Investigation into water heating properties with human sound production.

or

Yelling to let off steam

The pupose of this paper is to characterize the water heating abilities of the human vocal system.

Water

Find the energy required to heat one cup of water at a constant pressure from an initial temperature of 68 Fahrenheit to a final temperature of 212 Fahrenheit.

$\Delta T := 212 - 68 \qquad \Delta T = 144 \qquad \text{Rankine}$

The reduced 1st law of thermodynamics for a closed system is

$m \cdot \Delta U = Q$

For water, the specific heat remains approximately constant over the range of 68 to 212 Fahrenheit.

$c := 1.0 \quad \frac{\text{Btu}}{\text{lb} \cdot \text{R}}$

Water density is also approximately constant over the temperature range

$\rho := \frac{1}{0.0162} \qquad \rho = 61.728 \qquad \frac{\text{lbm}}{\text{ft}^3}$

The volume of one cup is

$\frac{1\,\text{cup}}{1} \cdot \frac{1\,\text{gallon}}{16 \cdot \text{cup}} \cdot \frac{0.13368 \cdot \text{ft}^3}{1 \cdot \text{gallon}}$

$V := 8.355 \times 10^{-3} \qquad \text{ft}^3$

Substitute

$\rho \cdot V \cdot \Delta u = Q$ The energy required is $\rho \cdot V \cdot c \cdot \Delta T = 74.267$ Btu

Acoustics

From *Fundamental of Acoustics,* [Kinsler, Frey, Coppens and Sanders], the shouting human voice can achieve a power output of 1000 microWatts

$\text{Time} = \frac{\text{Energy}}{\text{Power}} \qquad \text{Power} := 1000 \cdot 10^{-6} \ \text{Watts} \qquad \frac{0.9478 \cdot \text{Btu}}{1000 \cdot \text{watt} \cdot \text{s}}$

$\text{Time}_{sec} := \frac{\rho \cdot V \cdot c \cdot \Delta T}{\text{Power}} \cdot \frac{1000}{0.9478} \qquad \text{Time}_{sec} = 7.836 \times 10^7 \ \text{seconds}$

$\text{Time}_{days} := \text{Time}_{sec} \cdot \frac{1}{3600 \cdot 24} \qquad \text{Time}_{days} = 906.909 \ \text{days}$

$\text{Time}_{years} := \text{Time}_{days} \cdot \frac{1}{365} \qquad \text{Time}_{years} = 2.485 \ \text{years}$

Summary

Yelling for two and a half years generates enough energy to boil one cup of water.