Homework 3

June 6, 2023

Please provide short answers! Bullet points are also accepted as answer. You can submit one julia file which contains all the tasks, as well as only one set of csv files containing all the tasks.

Hand in until Monday, June 19 (16:00)

Task 1: Trade Costs depending on distance

In general, trade costs depend on the distance the energy carrier has to be transported. For this task, you should implement the functionality of distance depending trade costs.

1. Determine the distance between the five nodes in our model. For each of the countries (DE, FR, NO, DK, and UK) you can use the following website to determine the linear distance ("Luftlinie") between the capital cities. You can skip the combinations without a $MaxTradeCapacity_{r,rr,f}$.
   Website: https://www.luftlinie.org/

2. Write a parameter $TradeDistance_{r,rr}$ which takes these distances in km. Use the values with two decimals, the default can be 0. (Example: The distance between DE and FR should be 878.05 km)

3. Define another parameter $TradeCostFactor_f$ which specifies the costs of transportation of a specific fuel per kilometer. Add the value 0.0002 for power.

4. Additionally, increase the capacity for power trade for all available connections to 15.

5. Redefine the trade costs calculation in the model to correctly account for the distance depending costs. Use the $Export$ variable for the calculation.

Hint: The objective value should be: 22517.38 (rouded)

Task 2: Trade Losses and hydrogen trade

As a next step we want to include trade losses into the model formulation. When electricity is transported over long distances, some of it is lost. We want to be able to account for that. Additionally, we want to include the option to trade hydrogen without any losses.

1. Add the possibility to trade hydrogen between the regions. Use the same trade routes also available for power but set the trade capacity to 5 for each available connection. The $TradeCostFactor$ should be 0.0004.
2. Add a parameter $TradeLossFactor_f$ which describes how much energy is lost per kilometer transportation. Use the value 0.00003 for power, the default should be 0.
3. Now you have to model the fact that only $1 - TradeLossFactor_f$ times the $TradeDistance$ of exports actually arrives at on the importing node. We already have a constraint which you will have to modify to account for that. Make sure to put the factor on the correct side of the equation.

Hint: The objective value should be: 22523.33 (rouded)

Task 3: Natural gas and coal

Until now, natural gas and hard coal could be produced in every node. We want to remove this functionality now and only let a few nodes produce these fossil fuels, which then can trade them to other regions if needed.

1. The countries which can continue to produce natural gas are NO and DE, while UK is the only region remaining which can produce hard coal.
2. Remove the possibility for all other countries to produce natural gas or coal. There is different possibilities to do so and you can use one of your choice (as long as it works). For the country/fuel combinations which are still allowed, nothing should change.
3. Now, natural gas and coal need to be traded. Implement the possibility by setting the capacity for coal to 20 and for natural gas to 8 (for the same trade routes as available for power/H2).
4. For gas, there should be a loss-factor of 0.00001 while coal has no loss-factor at all. The costs are 0.0001 per kilometer for both.
5. Submit the dispatch graphs for coal and gas production for all countries and briefly explain them. Also highlight why countries like Norway or Denmark import/export coal without using it.

Hint: The objective value should be: 23946.64 (rounded)