
10 500 MW
30 days
days
0
4
16
22
34
36