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The Water-Energy Nexus: Reducing Costs Through Energy Efficiency

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Your Presenter Today…

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Questions?

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Today’s Learning

- Be able to perform a cursory ***Energy Audit*** of your facility, and achieve a quantifiable reduction in monthly energy cost
- Be able to identify and select energy-efficient lighting and equipment
- Be able to calculate ***Simple Payback*** of new or replacement equipment

A Few Energy Facts

- 4% of electricity in the U.S. is consumed by water and wastewater facilities
- U.S. energy costs are predicted to increase

  20% by 2035 (Source: U.S. DOE)
- $4 billion current annual energy costs
- 56 billion kWh
- 44.8 million tons of greenhouse gas

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Why Does This Matter?

- Water and wastewater energy use often consumes 30% to 60% of a small community's budget
- 10% reduction in water and wastewater energy use could save $400 million and 5 billion kWh annually

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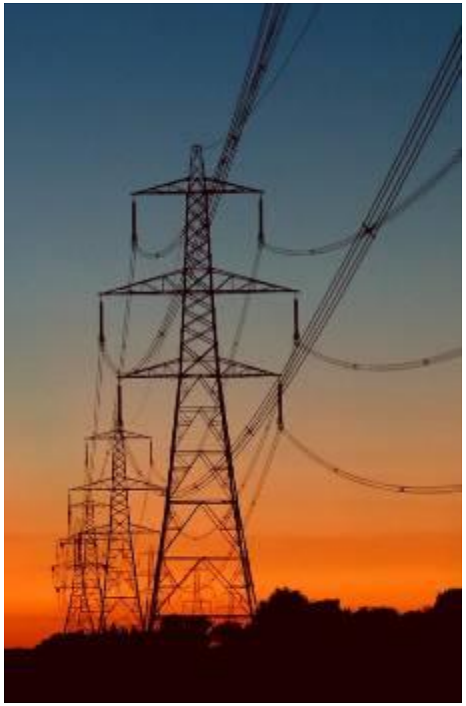
What is *Energy Efficiency*?

- The process of doing ***more*** with ***less***
- Accomplish the same tasks and functions as before, while using less energy
- Without compromising:
  - Quality
  - Safety
  - Regulatory compliance
  - Comfort



What is an *Audit*?

- Webster's Dictionary:
  - (1) a formal examination of an organization's or individual's accounts or financial situation,
  - (2) a methodical examination and review
- In Terms of Energy:
  - An analysis of the energy usage for a facility or operation and the identification of possible **energy conservation opportunities (ECO's)**

A Few Terms…

- Energy is the <u>capacity</u> to do work…(kW)
- Power is the <u>amount</u> of work being done (kWh)
- For **Electrical** Systems:
  - kWh = kW x hours
- For **Thermal** Systems:
  - BTU/hr = BTU x hours
    - BTU = amount of energy needed to raise (or lower) 1 lb of water by 1°F

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An Example…

- A 27-watt CFL is turned 'on'
  - 10 hours a day
  - 5 days a week
- The Power, or **<u>Demand</u>** is:
  - 27 watts / 1,000 = 0.027 kW
- The **<u>Energy Use</u>** is:
  - 0.027 kW x 10 hrs = 0.27 kWh/day
  - 0.27 kWh/day x 5 days = 1.35 kWh/week
  - 1.35 kWh/week x 52-weeks = 70.2 kWh/yr

Who Can Perform An Energy Audit?

- 'Certified' auditors
  - AEE (Association of Energy Engineers)
    - CEA / CEM / others
- Architects & engineers
- Technically proficient persons
- ***YOU!***

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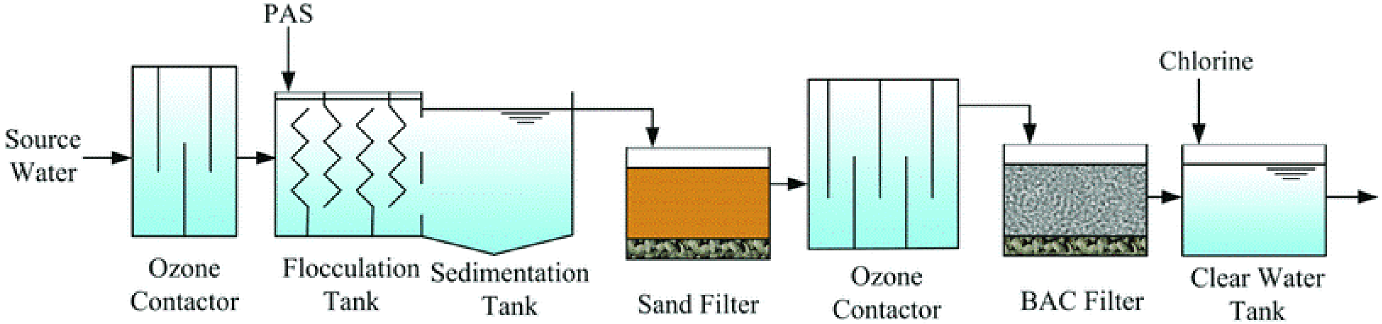
Benefits Of An Energy Audit…

- Benchmarking
  - Key Performance Indicators
  - Identifying Trends
  - Decision Tool for Change
    - Equipment, Processes, System
- Budget Planning
- Knowledge of the System
  - Water Loss / Leaks / Waste, etc
- Error Reduction
  - Billing, Payments, Meters, Chemicals

How an Energy Audit Starts…

- Understand Your Billing
  - Structure (Classification, Tariff, etc.)
  - Quantities (kW, kWh, kVAR, Power Factor, etc.)
- Understand Your Facility
  - Processes
  - Flows
  - Equipment
  - Goals



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The Physical Audit

- Evaluate equipment
  - Outdated or worn?
  - Improper controls?
  - Design vs. Actual usage
    - Can you adjust?
    - Can you reduce?
    - Can you eliminate?
  - ***Is there a more efficient alternative?***

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Pumps And Motors
(The Big Energy Wasters)

Why Aren't Motors Very Good At What They Do?

- Energy is converted to motion by the proximity of a magnetic field (induction)
- **Not all energy is converted** – some is lost to heat, friction, resistance

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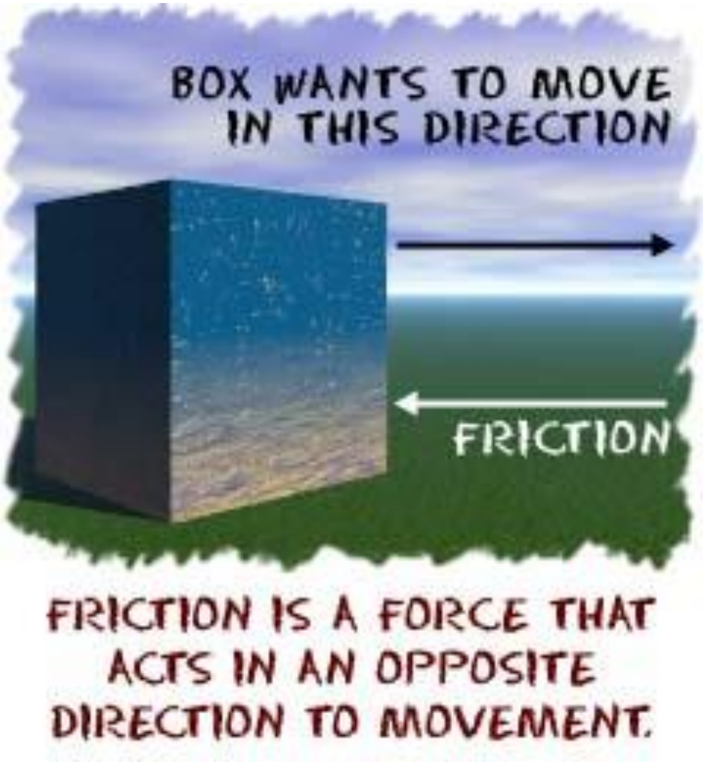
Why Aren't Pumps Very Good At What They Do?

- Not all rotational energy is converted to fluid power
- Some energy is lost to friction, wear, inefficiency



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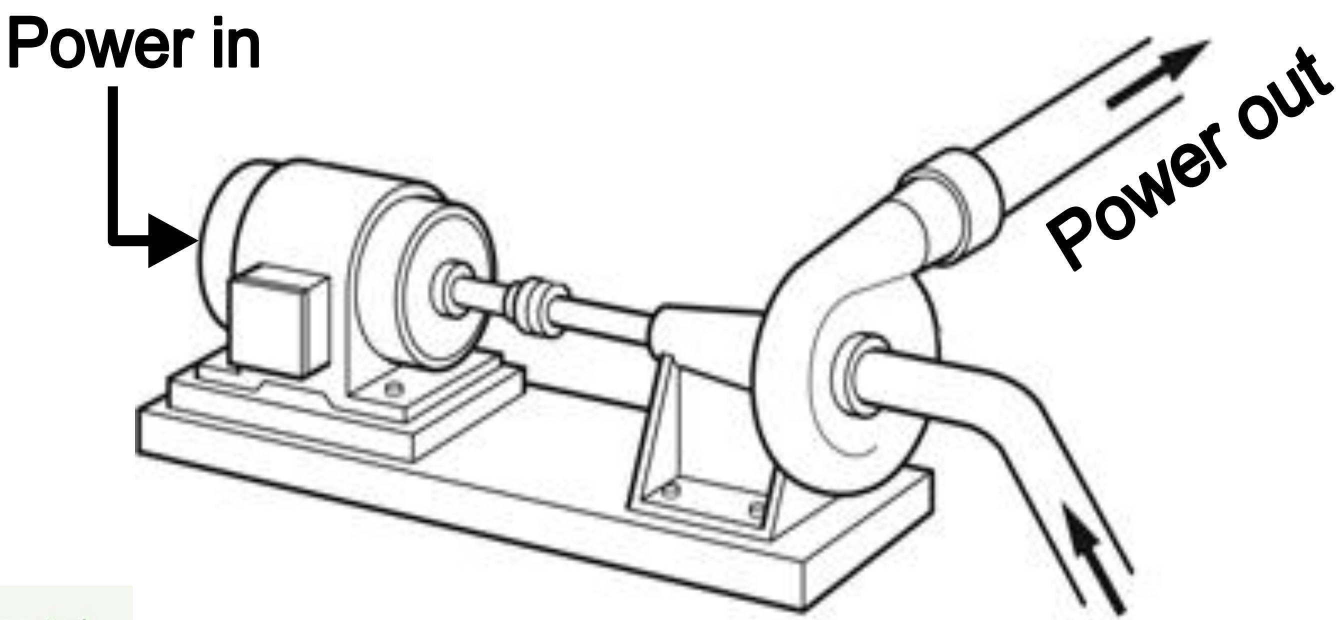
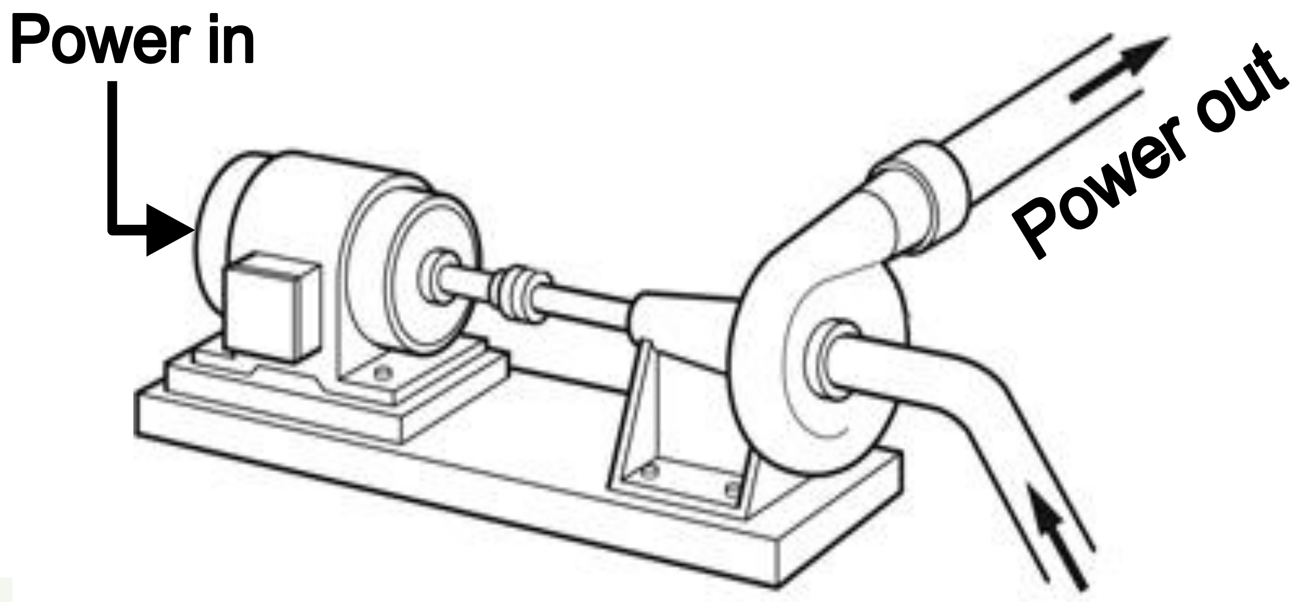
Basic Realities #1

- Motor output power is always less than input power



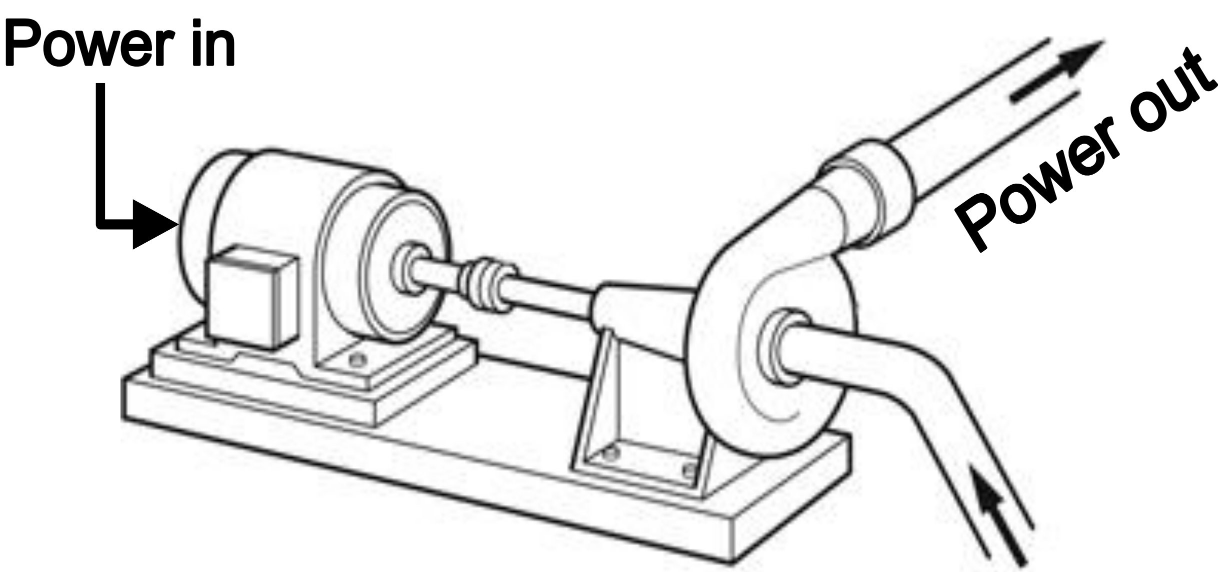
Basic Realities #2

- Fluid power is always less than motor output power

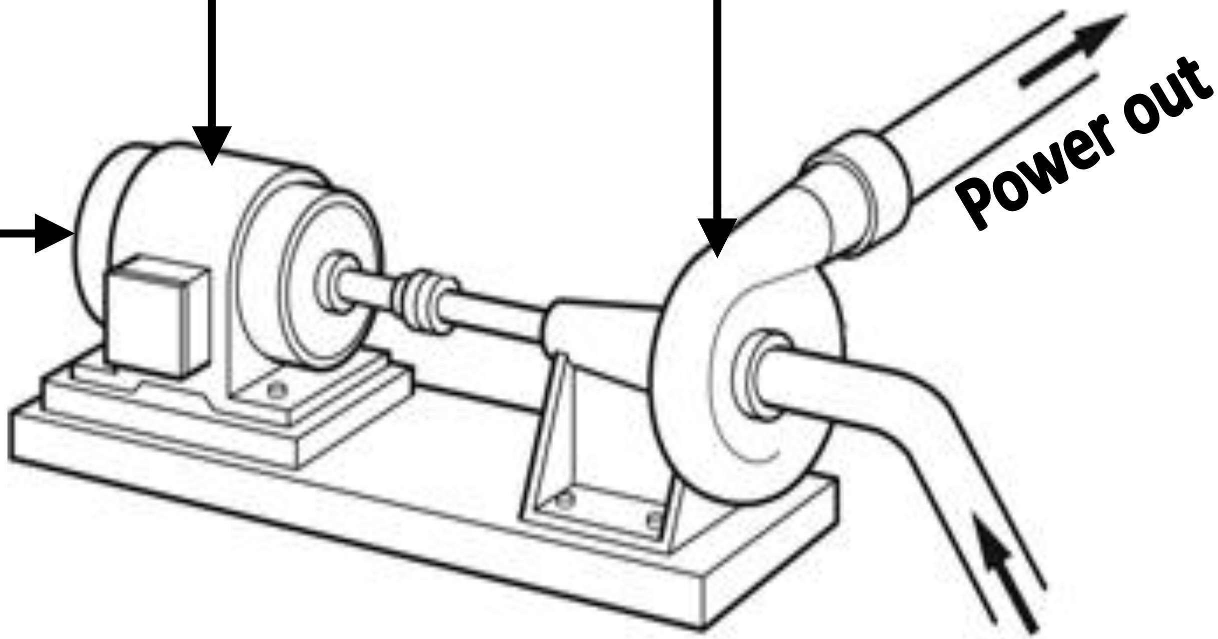


What Does This Mean?

- Ratio between input power and liquid power is called **"wire-to-water"** (WTW) efficiency



Power In: 20 HP (14.9 kW) x Motor Efficiency (.92) x Pump Efficiency (.75) = Power Out: 13.8 HP (10.3 kW)



Overall Wire-To-Water Efficiency in This Example = .69 OR 69%

Pump Assessment :

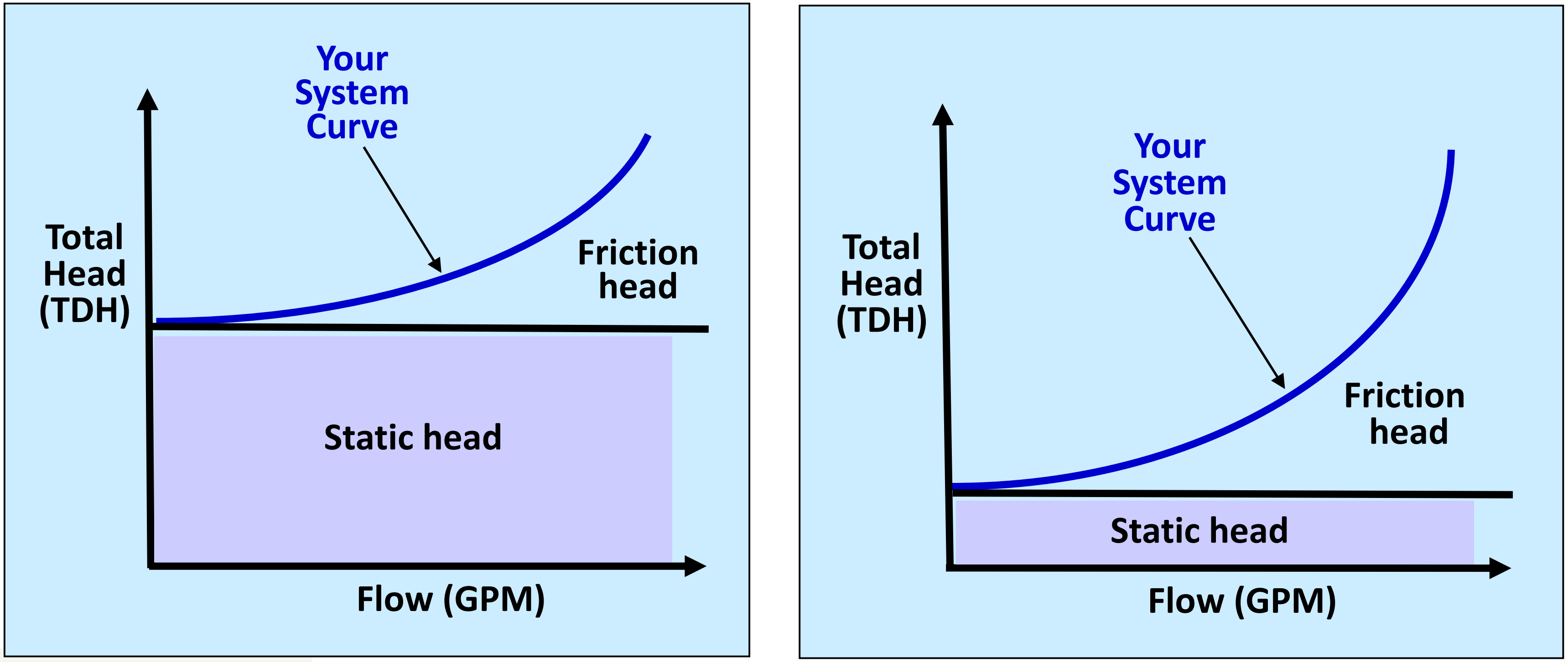
- Manufacturer's performance curve
- Motor specifications
- Drive data
- Design data (flow, head, etc.)
- Amp draw (field measurement)
- Existing flow conditions

Pump Assessment:

- Pump efficiency can often be <50%
- Wisconsin study of 1,690 pumps at 20 process plants
  - Many pumps operating below 10% efficiency - due to:
  - Throttling of valves
  - Over-sizing of pumps
  - ‘We’ve always done it that way’ mentality

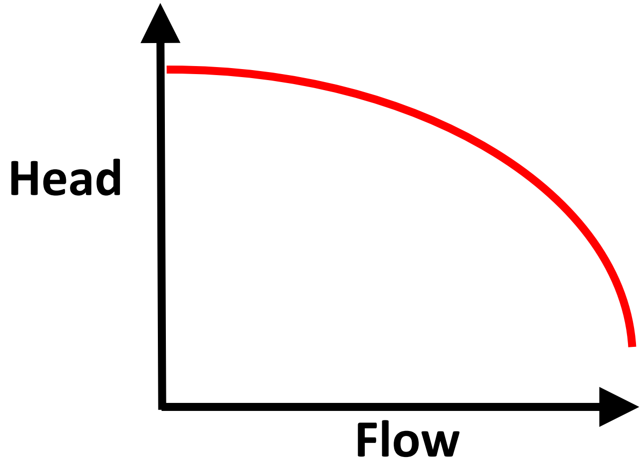
System Curve

- Hydraulic characteristics of ***YOUR*** system
- Usually can't be changed



Pump Performance Curve

- Provided by pump manufacturers
- Relationship between head and flow
  - As flow increases….
    - System resistance increases
    - Pump performance decreases



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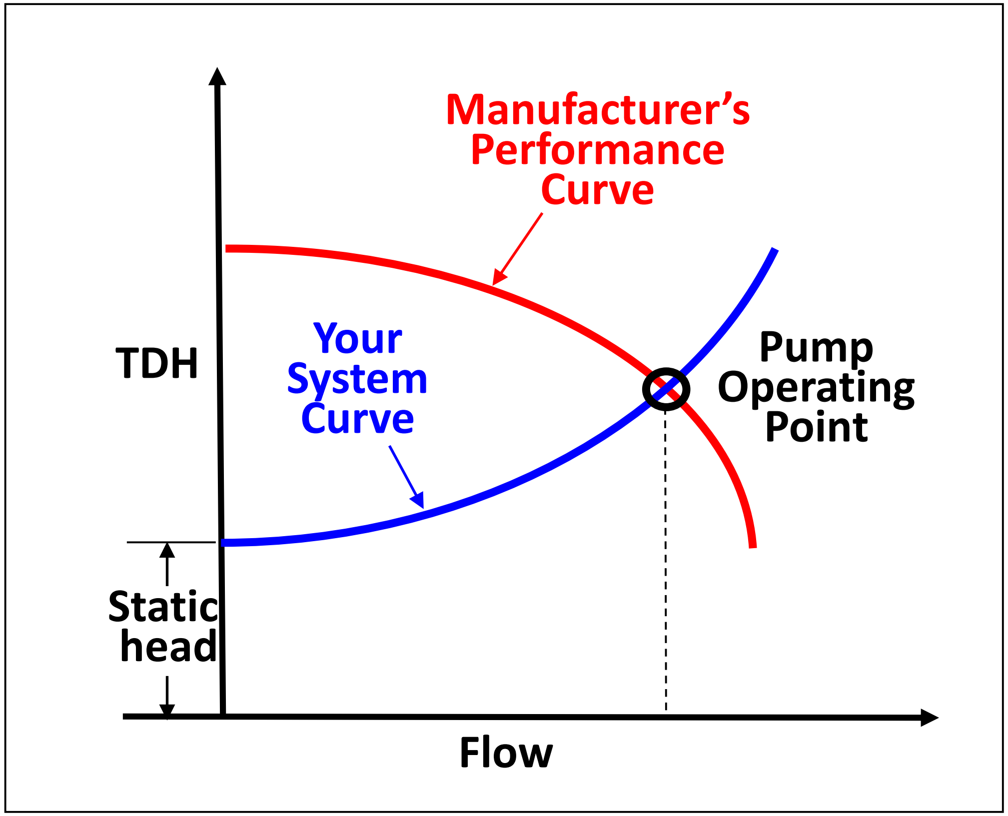
Pump Operating Point

- **Duty point:**
  - How much flow you need at a certain head
- **Pump operating point:**
  - Intersection of manufacturer's performance curve and your system curve



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Motor Efficiency Matters!

- In U.S. Industry, electric motors consume:
  - ~680 billion kWh/year
  - ~63% of all industrial electricity consumption
  - ~23% of all U.S. electrical consumption

Factors Influencing Motor Efficiency

- Age
- Capacity
- Speed
- Type
- Temperature
- Rewinding
- Load

Motor Calculations:

- Power Requirements:
  - $$kW = \frac{(HP) \times (0.746\ kW/HP) \times (\text{Motor Loading})}{\text{Efficiency}}$$
  - kWh = kW x Operating Hours
  - Simple Payback = Cost / Annual Savings

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Motor Question #1:

- A 10-HP, 1,800 RPM, 86.5% efficient motor operates 4,000 hrs/year at a LF of 0.7. The cost of electricity is $0.10/kWh. What is the cost per year to operate?

Cost To Operate:

10 HP x 0.746 x 0.7 / 0.865 = 6.04 kW

6.04 kW x 4,000 hrs. = 24,160 kWh

24,160 kWh x $0.10/kWh =

<u>$2,416.00/year</u>

Motor Question #2:

- If the same motor was replaced with a 91.7% efficient model, with the same operating conditions and power cost, what will be the new cost to operate?

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New Cost To Operate:

10 HP x 0.746 x 0.7 / 0.917 = 5.69 kW

5.69 kW x 4,000 hrs. = 22,760 kWh

22,760 kWh x $0.10/kWh =

$2,276.00/year

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Motor Question #3:

- If the higher efficiency motor in the previous problem had an installed cost of $380, what would be the simple payback in years?

Simple Payback:

Original cost to operate = $2,416.00

New cost to operate = $2,276.00

Energy savings = $140.00/yr

$380/$140 = ***2.71 years***

Rewinding

- Can reduce motor efficiency
- It’s tempting to have an old motor rewound, but….
  - If your motor is <40HP and more than 20 years old… ***buy a new motor!***
  - If rewinding/rebuilding your old motor costs more than 30-40% of a new motor… ***buy a new motor!***

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Lighting – the Low-Hanging Fruit

- Easiest to measure, identify, analyze, and implement
- Benefits include:
  - Lower cooling costs
  - Lower maintenance
  - Increased safety
  - Cost **$**aving**$**!

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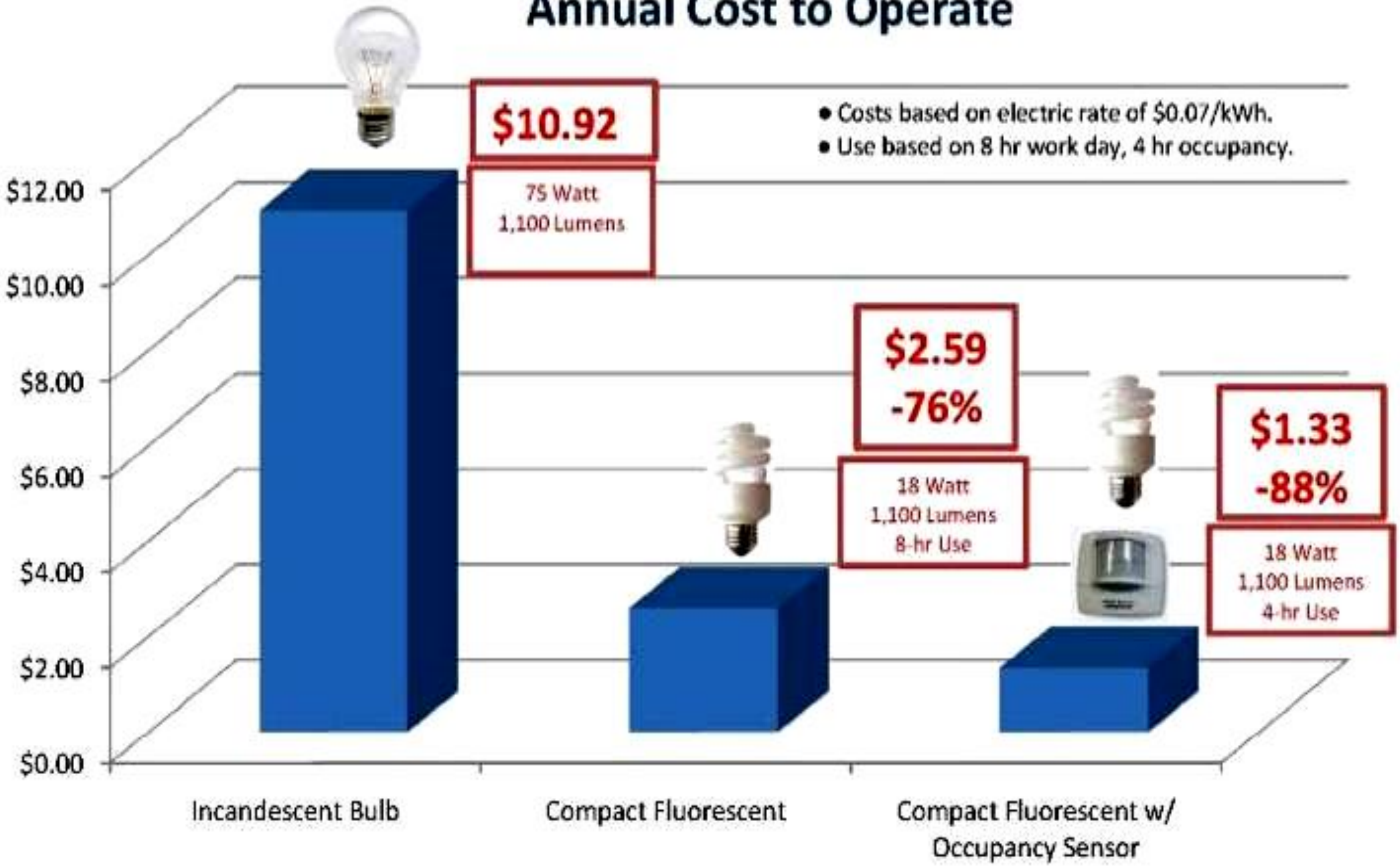
Annual Cost to Operate



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Lighting Audit Example 1:

- A facility has (25) 27w CFLs. Assume they operate 3,000 hrs per year, and the average cost of electricity is $0.14/kwh. What is the annual cost to operate?

Lighting Answer 1:

- 25 lamps x 27 watts / 1,000 = 0.675 kW
- 0.675 kW x 3,000 hrs = 2,025 kWh/year
- 2,025 kWh x $0.14/kWh = **<u>$283.50</u>** per yr

Lighting Example 2:

- From Lighting Example 1, replace the CFLs with 18-watt LED lamps. Still assume the 3,000 operating hrs and $0.14/kWh cost. What is the potential savings by replacement?

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Lighting Answer 2:

- 25 lamps x 18 watts / 1,000 = 0.450 kW
- 0.450 kW x 3,000 hrs = 1,350 kWh/year
- 1,350 kWh x $0.14/kWh = **$189.00** per yr
- $283.50 - $189.00 = **$94.50** annual savings

Lighting Example 3:

- From Lighting Examples 1 & 2, calculate the Simple Payback (SPB) if the cost per LED is $2.50

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Lighting Answer 3:

- **SPB = Cost / Annual Savings**
- SPB = ($2.50 x 25 lamps) = $165.00
- SPB = $165.00 / $94.50 = **1.75 years**

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What is HVAC?

- ***H**eating, **V**entilation, **A**ir **C**onditioning*
- Designed to provide:
  - Ventilation
  - Comfort
  - Humidity control
    - Effects on workers, equipment, computers, etc.
- 60% of energy use in commercial buildings
- Much less in WTP and WWTP

HVAC Efficiency Ratings

- Operating efficiency = how the unit turns energy into heating/cooling performance
- Higher efficiency = lower costs and energy usage
- They include:
  - SEER – Seasonal Energy Efficiency Ratio
    - 5-Ton and Under
  - EER – Energy Efficiency Ratio
    - Over 5-Ton
- **1 "ton"** of cooling = 12,000 BTUs/Hour

Estimating SEER:

Time of Installation	Typical SEER
Pre 1970	6
1970-1974	6.5
1975-1983	7.4
1984-1987	8.7
1988-1991	9.4
1992-2005	10
2006 -2010	13

SEER = BTU/Hr (cooling) / Watts

EER = BTU/Hr (cooling) / Watts

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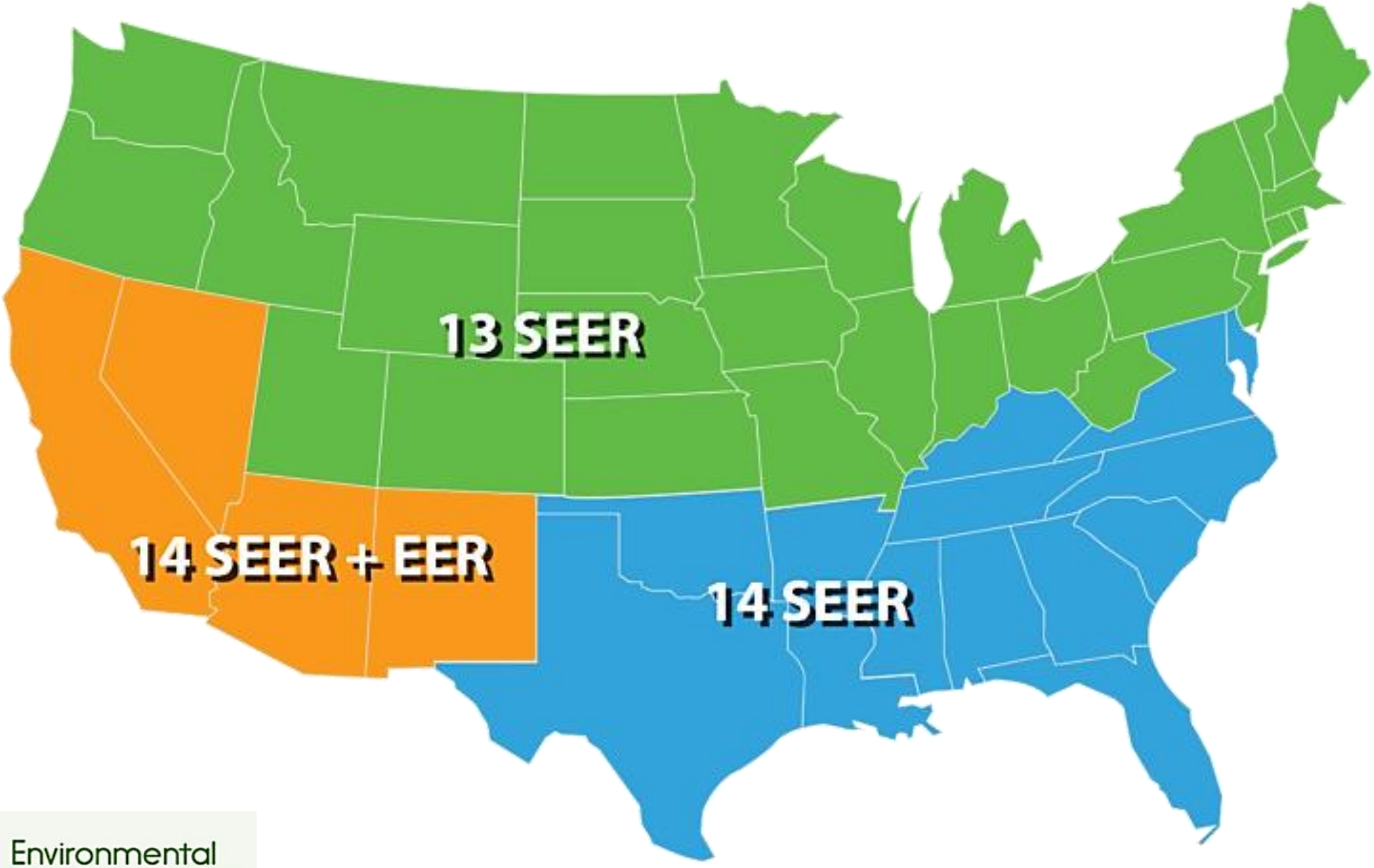
2019 SEER Minimums



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Heating

- Heating can come from many different sources:
  - Electricity
  - Gas
  - Fuel Oil
  - Wood
  - Thermal transfer
- Electric heat is always 100% efficient
- Natural gas is approx. 80% efficient
  - Consider fuel costs for evaluation

Heating Equivalents:

- **Heating is measured as BTU's**
  - Natural Gas: 1 Therm = 100,000 BTU's
  - Electricity: 1 kWh = 3,413 BTU's
  - Fuel Oil #2: 1 Gallon = 139,000 BTU's
  - Wood: 1 Pound = 9,000 BTU's

HVAC Energy Conservation Opportunities

- Regular service and inspection
- Changing filters regularly
- Programmable thermostats
  - A 10° reduction for 10 hours can save approx. 10% in energy cost

Resources

- US EPA (Environmental Protection Agency)
  - Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities, January 2008 (PDF)
- US Dept of Energy, EERE (The Office of Energy Efficiency and Renewable Energy)
- FocusOnEnergy.com
  - Water and Wastewater Energy Best Practice Guidebook, December 2006

Questions / Discussion

Thank You For Attending!

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