MAE 119: Homework 5

Due: Friday, Mar. 13, 2020

You must show all work for full credit. Joint submissions can be made in groups of two. All submissions and code must be uploaded to Canvas for full credit.

Problem 1 (100 points)

In homework 4 we designed a microgrid to power remote communities during power outages. The sizing of the microgrid components (solar, diesel, battery) was 'ad-hoc', which means that it was not based on careful analysis and therefore not optimal. In this homework we will design an *optimal* microgrid power system.
We will consider the following costs:

1. Reliability / Interruption costs. These are the costs per hour of power outage. A smaller power system will be less expensive, but result in a higher risk of power outages, which increases the interruption costs. Assume an outage cost per unserved kWh of $14/kWh.

2. Life cycle costs (as determined in HW4)

Consider the solar + battery system of HW4. Assume that the distribution grid would like to island during the entire year. Givens and assumptions are:

1. The average daily load curve for each month, i.e. 12 months x 24 hours of load.

2. 8760 hour solar power generation (from homework)

3. A battery system that is assumed to be 100% efficient.

Tasks:

1. Create a rule-based battery storage control algorithm.

   (a) When solar > load, the extra energy is stored in the battery. When the battery is full, then the extra solar energy is curtailed (wasted)

   (b) When solar < load, the battery is discharged to serve the load. When the battery is empty, a power outage results.

2. Simulate a year through 24 hours x 12 months = 288 hours. (Use the ad-hoc configuration found in HW4.)

   (a) To create the average solar day for each month, average all the days in the month. The demand can be found in the HW5_data folder.

   (b) Assume that the battery is initially full (state-of-charge = 100%). Apply the rule-based algorithm to simulate the battery state-of-charge throughout the year.

3. Repeat #2 for a range of battery sizes (10 to 200 MWh) and solar array sizes (10 to 80 MW). Add reliability costs and lifecycle costs to obtain the total cost (use the same inflation and discount rates as in HW4). Plot the total cost as a function of battery size and solar size and determine the optimal system size. Compare the optimal system to the ad-hoc sizing.