ECE 333 Green Electric Energy

Fall 2017
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Room 4052 ECEB

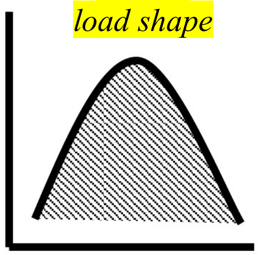
Homework 8 Solutions

Quiz Date: Tuesday, December 12, 2017 during class

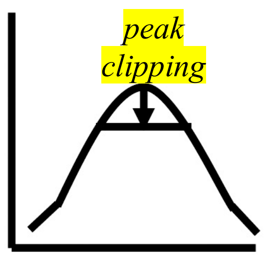
The quiz is based on the following material: Lecture 18, Lecture 19, and the problems in Homework 8.

Problem 1: Provide the names of the demand-side management programs illustrated below.

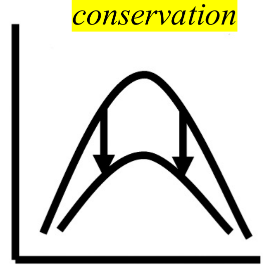
flexible load shape



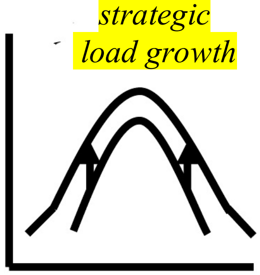
peak clipping



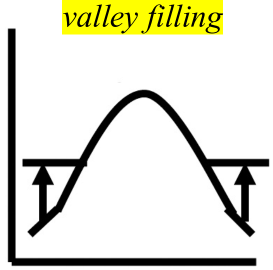
strategic conservation



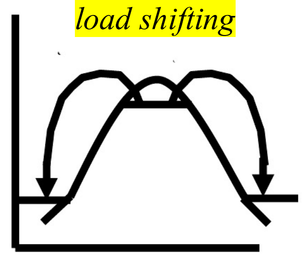
strategic load growth



valley filling



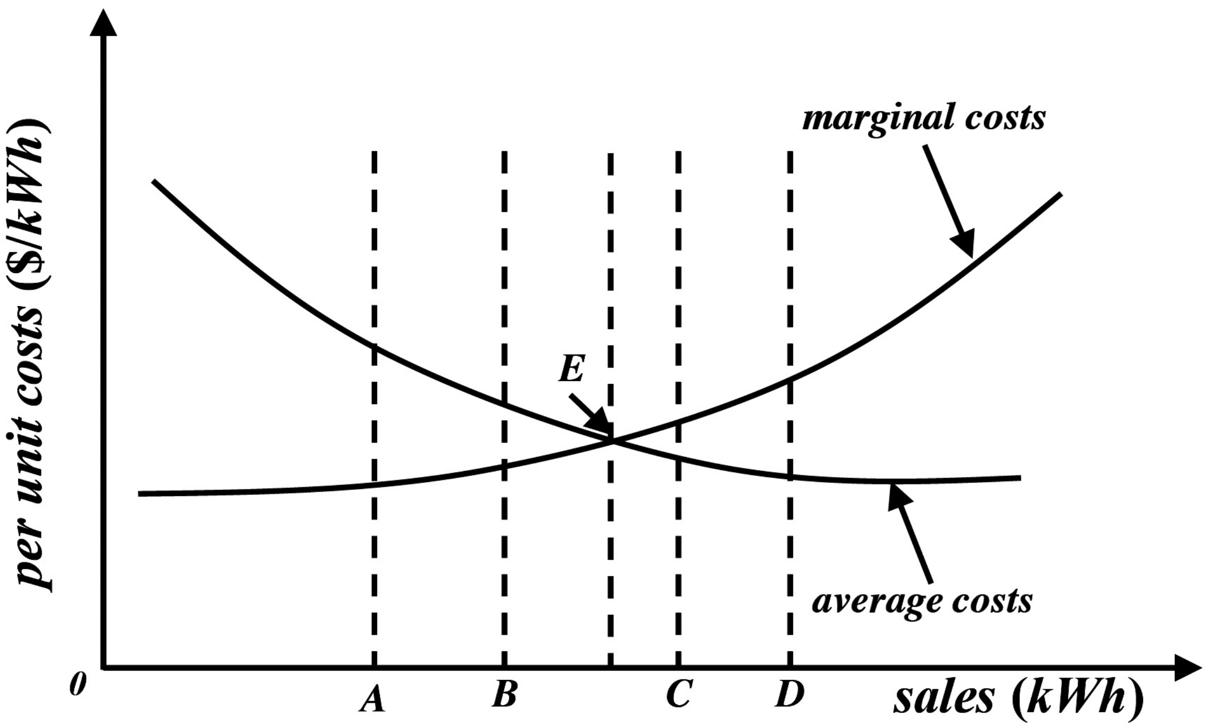
load shifting



Problem 2: List the appropriate *DSM* applications for intermediate load segments.

- building weatherization
- air-conditioner or heat pump efficiency improvements
- stricter appliance efficiency standards
- time-of-use rates

Problem 3: Consider the graph below.



a. For sales of **A** *kWh*, **state** whether marketing programs or consumption reduction programs must be implemented. **Justify** your answer.

Marketing programs make sense. Typically, the electricity rates charged for costumers are based on the average cost of electricity. At point ***A***, the electricity rates charged for customers is higher than the marginal to cost to generate electricity, hence it makes sense for the Electricity Service Providers (*ESP*) to implement marketing programs to increase their electricity sales.

b. For sales of **C** *kWh*, **state** whether marketing programs or consumption reduction programs must be implemented. **Justify** your answer.

Consumption programs make sense. Typically, the electricity rates charged for costumers are based on the average cost of electricity. At point ***C***, the electricity rates charged for customers is lower than the marginal to cost to generate electricity, hence it makes sense for the Electricity Service Providers (*ESP*) to implement consumption reduction programs to decrease their electricity sales.

Problem 4: Suppose you are the lead engineer on a project to install an energy storage resource (*ESR*) in a microgrid. The following table provides the renewable generation and the load data of the microgrid throughout the day.

hour	***load (kW)***	***renewable generation (kW)***
1	*50*	*50*
2	*60*	*40*
3	*50*	*50*
4	*60*	*60*
5	*50*	*40*
6	*90*	*30*
7	*110*	*70*
8	*150*	*80*
9	*170*	*110*
10	*140*	*120*
11	*100*	*160*
12	*80*	*170*
13	*50*	*180*
14	*50*	*160*
15	*50*	*160*
16	*60*	*140*
17	*90*	*130*
18	*140*	*100*
19	*170*	*40*
20	*150*	*30*
21	*140*	*20*
22	*90*	*20*
23	*70*	*20*
24	*50*	*30*

Determine the minimum required capacity and capability of the ESR so that no renewable generation in the microgrid gets spilled. **Assume** that the renewable generation and the load stays constant at the level specified for each hour. Moreover, **assume** that no energy is stored in the ESR at the beginning of the day. **State** all your other assumptions.

Our strategy is as the following:

- When the renewable generation exceeds the load, *ESR* operates in the charging phase.
- When load exceeds renewable generation:
    - ESR operates in the discharging phase when there is energy stored in the *ESR*
    - ESR operates in the idle phase when there is no energy stored in the *ESR*
- When the load equals renewable generation, *ESR* operates in the idle phase.

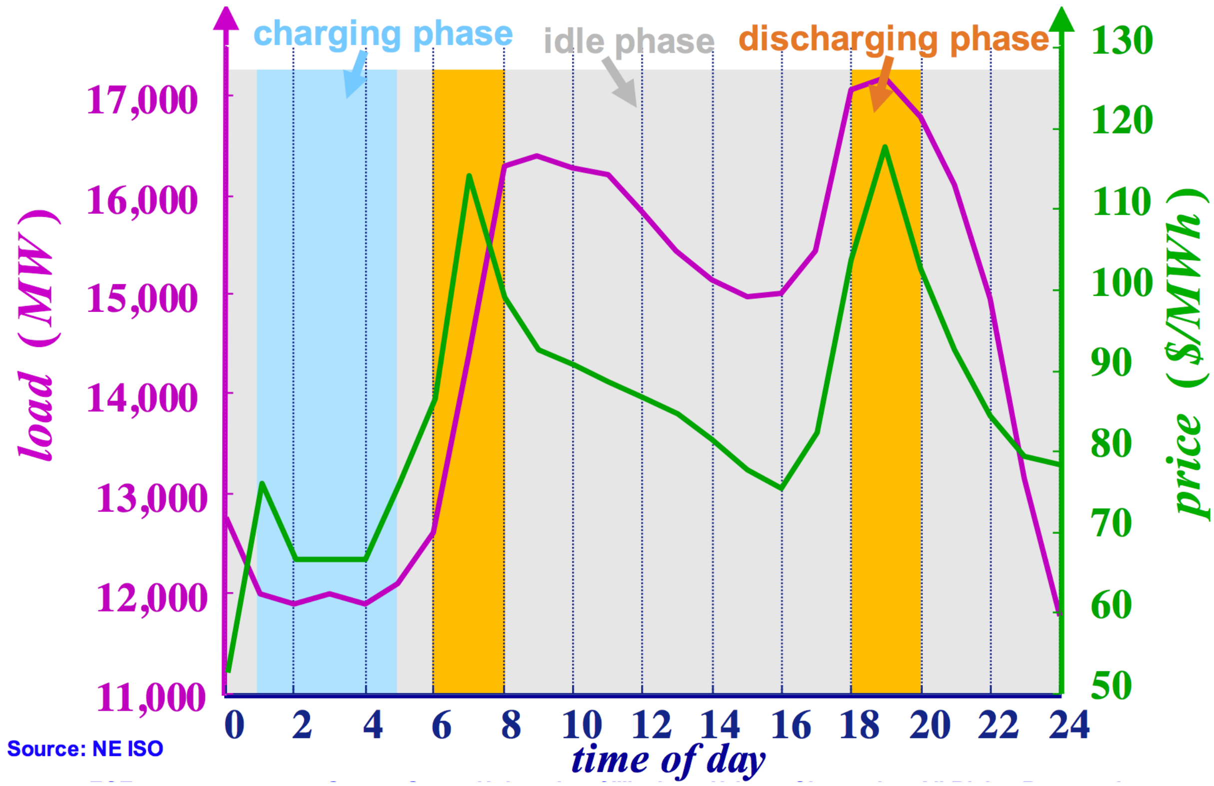
Using this strategy, we construct the following table, which shows at which phase the ESR operates, how much the ESR is charged/discharged at each time period, and the energy stored in the ESR at each time period.

w

hour	***load (kW)***	***renewable generation (kW)***	***operating phase of the ESR***	***charging /discharging amount***	***energy stored in the ESR (kWh)***
1	*50*	*50*	*idle*	*no charging or discharging*	*0*
2	*60*	*40*	*idle*	*no charging or discharging*	*0*
3	*50*	*50*	*idle*	*no charging or discharging*	*0*
4	*60*	*60*	*idle*	*no charging or discharging*	*0*
5	*50*	*40*	*idle*	*no charging or discharging*	*0*
6	*90*	*30*	*idle*	*no charging or discharging*	*0*
7	*110*	*70*	*idle*	*no charging or discharging*	*0*
8	*150*	*80*	*idle*	*no charging or discharging*	*0*
9	*170*	*110*	*idle*	*no charging or discharging*	*0*
10	*140*	*120*	*idle*	*no charging or discharging*	*0*
11	*100*	*160*	*charging*	*charging by 60 kW*	*60*
12	*80*	*170*	*charging*	*charging by 90 kW*	*150*
13	*50*	*180*	*charging*	*charging by 130 kW*	*280*
14	*50*	*160*	*charging*	*charging by 110 kW*	*390*
15	*50*	*160*	*charging*	*charging by 110 kW*	*500*
16	*60*	*140*	*charging*	*charging by 80 kW*	*580*
17	*90*	*130*	*charging*	*charging by 40 kW*	*620*
18	*140*	*100*	*discharging*	*discharging by 40 kW*	*580*
19	*170*	*40*	*discharging*	*discharging by 130 kW*	*450*
20	*150*	*30*	*discharging*	*discharging by 120 kW*	*330*
21	*140*	*20*	*discharging*	*discharging by 120 kW*	*210*
22	*90*	*20*	*discharging*	*discharging by 70 kW*	*140*
23	*70*	*20*	*discharging*	*discharging by 50 kW*	*90*
24	*50*	*30*	*discharging*	*discharging by 20 kW*	*70*

From the table, we can observe that the *ESR* capacity must be at least 130 *kW*, as in hour 19, the *ESR* is discharged by 130 *kW*. Moreover, the *ESR* capability must be at least 620 *kWh*, as 620 *kWh* is the maximum amount of energy stored in the *ESR* at any of the time periods of the given day.

Problem 5: State the three phases of *ESR*s. Consider the following graph.



Explain how the ability of *ESR*s to be in three phases is instrumental to take advantage of price differences throughout a day.

*ESR*s can operate in the charging phase, discharging phase, or in the idle phase.

As can be seen from the graph above, an *ESR* can be charged when the price of electricity is low, and can discharge when the price of electricity is high. In that way, an *ESR* facilitates the selling of electricity at a higher rate than the rate it is purchased. The fact that an *ESR* can remain idle is very instrumental, because it enables the selling of electricity (discharging of the *ESR*) when it is desired- and for the other time periods (as represented by the grey areas in the graph above), the *ESR* can remain idle.

Problem 6: State 2 *ESR* integrations with the grid**. Provide** the *ESR* owner's interest and the grid impacts for each integration.

Any two applications in Slide 41 of Lecture 19 can be selected.

Problem 7: State 2 challenges of the integration of variable energy resources to the grid. Explain how the integration of *ESR*s can address each challenge.

Any two challenges in Slide 43 of Lecture 19 can be selected.