U. S. Department of Energy
Energy Savings Assessment (ESA)

Overview of the Pumping System Assessment Tool (PSAT)

Date: December 15, 2008
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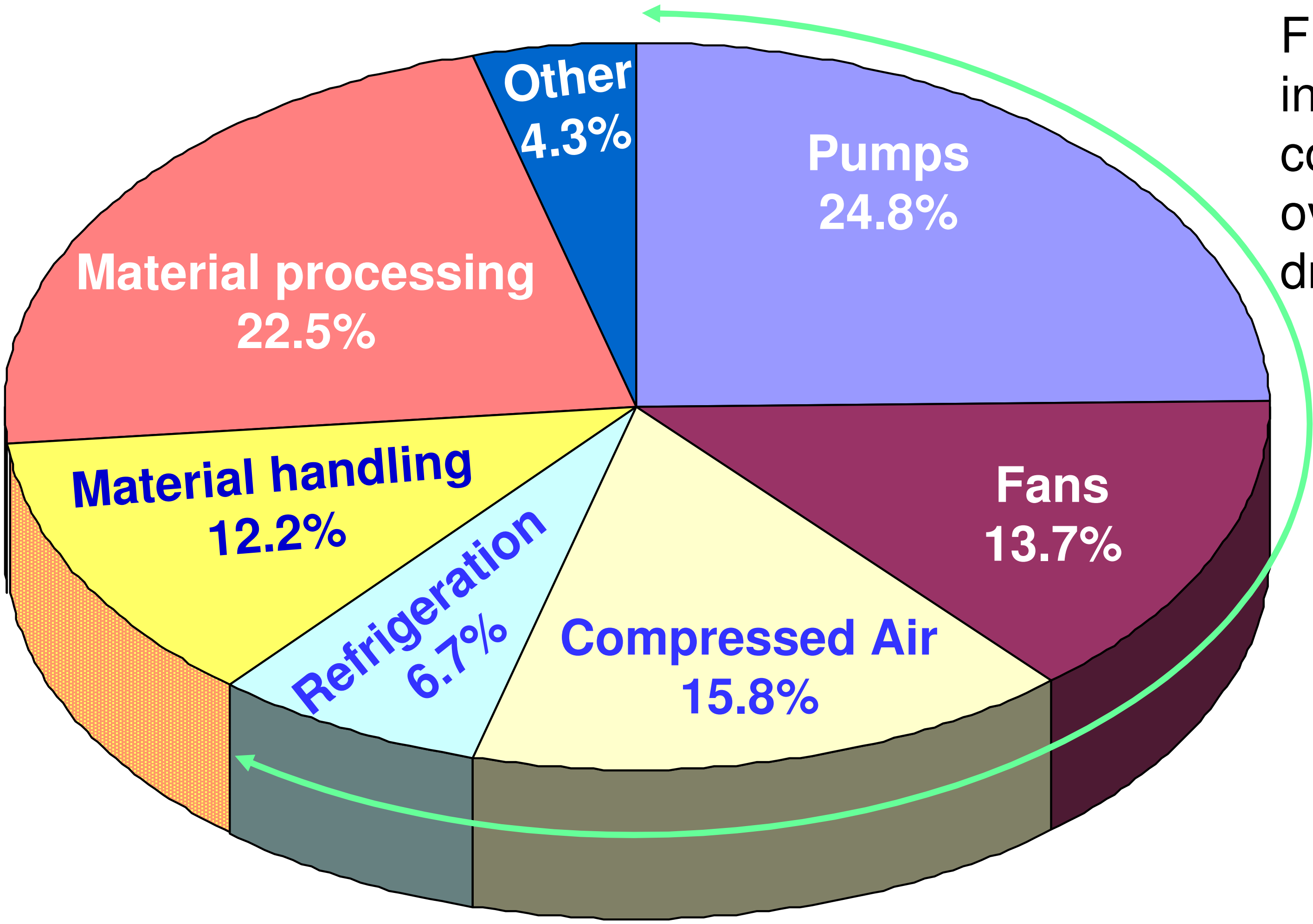
Motor-driven equipment is a dominant electricity consumer

Industrial motor systems:

- are the *single largest electrical end use* category in the American economy
- account for 25% of <u>all</u> U.S. electrical sales

Pumps are the largest industrial user of motor-driven electrical energy

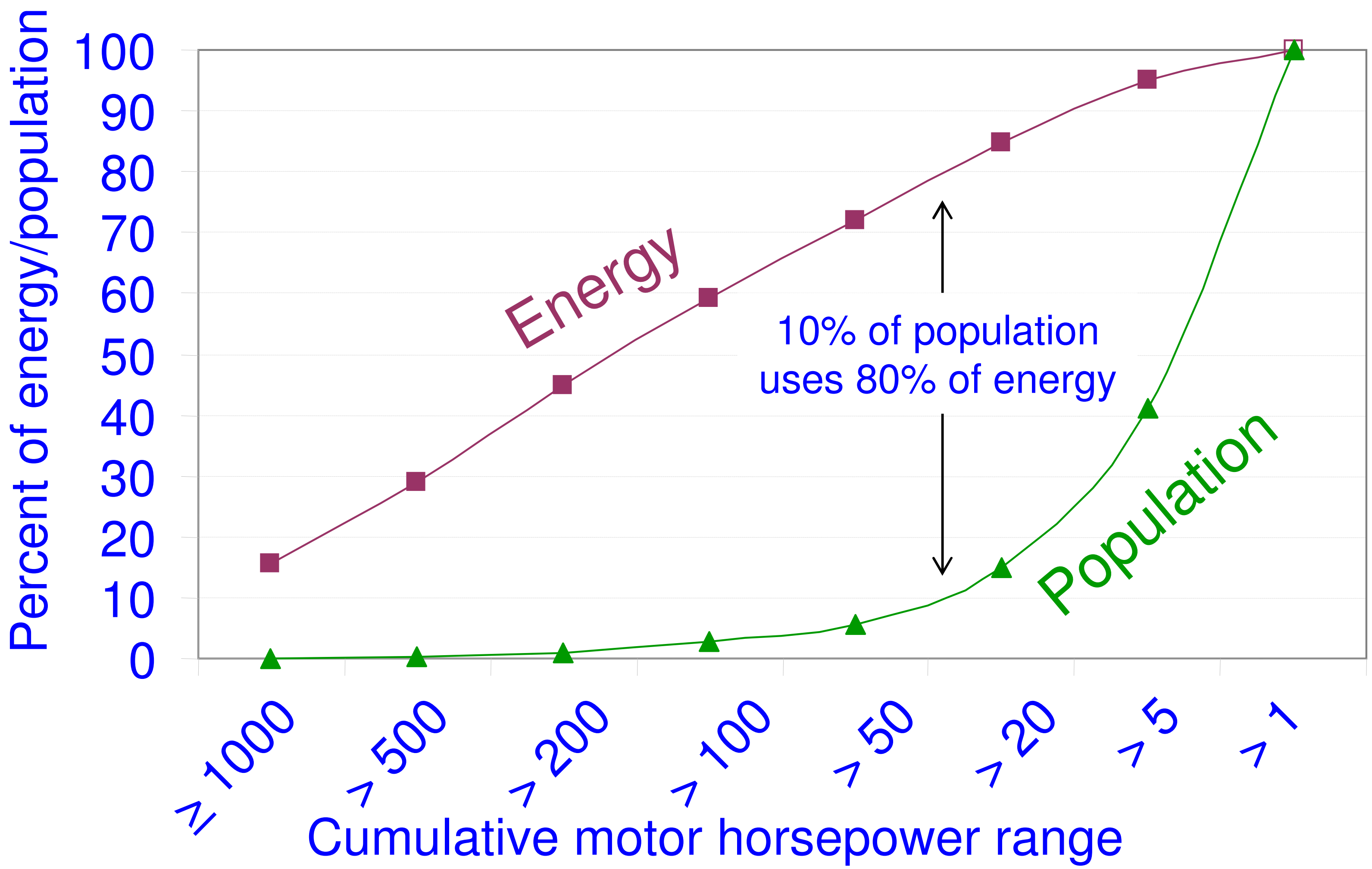


Fluid handling equipment, including pumps, fans, and compressors, account for over 60% of industrial motor-driven energy.

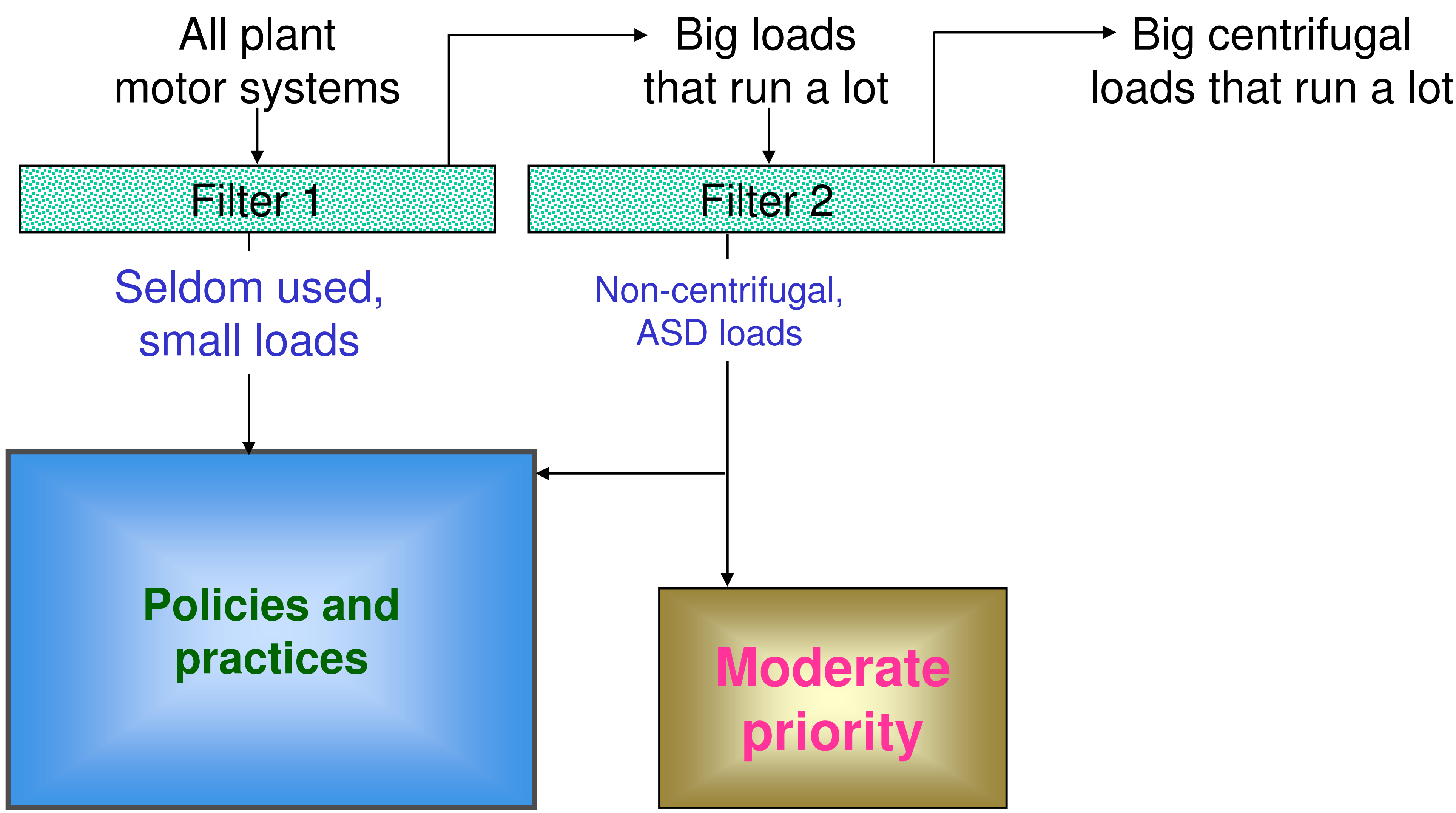
BestPractices encourages a three-tiered prescreening and assessment approach

- Initial prescreening based on size, run time, and pump type
- Secondary prescreening to narrow the focus to systems where significant energy reduction opportunities are more likely
- Opportunity assessment and quantification of potential savings

The bulk of motor-driven energy is used by a relatively small part of the population



Primary prescreening



Pump energy basics are fundamental to secondary prescreening

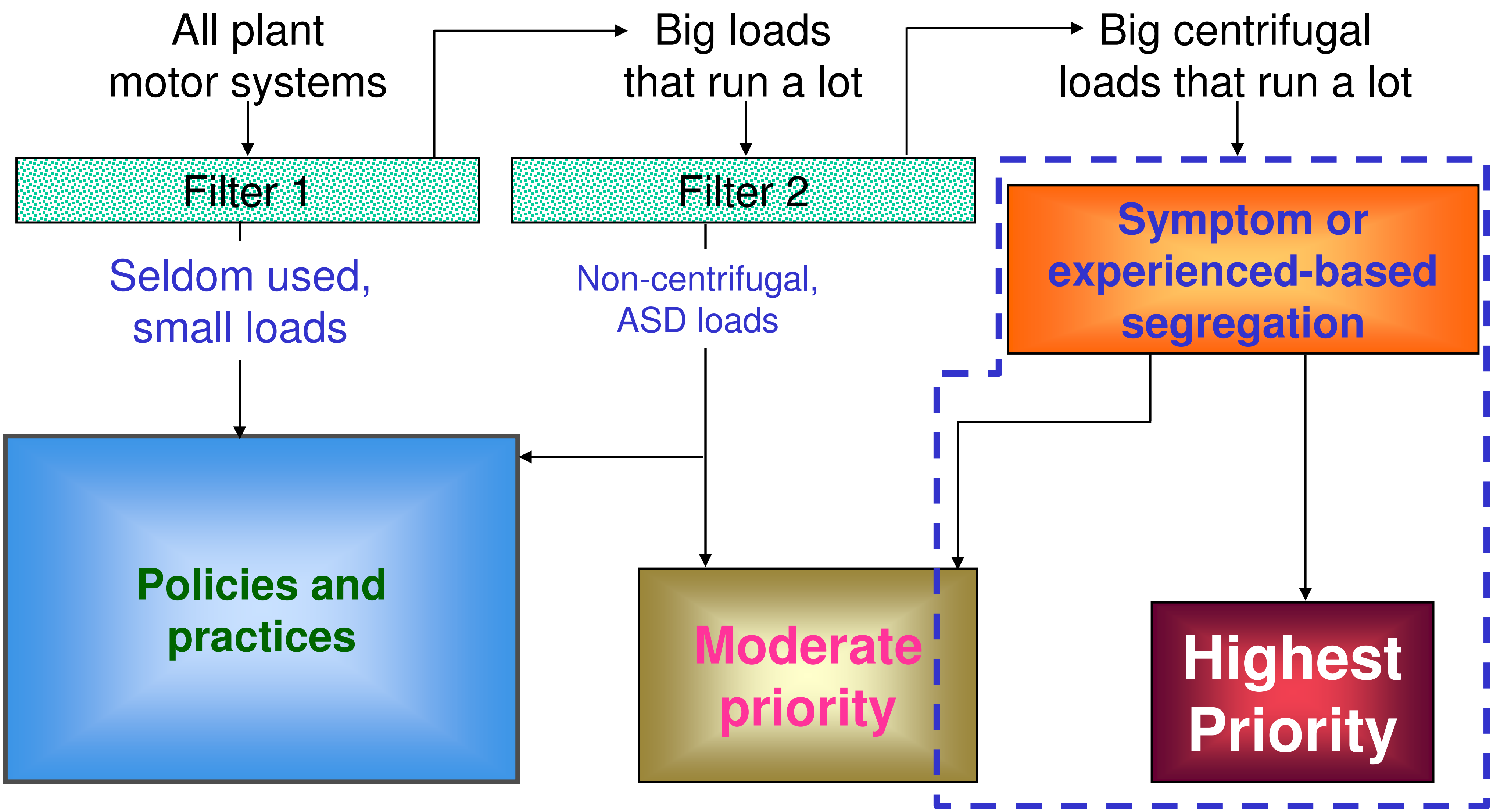
$$E = \frac{Q \cdot H \cdot T \cdot sg}{5308 \cdot \eta_{pump} \cdot \eta_{motor} \cdot \eta_{drive}}$$

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

Five basic causes of less than optimal pumping system operation

- Installed *components* are inherently inefficient at the normal operating conditions
- The installed *components* have degraded in service
- More flow is being provided than the *system* requires
- More head is being provided than the *system* requires
- The equipment is being run when not required by the *system*

Secondary prescreening



Some symptoms of interest

- Throttle valve-controlled systems
- Bypass (recirculation) line normally open
- Multiple parallel pump system with same number of pumps always operating
- Constant pump operation in a batch environment or frequent cycle batch operation in a continuous process
- Cavitation noise (at pump or elsewhere in the system)
- High system maintenance
- Systems that have undergone change in function

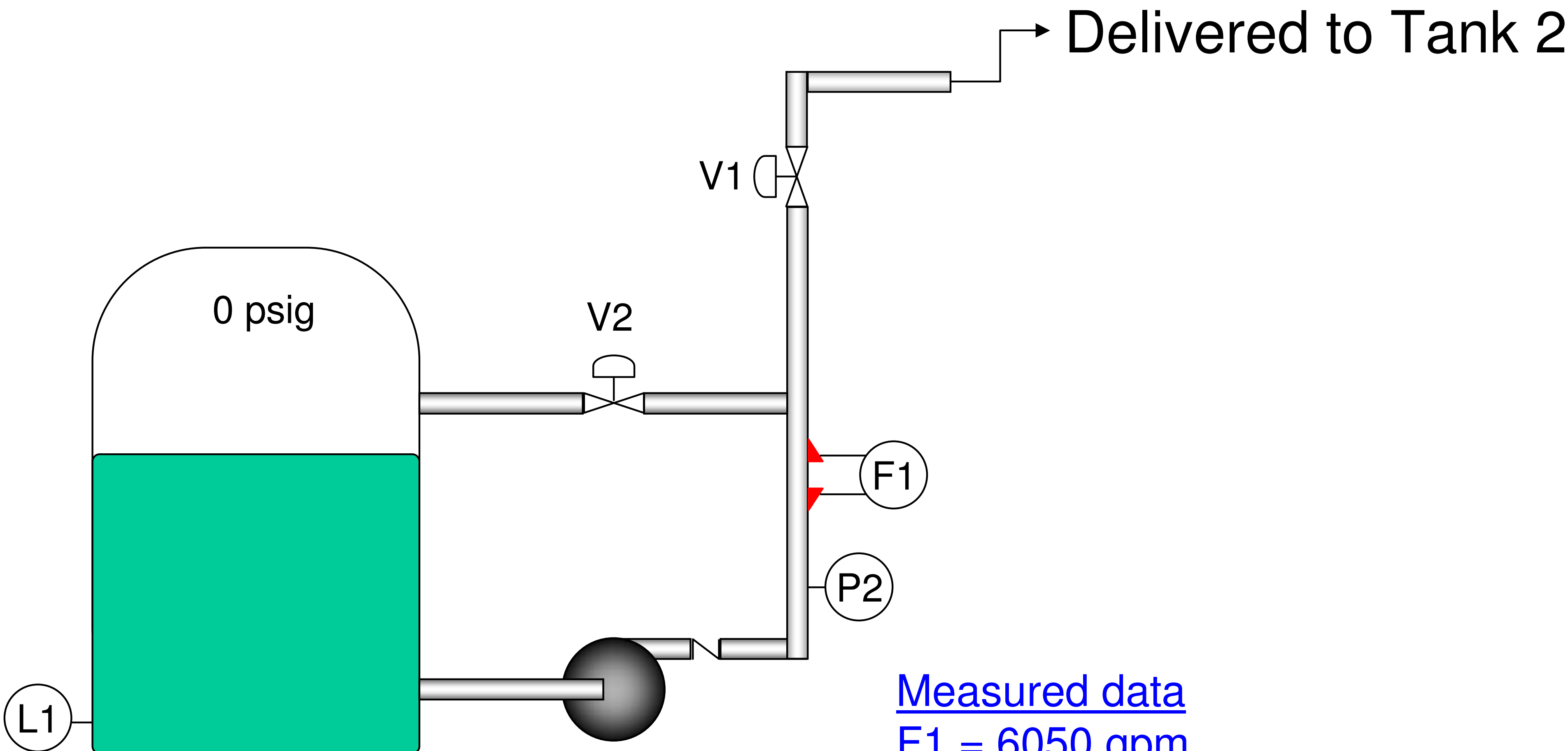
Pumping System Assessment Tool (PSAT)

- An <u>opportunity</u> quantification tool
- Relies on field measured (or estimated) fluid and electrical performance data
- Uses achievable pump efficiency algorithms from the Hydraulic Institute
- Motor performance (efficiency, current, power factor) curves developed from average motor data available in MotorMaster+ (supplemented by manufacturer data for larger size, slower speed motors)

A matter of focus

- PSAT is based on component performance
- It can be used to evaluate component-level performance
- But it can also be used to evaluate **system**-level conditions

An example system

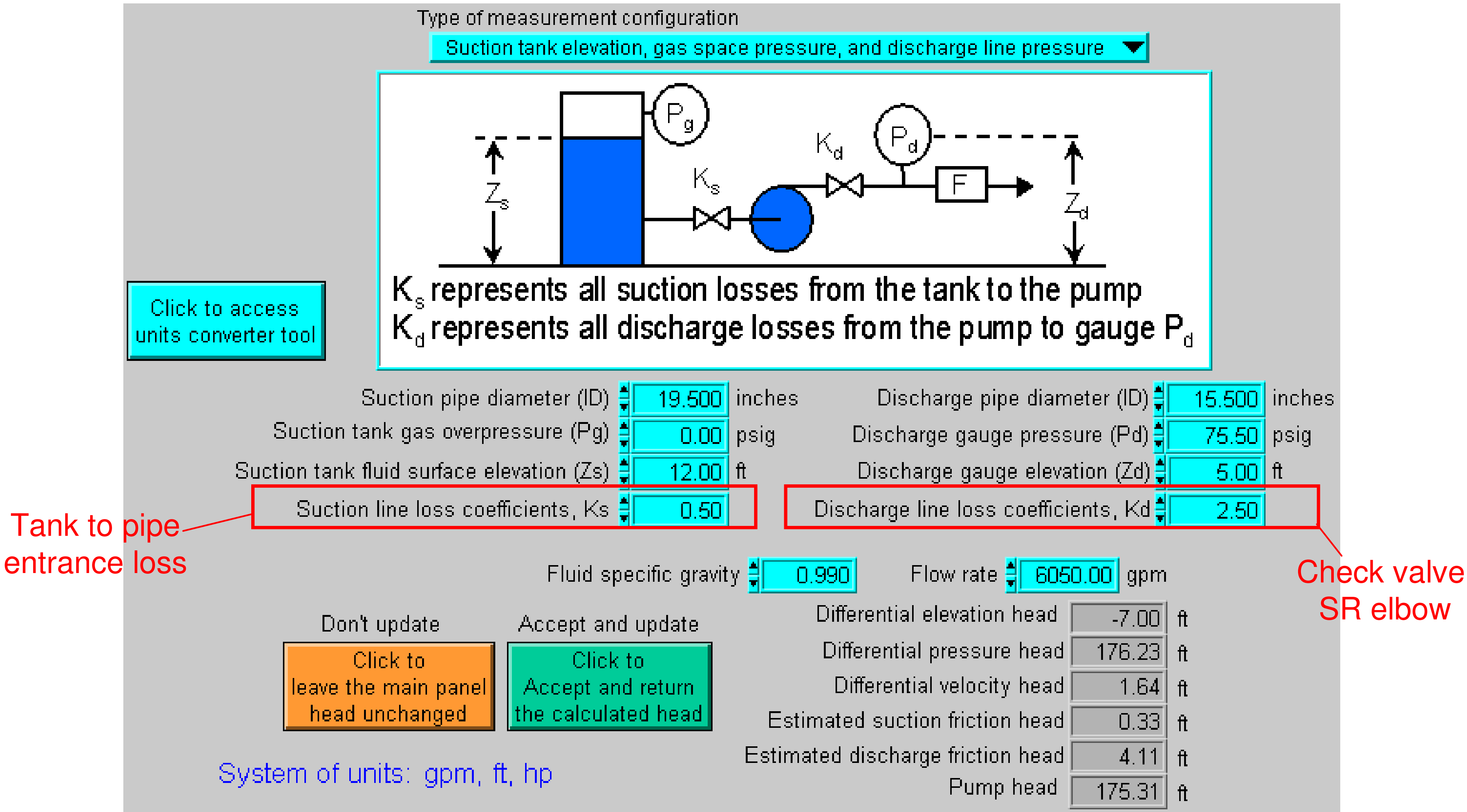


Motor nameplate: 350 HP, 1185 rpm, 83 amps, 2300 V
Suction line is 20-in Schedule 10 SS
Discharge is 16-in Schedule 10 SS

<u>Measured data</u>
F1 = 6050 gpm
L1 = 12 ft above ground
P2 = 75.5 psig (5 ft above ground)
Fluid = paper stock at 120 deg F
Motor current = 80.5 amps

Head calculation

PSAT includes a pump head calculator to support user-measured pressure, flow data.



Component-based analysis

Inputs

Condition A

End suction stock

Pump rpm: 1185
Drive: Direct drive
Units: gpm, ft, hp
Kinematic viscosity (cS): 1.00
Specific gravity: 0.990
stages: 1
Fixed specific speed? NO

Line freq.: 60 Hz
HP: 350
Motor rpm: 1185
Eff. class: Standard efficiency

Voltage: 2300
Estimate FLA
Full-load amps: 83.0
Size margin,%: 15

Operating fraction: 1.000
$/kwhr: 0.0390

Flow rate, gpm: 6050
Head tool
Head, ft: 175
Load estim. method: Current
Motor amps: 80.5
Voltage: 2300

Results

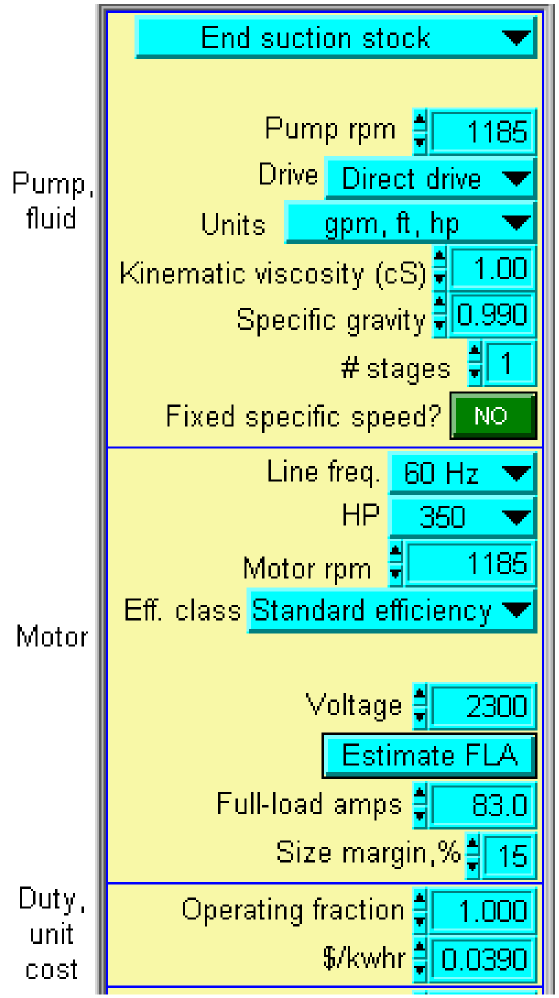
Condition A

	Existing	Optimal	Units
Pump efficiency	78.2	87.3	%
Motor rated power	350	350	hp
Motor shaft power	339.0	303.7	hp
Pump shaft power	339.0	303.7	hp
Motor efficiency	94.5	95.6	%
Motor power factor	83.4	83.8	%
Motor current	80.5	71.0	amps
Motor power	267.5	237.1	kW
Annual energy	2343.7	2076.6	MWh
Annual cost	91.4	81.0	$1000

Annual savings potential, $1,000: 10.4
Optimization rating, %: 88.6

Input sections 1-3

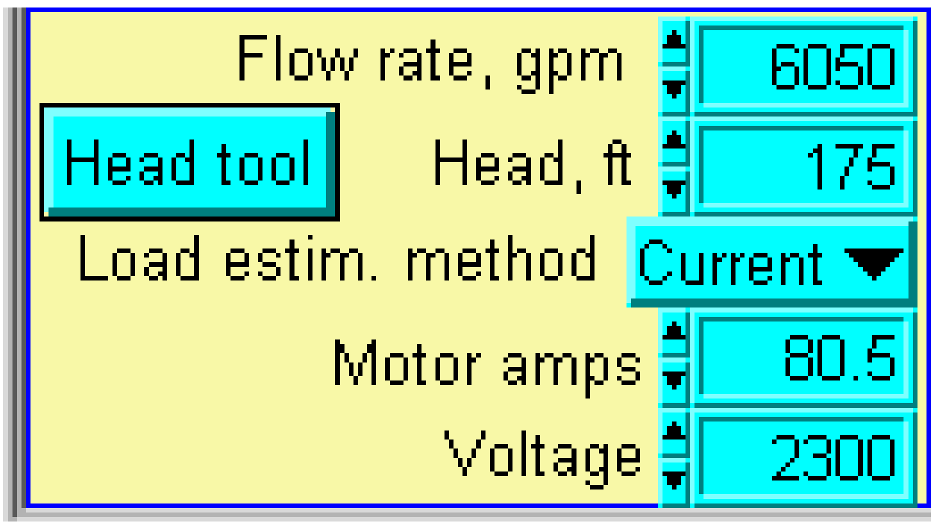
Basic design, operating profile and cost inputs



Input section 4

Accurate performance data is essential

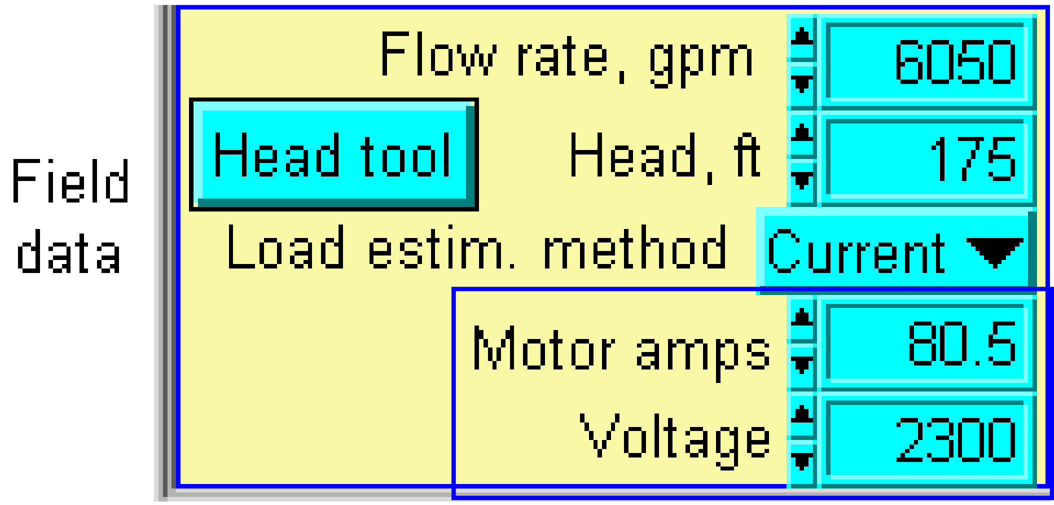
Field data



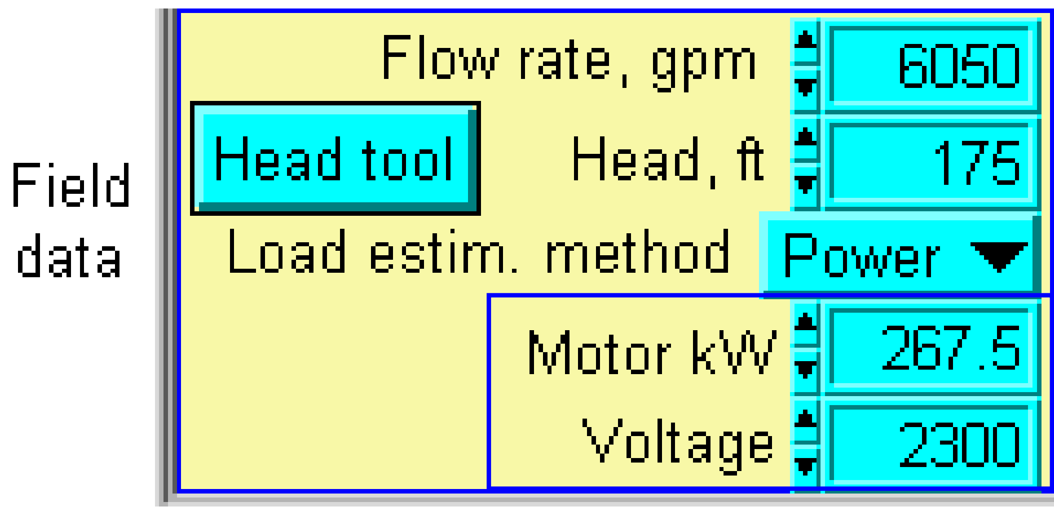
fluid

electrical

Alternate forms of electrical data input



Either motor current or power can be used to estimate the motor shaft load



Results: optimization rating

The optimization rating is akin to an exam grade of how well the existing operation compares with optimal.

Condition A	Existing	Optimal	Units
Pump efficiency	78.2	87.3	%
Motor rated power	350	350	hp
Motor shaft power	339.0	303.7	hp
Pump shaft power	339.0	303.7	hp
Motor efficiency	94.5	95.6	%
Motor power factor	83.4	83.8	%
Motor current	80.5	71.0	amps
Motor power	267.5	237.1	kW
Annual energy	2343.7	2076.6	MWh
Annual cost	91.4	81.0	$1000

Annual savings potential, $1,000	10.4
Optimization rating, %	88.6

$$\frac{237.1}{267.5} \times 100 = 88.6$$

Results: cost, savings potential

	Condition A Existing	Condition A Optimal	Units
Pump efficiency	78.2	87.3	%
Motor rated power	350	350	hp
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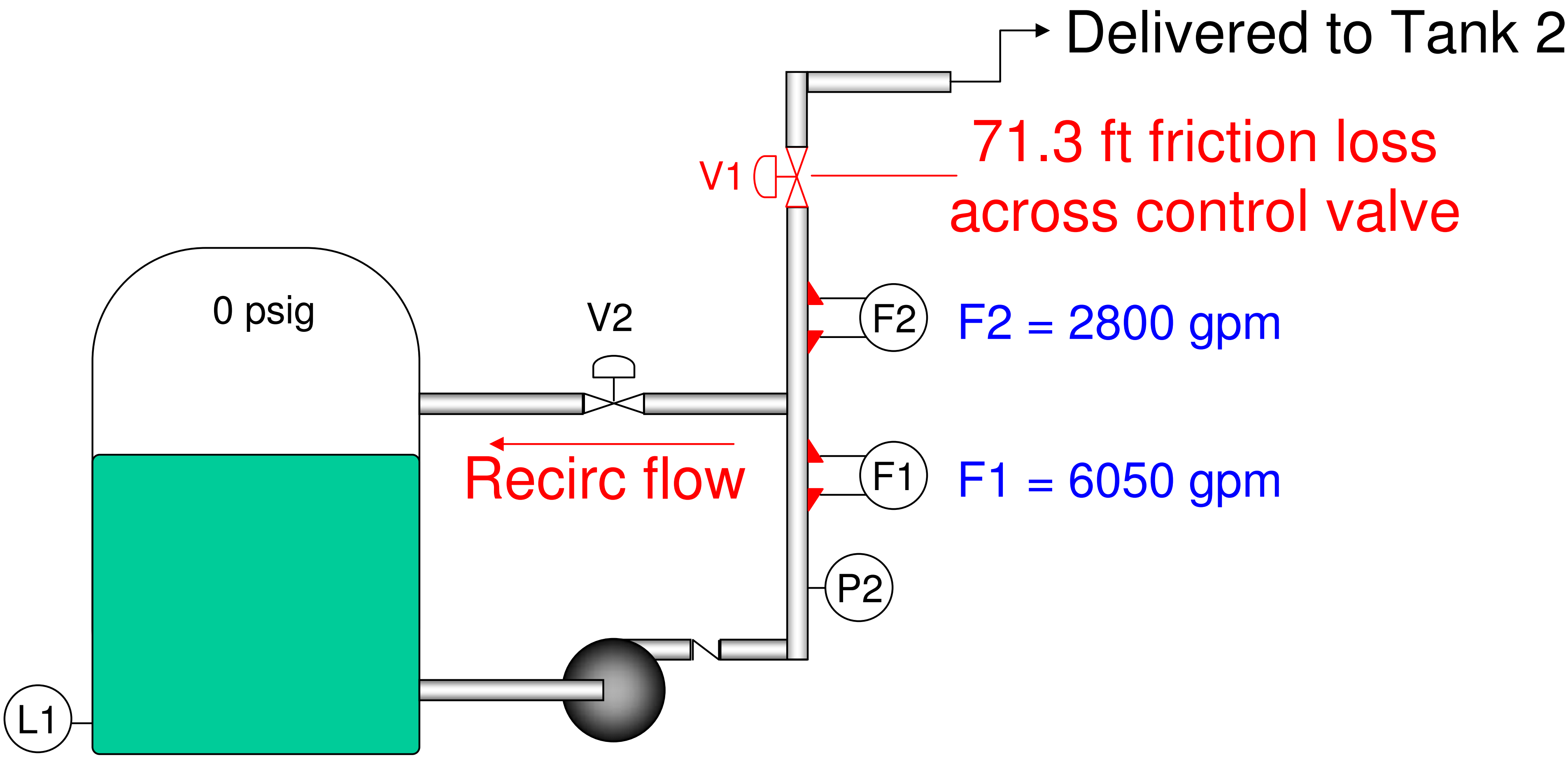
Annual cost	91.4	81.0	$1000

Annual savings potential, $1,000: 10.4

Optimization rating, %: 88.6

Annual energy costs for the existing and optimal cases are tabulated, and the potential cost savings is listed

A system-level perspective

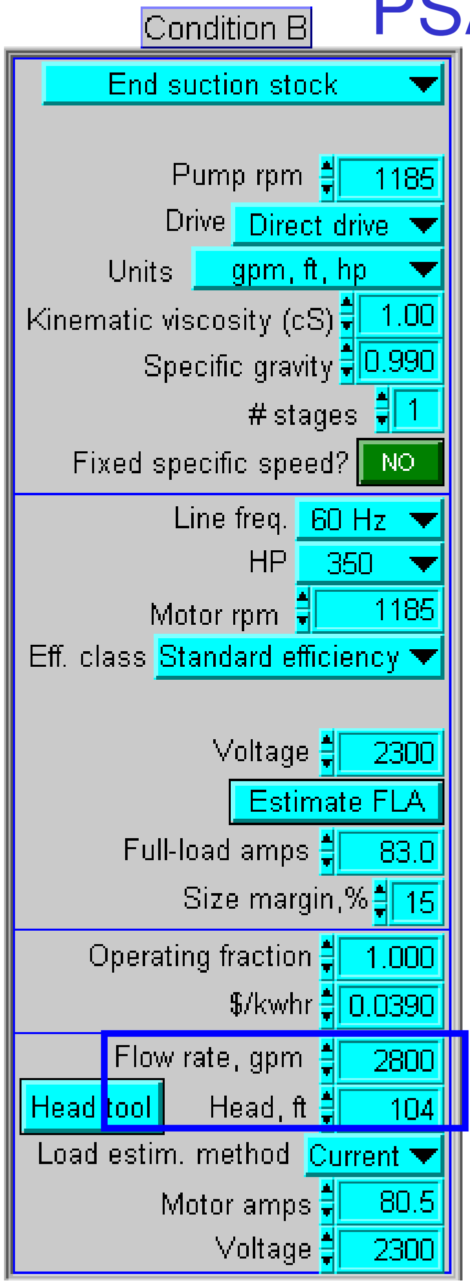


Required flow rate: 2800 gpm sent to Tank 2

Required head =	Pump head:	175.3 ft
	- valve loss	71.3 ft
		104.0 ft

A system-level perspective

PSAT analysis using the <u>required</u> fluid data



Condition B

	Existing	Optimal	Units
Pump efficiency	21.5	84.6	%
Motor rated power	350	100	hp
Motor shaft power	339.0	86.1	hp
Pump shaft power	339.0	86.1	hp
Motor efficiency	94.5	94.8	%
Motor power factor	83.4	82.3	%
Motor current	80.5	20.6	amps
Motor power	267.5	67.7	kW
Annual energy	2343.7	593.1	MWh
Annual cost	91.4	23.1	$1000
		68.3	
		25.3	

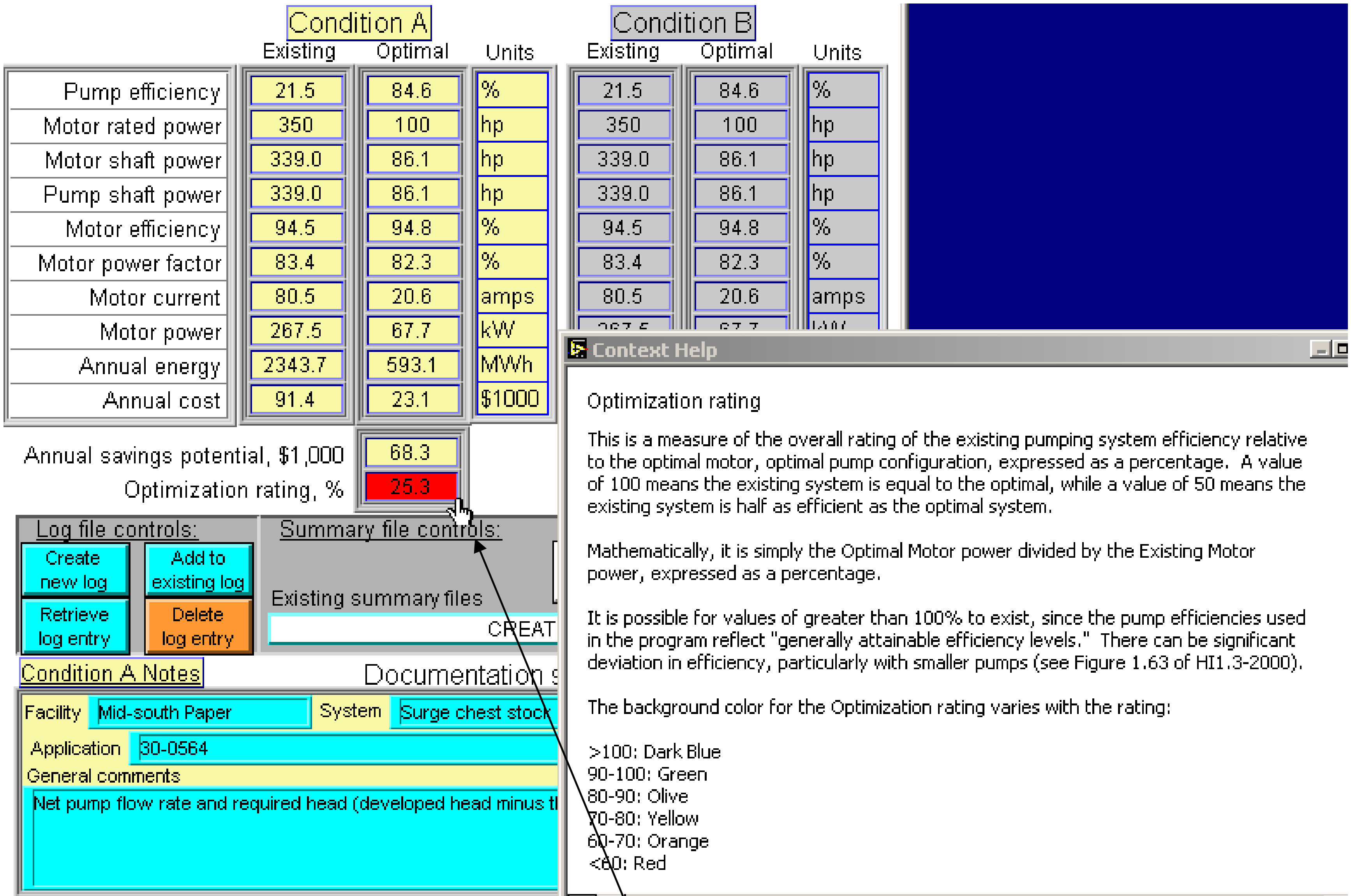
Optimal equipment sized to meet the <u>required</u> conditions could save over $68,000/year.

PSAT does not identify solutions; some options

- Trimmed impeller
- Reduced speed motor
- Adjustable speed drive
- Different pump

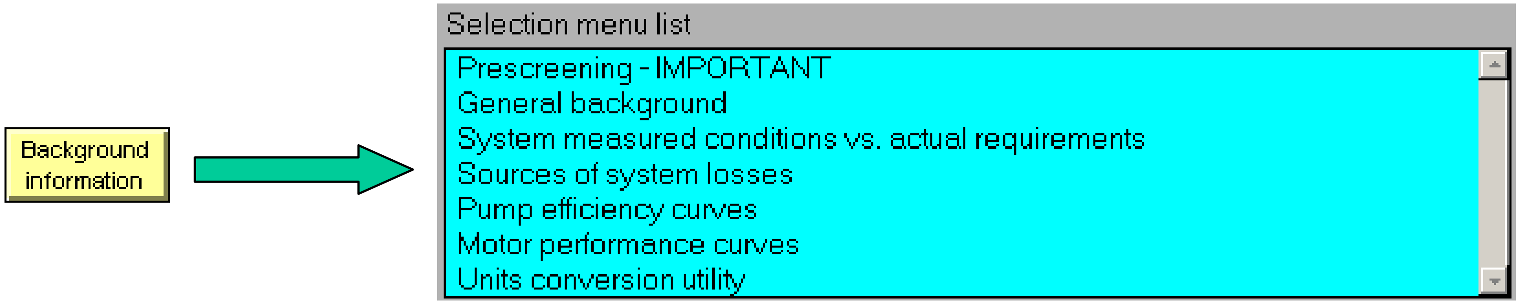
Other factors, such as load variability, extent of system head that is static, and pump details (curve, impeller size, etc.) would be needed to evaluate alternative solutions

Help pop-up screens provide run-time assistance

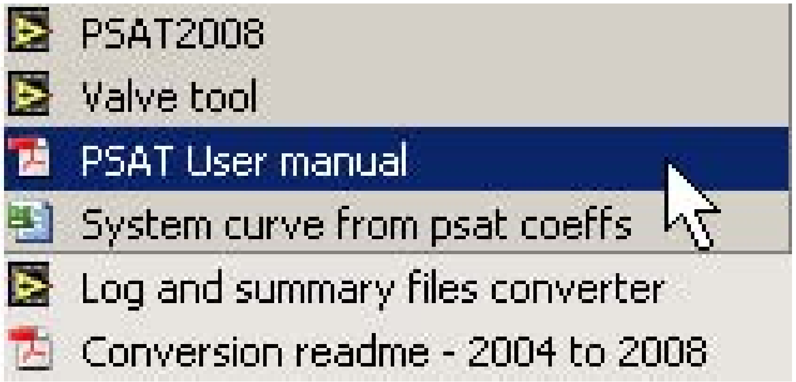


The Context Help window displays information about the control or indicator underneath the mouse pointer

The Background information button provides access to assessment guidance and curves used by PSAT to perform its calculations



User's manual and other support features are included



Users of PSAT2004 can convert saved log and summary files to the 2008 version (a one-time operation)

A demo of the tool use

Example system

Suction line size: 14-inch sch. 40 CS (13.1" ID)
Discharge (except reducers at valve V1): 12-inch sch. 40 CS (11.9" ID)
Fluid: water at 70°F
Valve V1 is 8-inch v-port ball
Cost of electricity is 5 cents/kWh
Motor is 460-Volt, 250-hp, 1780 rpm, nameplate efficiency = 95.8%
All pressure gauges at 5 ft above ground
Pump is single stage end suction
Both tanks are open to atmosphere

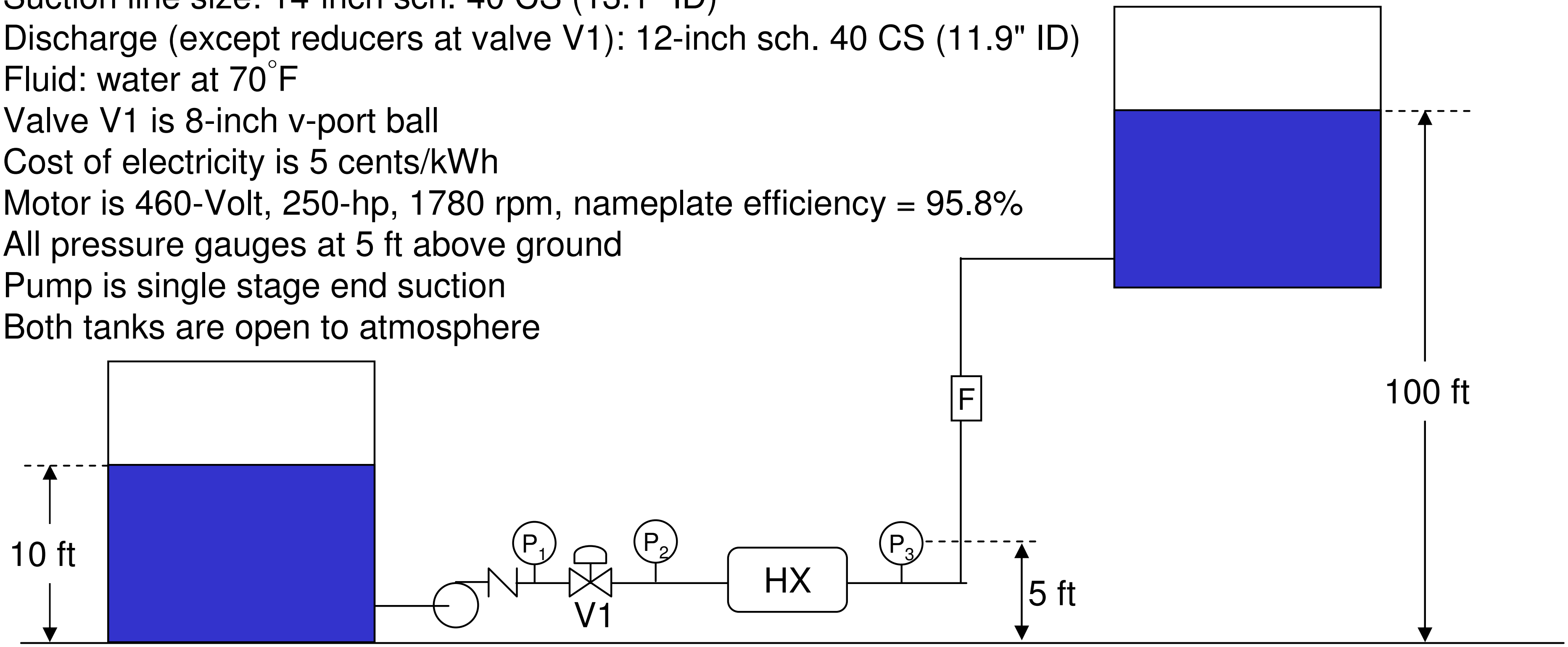


Table 1. Measured operating data

Condition	Q, gpm	P1, psig	P2, psig	P3, psig	Motor kW	% of time at Condition
A	2000	90	52	50	135	50%
B	3160	75	66	61	150	40%

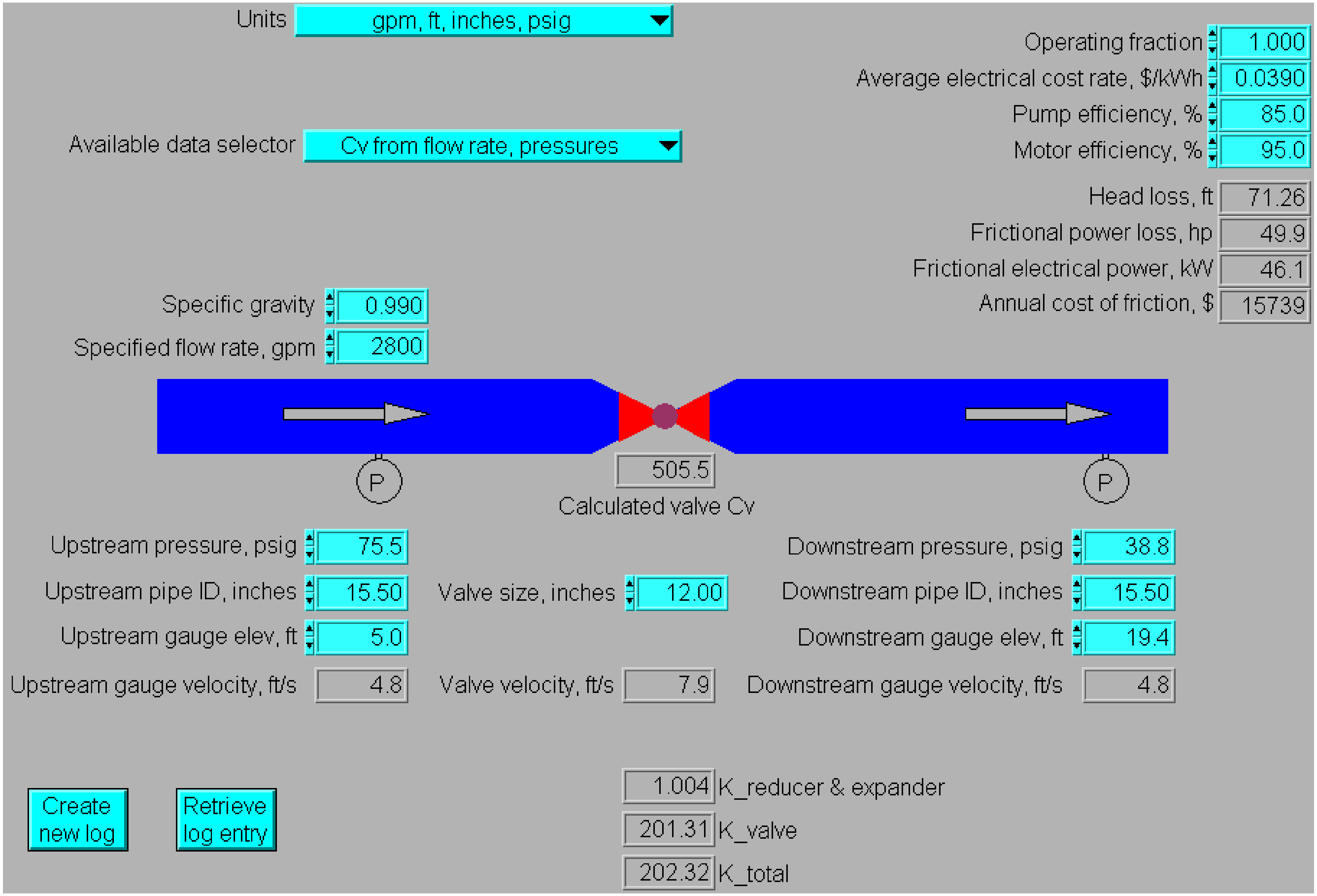
We'll do PSAT calculations for Condition A

- Calculate pump head
- Annual energy cost
- Potential savings
- Develop a system curve with artificial control valve losses eliminated
- Take a look at some of the background information and data

Other options for the side-by-side comparison

- Same pump, different operating conditions
- Same pump, different times - such as in periodic performance testing/trending
- Parallel pumps
- Old pump/new pump
- etc., etc.

A valve loss estimating tool accompanies PSAT



Based on standard valve equations (ISA 75.01)

Software download (free) and training links

www1.eere.energy.gov/industry/bestpractices/software.html

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BestPractices has a varied and expanding software collection. Much of the software can be accessed here. A few packages must be ordered from the EERE Information Center via e-mail or by calling 1-877-EERE-INF (877-337-3463).

With the right know-how, you can use these powerful tools to help identify and analyze energy system savings opportunities in your plant. While the tools are accessible here for download, you are also encouraged to attend a training workshop to enhance your knowledge and take full advantage of opportunities identified in the software programs. For some tools, advanced training is also available to help you further increase your expertise. Find out more about training. You can get help on software installation and operation from the EERE Information Center at 1-877-EERE-INF (877-337-3463) or email to eereic@ee.doe.gov.

DOE Industry Tools

- AIRMaster+
- Chilled Water System Analysis Tool (CWSAT)
- Combined Heat and Power Application Tool (CHP)
- Fan System Assessment Tool (FSAT)
- MotorMaster+ 4.0
- MotorMaster+ International
- NOx and Energy Assessment Tool (NxEAT)
- Plant Energy Profiler for the Chemical Industry (ChemPEP Tool)
- Process Heating Assessment and Survey Tool (PHAST)
- Pumping System Assessment Tool 2004 (PSAT)
- Steam System Tool Suite

There are two PSAT workshops

End-user

Specialist


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Software Tools

Pumping System Assessment Tool Qualification

List of Qualified PSAT Specialists

- By Last Name
- By Company
- By State

Earn recognition as a qualified pump system specialist in the use of DOE's Pumping System Assessment Tool (PSAT) software by attending a qualification workshop.

PSAT helps users assess energy savings opportunities in pumping systems, relying on field measurements of flow rate, head, and either motor power or current to perform the assessment. Using algorithms from Hydraulic Institute standards and motor performance characteristics from DOE's MotorMaster+ database, PSAT quickly estimates existing pump and motor efficiency and calculates the potential energy and cost savings of a system optimized to work at peak efficiency.

Demand is high for the software and training, and continues to grow. To meet the demand, and increase the number of PSAT experts to assist end users, DOE is working with the pumping industry, and its Allied Partner, the Hydraulic Institute, to train and qualify experts in the use of PSAT.

The qualifying workshops prepare professionals with extensive experience in pumping systems to use PSAT in their system assessments. Participants learn:

- How to accurately acquire input data for PSAT
- How to prescreen pumping systems to select the "vital" systems for further review
- How to use the PSAT software
- The difference between measurements and requirements
- The importance of a system perspective

Participants who complete the workshop and pass a qualifying exam will be recognized by DOE as Qualified Pump System Specialists, and will be listed on the BestPractices Web site. Specialists assist industrial customers in using PSAT to evaluate their pumping systems.

PSAT specialists are listed on the DOE web site

http://apps1.eere.energy.gov/industry/bestpractices/qualified_specialists/tool.cfm?software_id=2#find

Qualified BestPractices PSAT Specialists: by Last Name

‡ *indicates Qualified BestPractices Instructor*

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | R | S | T | U | V | W | Y |

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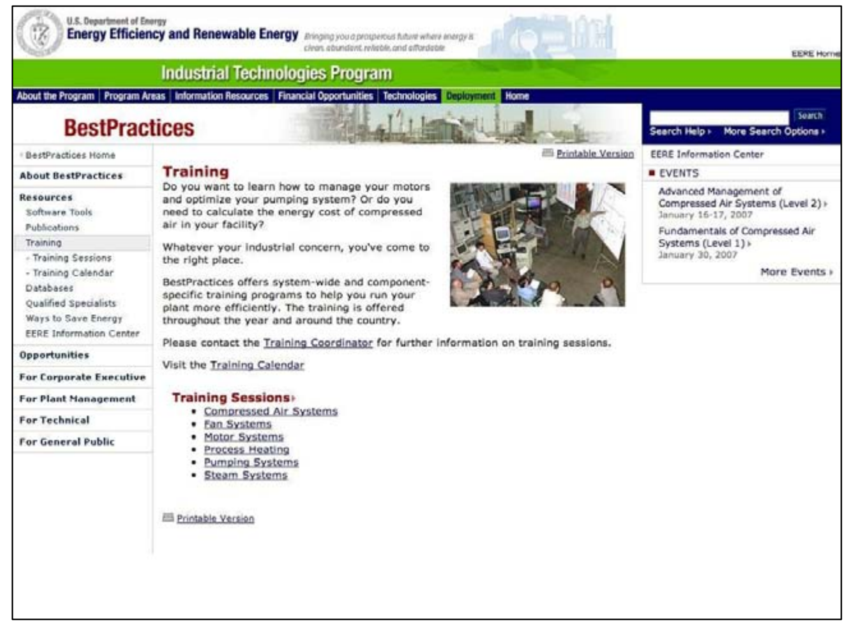
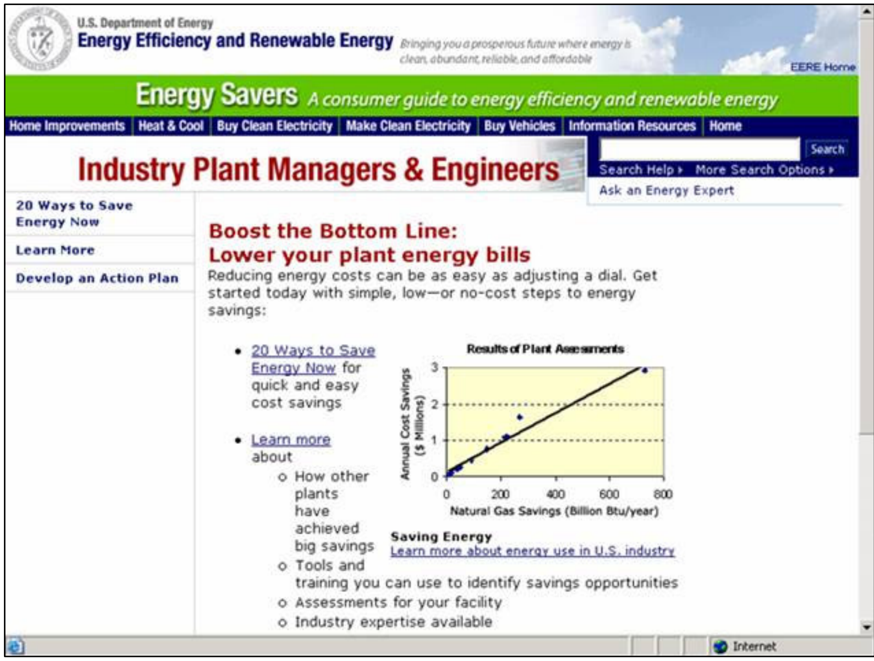


See the "Industrial Energy Savers" Web Site

- 20 ways to save energy now
- Tools and training you can use to identify savings opportunities
- Industry expertise available
- Assessments for your plant
- Develop an Action Plan
- Learn how others have saved
- Access the National Industrial Assessment Center (IAC) Database



- www.energysavers.gov/industrymanagers.html

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