

# Physics and Mathematics of Sustainable Energy

## Homework Four

Due April 29, 2011

1. 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?<sup>1</sup>
  - (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](http://www.marshellwind.com/mars_hill/regulatory.cfm) may be helpful. You could also use google maps.
2. Check out the web page for the Beech Hill Farm solar cells: <http://enlighten.enphaseenergy.com/public/systems/Dv2w10803>.
  - (a) How much energy have the cells generated in their lifetime?
  - (b) The cells have been running since Dec. 4, 2010. What power per area does this correspond to? I.e., what are the Watts per square meter.
  - (c) How much energy would you estimate that the cells will generate in a year? Take into account that it will generate more electricity in the summer than it did over the winter. How much is this amount of electrical energy worth in Maine?
3. Suppose you take a five minute shower using an efficient 2.5 gallons per minute shower head.
  - (a) Estimate how much energy it takes to heat the water you need for the shower. State any assumptions that you make. Express your answer in kWh.
  - (b) If you used electricity to heat this water, how much would this shower cost in Maine?
4. The Atlantis Platform in the Gulf of Mexico daily production capacity is 200,000 barrels of oil a day.<sup>2</sup> Assume that it typically operates at 50% capacity. The lifetime of this oil well is supposed to be 15 years.

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

<sup>2</sup> <http://www.offshore-technology.com/projects/atlantisplatform/specs.html>

- (a) What is the effective power of this oil well? I.e., take its total oil production per day and convert to Watts.
- (b) What area would be required for solar cells that produced a similar amount of power? Convert this area to something meaningful.