

## EnergyPLAN Exercise 2:

### Make Simple Energy System Analyses.

In exercise 2, you are asked to do a couple of energy system improvements of the energy system of exercise 1. Through the exercise and the guideline, you learn step by step how to analyse changes to the energy system.

Exercise 2 continues with the system defined in exercise 1, which is:

- Electricity demand of 49 TWh/year and “hour-eldemand-eltra-2001”
- Condensing power plant: 9000 MW coal –fired
- 2000 MW wind power using “Hour\_wind\_eltra2001”
- Annual district heating demand of 39.18 TWh (distribution “hour\_distr\_heat”)
- Fuel demand for individual house heating of 23.07 TWh divided into 0.01 coal, 6.72 oil, 9.05 natural gas and 7.29 biomass.
- Industrial fuel demand of 53.66 TWh divided into 3.37 coal, 26.92 oil, 18.19 natural gas and 5.18 biomass (including fuel for district heating and electricity production).
- Industrial district heating production of 1.73 TWh and an electricity production of 2.41 TWh. Use the hour distribution file “const”.
- Fuel demand for transportation: 13.25 TWh Jet Petrol, 27.50 TWh Diesel and 28.45 TWh Petrol.

The system has a primary energy supply of 286.27 TWh/year and CO<sub>2</sub> emissions of 77.62 Mt.

#### Exercise 2.1: Energy conservation in house heating

Open the EnergyPLAN model. Load the data of exercise 1. Assuming that the district heating demand of 39.18 TWh/year is composed of 20% grid losses, 20% hot water and 60% space heating, implement energy conservation in house heating equal to 50% of the space heating demand. Do the same for the individual house heating demand of 19.70 TWh/year assuming that the demand is composed of 25% hot water and 75% space heating.

Consequently, the annual district heating demand will decrease by 50% of 60% from 39.18 to 27.43 TWh/year. And the heat demand for individual houses will decrease by 50% of 75% from 19.70 to 12.31 TWh/year.

Note that such energy conservation measures change the duration curves and, consequently, the existing hour distribution curves have to be replaced by “Hour\_distr-heat-2-50procent.txt” and Hour\_indv-heat-50procent.txt.

*Question 2.1.1: What is the peak hour district heating demand before and after implementing the energy conservation?*

*Question 2.1.2: What are the primary energy supply and the CO<sub>2</sub> emission of the system after implementing such energy conservation measures?*

## **Exercise 2.2: Replace district heating boilers by CHP**

Replace the 27.43 TWh of district heating boilers by:

- 1.59 TWh of district heating boilers
- 10.00 TWh of small-scale CHP: 1350 MW, eff-th = 50%, eff-el = 41% on natural gas
- 15.84 TWh of large-scale CHP: 2000 MW, eff-th = 50%, eff-el = 41% on coal.
- Add boiler capacities of 5000 MJ/s in gr. 2 and gr. 3
- Add thermal storage capacity of 10 GWh in gr. 2 and gr. 3.
- Identify a 450 MW minimum production on the large-scale CHP units.

Move 1.73 TWh of industrial excess heat production (2.41 of electricity) to gr. 3.

*Question 2.2.1: What are the primary energy supply and the CO<sub>2</sub> emission of the system?*

## **Exercise 2.3: Add 3000 MW off-shore wind power**

Add 3000 MW off-shore wind power.

Use the hour distribution file “OffshoreHornsRef2003RAMSES.txt”

The electricity production from CHP in combination with wind power may lead to hours in which the production exceeds the demand, known as excess electricity production. The energy system analysis will identify and quantify this excess production. However, such balancing problems depend on the regulation of the electricity production units. Basically the model differs between operating CHP units 1) to meet solely heat demand or 2) to meet both heat and electricity demands (Regulation strategy 1 and 2).

*Question 2.3.1: What is 1) the excess electricity production, 2) the primary energy supply and 3) the CO<sub>2</sub> emission of the system if the CHP units are regulated solely according to the heat demand?*

*Question 2.3.2: What is the answer if the CHP units are regulated according to both the heat and the electricity demand?*

## **Exercise 2.4: Implement electricity-saving measures**

Decrease the electricity demand by 30% from 49 to 34.3 TWh/year.

*Question 2.4.1: What is 1) the excess electricity production, 2) the primary energy supply and 3) the CO<sub>2</sub> emission of the system if the CHP units are regulated solely according to the heat demand?*

*Question 2.4.2: What is the answer if the CHP units are regulated according to both the heat and the electricity demands?*

## **Exercise 2.5: Add heat pump and heat storage capacity to CHP plants**

Add heat storage capacity of 40 GWh to gr 2 together with a 300 MW heat pump with a COP=3.

*Question 2.5.1: What is 1) the excess electricity production, 2) the primary energy supply and 3) the CO<sub>2</sub> emission of the system if the CHP units are regulated according to both the heat and the electricity demands?*

***REMEMBER to save exercise 2. You will need it when doing exercise 3.***