Smart Energy Systems

Winter 2020-2021

Optimization Project Group

Milestone 2

Attachment I: ms2.pdf
Attachment II: bg1.pdf
Attachment III: bg2.pdf
Attachment IV: bg3.pdf
Attachment V: bg4.pdf

The objective of this milestone is to set up a stochastic unit commitment problem, gain familiarity with Monte Carlo sampling, and implement the L-shaped method so as to solve the devised problem.

Task Descriptions:

1. Modify your Assignment 1 code by modeling the problem description spelled out in Sections II and II of Attachment I.

2. Assume that the hourly load values are jointly Gaussian, where the mean value of the random variable for each hour is as provided in Table 1 and the variance is equal to $\frac{1}{3}$ of its mean value. Note that, for the sake of simplicity, we ignore the temporal correlation between the time periods and assume that the random variable representing the load in each hour is independent from that in the other hours. Analogously, we ignore the minimum uptime, downtime, and ramping constraints. Please peruse Sections II-A and III of Attachment I for the mathematical models.

3. Generate 1000 crude Monte Carlo samples to represent the uncertain load.

4. Assume that the microgrid has the capability to purchase energy both through a *forward contract* (reminiscent of the day-ahead market) as well as in real time (reminiscent of the real-time market). In purchase via the forward contract, the microgrid operator must set forth the amount of energy that will be purchased ahead of dispatch before the uncertain load values get revealed. Consider that the energy amount stipulated in the

forward contract must be purchased, even if it may not be required to meet the demand, in which case it would be *spilled*. In real time, energy may be purchased after the uncertain load values get realized. For detailed information, please see Section II-B in Attachment I.

5. Implement the L-shaped method to solve the devised stochastic unit commitment problem, where

   (a) the binary commitment variable $u_g[h]$ and the power purchased through the forward contract $p_\dagger^{\mathsf{i}}[h]$ serve as the first-stage decision variables

   (b) the power dispatch of the generators $p_{\gamma_g}^{\mathsf{i}}[h]$ and the power purchased in real time $p_\ddagger^{\mathsf{i}}[h]$ are the second-stage variables. Solve the coded optimization problem using Pyomo with Gurobi as the solver and simulate the objective function value and the optimal solutions over the study period using the parameters in Tables 1 and 2. Assume that $\lambda_\dagger[h] = 25¢/kWh$, $\lambda_\ddagger[h] = 30¢/kWh \quad \forall h \in \mathscr{H}$.

6. Study the sensitivity of the optimal solutions to the real-time purchase price of energy by varying $\lambda_\ddagger[h]$ from $15¢/kWh$ to $35¢/kWh$ in $5¢/kWh$ increments.

Useful Links/Resources for the L-shaped method:

1. Papavasilou, Anthony. "LINMA2491: The L-Shaped Method." YouTube, 8 Mar. 2014, https://www.youtube.com/watch?v=k4egixOm8Tc.

2. Attachments II-IV.

3. Chapter 3 of Attachment V.

Expected Outcome:
You are asked to

1. send me your source code by no later than 10 a.m. on December 15, 2020 at yurdakul@tu-berlin.de.

2. prepare a slide set depicting the work you carried out as well as the results you obtained. The prepared slide set is to be presented in class on December 15, 2020; the duration of the presentation is 15 minutes.

Table 1: *TGR* Parameters

γ_g	$[p^{\mathsf{i}}_{\gamma_g}]^m$	$[p^{\mathsf{i}}_{\gamma_1}]^M$	$\bar{c}_{\gamma_g}$	c_{γ_g}
γ_1	$0\ kW$	$12\ kW$	$\$0.128/kWh$	$\$2.12(10^{-5})/h$

Table 2: Expected Values of the Random Hourly Load

h	$\mathbb{E}[\tilde{\ell}](kW)$
1	8
2	8
3	10
4	10
5	10
6	16
7	22
8	24
9	26
10	32
11	30
12	28
13	22
14	18
15	16
16	16
17	20
18	24
19	28
20	34
21	38
22	30
23	22
24	12