

EXERCISE SET # 5: COMBINING ELECTRICAL AND HEATING SYSTEMS

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ASSIGNMENTS WEBSITE

The purpose of this problem set is to review and comprehend pre-developed code in order to gain an understanding of how wind turbines could be used to supply space heating demand in conjunction with electricity demand. This problem set will explore the effects of implementing such a system on the total cost of running the system, the required capacity of backup gas turbine generators, and the ability of the system to supply consumer demand. For this problem set, hourly wind speed data is taken from New York in NY_wind.xls, hourly space heating demand data (in MW) is taken from nyheatdemand.xls, and hourly electricity demand data (in MW) is taken from New York City data contained in nyelecdemand.xls.

The function you will be using, HW5_func.m, is designed to receive an array of turbines as input, and output a series of figures and costs that relate to the wind turbine system. The system is designed to first direct wind energy to the electricity demand, and then use any excess to supply heat demand (rather than put it into a battery as you did in Assignment 3). Any electricity demand that cannot be supplied will be supplied by a set of gas turbines that operate at a relatively higher cost, and any heat demand that cannot be supplied will be supplied by a boiler that operates at low cost (note that the entire cost table is given in table 1). You will be responsible for interpreting the flow of the function in more detail.

TABLE 1. Capital and Recurrent Costs for Energy Sources.

Energy Source	Capital Cost (\$ per KWh)	Recurrent Cost
Wind Turbine	1,333	0
Gas Turbine	600	\$ 10 per GJ of gas
Gas Boiler	50	\$ 10 per GJ of gas

Problem 1

Draw a flowchart of the logic used in lines 45-128.

Problem 2

Plot the hourly electricity demand and hourly space heating demand on the same figure. Discuss their properties.

Problem 3

Edit the given function so that it can output:

- (1) The percentage of the total electricity demand that the wind turbines supplied.

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- (2) The percentage of the total electricity demand that the gas turbines supplied.
- (3) The percentage of the total heat demand that the wind turbines supplied.
- (4) The percentage of the total heat demand that the gas turbines supplied.
- (5) The maximum capacity of gas turbines needed to supply any electricity that the turbine system could not.
- (6) The maximum capacity of gas turbines needed to supply any heat that the turbine system could not.
- (7) The total cost of the system, assuming the capacity costs and recurrent costs given in table 1. Note that 2.5 units of fuel used in a gas turbine supply 1 unit of electricity demand, and 1.1 units of fuel used in a boiler supply 1 unit of heat demand. Assume that the capacity of gas turbine and boiler required are the maximum capacity needed.

Problem 4

For 25,000 turbines, complete a simple analysis of the cost of the system that includes the total cost of the system, and the percentages of the total cost due to:

- Wind turbine capacity.
- Gas turbine capacity.
- Boiler capacity.
- Gas turbine fuel.
- Boiler fuel.

Problem 5

For a range of turbines from 0 to 40,000 with a step size of 10,000, create a table that includes the following figures:

- The amount of the wind energy that was used - this figure should include any energy that was not left in the boiler system, or spilled because the boiler was full.
- The percentage of the total electricity demand that was supplied by wind turbines.
- The percentage of the total electricity demand that was supplied by gas turbines.
- The percentage of the total heat demand that came from surplus wind energy.
- The percentage of the total heat demand that came from a boiler.
- The maximum capacity of gas turbines needed to supply any electricity demand deficit.
- The maximum capacity of boilers needed to supply any heat demand deficit.
- The total cost of the system.

Problem 6

For the same range of turbines, create a table that shows the percent of time that the wind turbines, gas turbines, and boilers were operating.

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