Tasks – providing hands-on experience with the electricity market

## Task 1

The purpose of task 1 is for you to gain insight into what real supply and demand curves might look like, and how the supply curve depends on fuel prices and availability of renewable energy plants. You will also learn how the price-setting plants determine the area prices.

You enter PMS-Education. Here you must calculate area prices and find the price-setting plant in the three areas. You must use default values ​​for fuel prices, availability, etc. - except that you shall calculate on a winter weekday between 11 am and 12 pm in the year 2024.

## Task 2

Now you shall investigate how wind production affects the supply curves and thus the area prices.

As a producer, you shall go in and increase the availability of wind power to 100%. You shall then repeat the calculation in task 1. Determine how the area prices change and identify the price-setting plants.

## Task 3

Now we will investigate how increased expansion of wind and solar affects area prices. We will also find specific values ​​for producer, consumer and transmission surplus. We will later use these values ​​to assess who wins and loses when transmission lines are established between the areas.

You shall start by installing a solar cell plant in VE1 of 1000 MW in 2020. Then you shall set the availability of solar and wind to 100% and calculate area prices. What will be the area price in VE1, and which plant is price-setting?

Click on “Show results” and read the production, consumer and transmission surplus for the three areas - separately and together. Save these values, they will be used in task 4.

## Task 4

In this task, we will look at how transmission lines affect area prices.

As a TSO, you must install a transmission line between the areas VE1-HY of 1000 MW in the year 2020. You must then calculate the area prices and read the new production, consumer and transmission surpluses for the two areas (VE1 and HY). By comparing these surpluses with the result without the transmission line (from task 3), you must calculate how much the total social surplus increases and who (producers or consumers) in the two areas benefit financially from the connection.

Finally, you must calculate the transmission surplus yourself and check whether you get the same result as PMS.

## Task 5

Now we will analyze the relationships between transmission capacities and bottlenecks a little more closely.

You must find out at which transmission capacity between VE1 and HY the bottleneck disappears at the hour in question. You can do this by installing different transmission capacities and trying it out. But there is an easier method.

## Task 6

This task is primarily intended to help you do your own analyses with PMS. It is possible to build your own electricity market with PMS. So that you do not have to start from scratch every time, you can save current changes in a file that you can later load and work with.

Now you must set the capacity on the VE1-HY line back to 1000 MW and save the changes you have made by clicking on "Export settings". The export file is saved on your own computer.

## Task 7

Now we will investigate how flexible consumption in the form of PtX plants can affect the electricity market.

You start by establishing a PtH (Hydrogen) plant of 1500 MW in VE1 in the year 2020. You do this under electricity consumption. You also choose that the plant will buy electricity for a maximum of 100 EUR/MWh. You must then calculate area prices for VE1 and HY.

How much electricity will the PtH plant consume in the hour in question (year 2024, winter, weekdays 11-12)?

Why is it not running at full load?

## Task 8

Now you must investigate how investment costs for different technologies affect the future expansion of electricity generation plants. You do this by using the investment part of PMS-Education.

You start by reloading the saved settings from task 6. Then go to “Establishment automatically” and set the calculation period to 2024 – 2040. Also select that it is the solar cell plant in VE1 that you want to calculate the total contribution margin for in the period. Click on VE1 and HY, which are the two areas for which we are making the scenario calculation. Start the calculation, and then click on “Show invest”.

What will be the contribution margin for the solar cell plant?

What does the model invest in?

Refresh (Ctrl F5) and reload the saved settings.

Go into “Establishment automatically” and increase the investment price of solar cells to 0,8 million EUR/MW. Also remember to tell the model that it should calculate the contribution margin for the solar cell system. Repeat the investment calculation.

What is the difference to the previous calculation?

• The difference in what is invested in

• The difference in the contribution margin for the solar cell system

Explain the differences.

## Task 9

In task 9 we leave PMS-Education and open PMS-Hour. This requires purchasing a license. In PMS-Hour you can calculate for the whole world. Data for production plants comes from Enerdata. Enerdata has collected information on almost all electricity production plants in the world. There are some areas where it has not been possible to collect individual data for certain technologies. In those countries, the missing plants are grouped together. They can be seen as yellow bubbles on the supply curve.

In order to identify these groups of plants, you must open the bubble diagram with supply and demand curves for the western part of Denmark (DK1), and find the decentralized CHP plants on the supply curve. Once you have found them, you must increase the efficiency of these CHP plants to 80% and explain what happens.

The PMS model has hourly profiles for production from solar cells, wind turbines, run-of-river hydroelectric power plants and CHP plants in the different countries. You can see how the production of solar cells and CHP plants varies depending on the season, day type and time, by looking at the availability (sliders) when you change the season, day type and time. Do this exercise for DK1.

Once you have done this, you must refresh and set the calculation time to winter, weekdays 4 – 5 pm in the year 2024.

With PMS it is possible to access the data used for all production plants and consumption plants, and it is possible to change this data. You should try it now.

The production data is a few years old – and from a time when it was expected that the electrolysis plant in Esbjerg (DK1) would be commissioned in 2024. You must now go in and change this to commissioning in 2027.

Calculate area prices for the Nordic countries and Germany (year 2024, winter, weekdays 4-5 p.m. Efficiency of CHP = 50%, availability of CHP = 78%)

After you have calculated the area prices, you must increase the availability of wind power to 100% and see what happens to the area prices.

You will notice that the area prices will be very low. In this situation, the owners of hydroelectric power plants with reservoirs will register the hydroelectric power at a higher price. You must therefore do so. Set the water value to 30 EUR/MWh and repeat the calculation. How does this affect the area prices?

In the calculation, there are many hydroelectric power plants that are in operation, and they produce a significant part of the electricity consumption. But the area prices are not 30 EUR/MWh. Why not?

## Task 10

Now you have learned how to analyze different market situations with the PMS model. It is therefore time for you to ask the questions yourself, imagine the answers, and test whether your ideas hold true.

In Task 10, you will therefore do your own analyses with PMS-Education and PMS-Hour.