

# 1 Power Plant on a River

At a power plant that produces 1 GW ( $10^9$  watts) of electricity, the steam turbines take in steam at a temperature of  $500^\circ\text{C}$ , and the waste energy is expelled into the environment at  $20^\circ\text{C}$ .

- (a) What is the maximum possible efficiency of this plant?
- (b) Suppose you arrange the power plant to expel its waste energy into a chilly mountain river at  $15^\circ\text{C}$ . Roughly how much money can you make in a year by installing your improved hardware, if you sell the additional electricity for 10 cents per kilowatt-hour?
- (c) At what rate will the plant expel waste energy into this river?
- (d) Assume the river's flow rate is  $100 \text{ m}^3/\text{s}$ . By how much will the temperature of the river increase?
- (e) To avoid this "thermal pollution" of the river the plant could instead be cooled by evaporation of river water. This is more expensive, but it is environmentally preferable. At what rate must the water evaporate? What fraction of the river must be evaporated?