OPTIMISATION AND OPERATIONS RESEARCH II: PROJECT HANDOUT 1, REVISION 1.0

1. Power Generation

Power companies can generate electricity in various ways: *e.g.,* using coal-fired or natural gas power plants. Each power plant has different characteristics and costs. Power companies must determine how to most efficiently use their capital assets (power generators) to fulfil demands. This is the optimisation problem we will be solving.

There are various versions of this problem. We will start the problem of optimal allocation of power generation to a set of power plants: often called the *economic dispatch problem.* We will progress later in the project to the problem of *unit commitment* where power-plants can be switched on and off.

We concentrate here primarily on fossil fuel plants because the optimisation problem is simpler in this case.

1.1. **The problem.** Imagine we have a set of power plants, each with different capabilities and characteristics. In particular, they can each provide different ranges of power (thermal power plants have a minimum output as well as a maximum); and they each have different costs to run. Table 2 gives the characteristics of three reasonably realistic power plants.

Thermal power plants work by burning some fuel to create heat H, and then converting that heat into power P (usually by creating steam to run a turbine). The amount of heat created is a linear function of the amount of fuel burnt given in Table 1.

Table 1. Cost of fuel for thermal generating units. The unis are cost per Megawatt hour (that is the cost to generate a Megawatt of heat for 1 hour).

Energy Source	Fuel Price
Coal (sub-bituminous)	\$36.00/MWh
Natural gas	\$40.00/MWh
Diesel oil	\$48.00/MWh

Heat is turned into electrical power through some type of turbine. However, electrical-power output is not a linear function of the input. Table 2 shows the input heat required to generate a given output power.

Table 2. Characteristics of thermal power stations: H_i is the input heat, P_i is the output power, and P_{min} and P_{max} are the minimum and maximum output powers, respectively. Units are megawatts (MW).

Generating Unit	Energy Source	Input-Output Characteristic (MW)	Operating Output Limits $P_{\min}$ (MW)	$P_{\max}$ (MW)
A	Thermal coal	$H_A(P_A) = 192.0 + 2.56P_A + 0.002P_A^2$	200	600
B	Natural gas	$H_B(P_B) = 133.0 + 2.25P_B + 0.0025P_B^2$	160	400
C	Diesel oil	$H_C(P_C) = 72.0 + 1.80P_C + 0.003P_C^2$	100	275

The economic dispatch problem is to minimise the fuel costs of meeting a given demand for electricity in a city. In the economic dispatch problem all power plants are spinning (*i.e.,* they are on continuously.

Note that the problem, as described above is a (small) abstract version of the real problem. As the project progresses, we will make the problem closer to the real problem. You will need to design your solution so that it can be adapted and expanded to include data and more realistic constraints. Note that more details will be forthcoming, but that they are not all available now – this is deliberate! You need to learn to plan your project under uncertainly.

Date: August 19, 2019.

1.2. **Tasks.** In this section we briefly outline the component tasks you will need to undertake in this project.

(1) Perform your own research on the problem so that you have a clear idea of the context of the problem.

(2) Formulate the problem: translate the words into an optimisation problem. You will need to indentify
- variables,
- optimisation objective,
- and constraints.

You will note that these are not as trivial to extract because the information must be combined together from two tables.

(3) Perform approximations to make the problem linear.
- You should try at least two approximations so that you can report on why you make the final choice you make.

(4) Solve the optimisation problem.
- You may use MATLAB or any other solver you have access to, or you may need to write your own program to find the solution.

(5) Perform sensitivity analysis.
- You will test your solution with respect to its robustness to the assumptions made.

(6) Add additional constraints.
- The problem as described above, for instance, assumes that all power-plants are always "on".

(7) Solve a larger problem given a data file with the problem parameters.

(8) Report on your solutions.

Additional information will be provided as the project progresses.

1.3. **Assessment.** You will be assessed based on
- The quality of your solutions.
- Your project management success, *e.g.,* meeting milestones along the way.
- How well you present your work.