GovEnergy
www.govenergy.gov
The Premier Energy Training Workshop and Trade Show for Federal Agencies

A River of Energy Solutions

Assessing the cost of change in pumping systems

Daryl Cox, Oak Ridge National Laboratory

It is not necessary to change.

Survival is not mandatory.

– W. Edwards Deming

If you have always done it that way, it is probably wrong.

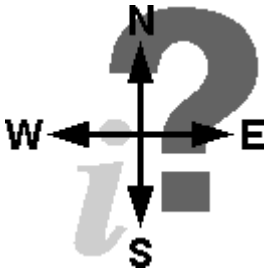
– Charles Kettering

Why change?

- Part of the process this system is supporting has changed.
- Part of the process supporting this system has changed.

Mapping sensible change

- What is the ultimate goal?
- How do you identify the need for change?
- How much energy should it take?
- How much is already being spent?
- Is there enough difference to motivate change?



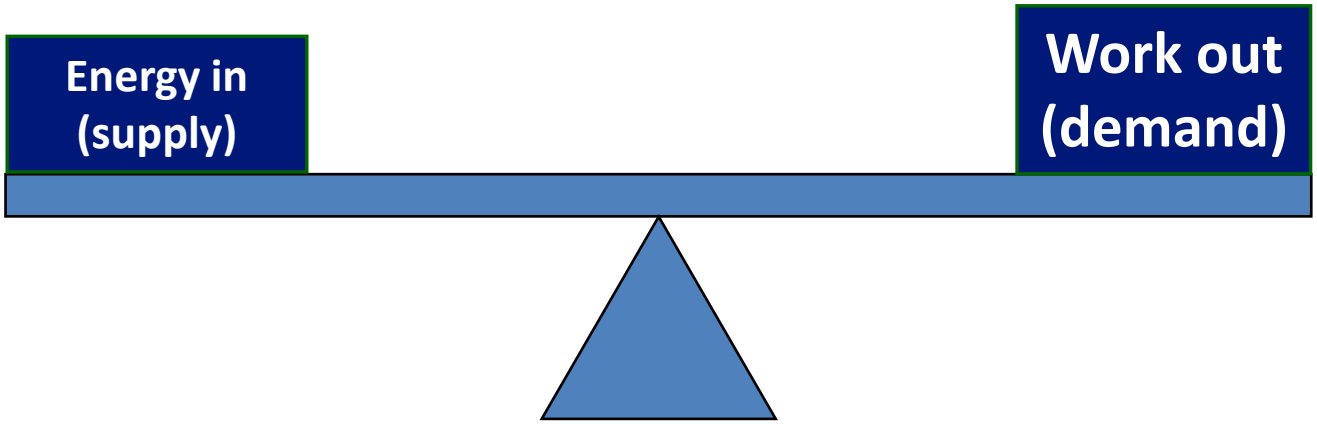
Define the Goal

- What does not happen when the system is unavailable?
- A goal is not performance metrics

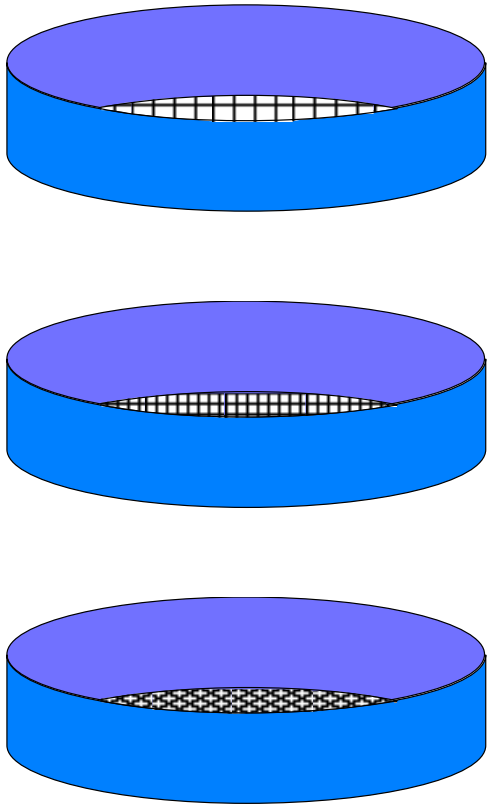
Determining if Change is Warranted

- Performance issues
- Cost of operation

It's all about balance



Using a three-tiered approach to prescreening and assessment



Prescreen by size, run time, and application

Symptom-based prescreening to help identify systems where significant opportunities may exist

Detailed assessment and quantification of potential savings

GovEnergy
www.govenergy.gov

Pumping system energy basics are fundamental to secondary prescreening

$$E = \frac{Q \cdot H \cdot T \cdot sg}{5308 \cdot \eta_{pump} \cdot \eta_{motor} \cdot \eta_{drive}}$$

E	energy, kilowatt-hours	
Q	flow rate, gpm	System-level opportunities
H	head, ft	System-level opportunities
T	time, hours	System-level opportunities
sg	specific gravity, dimensionless	
5308	Units conversion constant	
η_{pump}	pump efficiency, fraction	Component-level opportunities
η_{motor}	motor efficiency, fraction	Component-level opportunities
η_{drive}	drive efficiency, fraction	Component-level opportunities

Common causes of sub-par SYSTEM performance

- The installed components are not efficient at the current operating point
- The installed components (system) have degraded
- More flow is being provided than is required by the system
- More head is being provided than is required by the system
- The equipment is running when it is not needed by the system

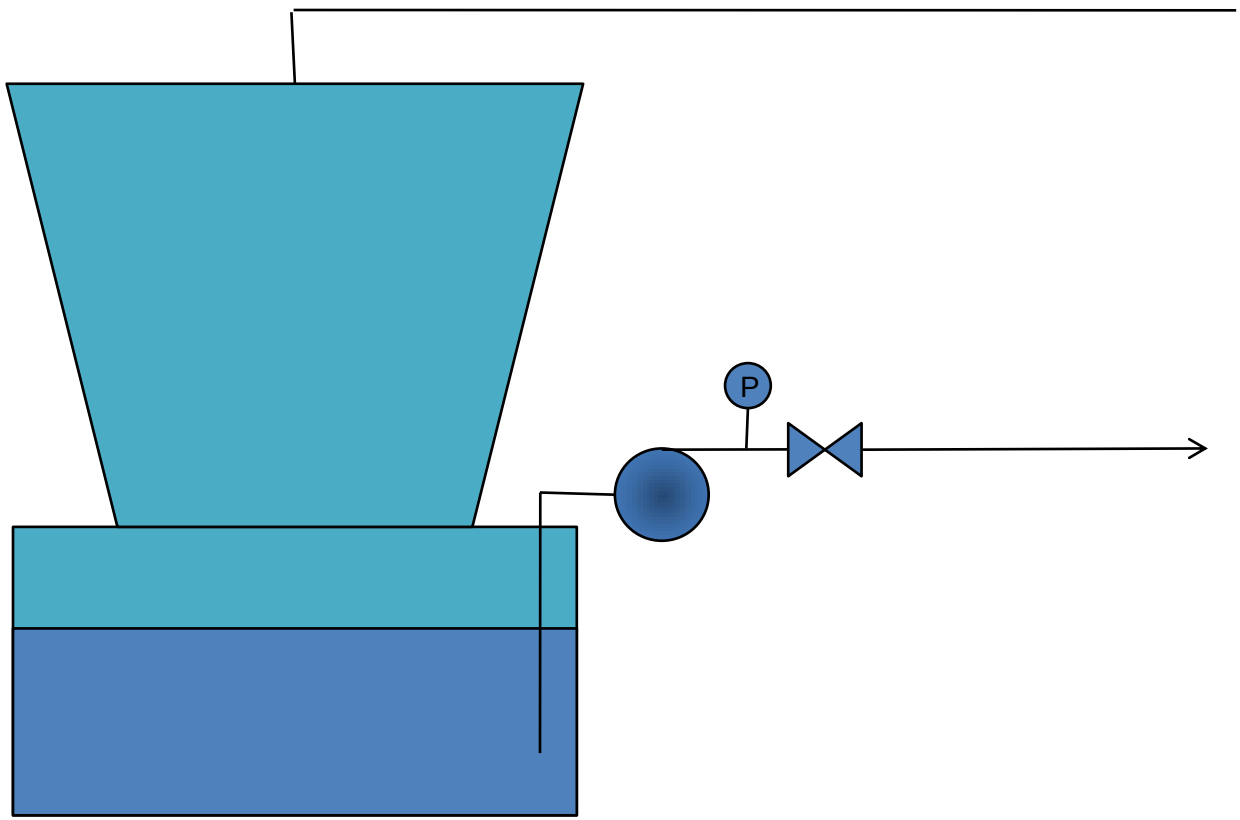
Let’s use an application to demonstrate the principles

First, a component level assessment

- At the component level, all we need to know is what we have and what the system is doing
  - Flow rate
  - Head
  - Power (or current)
  - Equipment

Installed condition and background

- Vertical turbine pump is 30 years old
  - standard efficiency motor
  - 200 HP
  - 3 stages
  - 228.6 FLA
- 14 inch carbon steel pipe
- $0.05/kWh electrical costs



Flow rate is 3315 gpm

Discharge pressure is 90 psig, measured 2 ft above basin

Water surface is 4 ft below rim of basin

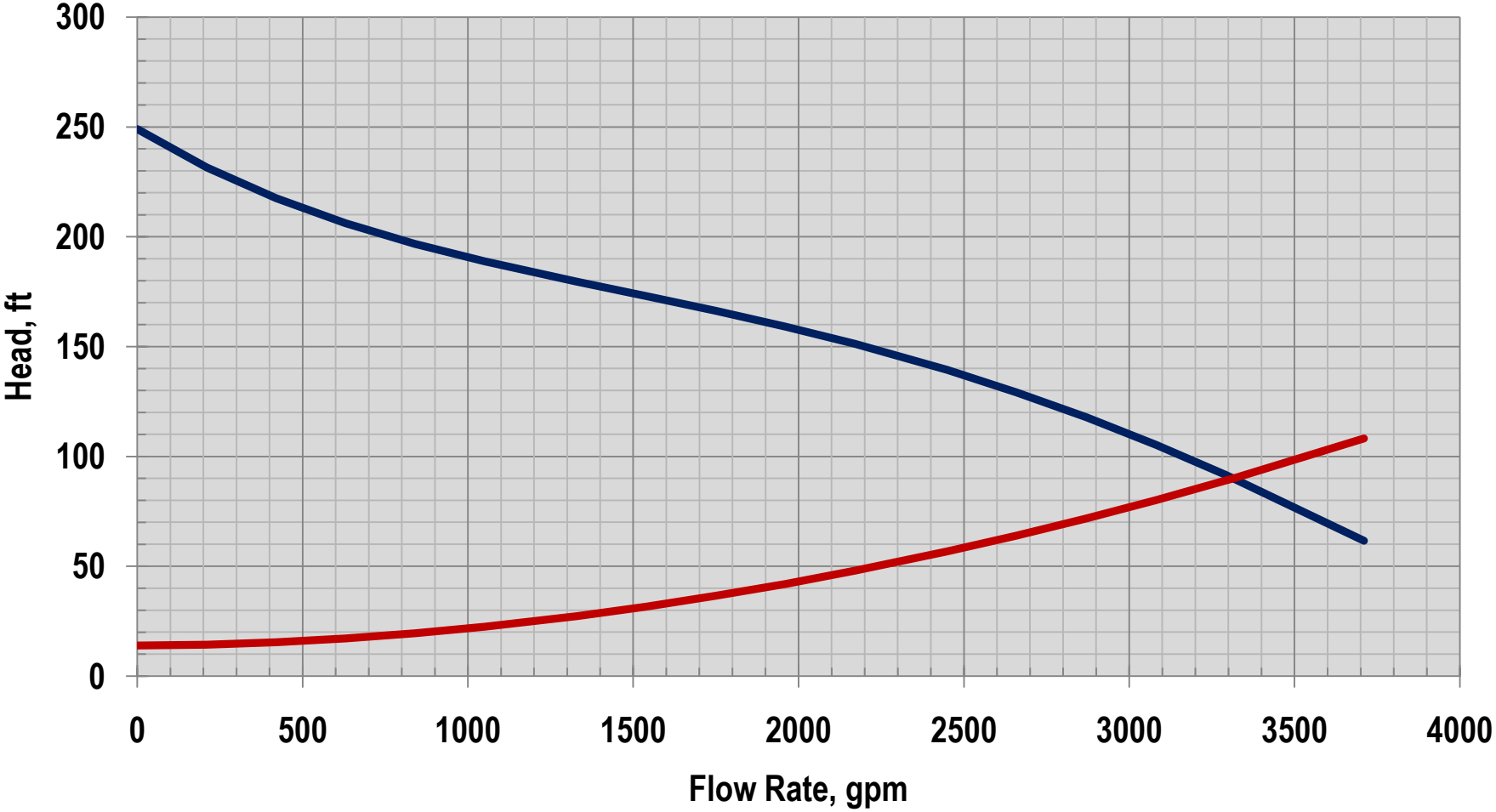
Motor power 73.6 kW

GovEnergy
www.govenergy.gov

How do we establish losses?

- Static Head
  - Elevation
  - Fixed Pressure
- Frictional Head
  - Pipe
  - Valves
  - Fittings
  - etc.

Pump and system Curves

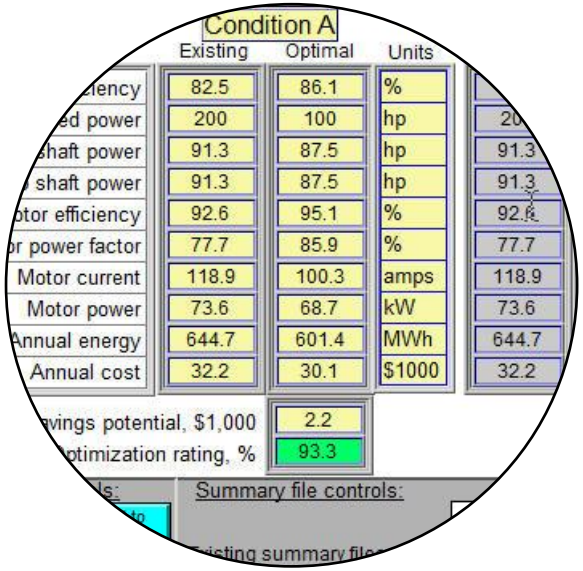


GovEnergy
www.govenergy.gov

Some sources of head loss

Software tools can help quantify potential savings

- An optimization rating of 93 is great!
- The pump currently costs us $32K/yr in electricity
- If we had the optimum pump and motor combination we could save over $2,000/yr



Condition A

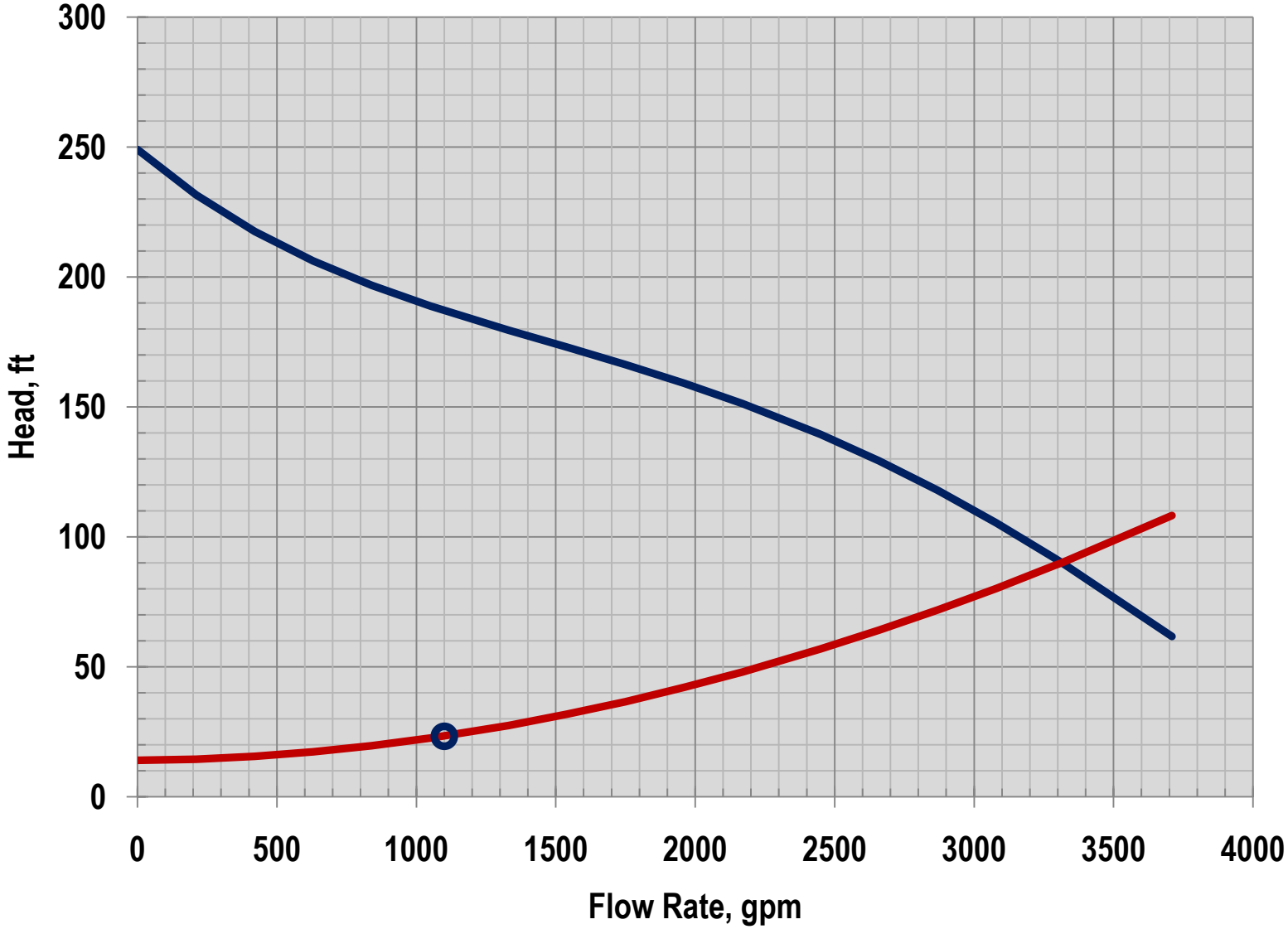
	Existing	Optimal	Units	
iency	82.5	86.1	%	
ed power	200	100	hp	20
shaft power	91.3	87.5	hp	91.3
shaft power	91.3	87.5	hp	91.3
otor efficiency	92.6	95.1	%	92.6
r power factor	77.7	85.9	%	77.7
Motor current	118.9	100.3	amps	118.9
Motor power	73.6	68.7	kW	73.6
Annual energy	644.7	601.4	MWh	644.7
Annual cost	32.2	30.1	$1000	32.2
vings potential, $1,000		2.2		
ptimization rating, %		93.3		

Summary file controls:

GovEnergy
www.govenergy.gov

What if we looked at the system?

- Worst-case the tower is designed for 8°F ΔT
- We are currently measuring 3°F ΔT
- We have more flow than we need
- What flow rate do we need for the amount of heat we are actually rejecting?



GovEnergy
www.govenergy.gov

Background

- The tower requires a minimum flow rate of 1100 gpm
- Assume there is 14 ft of static head in this system
- The system required head at 1100 gpm is 23.3 ft

Pumping System Assessment Tool

File Tools Help

PSAT 2008

	Condition A	Condition B
Pump, fluid	Vertical turbine	Vertical turbine
	Pump rpm 1780	Pump rpm 1780
	Drive Direct drive	Drive Direct drive
	Units gpm, ft, hp	Units gpm, ft, hp
	Kinematic viscosity (cS) 1.00	Kinematic viscosity (cS) 1.00
	Specific gravity 1.000	Specific gravity 1.000
	# stages 3	# stages 3
	Fixed specific speed? YES	Fixed specific speed? YES
Motor	Line freq. 60 Hz	Line freq. 60 Hz
	HP 200	HP 200
	Motor rpm 1780	Motor rpm 1780
	Eff. class Standard efficiency	Eff. class Standard efficiency
	Voltage 460	Voltage 460
	Estimate FLA	Estimate FLA
	Full-load amps 228.6	Full-load amps 228.6
	Size margin,% 0	Size margin,% 0
Duty, unit cost	Operating fraction 1.000	Operating fraction 1.000
	$/kwhr 0.0500	$/kwhr 0.0500
Field data	Flow rate, gpm 3315	Flow rate, gpm 1100
	Head tool Head, ft 90.0	Head tool Head, ft 23.3
	Load estim. method Power	Load estim. method Power
	Motor kW 73.6	Motor kW 73.6
	Voltage 460	Voltage 460

Retrieve defaults | Set defaults | Copy A > to B > | Copy B < to A < | Background information

System curve tool: select below

STOP

	Condition A Existing	Condition A Optimal	Units	Condition B Existing	Condition B Optimal	Units
Pump efficiency	82.5	86.1	%	7.1	78.2	%
Motor rated power	200	100	hp	200	10	hp
Motor shaft power	91.3	87.5	hp	91.3	8.3	hp
Pump shaft power	91.3	87.5	hp	91.3	8.3	hp
Motor efficiency	92.6	95.1	%	92.6	91.1	%
Motor power factor	77.7	85.9	%	77.7	80.6	%
Motor current	118.9	100.3	amps	118.9	10.5	amps
Motor power	73.6	68.7	kW	73.6	6.8	kW
Annual energy	644.7	601.4	MWh	644.7	59.3	MWh
Annual cost	32.2	30.1	$1000	32.2	3.0	$1000
Annual savings potential, $1,000		2.2			29.3	
Optimization rating, %		93.3			9.2	

Log file controls: Create new log | Add to existing log | Retrieve log entry | Delete log entry

Summary file controls: Create new summary file

Existing summary files: CREATE NEW

Documentation section

Condition A Notes

Facility | System | Date

Application | Evaluator

General comments

Condition B Notes

Facility | System | Date

Application | Evaluator

General comments

GovEnergy
www.govenergy.gov

Comparing the Options

Pump Operating Costs and Savings			
Units	Base Case	Better Pump	Matched to System
kW	73.6	68.7	6.8
MWh/yr	644.7	601.4	59.3
$/yr	32,200	30,100	3,000

Results

- Major difference between what the system was designed to do and what the system currently needs to do
- By looking at system requirements potential savings go from $2.1K/yr to at least $29K/yr
- We still need to know the specifics of “why” and we also need to know if there are actually more savings

At the system level we need more information:

- History
  - System used to supply cooling water for multiple production-type loads that no longer exist
- Questions
  - What is the actual minimum flow per the manufacturer?
  - Could the load be shifted to another tower and shut this one down?
  - How much of the savings could we get with variable speed pumping?

More questions

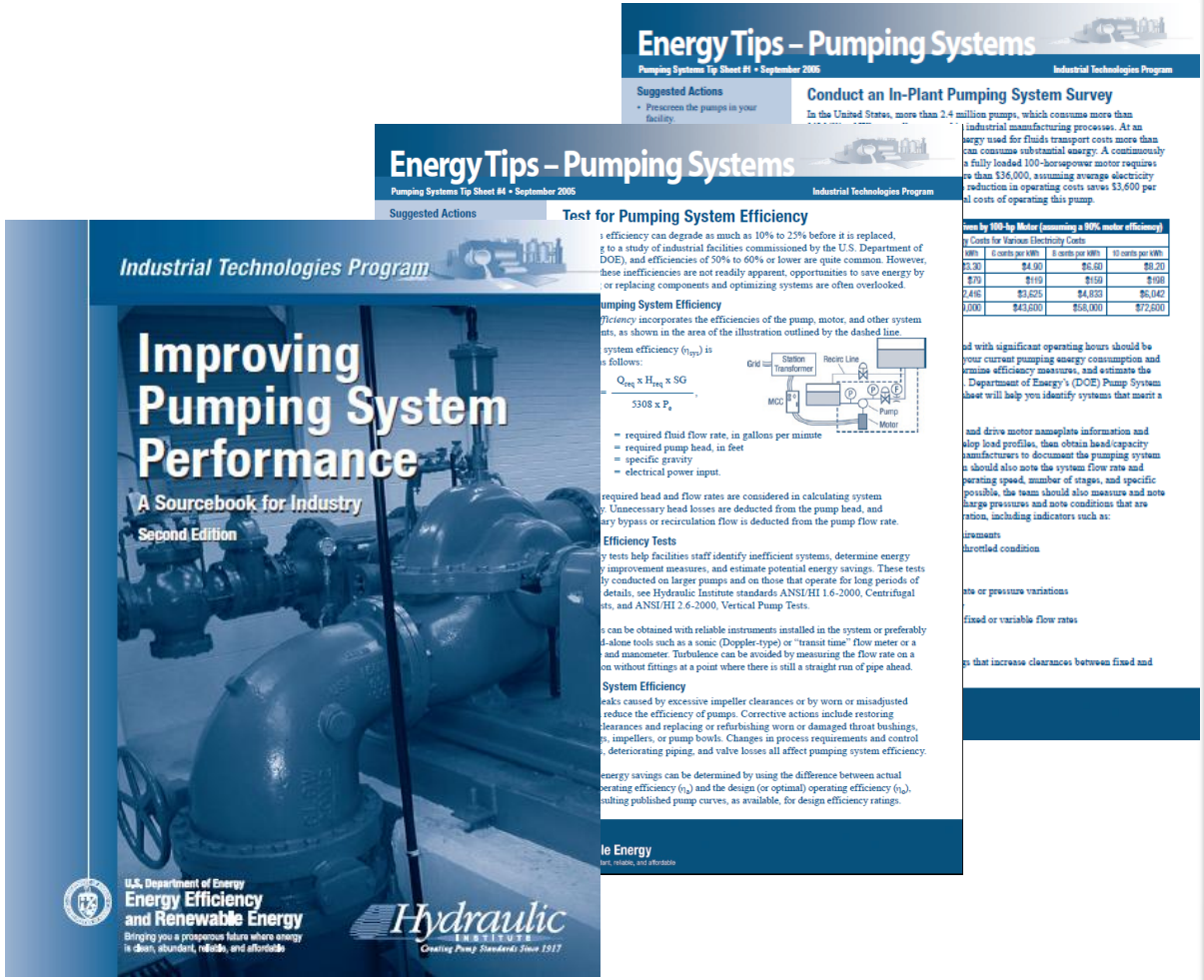
- Should we replace the pump and tower?
- What comprises the load on the system?
  - If the requirement has gone from supporting a production process to building HVAC would it make sense to switch to a packaged HVAC unit or heat pump instead of a chiller, tower, etc.?
  - Have buildings or processes been removed from the system?

Savings Summary

- Considering all these, the major pumping system retrofit may be cost effective after all…
  - Equipment kWh
  - Water gallons
  - Sewer gallons
  - Chemical Treatment $
  - Maintenance $
  - Productivity $
  - Emissions

BestPractice Publications

- Source Book
- Tip Sheets
- Fact Sheets



http://www1.eere.energy.gov/industry/bestpractices/techpubs_motors.html

GovEnergy
www.govenergy.gov

BestPractice Case Studies

- By Industrial System: Pumping Systems
  - http://www1.eere.energy.gov/industry/bestpractices/case_studies_system.html#pump_sys
- Performance Spotlights
  - Qualified Specialists and Industry Partners
  - Software Tools Utilized
  - http://www1.eere.energy.gov/industry/bestpractices/case_studies.html#Performance_Spotlights

Contact:

Daryl Cox
Oak Ridge National Laboratory
865.576.6639
coxdf@ornl.gov