aquafficiency®

Water System Energy **FACTS AND FIGURES**

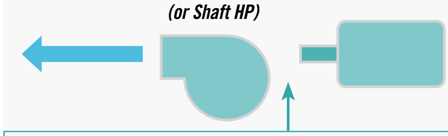
PROBLEM	DESCRIPTION	SOLUTION
Looping	Redundant pumping of the same water. Can occur when water descends through a PRV into a lower zone and then is boosted back into the original zone.	Use hydraulic model to identify. Modify PRV settings to keep water in desired zone. Determine if pumps are appropriately sized.
Leaping	Boosting water to a higher zone than necessary and using PRVs to supply a lower zone.	Install pipeline or other facility to bypass higher zone; supply target zone directly.
Losing Head	Breaking pressure prematurely, e.g., at a spring or wholesale delivery point, when pressure could be used beneficially.	Configure system to maintain and/or reroute pressure.
Loading	Intermittent pump operation—spikes for short durations. Can occur when a facility is oversized for the current demand or when equalization storage is not used efficiently.	Implement controls to pump more consistently, install jockey pump, and/or use storage rather than pumps to meet peak demand.
Leaking	Water loss through aged pipes, loose equipment, and unmetered use. Water loss is also energy loss and revenue loss.	Invest in leak-detection equipment. Start leak-detection program and fix leaks. Use model to identify hotspots. Reduce pressure in system to minimize leaks.
Poor Storage Utilization	Little or no fluctuation in tank levels; sources peak with demand.	Keep sources as constant as possible and use storage to balance supply and demand.
Poor Source Prioritization	Water sources are dispatched without considering their energy requirements. Some sources may be much more efficient than others.	Prepare an energy map that determines the energy intensity for each source. Prioritize and dispatch sources accordingly.
Oversized Pumps	Pumps are designed for build-out or peak-day demand and operate inefficiently under existing typical conditions (off the pump curve).	Redesign pumps, install VFDs, and/or install jockey pump for everyday demand.
Inconsistent Operation	Operation is mostly manual and inconsistent.	Optimize and automate operations for storage, sources, valves, etc.
Excessive Pressures	High pressures waste energy and water, including through leaks.	Manage pressures responsibly. Lower pump heads or implement new pressure zone.
Poor Maintenance	Poor maintenance wastes water and energy, e.g., leaks, worn impellers, worn motors, clogged pipes, malfunctioning controls.	Implement pipeline replacement and facility maintenance schedule.
Lack of Awareness	Utility staff unaware of energy issues, including policy, costs, and implications. Little or no organizational commitment.	Educate staff, develop energy policy, and commit entire organization to energy efficiency.

1 PUMPING ENERGY CALCULATIONS

BASIC EQUATION

$$\frac{GPM \times Feet}{3960} \times \frac{1}{Pump\ Eff} \times \frac{1}{Motor\ Eff} \times 0.746 = kW\ from\ utility$$

Water HP — *Brake HP (or Shaft HP)* — *Motor HP*



$$Input\ HP \times 0.746 = motor\ input\ kW^*$$

Include transmission loss between motor and machine if not direct coupled:

Gear box - 92-98% depending on type

V-belt - 89-95% depending on proper tension

"cogged" or "synchronous" belt - 98%

VFD EFFICIENCY

$$^*Input\ motor\ kW \times \frac{1}{VFD\ eff} = VFD\ input\ kW$$

VFD efficiency = 97%

Running at 100% speed consumes 3% more energy than running without a VFD.

Estimating energy from nameplate data

BHP ≈ Motor Nameplate HP x 90% (for mixers) x "% of Full Load Power"

BHP ≈ Motor Nameplate HP x 80% (for pumps) x "% of Full Load Power"

BHP ≈ Motor Nameplate HP x Operating Amps / Full Load Amps (FLA)

$$\frac{Brake\ Horsepower\ (BHP) \times 0.746}{Motor\ Efficiency} \times hours = kWh$$

It takes 3.14 kWh to lift 1 million gallons 1 foot at 100% efficiency

Saving energy in pumping

- **Reduce the head** static and/or friction
- **Reduce the flow** pump only what is needed
- **Improve equipment efficiency** new equipment or better operating point

2 VFD SAVINGS ON PUMPS

% DUTY/ SPEED	CYCLING % POWER	VFD % POWER	VFD % SAVINGS
100%	100%	103%	-3%
90%	90%	78%	12%
80%	80%	56%	24%
70%	70%	39%	31%
60%	60%	26%	34%
50%	50%	16%	34%
40%	40%	9%	31%
30%	30%	4%	26%
20%	20%	1%	19%
10%	10%	0%	10%
0%	0%	0%	0%

AFFINITY LAWS:

Flow $\propto$ Speed

Pressure $\propto$ $(Speed)^2$

Power $\propto$ $(Speed)^3$

$\propto$ means "proportional to"

REAL WORLD:

% Power = $(\%\ Speed)^{2.7}$

NOTE The chart above works well for closed loop pumps (e.g. hot water hydronic loops), fans (e.g. odor control), and mixers. For constant torque loads (compressors, PD "Roots" style blowers): **% Power ≈ % Speed**

3 POWER/ENERGY ESTIMATES BASED ON MOTOR HP

MOTOR HP	POWER (kW)	ANNUAL ENERGY (kWh)
0.5	0.3	2,800
1	0.6	5,500
5	3.1	27,500
10	6.3	55,000
20	12.6	110,100
50	31.4	275,200
75	47.1	412,700
100	62.8	550,300
150	94.2	825,500
200	125.6	1,100,600
250	157.1	1,375,800
300	188.5	1,650,900
500	314.1	2,751,600

Assumes 80% motor load, 95% motor efficiency, 24/7 operation.

4 CALCULATING POWER FROM AMPS

For three phase power (be wary of using amps from a VFD panel readout)

$$Amps \times Volts \times 1.73 \times Power\ Factor \times \frac{1}{1{,}000} \times hours = kWh$$

5 USEFUL TIME AND ENERGY CALCULATIONS

Constant (24/7) running is 8,760 hrs annually

8 hr/day for 7 days/week = 2,920 hours

8 hr/day for 5 days/week = 2,085 hours

Runtime reductions
1/24th = 4.2% **1/7th** = 14.3% **1/12th** = 8.3% **1/52** = 1.9%

Quick conversions
1 HP = 0.75 kW **100 HP** = 75 kW **10 kW** = 13.4 HP

Rough kWh **10 HP 24/7** = 65,000 kWh

6 MOTOR EFFICIENCY

MOTOR NAMPLATE HP	STANDARD EFF.	PREMIUM EFF.	APPROX. POWER FACTOR
1	74%	82%	0.62
5	84%	90%	0.70
10	87%	91%	0.73
25	90%	93%	0.77
50	91%	94%	0.80
100	92.2%	94.7%	0.82
250	93.3%	95.2%	0.85
500	94.0%	95.5%	0.91
1000	94.5%	95.7%	0.92

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