Assignment 3b: Investment planning

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1 Exercise 1

a)   The expected net present value f_{NPV} is 105.455M€.

b)   The resulting CO_2 reduction for this solution is 2032.7

c)   In this scenario, all investments are made in the first level/stage of the model. The back-pressure turbine has size 30, the condensing turbine has size 1.36, the 100°C distinct heating has size 16.3, the distinct heating LP steam has size 4.65 and the lignin extraction has size 53.6. DH60 is never invested in. Measures taken are Blowdown, Blowout, ConVap7lig, HWWS, Piping, Press and WoodYard. These are taken at the first stage as well.

2 Exercise 2

a)   The CO_2 reduction of this scenario is 2320.58.

b)   In this scenario, BP is activated in stage 4, with a size of 26.58. DH60 is invested in at the first stage, with a size of 41.04. LIG is invested in at stage 4 as well, with a size of 77.46. These are the only investments. Measures taken include Blowdown, Blowout, ConVap7lig, Flash, HWWS, Piping, Press and WoodYard at the first stage, PIvap7lig at stage 4 and then ConVap7lig again at stage 5.
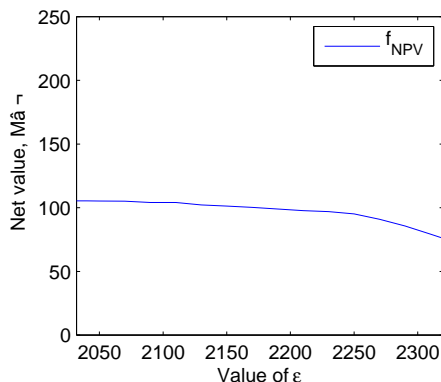

Figure 1: Pareto graph of the original problem. Note that the graph is plotted with respect to ϵ, and thus the economic optimum is to the left and the CO_2 optimum is to the right. It can be seen that the decrease of f_{NPV} is slow close to the economic optimum.
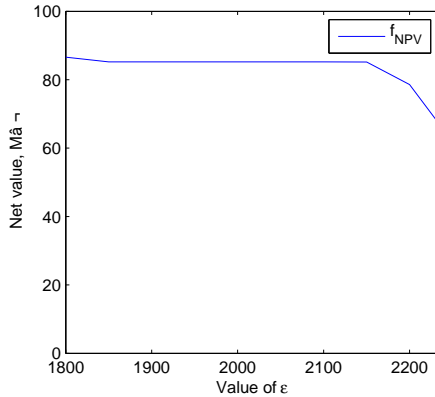
Figure 2: Comparing the pareto graph of this BAU-only model with the original one, you can see that the overall net value is much lower. However, one can push the value of ϵ quite far before net value drops further, which could be a good thing.

3 Exercises 3 & 4

The pareto curve (Figure 1) clearly indicates that heavy constraints will affect net value dramatically. However, it also indicates that a fair amount of CO_2 decrease can be forced without sacrificing too much of the net value. The fact that f_{NPV} decreases slowly near the economic optimum can be attributed to the fact that industry actually contains a high flexibility and can reduce CO_2 emissions a fair bit before taking large economic hits.

4 Exercise 5

a) Repeating exercise 1 for this case yields a CO_2 reduction of 1774.29 and a net value of 90.24€. The measures Blowdown, Blowout, ConVap7el, Flash, HWWS, Piping, Press, RBU and WoodYard are all taken at the first stage. BP is invested in at the first stage, with sixe 39.8. CT and DHLP are also invested in at this stage, with sizes 11.7 and 20.9, respectively.

Repeating exercise 2 yields a CO_2 reduction of 2234.42. The investment plan is not entirely unlike the previous case, with the only measure changes being a removal of RBU and replacing ConVap7el with ConVap7lig. All investments are made at the first stage; BP with a size of 26.9, DH60 with size 39.55, DHLP with size 1.49 and LIG with size 75.6.

The pareto graph can be seen in Figure 2.

b) Repeating exercise 1 for this case yeilds a CO_2 reduction of 2006.03 and a net value of 110.225€. Measures taken include Blowdown, Blowout, ConVap7lig, HWWS, Piping, Press and WoodYard, all taken at the first stage. Investments are also made exclusively in the first stage, and include BP with size 30, CT with size 1.36, DH100 with size 16.25, DHLP with size 4.65 and LIG with size 53.6.

Repeating exercise 2 yields a CO_2 reduction of 2385.43. Measures taken are Blowdown, Blowout, ConVap7lig, Flash, HWWS, Piping, Press and WoodYard at the first stage, and then ConVap7lig again at stage 4. Investments include BP at stage 1 and 4, with size 26.99, DH60 with size 41 at stage 1, DHLP with size 1.49 at stage 1, and LIG with size 97.57 at stage 1 and 4.

The pareto graph can be seen in Figure 3.

5 Exercise 6

a) This change will increase the net value from by rougly 230 000€. The CO_2 reduction remains unchanged, and so do the investments and measures taken.
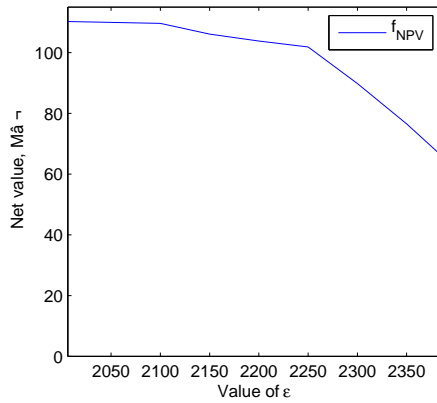
Figure 3: This case displays a very disappointing pareto curve. Net value is low, and decreases quickly even close to the economic optimum. There is not much flexibility to impose CO_2 constraints.

b) The change of piping costs reduce the expected net value by roughly 6M€, down to 99.1797M€. CO_2 reduction is also reduced down to 1887.19. Clearly, this is not a desirable change.

The only major changes in the actual investment plan is the increase of CT size to 3.69, the replacement of DH100 with a size 1.66 DH60 and a size increase of DHLP to 19.2. Measure changes include an introduction of Flash at the first stage, and that Piping measures are taken later (and twice) at stages 2 and 4.

Estimated time spent on this assigment: *roughly 5 hours* (preparation of presentation not included)