Concentrating Solar Power (CSP)

Based on Robert Pitz-Paal, "How the Sun gets into the Power Plant," in Renewable Energy: Sustainable Energy Concepts for the Future, Roland Wengenmayr and Thomas Bürke, eds. (Wiley-VCH, 2009), pp. 26-33.

1. What are the geographic limitations for generating electricity with CSP?
   Sun belt. +/- 35th latitude

2. Why do photovoltaics work over a broader range of latitudes?
   CSP requires intense parallel rays.
   Photovoltaics can function with diffuse light of any intensity.

3. What are the elements of a complete Solar Electricity Generating System (SEGS)? (Figure 2)
   Concentrator + receiver + turbine + cooler (HX w/air or H_2O) + pump = Closed loop system

4. Why is it necessary to reach such a high fluid temperature using CSP **for generating electricity**?
   http://en.wikipedia.org/wiki/Stirling_engine
   A Stirling cycle's (and any heat engine's) efficiency grows with ΔT.

5. Currently, how does the cost of a CSP plant compare to photovoltaic power plants and to wind power plants. (p. 31)
   SEGS plants cost $0.17-$0.22/kWh, depending on location.
   Wind is about half this and photovoltaics are about twice this.
   Conventional power plants cost less than $0.06/kWh.
   Photovoltaic is closer to $1/kWh (I think)

6. What are some of the proposed improvements to reduce operating cost? (p. 32)
   1. Higher operating temperature.
   2. Fresnels systems for size reduction, denser packing, reduced wind load.
   3. Use of pressurized air instead of steam to drive the turbine.
   4. Thermal energy storage reservoirs.
   5. And of course, mass production, improved reliability and plant automation.

7. Compare the CO_2 emissions of various electric power generating sources, including CSP. (p. 33)
   CSP: 12 kg/MWh
   Hydroelectric: 14 kg/MWh
   Wind: 17 kg/MWh
   Photovoltaic: 110 kg/MWh
   Gas: 435 kg/MWh
   Coal: 900 kg/MWh

Wave Energy

Based on Kai-Uwe Graw, "Energy Reserves from the Oceans," in Renewable Energy: Sustainable Energy Concepts for the Future, Roland Wengenmayr and Thomas Bürke, eds. (Wiley-VCH, 2009), pp. 76-82.

1. What is the total energy content of the ocean waves on the Earth? Where is the wave energy concentrated? (p. 76)
   10 million TWh/year = 10^{16} kWh/8760hours = $1x10^{12}$ kW or 1 billion MW
   The energy is mostly available on west coasts.

2. What limits and what depletes the energy in a wave? (p. 77)
   1. Nonlinearity – e.g. more energy makes a bigger wave to a point, beyond which the wave can no longer grow.
   2. Turbulence
   3. Wave breaking – usually caused by turbulence

3. Describe the OWC method for converting wave energy into electricity? (p. 78)
   Oscillating Water Column collects wave water into a vertical tapered tube. As the water comes in, it pushes air out of the top of the tube through an air turbine. The turbine must be designed to spin the same direction regardless of the direction of airflow.

4. What is the "main economic problem of wave energy plants"? (p. 80)
   Survival of "monster waves"

5. Compare the potential cost of energy produced by waves to other renewable. (p. 82)
   OWC energy will cost approx. $0.14/kWh. Wind is a little less, but similar.
   Solar $0.70-$1.40/kWh (this must be photovoltaic?)