



Pumping Energy Analysis

High-service pumps lift treated water into the distribution system. Analyze the energy and cost of one pump.

Name _____ Date _____

Given: flow $Q = 0.50 \text{ m}^3/\text{s}$, total head $H = 60 \text{ m}$, water density $\rho = 1,000 \text{ kg/m}^3$, $g = 9.81 \text{ m/s}^2$, pump efficiency 75%, motor efficiency 95%, runs 20 hours per day, electricity \$0.10 per kWh.

Hydraulic power: $P = \rho g Q H$

1. Calculate the hydraulic (water) power in kW.

2. Calculate the electrical power the motor draws from the grid.

3. Calculate the daily energy use (kWh) and daily cost.

4. Estimate the yearly cost of running this one pump.

5. Convert the flow to million gallons per day ($1 \text{ m}^3 = 264.2 \text{ gal}$).

6. A new pump with 85% efficiency costs \$120,000 to install. How many years until the energy savings pay for it?

7. Name two design changes, other than a new pump, that could reduce the head the pump must overcome.



For teachers

Grade 10 Answer Key

Accept reasonable answers that are supported by evidence.

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1. $P = 1,000 \times 9.81 \times 0.50 \times 60 = 294,300 \text{ W} = \mathbf{294.3 \text{ kW}}$
2. $294.3 \div 0.75 \div 0.95 = \mathbf{413.1 \text{ kW}}$
3. $413.1 \text{ kW} \times 20 \text{ h} = \mathbf{8,261 \text{ kWh/day}}$; $\times \$0.10 = \mathbf{\$826.11/\text{day}}$
4. $\$826.11 \times 365 \approx \mathbf{\$301,528 \text{ per year}}$
5. $0.50 \times 86,400 \times 264.2 \approx \mathbf{11.4 \text{ MGD}}$
6. New motor draw = $294.3 \div 0.85 \div 0.95 = 364.5 \text{ kW}$; savings $\approx \$35,474/\text{yr}$; payback $\approx \mathbf{3.4 \text{ years}}$
7. Examples: larger-diameter or smoother pipes to reduce friction losses, fewer bends and valves, lower storage-tank elevation, variable-speed drives.