1. Wave Power:

Using internet resources, determine the typical wave amplitude and wavelength for ocean waves off of the eastern and western coasts of the US. Also examine the Gulf of Mexico region. Use these values to estimate the power per unit length along the wavefront (i.e. parallel to the coastline) for these regions, and then estimate the maximum power that could be converted into electricity if 10% of the available coastline were dedicated to this purpose. What fraction of total US electrical power demand does this represent?

2. Geothermal Energy:

A geothermal heat mine located at a depth between 10 and 11 km deep, and the volume to be mined has horizontal dimensions of 1 km x 1 km. Use the MIT Report on Hot Rock Geothermal Energy (located on the class website) to estimate the energy required to (a) drill and (b) operate such a heat mine. Cite your sources. (c) if the mine has a power output of 100 MW, on what time-scale does the rock cool down? How might this relate to the lifetime of the mine?

3. Solar Thermal Power:

During the lecture in class about solar thermal power systems, we found the following time-dependent energy balance equation for the case where there was no heat input into the system (e.g. night time without any auxiliary power input from e.g. natural gas combustion).

\[ \rho C_p V \frac{dT}{dt} = -\frac{1}{\eta_a} \frac{dW}{dt} \]

a. Define and explain the meaning of each term in this equation.

b. Assuming all terms except T are constant and the temperature is a function of time, find the exact solution T=T(t).
c. If the power output of such a system is 50 MW, the working fluid was molten salt (see e.g. [http://en.wikipedia.org/wiki/Solar_thermal_energy](http://en.wikipedia.org/wiki/Solar_thermal_energy) for more information the properties of such a thermal storage system.) estimate the volume \( V \) such that the e-folding time of the system is at least 12 hours (i.e. enough to last through the night).

4. Solar Thermal Power

For the system described in the previous problem:

a) If there is power input into the system from the sun, which we denote as \( P_{\text{in}} \), what would be the new energy balance equation? In order words, how would you modify the equation above to account for the power input?

b) If this input power from the sun is constant in time, and the system had zero output power, what would the functional form of \( T(t) \) be?

c) If the solar intensity is 300 W/m\(^2\) and the thermal conversion efficiency is 30%, what is the area of the collecting mirrors required for a 100 MW output power? You may assume that the plant would be operating in steady-state.

5. Tidal Power

The Rance Tidal Power Station is a utility-scale tidal power system located in France. Find the power output of this station. What is the typical height of the tides in this system? What is the tidal basin area (i.e. the surface area of the water impounded and utilized in this station? Using the simple models developed in lecture, compare the idealized power output to the published power output of this station. What fraction of France’s electricity demand is met by this station? Using internet resources, what is the estimated global power capacity of feasible tidal basins that could be used to generate electrical power? What fraction of current global demand does this represent?