

Thermal Energy

Physics and Mathematics of Sustainable Energy

College of the Atlantic. 7 October 2025

1. You decide to take a warm bath and fill up a 50 gallon bathtub. Estimate the energy needed to warm up the water. Assume that you need to heat the water from 5C to 40 C. How much energy does this take? Express your answer in MJ, kWh, and BTUs.
 2. A house might have a volume of approximately 12,000 cubic feet.
 - (a) How much energy would it take to heat the air in the house from -10C to 25C
 - (b) If you had to heat this air 12 times a day for a month, how much energy would be needed. Express your answer in MMBTU and kWh.
 3. In 2015–16 the Seafox Dormitory used 3185 gallons of heating oil.
 - (a) How much would this fuel cost?
 - (b) How much energy thermal energy is this? Answer in BTUs, MMBTUs, and kWh.
 - (c) How much carbon dioxide is released into the atmosphere as a result of burning this fuel? Put this number into context.
 4. Suppose the Seafox furnace is 70% efficient. In that case, how much of the thermal energy from burning the oil ends up inside Seafox? This quantity is known as the *heating load*.
 5. Suppose we replaced the Seafox furnace with one that is 90% efficient.
 - (a) How much fuel would we need to heat Seafox with this more efficient furnace?
 - (b) How much money would you save in one year?
 - (c) How much less CO₂ would be emitted in one year?
- 1 kWh = 3.6 MJ = 3412 BTU
 - 1 MMBTU = 1,000,000 BTU
 - Calorific value of heating oil: 12.8 kWh/kg, 37.3 MJ/L, 139,000 BTU/gallon
 - Carbon intensity of heating oil: 260 g of CO₂ per kWh of thermal energy. 10.2 kg CO₂ per gallon of fuel. 74.1 kg CO₂ per MMBTU of thermal energy.
 - 1 gallon = 3.8 liters
 - Current average cost of heating oil in Maine: \$3.33/gallon. (Note: unlike electricity, fuel prices vary significantly over time.)