

Problem Set 7

Intro to Sustainable Energy 2.650/10.291/22.081

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Sustainable Energy 1.818/2.65/10.391/11.371/22.811/ESD.166

For each of the problems you work out, provide a list of sources for any data you used, as well as your assumptions. Be sure to mark which course number you are registered for on your solution. You can turn in the homework online (via Stellar) or in class.

Intro to SE Students: Pick any 2 of the 4 problems to solve.

1. *Home Solar PV Installation:* The recent conversations about energy security have included a lot of discussion on programs to install PV solar generation in homes.
 - a. Find a reference for the average electrical energy usage of a home in your home state.
 - b. Based on this usage, choose a system for generation of this energy by solar power. Calculate the required area of solar panels and estimate the costs for the panels plus installation. Keep in mind that capacity factor will depend on location.
 - c. Based on electricity prices in your home state, how long will it take for the system to pay for itself in electricity bill savings?
2. *Geothermal in the U.S.:* Some argue that geothermal energy is a dilute, low-grade energy resource that is too small to make a difference.
 - a. Given that the U.S. consumes about 100 quads annually, estimate the minimum mass of hot rock needed to meet annual demand assuming the rock mass is at 200 °C initially.
 - b. Given that the average geothermal temperature gradient is 20 °C/km for the US, how much thermal energy is stored in rock to a depth of 10 km corresponding to depths that can be reached using conventional drilling technology?
 - c. An ambient temperature of 25 °C can be assumed. The surface area of the U.S. is $9.37 \times 10^6 \text{ km}^2$. You can assume that the rock mass under the surface of the US is solid granite with a density of 2500 kg/m³ and a heat capacity of 1000 J/kg K.
3. *Tradeoffs in geothermal:* In dealing with EGS geothermal energy there is always the option to drill deeper to reach higher rock temperatures. Higher temperatures would provide some thermodynamic advantages as the availability or work producing potential would increase – so less geofluid would be needed per unit of electrical energy generated. However, drilling deeper increases the cost of wells. Discuss the inherent tradeoffs that exist in EGS development and prepare a qualitative plot of capital cost on the y-axis versus reservoir temperature on the x-axis showing three curves - one for the subsurface system (wells and reservoir), one for the surface power plant, and one for the total capital cost. A lower grade of the EGS resource should be used as a basis to define how rock temperature increases with depth where the average gradient is about 30 °C/km.
4. *New solar generation prospects for Europe:* Read the article “Sending African Sunlight to Europe, Special Delivery”, from Science Magazine’s August 2010 edition:
<http://www.sciencemag.org/cgi/reprint/329/5993/782.pdf>.

Imagine you are an advisor to a European government considering investing in this project. In a few pages, sum up the risks involved from a financial, technical, and geopolitical standpoint. Conclude your commentary with recommendations to your advisee.

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<http://ocw.mit.edu>

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