Final Exercise: Making a US Energy Plan

Physics and Mathematics of Sustainable Energy

College of the Atlantic

- Please feel free to do this in pairs if you wish and hand in only one write-up.
- There is no need to word-process your work; handwritten is fine. But please make your work readable.
- For this assignment use the 2018 energy US flow chart at: `https://flowcharts.llnl.gov`.
- Along the way you'll need to make some assumptions. Be sure to state what assumptions you make.

Your goal in this exercise is to come up with a plan that electrifies the transportation sector and replaces all the natural gas and petroleum used by the residential and commercial sectors with heat from electric heat pumps. We won't worry about the industrial sector. You'll first figure out how much electricity we'll need to generate, and then you can figure out how you would like to generate this electricity.

1. **An Initial Conversion:** One Quad per year is how many GW? (In what follows, use GW for all powers.)

2. **Transportation:** Assume that the engine of an electric car is 85% efficient. How much electric power would be needed to electrify the transportation sector?

3. **Heating:** Let's assume that all the natural gas and petroleum consumed in the residential and commercial sectors is used for heat. Assume that the average efficiency of these heaters is 80%. Suppose we were to supply this heat with electric heat pumps instead. Assume that the heat pumps have an average COP of 3. How much electric power would this take?

4. **Add up Electric Power:** How much total electrical power will be needed. Add together your answers to the above two questions, and then add to this the electricity that is already used by the residential, commercial, and industrial sectors.

5. **Decide:** how you want to generate this amount of power without using fossil fuels. Assume that we'll have 3 Q/year of hydro power. Then choose among the following non-fossil sources of electricity:

   - Solar PV
   - Nuclear
   - Onshore Wind
   - Offshore Wind

   Assume that hydro power in the US stays at or near its current amount. Ignore grid considerations and seasonal fluctuations.

6. **Calculate Areas:** How much total land, in km^2, is needed for each of the power sources you chose above?

7. **Map It:** Make a map on which you have indicated the land areas you'll use for Solar and on and off-shore wind. Don't worry about making a beautiful map, but try to make it somewhat clear. Rather than plotting each area as one giant square, I'd suggest breaking each area up into several smaller squares.