Chalmers University of Technology
University of Gothenburg
Mathematical Sciences

Nonlinear optimization
TMA947
MMG621

Planning of the natural gas transmission, part II: The optimal plan, with a sensitivity analysis

September 1, 2020

1 Introduction

The Belgian government were very happy with your report on how to optimize their gas transmission. Therefore, they want you to be responsible for the planning of the gas transmission. You have accepted their offer.

In this task, you are provided with a AMPL model describing the problem in Part I that you have considered (Belgium.mod, Belgium.dat, Belgium.run available from the course homepage). First you need to check out the model files and understand them. In addition, you have access to AMPL with various nonlinear programming solvers such as SNOPT, BARON, etc. You will need to modify Belgium.run in order to locate the path to the solvers. Your task is to answer the questions in the following sections and write a concise report that describes your answers.

The report should be written in groups of two or three. Names and personal code numbers of the group members as well as the e-mail addresses should be given on the front page of the report. You may discuss the problem with other students. However, each group must hand in their own solution. The report will be checked for plagiarism via `http://www.urkund.com`. **The deadline for handing in the model report through Canvas is October 9!**

Good luck!

2 Questions, group I

Solve the given AMPL optimization model, and answer the following questions:

1. What is the total cost of the gas supplying the demands in Belgium?
2. How much gas should be sent from Zomergem to Gent?
3. How much Algerian gas should be purchased?

4. How much gas is being transported from Warnant to Sinsin as a result of the compressor working on this active pipeline?

3 Questions, group II

Answer the following questions:

1. Is the solution obtained locally optimal? Globally optimal? Explain your answers. Also explain if the approach you adopt to verify optimality works in general cases beyond this exercise.
2. In the given AMPL model, the pressure-related decision variables are not exactly the pressures at the nodes. What are these decision variables? Why can we use these variables, and why do we want to use them?
3. Describe conceptually how to find a feasible solution without using any given nonlinear programming solver (this is useful in case the solver actually requires you to provide a feasible initial solution).

4 Questions, group III

The following questions deal with sensitivity analysis. You need to solve the original optimization model, and also modify the model and solve the modified models. Then you compare the optimal solutions if necessary.

1. Assume that Norwegian gas supply is reduced. Specifically, both the minimum and maximum quantities of the supply from Voeren are reduced to 80% of their original values.
   a) How does the total amount of Algerian gas purchased change?
   b) How does the total amount of Norwegian gas purchased change?
   c) Explain why the above changes occur!
2. What and how much can be changed in the data of the problem to make the compressor on the pipeline from Warnant to Sinsin active? How can you tell the compressor is indeed active? Hint: the answer to this question need not be unique.
3. Consider the case of increased demands:
   a) The demands at all demand nodes are doubled, while the supply at each supply node remains the same. Is this optimization model feasible? Explain your answer.

b) The demands at all demand nodes are doubled, and the maximum supplies at all supply nodes are also doubled. Is this optimization model feasible? Explain your answer. Hint: make sure you use the appropriate solver to make your statement.

4. Consider the marginal reductions of the minimal supplies of Norwegian and Algerian gas. Consider one limit at a time. What are the approximate derivatives of the total cost with respect to changes of the minimal supplies of Norwegian and Algerian gas, evaluated at the original optimal solution? Describe how you obtain these approximate derivatives. In addition, compare the results with the values of the dual variables for the limiting constraints in the optimal solution to the original problem.