Homework 3 & 4

June 29, 2020

Task 1 DCLF I: The Model

In the lecture we introduced DC Load Flow as a method to include physical flows in the dispatch model. The goal of this task is to work with different configurations of markets, including DC Load Flow constraints, along the examples of the paper by Ehrenmann & Smeers. A template is provided together with this homework.

The goal of this task is to familiarize with the model structure and assumptions. Keep your answers concise with only a **few** sentences.

a) Describe the objective function of the problem and distinguish between different subsets of nodes.

b) Explain how the market price is defined and the meaning of the parameters a, b in that context. What critical assumption regarding demand and generation is changed compared to previous models used in the lecture?

c) The model formulation in the template is different to formulation in the paper. Explain why both formulations are equivalent and describe possible benefits of both.

d) The template comes with an additional script that provides the function `calculate_ptdf` that will generate a PTDF matrix. Explain what the PTDF matrix does, what assumptions it employs and the information that is used to derive it.

e) Run the template. To which result from the paper does this problem formulation correspond? Does this result yield feasible load flows?

Task 2 DCLF II: Equations and Results

The goal of this task is to implement the DC Load Flow constraints into the template, discuss the methodology and recreate the different results from the Ehrenmann & Smeers paper. The last task will relate the different topologies to theoretical concepts from the lecture.

a) Based on the results of the running the template model without modification, the price by dual (i.e. by the dual of the energy balance) and the price by demand/supply function are different for Node 4. Explain the difference based on node type and what is captured in either way of calculating the price.

b) Implement two constraints which enforce upper- and lower limits in line flows (use the 3-Node example as a reference for implementation). Make sure this constraint only applies to the lines "1-6" and "2-5". The result should correspond to Table 4 in the paper. Explain why the market- and dual price are now equivalent.

c) Implement a constraint that forces the market prices (defined by the demand/supply function) to be equal to a new variable, that represents the price for all nodes within a price zone (as described in Section 4.1.1: Ideal market Splitting). You can use a similar approach as in the plants-at-node dictionary from the transport model[1].

d) Use this constraint to implement configurations 2.1 and 2.2 from the paper. Confirm the results with Tables 11 and 12. Compare the resulting prices from the definition and the ones by the dual and give reason for differences.

e) In the lecture we talked in the context of the Energy-Only Market about **Market Coupling**. In the Ehrenmann & Smeers paper **Market Coupling** and **Market Splitting** are discussed. Describe these two concepts and put them into context the Ehrenmann & Smeers model. **Explain** how these concepts can be represented in the model and how they differ in terms of load flow constraints.

[1] The basic structure of this constraint is hinted at line 77 in the template.

Task 3 Investment model

We talked about investment models in the lecture. This version optimizes the investment decision as well as the the dispatch decision for a electricity system. In exercise 3, we discussed the integration of other sectors into the electricity market. Your task is to to expand the investment model in order to represent an integration with the heat sector in a simple way. Consider the following:

technology	p2h
vc	0
lifetime	20
investment_generation	2
investment_charge	0
investment_storage	5
storage_efficiency_in	0.8
storage_efficiency_out	0.8

Table 1: Power-to-heat technology data

- Use the heat demand time series that we used in exercise 3
- Assume one power-to-heat technology with these parameters from table 1.
- Be aware of the fact that this technology consumes electricty in order to generate heat!

Add the electricty consumption from the power-to-heat technology to the "result_demand" DataFrame accordingly. Discuss how the results change.

Please sent your results to riw@wip.tu-berlin.de until July 27th 2020.