



# Energy Basics for Water and Wastewater Treatment

a presentation by

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## The Schatz Energy Research Center



- Based at Humboldt State University
- Founded in 1989
- Mission: to promote the use of clean and sustainable energy

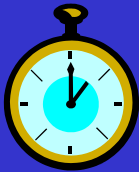
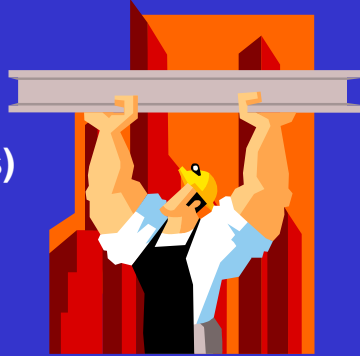


## First, let's define a few terms

Energy = the ability to do work

Units of energy include

- kWh (electricity)
- Therms (natural gas)
- BTU (heat)



Power = the *rate* at which work is performed

Units of power include

- kW (electricity)
- BTU/hr or BTUH (heat)





So energy is a *quantity*, while power is a *rate*.

Some common quantities and rates:

Quantity

Rate



Miles

Miles per hour (MPH)

Gallons

Gallons per minute (GPM)

kWh

kW

BTU

BTUH (BTUs *per* hour)



BTUs are not something you see on utility bills, but they're widely used for comparing energy content of different fuels or different systems of units.

100 cubic feet of natural gas = 1 therm = 100,000 BTU

1 kWh = 3,413 BTU

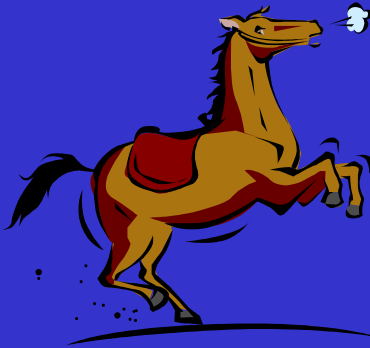
1 gallon of gasoline = 125,000 BTU

1 barrel of crude oil = 5,100,000 BTU

1 cord of firewood = 30,000,000 BTU



How do you convert kilowatts to horsepower?



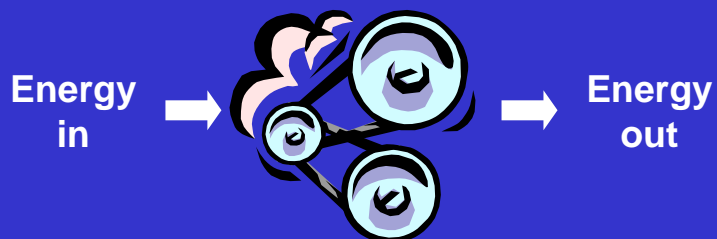
$$1 \text{ HP} = 746 \text{ W} = 0.746 \text{ kW}$$

$$1 \text{ kW} = 1.34 \text{ HP}$$



Let's do a few quick calculations

$$\text{Energy efficiency (\%)} = \frac{\text{Energy out}}{\text{Energy in}} \times 100$$



For a pump that requires 7.6 kW of electric power and produces 5 HP of thrust to the fluid:

$$\text{Efficiency} = \frac{5 \text{ HP}}{6.7 \text{ kW}} \times 100 = \frac{5 \text{ HP} \left( \frac{0.746 \text{ kW}}{1 \text{ HP}} \right)}{6.7 \text{ kW}} \times 100$$
$$= 0.56 \times 100 = 56\% \text{ efficient}$$



Ohm's Law:

Volts X Amps = Watts

Example:

$$240 \text{ V} \times 3.2 \text{ A} = 768 \text{ W} = 0.768 \text{ kW} \cong 1 \text{ HP}$$



## Energy Cost Reduction Strategies

### 5 Basic Types

**Conservation:** use less energy

**Efficiency:** improve (increase) ratio of energy out to energy in

**Load shifting:** change equipment use schedules to reduce peak demand or avoid high time-of-use rates

**Fuel switching:** find a less expensive type of energy to get the job done

**Rate shopping:** change rate schedule or energy supplier to pay less per unit of energy



### Conservation Example



Imperial Lighting Maintenance Company

Take half the tubes out of fluorescent fixtures in an area that's overlit



## Efficiency Example

Infomine.com



Replace a 72% efficient pump with an 80% efficient model



## Load Shifting Example

Reschedule some daytime pumping operations to take advantage of time-of-use utility rates.

## Fuel Switching Example

Replace electric space heaters with propane- or natural gas-fired radiant heaters.

## Rate shopping

Ask PG&E for an electric rate comparison and switch rates if the analysis shows an advantage.



## Energy Use at Water and Wastewater Facilities

- Water and wastewater pumping and treatment use about 4% of all electricity consumed in the U.S. ( $\frac{4}{5}$  for pumping,  $\frac{1}{5}$  for treatment)
- The EPA estimates that water and wastewater treatment plants will need to increase their capacity by 5-8% over the coming decade to keep up with demand.



## Energy Use at Water Treatment Plants

- In surface water systems, most energy is used for treatment.
- In ground water systems, most energy is used for pumping.
- Overall, ground water systems use ~20% more total electric energy than surface water systems.



Source: EPA

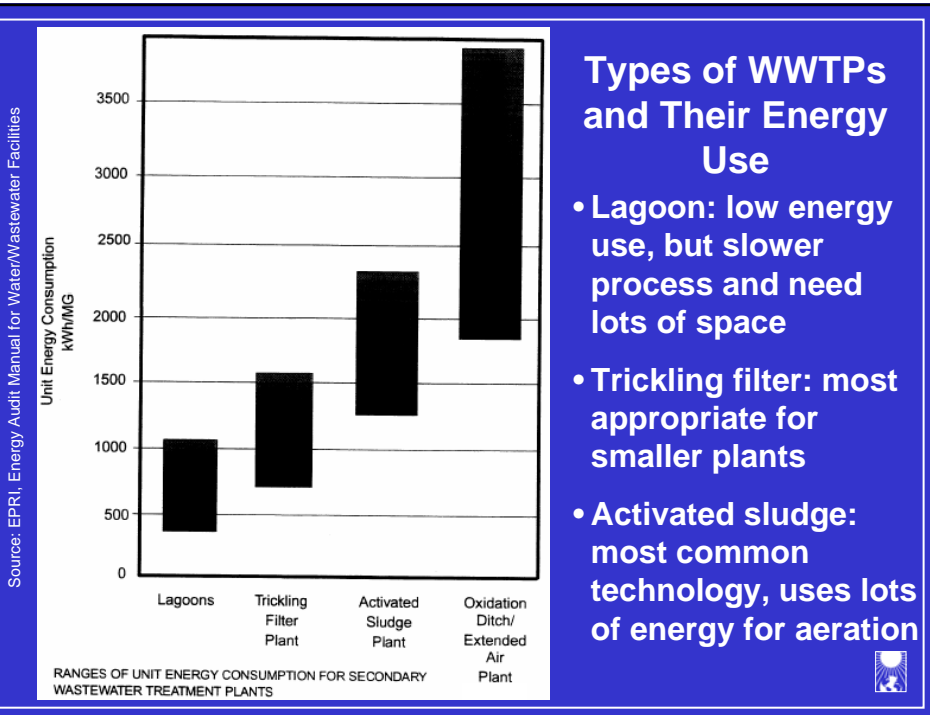


## Energy Use at Wastewater Treatment Plants

- Wastewater treatment is the single biggest electricity use for most local governments.
- At the plant, energy makes up 25-40% of total operating costs, second only to labor.



Source: EPA



## Pumps, Blowers, and Motors

Pumps and Blowers are the main energy users at WWTPs: ~86% of total electricity use

- 46% for pumping
- 40% for aeration

Main end uses of electricity:

- Wastewater, sludge, and scum pumping
- Aeration (blowers)
- Stirring or agitation (clarifiers, RBCs)



U.S. National Archives and Records Administration

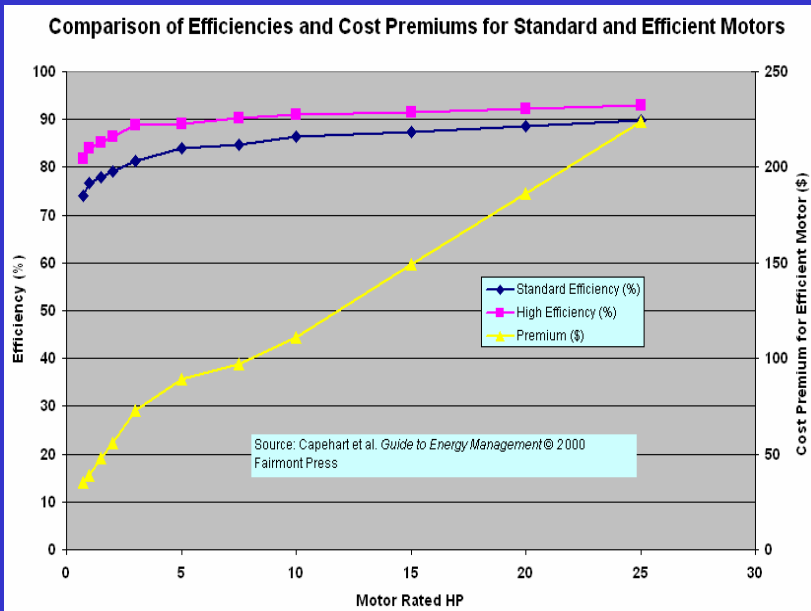


## Common Cost-Effective Opportunities for Reducing Pump, Blower and Motor Energy Costs

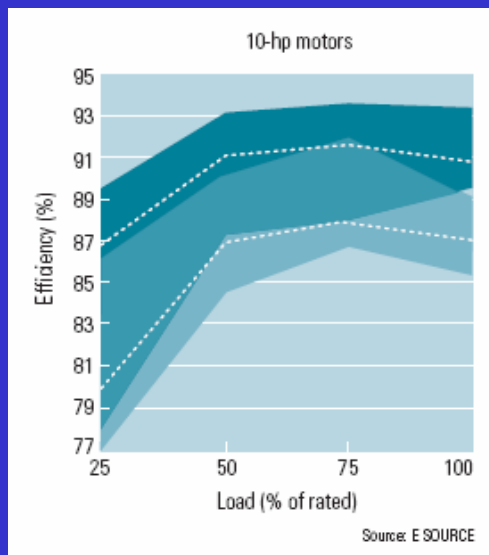
- ✓ Replacing old and inefficient equipment
- ✓ Matching equipment to loads
- ✓ Using variable frequency drives (VFDs)
- ✓ Measures to improve efficiency of whole drive system
  - Belts
  - Lubrication
  - Maintenance



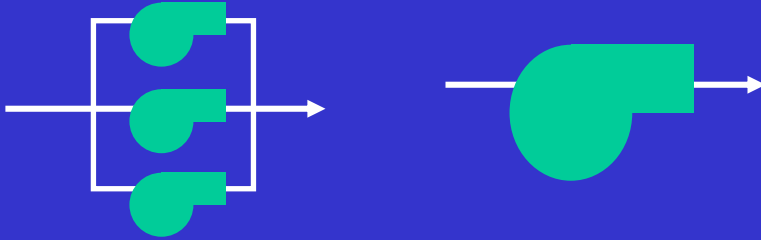
## Specify efficient motors at replacement time



## Match Equipment to Loads (don't oversize pumps or blowers)



## Staged Pumps

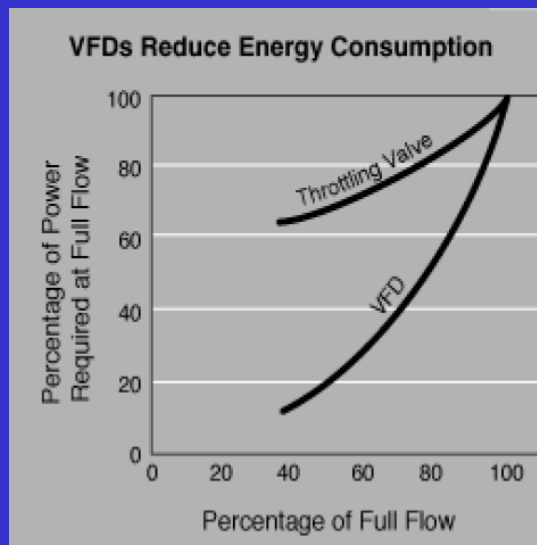


Multiple small pumps in parallel vs. 1 big pump

- More redundancy for greater security
- Higher operating efficiency at all flow levels



## VFDs are a much more efficient way to control flow than throttling



California Energy Commission



## Other Opportunities to Reduce Plant Energy Costs

- ✓ Load shifting
- ✓ Fine-pore aeration
- ✓ Renewable electric generation
  - Solar photovoltaics (PV)
  - Wind
- ✓ Biogas recovery
  - Thermal use to speed biological processes
  - Electricity generation
  - Both (cogeneration)



## Energy Economics

To perform a basic economic analysis of any energy saving project, consider costs and savings.

### Costs

- Materials
- Labor
- Administrative costs (procurement, permits, etc.)
- Recurring costs (maintenance)

### Savings

- Energy savings (kWh, therms)
  - Demand savings (kW)
  - Labor savings, if any
  - Equipment savings, if any
- } Convert all to \$/year



## Economic Tests

- Simple Payback
- Return on Investment
- Life Cycle Cost



## Simple Payback

$$\text{Simple Payback (yrs)} = \frac{\text{cost}}{\text{annual savings}}$$



## Return on Investment

$$\text{Simple ROI (\%)} = \frac{\text{annual savings}}{\text{cost}} \times 100$$



## Life Cycle Cost

Neither Simple Payback nor Simple ROI takes into account the changing value of money over time.

Life cycle cost (LCC) of a measure is the *net present value* of all future costs and savings. LCC requires more calculation, but it gives a more complete and “real” economic evaluation that considers time value of money.

LCC is a great tool for comparing alternatives.

To learn more about LCC, download:

[www.oit.doe.gov/bestpractices/pdfs/pumplcc\\_1001.pdf](http://www.oit.doe.gov/bestpractices/pdfs/pumplcc_1001.pdf)



## Utility Rates

Saving energy and saving money aren't always the same thing:

- Switching rate schedules may allow you to save \$ without making any change in total energy use or treatment volume.
- Reducing peak demand for any demand-metered account can cut demand charges. Strategies may include staggering operations to reduce the number of pieces of equipment being run at any given time.



Please contact me if you have any follow-up questions:

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