Energy Markets

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Exercise Session 2: Day-Ahead electricity markets - Advanced

The aim of this exercise session is to appraise and better understand the basic structure of electricity markets, and most particularly its day-ahead mechanism. It is a direct continuation of the Exercise session 1.

Problem 1: Problem 1: Formulating the market clearing more mathematically

Consider the market setup and list of supply offers of Problem 2 (in Exercise session 1), while assuming that the electric power demand to be met is fixed to 180MWh.

1.1 What is the most simple way to find the equilibrium point? Intuitively, what is the clearing price, who will produce and how much?

1.2 Since demand is fixed, what is the objective of the market clearing with the supply side? Write it as an objective function. Is it a maximization or minimization problem?

1.3 What is the balance condition for the market (between supply and demand)? Write it as a balance constraint.

1.4 Deduce the complete linear program to be used for clearing the market.

As an extension, we now consider that the list of demand offers that is given in Problem 3 of Exercise session 1.

1.5 What should be the objective function of the market-clearing (since having to consider both supply and demand sides)? Write it as an objective function. Is it a maximization or minimization problem?

1.6 What is the balance condition for the market (between supply and demand)? Write it as a balance constraint.

1.7 Deduce the complete linear program to be used for clearing the market.

Feel free to implement those linear programs in Python/R/Matlab/GAMS/etc. in order to verify that you obtain the same solution as in Problem 4 of Exercise session 1. It can only help you for the further work to be done for the first assignment.

Problem 2: Settlement and revenues

For this problem, you should consider the list of supply and demand offers presented in session 1.

2.1 Look through the lecture slides, and define the difference between "pay-as-bid" and "uniform pricing".

2.2 Determine the revenues of various market participants on the supply side under uniform pricing settlement. What if using pay-as-bid instead?

2.3 Determine the payments for various market participants on the demand side under uniform pricing settlement. What if using pay-as-bid instead?

Problem 3: Day-ahead market with 2 zones

Let us now complexify a bit the market set-up and make it more realistic. Our market is now split into two zones (West and East). The various suppliers and demands are associated to these zones as follows:

Supplier Name	Supplier id.	Zone	Quantity [MWh]	Price [€/MWh]
Flexigas	G_1	East	15	75
Nuke22	G_2	West	100	15
ShinyPower	G_3	East	32	0
RoskildeCHP	G_4	East	25	42
BlueWater	G_5	West	70	10

Demand Name	Demand id.	Zone	Quantity [MWh]	Price [€/MWh]
WeLovePower	D_1	East	35	65
CleanChange	D_2	East	23	78
JyskeEl	D_3	East	12	10
ElRetail	D_4	East	38	46
QualiWatt	D_5	West	43	63
IntelliWatt	D_6	East	16	32
El-Forbundet	D_7	West	57	50

The available transmission capacity between these 2 zones is of 30MW. In the following we will assess how this may affect the previous market clearing and revenues that were obtained when not having such transmission constraints.

3.1 Make a schematic representation of the system layout (i.e., the two zones with its players, as well as the transmission constraints between these two).

3.2 Assess whether the previous market clearing (from Problem 1) is feasible or not by comparing the scheduled supply and demand locally and the amount of energy that should be transmitted between the two zones.

3.3 Obtain the supply and demand curves for both zones (as if there was no connection between the two).

3.4 Update this curves by adding extra virtual offers representing transfer of power from one zone to the next. From which and to which zone should the power flow?

3.5 Determine equilibrium price in both zones as well as revenues and payments for each market participant when

(a) There is no transmission between the two zones.

(b) There is 30 MW of transmission between the two zones.

3.6 Compare the prices with the case where there was no transmission constraint at all (i.e. as if the two zones where one).

3.7 What would be the minimum transmission capacity needed here for the price to be the same in the 2 zones?

Problem 4: Extract and analyse data for a day-ahead market

Besides some of the basic modelling and market concepts dealt with through the previous problems, a key aspect of working with electricity markets (including the day-ahead stage) is to develop an ability to find and analyse relevant data. In the present problem, emphasis is then placed on extracting data from the Nord Pool website in order to appraise what is going on there.

4.1 Pay a visit to the market data page of the Nord Pool website and have a look at prices in tables in chart for the last cleared day. How similar are prices for the 2 market areas of Denmark? What are the daily variations, and can you explain them?

4.2 One may also download more extensive datasets from the historical market data webpage of the Nord Pool website. There you may for instance get some of the data for 2020 so far:

- hourly consumption data used at the time of clearing the market,
- hourly wind power forecasts used at the time of clearing the market,
- hourly market prices as the result of the market-clearing process.

Download these data and choose your favorite data analysis environment (Python/R/Matlab/Excel/etc,).

4.3 Find a typical day with high wind power production in DK1, and look at the corresponding prices. Do the same with a typical day with very low wind power production. Is there something to learn here?

4.4 What is the average day-ahead, also called spot prices, for DK1 (Western Denmark) as a function of the time of the day? Its maximum and minimum? Are they defined limits for these minimum and maximum values (i.e., as set by the market rules)?

4.5 What is the average consumption for DK1 and DK2 (Eastern Denmark) as a function of the time of the day?