Homework Two

Physics & Mathematics of Sustainable Energy

College of the Atlantic

Due Tuesday, April 12, 2016

Please print out this cover sheet and attach it to your problem solutions. Completed assignments should go in my mailbox or be handed in during class. Please don't hand them to me other times, as I might end up losing them and that would make us both sad.

Your Name: _____

Please list all the students you collaborated with on this assignment:

_____ _____

_____ _____

_____ _____

Did you get help from Aura or Morgan?

Did you consult any resources other than our textbook or class notes? (If yes, please include citations in your solutions.)

Were you able to get enough help so you could complete this assignment to your satisfaction?

Approximately how many hours did you spend on this assignment?

Anything else of note about this assignment? (It was too hard, too easy, lots of fun, too repetitious...)

The work I am turning in for this assignment is an accurate reflection of my own understanding of the material.

Signature: _____ Date: _____

Assignment is on the next page....

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1. There is currently an 800 acre fire burning in Tennessee[1]. Convert this area to something meaningful—something that can be visualized in some way. Probably this means figuring out the side of a square that has the same area as 800 acres[2]. But you could also compare it to the area of MDI or your hometown or a football field or whatever.

2. How much area would it take to generate all of your energy needs from electricity generated on a terrestrial wind farm?[3]

3. Optional: how much land is required to grow the food that you eat? I have no idea what the answer to this is, but I'd be curious to find out. Probably different people have estimated this in different ways, and surely it depends a lot on ones diet. I'd be interested to see what estimates are out there. If you find any (semi)reliable references for this, please let me know. (Again, this problem is 100% optional.)

4. Suppose that a certain wind turbine generates a certain amount of energy per month. What would happen to the energy generated per month if:

   (a) The diameter of the blades was increased by 20%?
   (b) The turbine was re-located someplace where the average wind speed was 30% higher?
   (c) The turbine was re-located someplace where the density of the substance flowing around it was twice as large?

5. In this problem we'll think some about off-shore wind in the Gulf of Maine.

   (a) First, let's collect some facts: Write down the following values. (All of these figures should be in your class notes. They're also in MacKay and also my book.)
      i. The average total energy consumption per person in the US, in units of kWh per person per day.
      ii. The worldwide average emissions per person per year, in tons of CO_2 equivalent.
      iii. The average emissions per person per year of the average American, in tons of CO_2 equivalent.
      iv. The average amount of CO_2 released per kWh of electricity generated.
   (b) What power would be needed to provide the total energy needs of everyone in Maine?
   (c) Would would be the area needed for an offshore windfarm that could deliver this power. Assume that the offshore windfarm generates 3 Watts per square meter. Express your answer in km^2 and mi^2.
   (d) What is side of a square whose area is equal to the area you found in the above problem?
   (e) Find and print out map of New England that includes the Gulf of Maine. Be sure this map includes a scale. Draw on this map a square that is the size of the square you calculated in the previous question. Be reasonably careful when you draw the square, but don't stress out about getting the size super accurate.

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[1] `www.local8now.com/content/news/Forest-fire-burning-near-Newport-in-Cherokee-National-Forest-374540001.html`

[2] Use meters, miles, yard, kilometers: whatever seems appropriate and is the most meaningful to you

[3] Assume that you are an American. Or that you are consuming at the rate of a typical American while living in the US.

(f) Assuming that this electricity from wind replaced "average" US electricity, how much CO_2 has been prevented from being released into the atmosphere. Express your answer in terms of tons of CO_2 per Mainer per year. Is this a lot or a little?

6. Optional, but recommended: In class we derived the following:

$$\text{wind farm power density} = \frac{\pi}{200}\frac{1}{2}\rho v^3 \,, \tag{1}$$

where v is the windspeed and ρ is the density of air. If the average windspeed is 6 m/s, what is the power density of the wind farm? (The density of air is $\rho = 1.225$ kg/m^3.)