

Problem 1: The historic rise in power use

Background. This problem is based on a long assigned reading, Braudel, “**The Structures of Everyday Life**”, the “**Energy**” chapter. Read for the ideas, not to memorize numbers. You may skim very lightly over the long section on animal power.

In this problem you’ll use Braudel’s numbers to estimate the per capita power use in pre-industrial-revolution Europe (1700s). The goal is to understand how far we had come in the historical progression from 100 W → 10,000 W. Braudel’s estimates cover most economic activities, including wood-burning for household and industrial heat, hydropower, human power, and animal power. He excludes wind, and coal, which was still small. In this problem you’ll use the figures that Braudel states in his concluding pages for Europe’s power use, bookkeep all Braudel’s horsepower and tons of wood values and convert each to W and then to W/person.

Before you can get a total estimate, you do need to correct a few errors and inconsistencies of Braudel’s. The first issue: on p. 367, he relates work in horsepower to the chemical energy in wood (that is released as heat on burning), but he worries that his calculation may not be very accurate. (It isn’t.) The second issue: for animal power, Braudel counts mechanical work outputs, not primary energy inputs (the work animals do rather than the power in animal feed). That’s presumably why he decides to scale down his wood number on p. 371 (to 30% of total chemical energy content). He is presumably thinking of the mechanical efficiency of engines driven by burning wood. But that’s an odd choice, as in pre-modern times, people were burning wood for heat. It’s better to achieve consistency by counting total primary energy use (all wood that is burnt, plus the food that powers domestic animals).

- A. First, state Braudel’s assertion: how many horsepower does he think correspond to how many tons of wood? Convert this value to MJ/kg in wood. How wrong is Braudel’s number? (Remember wood is just a carbohydrate, and so you know its energy density from Problem 2.)
- B. Recalculate the power usage as wood in Europe (in W) with your new value for energy density.
- C. Convert units to give the wood use as power per capita (W/person) by assuming a population for Europe. You can assume that the workers who provide the human-power in Braudel’s inventory make up 1/3 of the total population (the rest being the elderly and children).
- D. Now, to make your calculation comparable, recalibrate Braudel’s estimates for animal and human power to state the power consumption as primary energy (food) rather than output (work). Use what you now know about the efficiency of the person-engine. Give the values again as Watts per person.
- E. Make an estimate for windpower, using Braudel’s estimate of its size relative to hydropower.
- F. Write out a list of all power sources in Europe in W/person and their total. Discuss.
- G. Finally, for fun, check the historical understanding of horsepower. On p. 337 Braudel quotes Forest de Belidor’s estimate of the relative power output of man and horse. Is that estimate consistent with your answers in PS4 and the value of a horsepower?