**WINTER 2022**

# ELEN 285: Introduction to Smart Grid

## Instructor

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## Office Hours

15 mins before and 30 mins after class every week. Or by appointment.

## Course Description

*Smart Grid: What, Why, How, Who*

*Topics:* Energy use, Electricity Demand, Traditional Grid, Generation, Transmission, Distribution, Consumption, Evolution of Electric Grid, Electricity Communication Networks, Demand Response, Automated Metering Infrastructure, Distribution Automation, Standards, Renewables, Climate change and its impact on the grid, Storage, Electric Vehicles, Smart Buildings: Design and Energy Efficiency, Case Study, Advanced Topics.

## Course Style

Mostly qualitative and descriptive with some quantitative analysis at places for deeper understanding.

## Grading

Mid-Term: 20% (First 4 lectures) (1 hour 15 mins)

End-Term: 30% (Whole course but mainly last 5 lectures) (1 hour 30 mins)

*Exams will have mostly short descriptive type questions with one or two problems.*

Project: 40%

Attendance and Class Participation: 10%

## Course Materials

No text book. All slides will be loaded to Camino. Reading suggestions are provided at the end of each lecture.

## Course Schedule

1. Course Intro and Organization, Project, Introduction to the US Power Grid (01/04)

2. Electricity Markets, Smart Grid Notion (01/11)

3. Smart Grid Communications (01/18)

4. Demand Response, Advanced SG Communications (01/25)

5. Mid Term (02/01) (On first 4 lectures)

6. Renewables (02/08)

7. EVs, Storage, Micro Grids (02/15)

8. Building Energy Management, Efficiency (02/22)

9. Case Study - Net Positive Home & Micro Grid Extensions (03/01)

10. Advanced Topics (03/08) *Project Due, preferred date. Email is fine.*

11. *Final Exam* (03/15) (On all lectures but mainly the last 5 lectures).
    *Last chance for turning in Projects*

# ELEN 285 Course Project

This project focuses on analyzing real-world electricity load traces of commercial sites participating in demand response services. The project will involve data analysis, which will be summarized in a project paper and submitted for grading. Students should be able to start the project after Lecture 4 on (1/25).

## Logistics

Please form groups of 2 or 3 people. For 2 member groups I expect at least 2 sites to be analyzed. For 3 member groups I expect at least 3 sites to be analyzed. No harm in analyzing more sites but be careful about report length. *Please inform me on class 2 (1/11) about your group members.* Describe your results and analysis in a project paper that is no more than 10-15 pages in length, including plots and references.

*Deadline:* **Tuesday, March 08.** Please submit the project paper in class. If there is some scheduling conflict, ask me for an extension to 15th. 15th is the Final Exam and last chance to submit the project.

For the analysis part, you can use Matlab, R, or any other software package that you are familiar with. Even Microsoft Excel is fine if you can manage with that. Instructions for downloading R are included below. You don't need to have prior familiarity with these tools. This project would be a good opportunity to get experience with them. *Strongly encourage you to learn R as employers are looking for that skill.*

## Project steps

1. Choose two or more sites from https://open-enernoc-data.s3.amazonaws.com/anon/index.html
   This site contains 5 min interval energy use data for various commercial and industrial sites.
2. Using Matlab or R, or any other tool analyze each site's load behavior, *e.g.*
   a. Load on weekdays vs. weekends.
   b. Min. and max. Load.
   c. What fraction of the data points are missing (if any)?
   d. Are you seeing some interesting behavior? What do you attribute it to (some basic information about each site is included in the meta-data file on the website in 1 above)?
   e. Include plots of the portions of the data that illustrate your observations.
3. Find out and describe which ISO/utility is responsible for calling DR events for each site and if applicable, which zone each site is in (some DR events are called per zone).
4. Find out and describe what DR programs are possibly applicable to each site.
5. Find out and describe what kind of DR baseline is used for each program. What do you think are the weaknesses of the baseline computation approach that was used?

6. Find at least one instance of a DR event in which the site you chose participated (*e.g.* find out officially announced DR events and check if the site curtailed its usage during those days and times). Include a plot of the load during the DR day, along with a curve for the baseline the utility must have used.
7. Analyze the plot -- do you see anything interesting? What do you attribute it to?
8. If you were to design an algorithm to automatically detect whether a DR event has occurred, what load behaviors would this algorithm look for? What is challenging about designing this kind of algorithm?

***Beware that some of the data files contain duplicated data. If after downloading and analysis the usage profile of two sites look very similar please discard one of them.***

## Installing R

1. R is available for Windows, Mac OS and Linux and can be downloaded from http://www.r-project.org.

2. Download the "Desktop" version of RStudio from http://www.rstudio.com/ide/download/. RStudio is a GUI interface for R.

3. Note that you may need to install some R packages if you end up using more sophisticated R functionality.

4. Example basic commands (type on R prompt):

a. Read site data: site <- read.csv('44.csv', header = T)

b. View data that was read in step a site

c. Or view some subset of the data site[5000:5010,]

d. View the structure/fields of the variable site str(site)

e. View load data for the site site$value

f. Or view some subset of the load data site[5000:5010,]$value

g. Plot a subset of the load data
plot(site[5000:5288,]$value, col='red', main = 'Site Load', type = 'p')

h. Example R function:

```
maxLoad<- function(csvFileName) {
  site <- read.csv(csvFileName, header = T)
  return(max(site$value))
}
```

The above code can be saved in a file maxLoad.R. To use the function, type the following at the R prompt:

```
source('maxLoad.R') # instantiates the function in the R environment
ml = maxLoad('44.csv') # store the computed maximum load in the variable ml
```

i. Note that depending on the operating system you are using, single or double quote usage may differ. Try using double quotes if you get an error while using single quotes and vice versa.

j. To get out of the execution of a command or script (e.g., because it is running too slowly and you want to interrupt it), press the “Esc” key.

k. To find information on various commands, type*?command name* on the R prompt, e.g.plot

5. Extensive documentation of R is available on-line and on various discussion forums