31761 - Renewables in Electricity Markets

Exercise session 3: Intra-day and balancing markets

The aim of this exercise session is to appraise and better understand the basic structure of electricity markets, and most particularly its intra-day and balancing mechanisms. The session relies on Lectures 1-5 available at "Lecture notes for 31761 - Renewables in Electricity Markets".

Problem 1: General description of intra-day and balancing markets

This Problem is based on the Nord Pool website, as well as the Energinet webpages for the wholesale electricity market and the ancillary service market.

1.1 What is the common name of the intra-day market in Nord Pool? How does it work?
1.2 When is it possible to trade in the intra-day market? Can one trade just 5 minutes before delivery?
1.3 What is the area covered by this intra-day market? Is that the same than for the day-ahead market?
1.4 What is the intra-day market for, and who could have interest in participating?
1.5 What is the purpose of the balancing market? Who is responsible for activation of regulating power in Denmark?
1.6 What is the name of the (dynamic) list for all available regulating power on a given day in Scandinavia?
1.7 Is that possible that a generator in Norway helps balancing the system in Denmark?

Problem 2: Setting up our own balancing market

This Problem builds on Exercise Session 1 which focused on day-ahead markets. Especially, we assume that the day-ahead market was cleared following Problem 4, i.e., based on the list of supply and demand offers described in Problems 2 and 3, respectively.

Before actual operation, a list of market players who can provide balancing services for that time unit is gathered. To simplify things, all of these players already participated in the day-ahead electricity market. Only generators (not demand) are ready to provide balancing. These include:

Supplier name	Supplier id.	Up. quant. [MWh]	Up. Price [€]	Down. quant. [MWh]	Down. Price [€]
FlexiGas	G_1	15	80	-	-
RoskildeCHP	G_4	5	50	15	15
BlueWater	G_5	20	35	20	5

2.1 What is the generation schedule for these generators after the market clearing of Problem 4 (in Exercise Session 1)? Please re-calculate their revenues after day-ahead market clearing.
2.2 Draw the supply curve corresponding to these balancing offers.
2.3 Nuke 22 has a problem with its cooling system, yielding a shortage of 22MWh in comparison with the amount contracted through the day-ahead market. What is the resulting demand for our balancing market? Add this demand curve to your previous drawing.
2.4 What is the resulting balancing price, and who will provide the balancing service? How many MWh and in which direction?
2.5 Calculate the revenues and payments for all participants in this balancing market. Deduce the combined revenues, considering both day-ahead and balancing markets.
2.6 Go again through points 2.3-2.5 now considering that it is CleanCharge that needs 10 MWh more than in the original day-ahead contract.

Problem 3: One-price vs. two-price imbalance settlements

This Problem is a follow-up of Problem 2 (hence similarly building on Exercise Session 1). We therefore still assume that the day-ahead market was cleared following Problem 4, i.e., based on the list of supply and demand offers described in Problems 2 and 3, respectively. The list of players who can provide balancing services for that time unit was given in Problem 2.

Quite a few market participants are not able to meet their contracts, and will then induce imbalances. The full list includes:

Participant name	Participant id.	Deviation [MWh]
ShinyPower	G_3	+5
WeLovePower	D_1	+8
Nuke22	G_2	+10

In the above table, a deviation of +10 MWh means that the market participant *(i)* generates 10 MWh than his contract if being a supplier, or *(ii)* consumes 10 MWh more than his contract if on the demand side. We now aim at performing the imbalance settlement following both one-price and two-price systems.

3.1 Assess the overall system imbalance resulting from this individual imbalances. Will the system need upward or downward regulation?
3.2 Which are the units whose imbalance are putting the system off-balance, and which are (involuntarily) helping the system getting back to balance?
3.3 Clear the balancing market as in Problem 2. Determine the balancing price and the schedule of the generator(s) involved in balancing.
3.4 What is the difference between the one-price and two-price imbalance settlements?
3.5 Calculate revenues and payments for the 3 market participants in imbalance, and for the generator(s) providing balancing under a one-price settlement.
3.6 Calculate revenues and payments for the 3 market participants in imbalance, and for the generator(s) providing balancing under a two-price settlement. Compare with the outcome of 3.5.
3.7 Let us imagine that these 3 market participants in imbalance could have known about their real consumption/supply before the day-ahead market settlement. Adapt the list of offers of Exercise Session 1 and clear the day-ahead market. Deduce the revenues and payments of these 3 market participants. Would they have been better off in that case?

Problem 4: Analysis of the balancing situation for a given day based on data

For this Problem, we aim at understanding the balancing situation for a given day based on the data publicly available on the NordPool website. The webpages of interest are that for day-ahead prices and that for regulation and regulation prices. Let us focus on the market area DK1, for the case of 21 January 2015.

4.1 Extract day-ahead and regulation prices ("Price up" and "Price down") to have them on a piece of paper, or a file to import in Matlab/R/Excel/etc. What do these prices mean?
4.2 Are these prices always equal or not?
4.3 Find example hours for each of the 3 potential balancing situations (up, down and no-regulation).
4.4 Do you expect the price for upregulation to be higher/lower than the day-ahead price? Explain why?
4.4 Same questions for the downregulation price.
4.5 Have a look at some other days in January to see how often the various balacing situations occur, and how different prices can be.

Optional extra Problems (available on demand)