ECE2795 Homework Assignment #1

Due date: 01/29/2015

For all questions elaborate some few conclusions or comments about the results. For all questions with simulations include a graph with the used model. State all the assumptions considered in the analysis. You are free to do as many assumptions you consider appropriate.

1) Find a microgrid deployed anywhere in the world. Examine how well such microgrid meets the DOE definition of a microgrid. Then, list the main operating requirements of this microgrid and explain how these requirements influenced the design of this microgrid. Could these design requiments be met by a "megagrid"? Why?

2) Suppose you want to use a PEMFC as an energy storage device. In order to do so, you have a PEM electrolyzer/fuel cell that you can use either as an electrolyzer to produce H_2 from liquid water by applying a voltage between cathode and anode or as a fuel cell to produce a voltage between anode and cathode by circulating H_2 through the stack (this view of a single stack that can work in both directions is a simplification for this problem; however, PEM electrolyzers that operate like fuel cells in the reverse direction do exist). When operating as an electrolyzer, H_2 is compressed in 350-bar cylinders. For the PEM stack in slide 16 of the class notes operating with a 1 A/cm^2 current in both directions, what is the total one discharge/charge cycle efficiency of this energy storage device? This efficiency can be defined as the power taken by the load during a "discharge" (i.e., when it is working as a fuel cell) over the same power plus all other power provided to the system during the charge and discharge cycles. What is the voltage that you need to apply during the electrolysis phase? Although in reality not all H_2 molecules generate electricity in a PEMFC and not all water molecules produce H_2 in an electrolyzer you can assume otherwise for this problem. You can also do educated assumptions (i.e., search for data on the Internet) about electric machines efficiency (e.g. for pumps), electric circuit efficiencies (e.g. rectifiers) and other relevant components or processes affecting this system round efficiency. You can also assume that the discharge cycle last the same time than the charge cycle. Additionally, although in general Wikipedia may not be a good source of references, in the particular case of PEM electrolyzers, Wikipedia has a nice description that you can use as a guide. You can also use the paper by Zhang et. al. in CourseWeb as a general guide, too, but be aware that there seems to be an error in a key equation (can you spot what the error is? hint: just check the units of the equations and how some variables are defined).

3) What is the hydrogen flow rate of an ideal fuel cell measured in gr/kWh? Consider that you are using a 50% efficient PEMF cell to power a load with a nominal power of 5 kW. How many Praxair S-Type cylinders will you need in order to operate such PEMFC for a month if the utilization factor is 0.3? Remember that the ideal gas law is $pV=nRT$ where p is the pressure in Pascals, V is the volume in m^3, n is the number of moles, R is the universal gas constant (8.314 J/(Kmol)) and T is the temperature in Kelvin (for this problem you can assume T = 300 K). Information about the cylinders can be found at http://www.praxairdirect.com/PXItemDisplay?storeId=10152&catalogId=10051&langId=-1&itemID=67107&categoryId=11531&top_category=11501&parent_category_rn=11504