

Physics and Mathematics of Sustainable Energy

Homework Four

Due April 30, 2010

1. In class Anna mentioned that the changes made to the coast guard house resulted in reducing CO₂ emissions by 52,000 lbs a year. Is this a lot or a little? Explain.
2. This problem concerns the Mars Hill Wind farm, in Mars Hill Maine. To find it on google maps, search for “big rock ski area” and Mars Hill. Zoom in a bunch. The wind turbines are on the same ridge as the ski area toward the Northeast. The wind farm consists of 28 1.5 MW turbines. Assume the turbines operate at 33% capacity. The turbines have a diameter of 77 meters.
 - (a) How much power does the wind farm deliver? Is this a lot or a little? Explain.
 - (b) How many such wind farms would be needed to meet all of Maine’s residential electricity needs?
 - (c) How many such wind farms would be needed to meet all of Maine’s residential, commercial, and industrial electricity needs?¹
 - (d) Estimate the watts per square meter of the Mars Hill wind farm. How does it compare to Scottish and Welsh hilltops? See the info at <http://www.inference.phy.cam.ac.uk/mackay/presentations/WIND2/index.html> for comparisons. To estimate the area of the Mars Hill installation, the figure on page nine of the report on Bird and Bat mortality at http://www.marshellwind.com/mars_hill/regulatory.cfm may be helpful. You could also use google maps.
3. Four people need to travel from Bar Harbor to New York City. What is the energy cost per person if:
 - (a) They drive (in the same car)?
 - (b) They take a train? (assume such a train exists.)
 - (c) They fly?

Clearly state any assumptions and approximations you make.

4. You live in Boston and are deciding between two beer options, A Hop Devil Ale by Victory Brewing Company, and Punk IPA by BrewDog Brewery. Assume that the Punk IPA travels to you by container ship and the Hop Devil via truck. What is the energy cost of transporting each beer to you? Is this a lot or a little? Compare to the typical American’s daily energy use.
5. Take a look at Weber and Matthews, Food-Miles and the Relative Climate Impacts of Food Choices in the United States, *Environ. Sci. Technol.*, **42**(10):3508–3513. 2008. Available at <http://pubs.acs.org/doi/full/10.1021/es702969f>. In table 1

¹See <http://www.eia.doe.gov/cneaf/electricity/esr/table5.html> for useful data.

the authors list energy costs associated with different types of transportation. Weber and Matthews give the energy costs in MJ/t-km. Convert their figures to MacKay's kWh/t-km. Just do it for truck, air, and train. Do Weber and Matthews agree with MacKay? If not, discuss.

6. **Optional:** Suppose you live somewhere in the middle of the U.S. California wine arrives at your local wine store via truck, originating in San Francisco. Spanish wine takes a container ship from Málaga to New York, at which point it takes a truck the rest of the way. If you are in New York, it is better to get the Spanish wine. (I.e., it uses less energy. We'll assume that the Spanish and Californian wines you are considering are of similar quality and price.) Approximately where in the U.S. is the transportation cost of the two wines the same?