

Due: 17 Sept 2025

Energy: Science, Technology, and Society

Problem Set 2

Indicate assistance obtained with each of the tasks defined below, e.g., by naming web source (Wikipedia, Google/Gemini, ChatGPT,...) and a (summary) prompt.

1. Power and Energy



In June of 2025, the exercise and media company Peloton had 2.8 million connected fitness subscribers. Many of them exercise by riding a stationary power-bicycle, which has a production cost equivalent to 3,500 kWh. Assume an average weight of 75kg for a rider and an applied mechanical power of about 300 watts, required to satisfy the exercise protocol.

- a) How many hours of exercise would match the bike's production cost in mechanical work done by the average biker?
- b) What fraction of the daily electricity (energy) demand of one U.S. household could be satisfied by a biker run with this protocol for 8 hours each day, assuming a perfect conversion of the mechanical input to electrical power output?

2. Chemistry of Coal Burning



Coal has a good heating value of 30 MJ/kg but comes with various contaminants that affect the emission of the undesirable, polluting greenhouse gases SO_2 and NO_2 . Emission standards adopted in the 1970s set limits of 516g for SO_2 per GJ of total energy produced in coal burners and 260 g/GJ for NO_2 .

A certain coal has the effective molecular composition $C_{100}H_{100}S_1N_{0.5}$. Assume maximum oxidation in an oxygen atmosphere, i.e., neglect additional NO_x production.

- a)** Calculate the number of constituent moles in one coal molecule.
- b)** Calculate emission rates for the emitted gases SO_2 and NO_2 in units of g/GJ for this coal. Is the burner in compliance with the standards?

Use the standard atomic mass scale based on C-12 (12u), N(14u), O(16u), S(32u). and $1u \cong 1.66 \cdot 10^{-24}g$, $A = 6.022 \times 10^{23}$ particles/mol.

3. Energy Contents of Carnivorous and Vegetarian Diets



The average person needs a daily food intake of about 2,100 kcal. For a carnivorous (meat centered) lifestyle in the U.S., this is satisfied by a mix of meats from chicken (unit weight=3 kg/broiler), beef (640 kg/cow), pork (125 kg/pig), and turkey (15kg/bird). Assume that these animals are raised on biological feed.

- a)** Determine the Feed Conversion Ratios (FCR) of the above different animals.
- b)** Determine the metabolizable energy (ME) contents (MJ/kg) in the feed mass corresponding to the respective actual weight gains (minus water content).
- c)** Calculate the feed energy (kWh) to raise each of the above animals.
- d)** Determine the average American's daily meat diet mix in terms of species' numbers and the feed-related energy cost (kWh).
- e)** Give an order of magnitude estimate, how much energy a corresponding vegetarian diet would cost per person.