Lecture 9: Limiting CO_2 emissions

DTU Course 46770: Integrated Energy Grids

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Problem 9.1. Producing electricity in coal and gas power plants entails the efficiency, CO_2 emissions and fuel cost shown in Table 1. What is the cheapest option to produce electricity? Which CO_2 tax would be necessary to alter the merit order of the two technologies and incentivise lower CO_2 emissions per MWh of produced electricity?

	Coal Power plant	Combined Cycle Gas Turbine (CCGT)
Fuel cost (USD/MWh thermal energy)	6.2	20.1
Efficiency of power plant (MWh electricity / MWh thermal energy)	0.33	0.59
Emissions (tCO2/MWh thermal energy)	0.336	0.198

Table 1: Electricity production in coal and gas power plantns.

Problem 9.2. Use the model built in PyPSA described in Problem 8.2 and assume that methane gas emits 0.198 tCO2 per MWh of thermal energy contained in the gas.

Consider the annualized capital costs and marginal generation costs for the different technologies in the following table.

Technology	Annualized capital costs (EUR/MW/a)	Marginal generation costs (EUR/MWh)
Onshower Wind	101,644	0
Solar PV	51,346	0
OCGT	47,718	64.7
CCGT	104,788	46.8
Battery inverter	12,894	0
Battery energy capacity	24,678	0

Table 2: Costs assumptions.

Limit the maximum CO_2 emissions to 5 MtCO2/year.

a) Calculate the optimal installed capacities and plot the hourly generation and demand during January.

b) What is the CO_2 tax required to meet this CO_2 emission limit?

Problem 9.3. For the model built in PyPSA described in Problem 9.2 but not including the CCGT generator with exogenous capacity.

a) Calculate the revenues collected by the OCGT plant throughout the year and show that their sum is equal to its costs.

b) Solve the problem for different CO_2 values ranging from 5 MtCO2/year to zero. Plot the total system cost and the required CO_2 prices as a function of the emissions allowance.