Designing Pump Systems to Reduce Energy Consumption for Greater Sustainability

PUMP SYSTEMS MATTER

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Hydraulic Institute/Pump Systems Matter

The Hydraulic Institute (HI) centers the pump industry around excellence and efficiency to power everyday life. HI's mission is to advance the pump manufacturing industry by becoming the world's resource for pumping solutions and advancements in the industry by: Addressing Pump Systems, Developing Standards, Expanding Knowledge and Resources, Educating the Marketplace and Advocating for the Industry.

Pump Systems Matter (PSM) supports the industry regarding strategic, broad-based energy management and pump system performance optimization by providing the marketplace with training, tools, and collaborative opportunities that progress sustainability practices into normal business operations.

For more information on the Hydraulic Institute, Pump Systems Matter, its member companies and Partners, visit www.Pumps.org

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Driving all Pump System stakeholders towards a sustainable future

Advancing Solutions for Pump System Performance and Efficiency

Developing Standards and Technical Resources

Educating the Global Marketplace

Advocating for the Industry

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Educational Foundation of the Hydraulic Institute

Driving all Pump Systems to run at Best Efficiency Point (BEP)

Developing and delivering training and tools focused on increasing pump system efficiency and reliability

pumps.org

training.pumps.org

Meet Your Instructor

Matthew Derner is the Manager, Business Development, Pump System Products. He holds a leading role in promoting pump system related programs that deliver energy efficiency in commercial and industrial settings. Additionally, he is responsible for managing Pump Systems Matter (PSM), HI's training subsidiary, and for the overall promotion and growth of the Hydraulic Institute's portfolio of training and certification programs that focus on pump system optimization, and efficiency.

Matthew has a strong background in global sales of pumps, drives and various rotating equipment in both the manufacturing and distribution segments, with an emphasis on energy efficiency and total cost of ownership.

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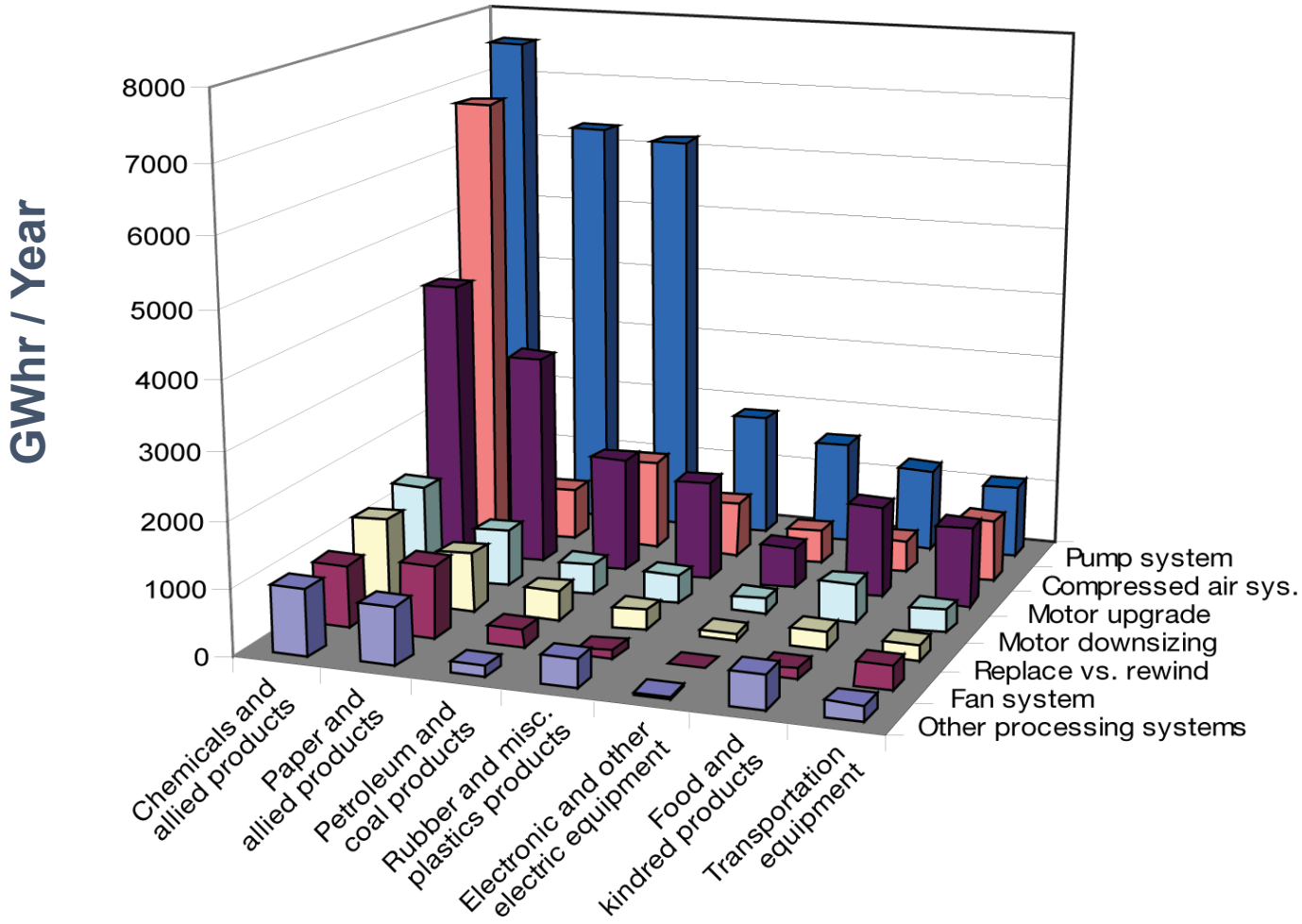
Agenda/Learning Objectives

- Energy Savings and Life Cycle Cost of Pumping Systems
- Pump Curve Review
- System Curve Review
- Pump Efficiency
- Pump System Optimization
- Pump System Assessment
- DOE Regulations and ER Label
- HI Free Tools and Training Resources

Energy Savings Potential by Industry & System



Pumps Systems are Energy Intensive with Largest Potential

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Source: U.S. Industrial Motor Systems, Market Opportunities Assessment, U.S. Department of Energy

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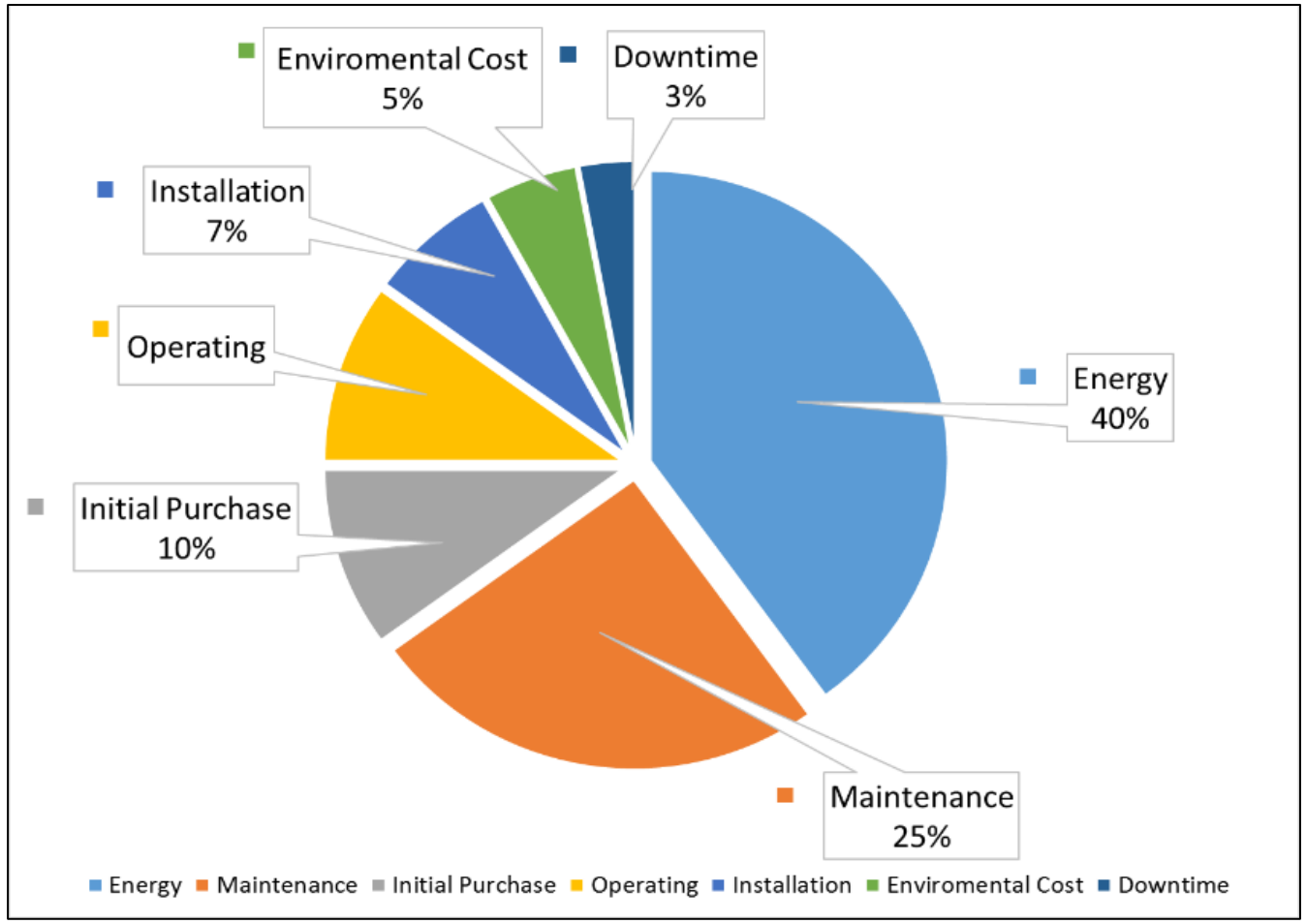
Life Cycle Cost of Typical Pumping System



<u>Focus on Energy & Maintenance presents 65% of LCC</u>

Focusing on initial cost misses the big picture

On average, 20% electrical energy savings is achieved by optimizing a pumping system, but in some cases 65% or more can be realized

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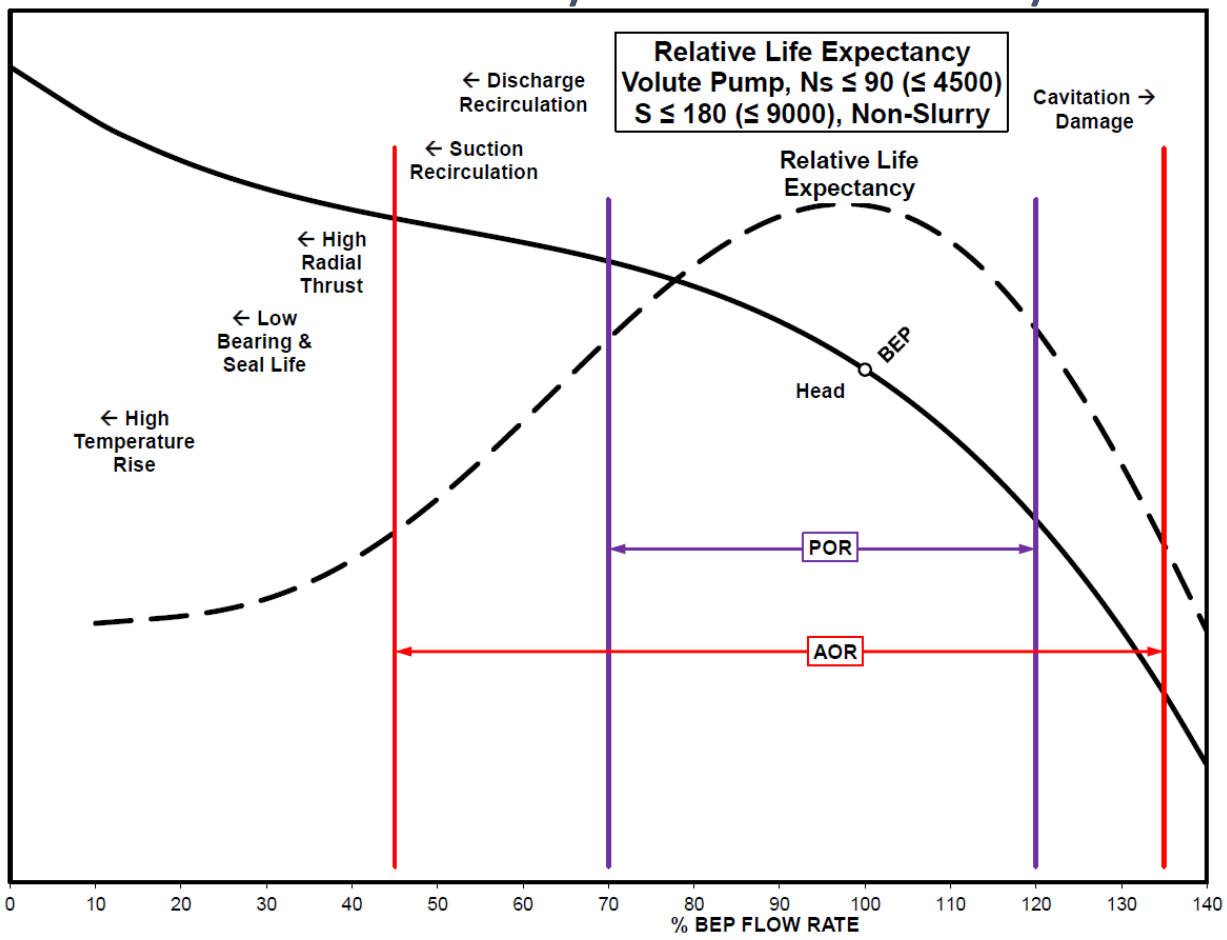
Pump Curve

Look Beyond Energy Savings

Energy cost is a top consideration, but there are also values for non-energy benefits:

- Higher Reliability
- Increase Productivity
- Less Equipment Wear and Tear
- Reduce Maintenance Cost
- Reduce Production Losses
- Increase Capacity Utilization
- Reduce Environmental Impact
- Increase plant safety

Efficiency = Reliability



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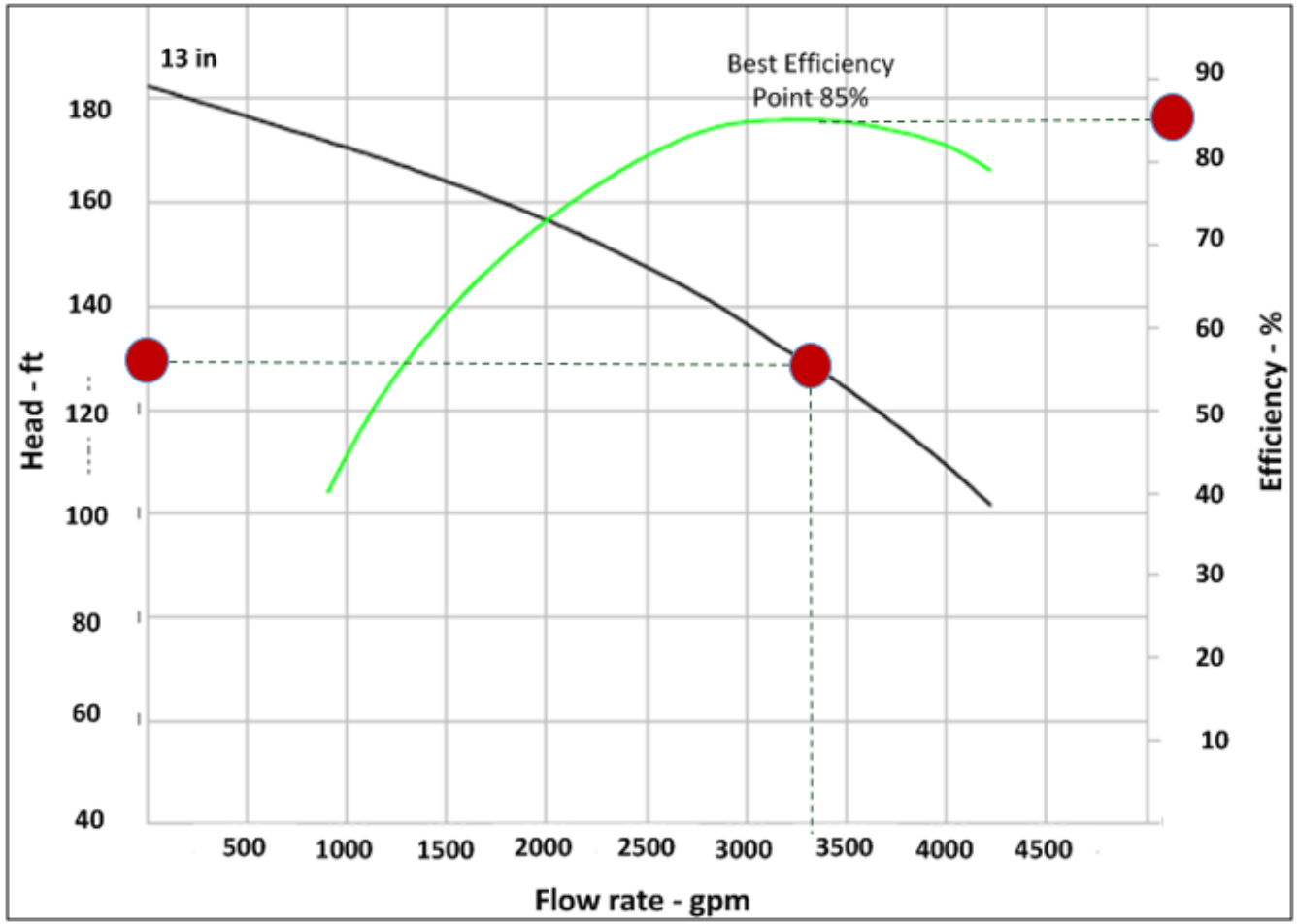
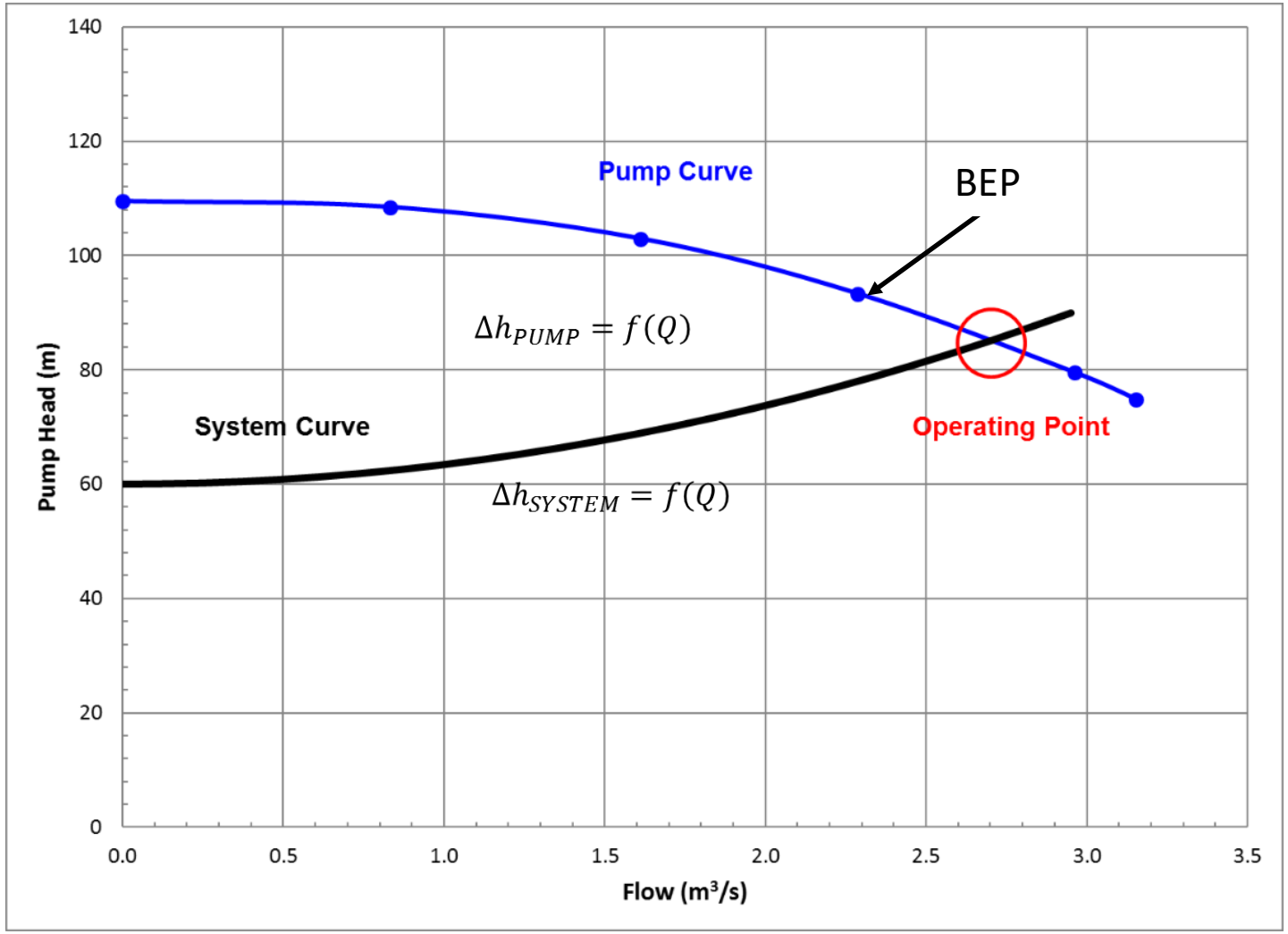
Best Efficiency Point (BEP)

BEP is the rate of flow and head at which the pump efficiency is maximum

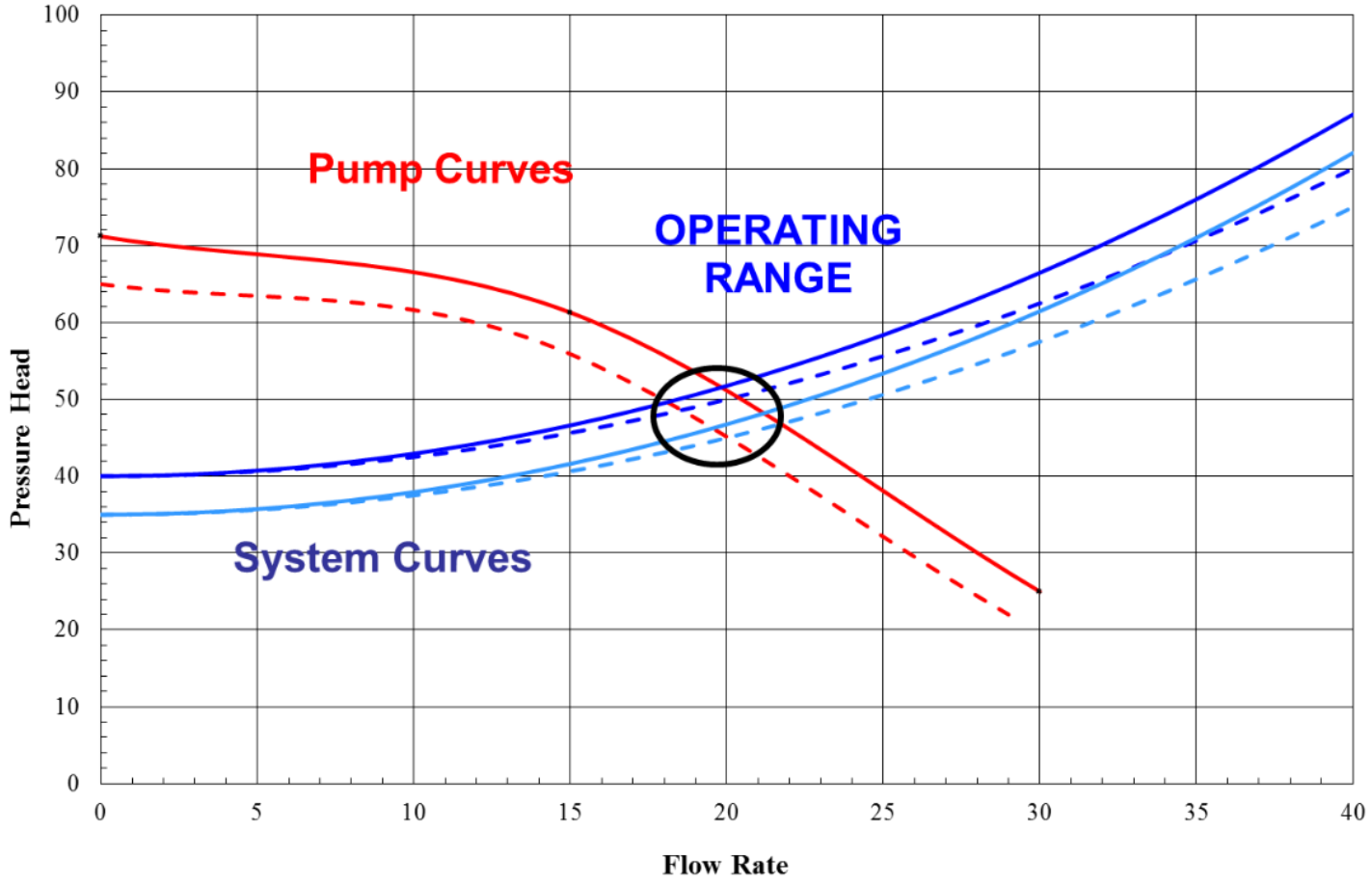
Operating point where reliably is maximized



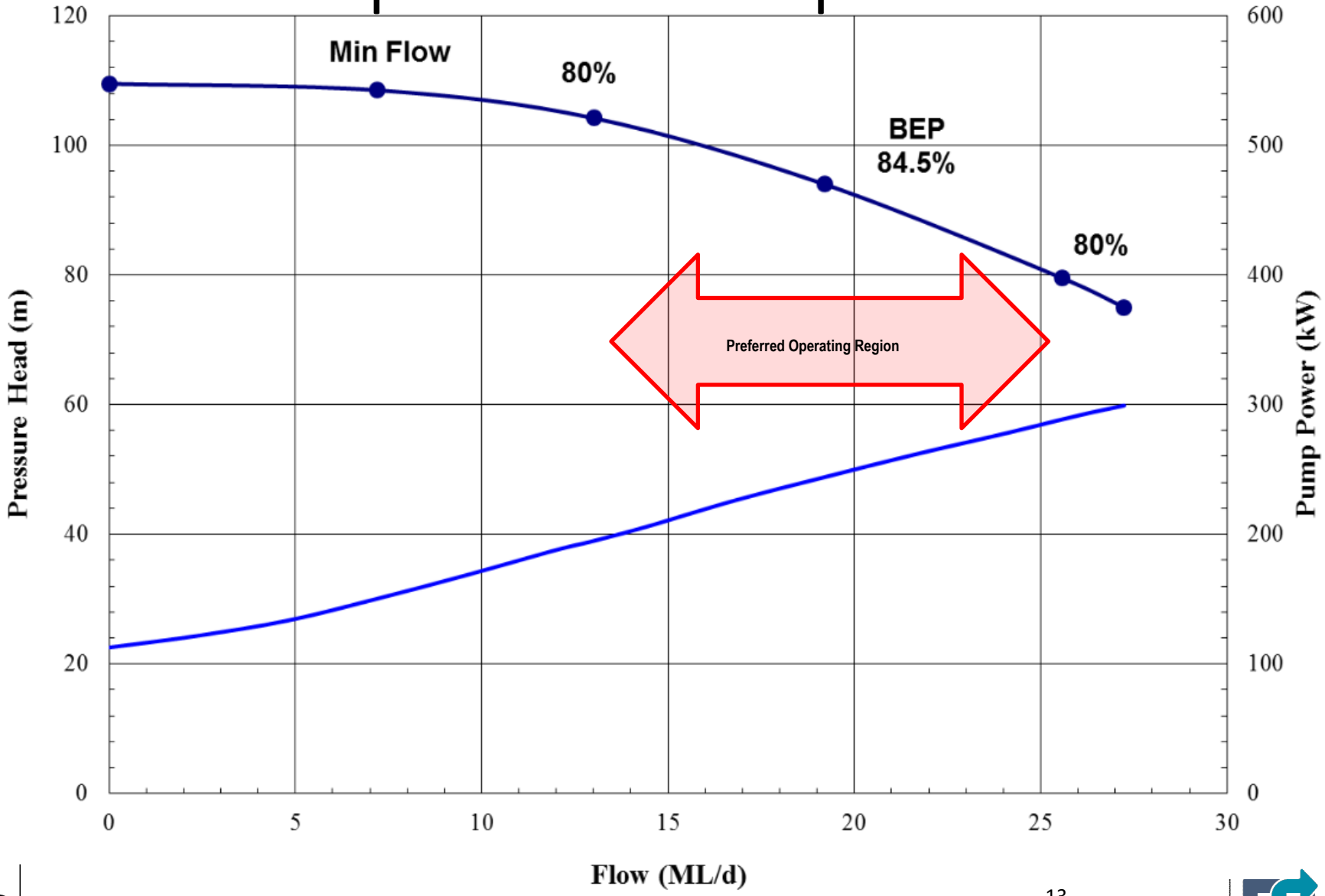
Single Operating Point



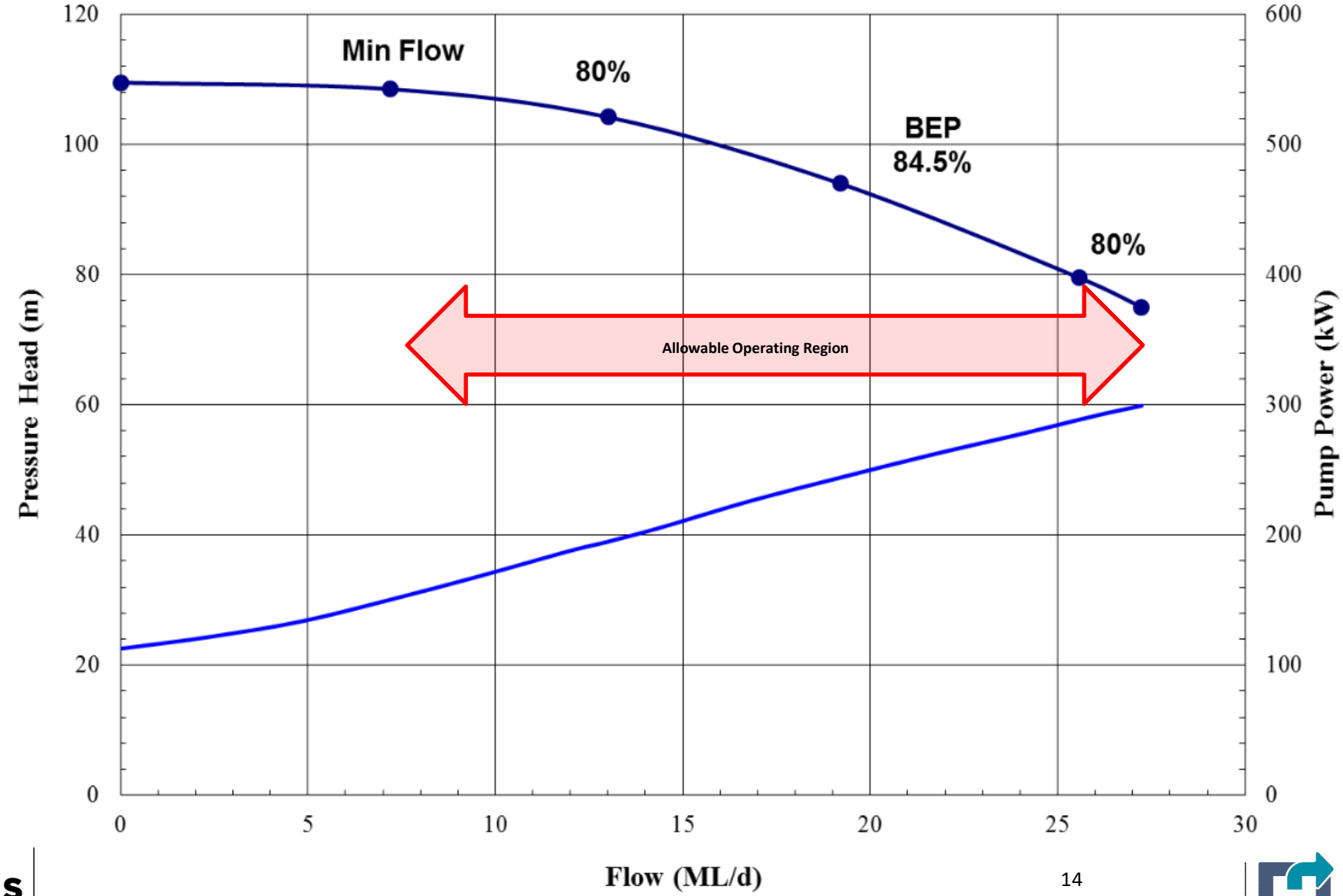
Real World Pump Operation Uncertainty



Simplified Pump Curve



Simplified Pump Curve



Remember: Efficiency = Reliability

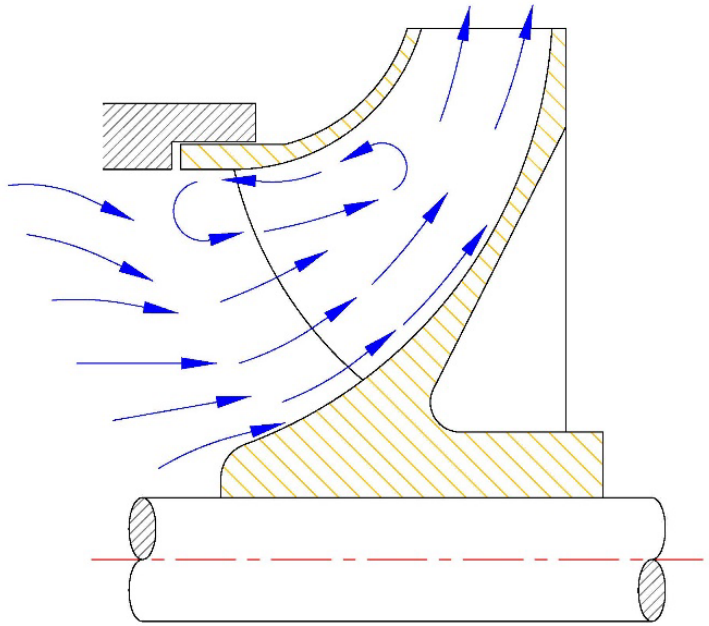
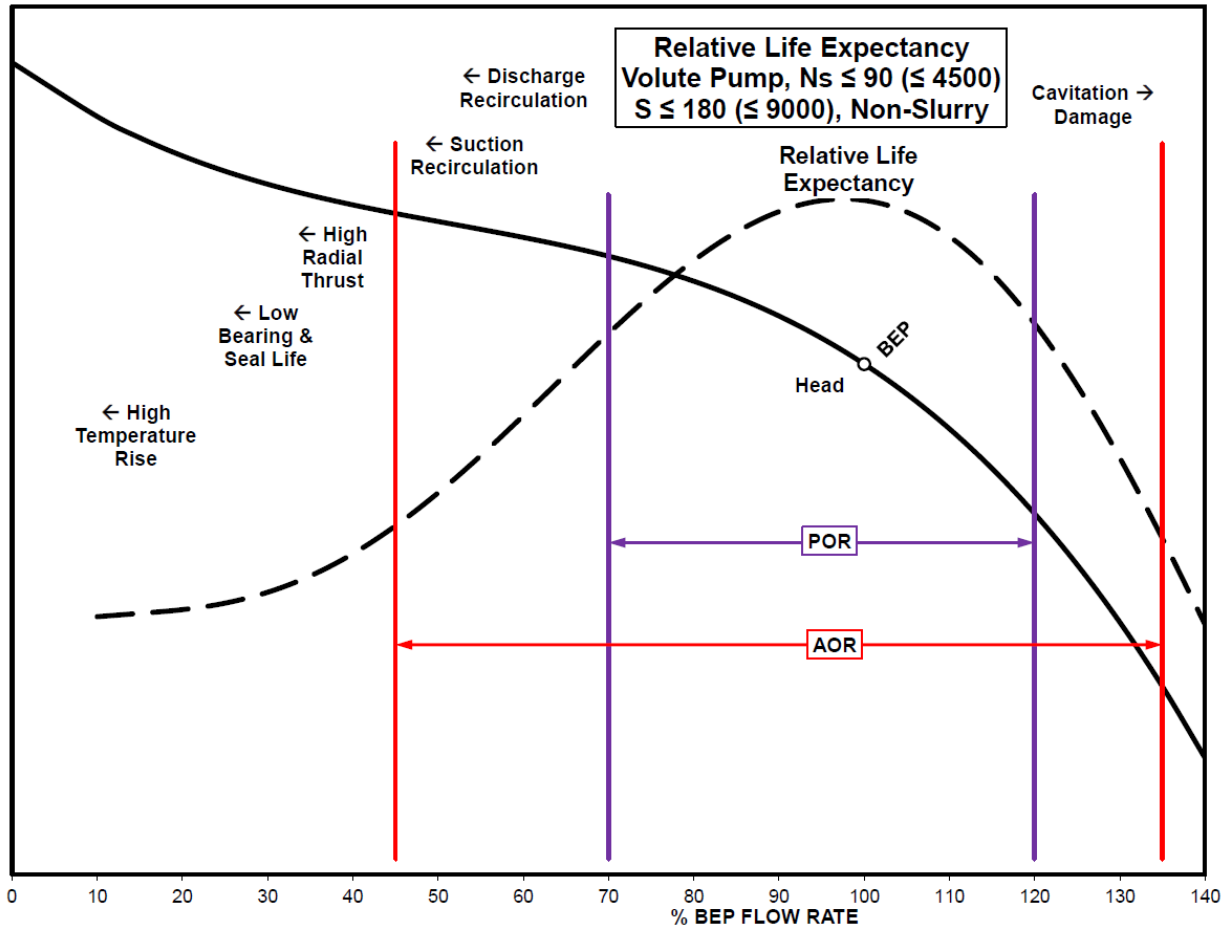
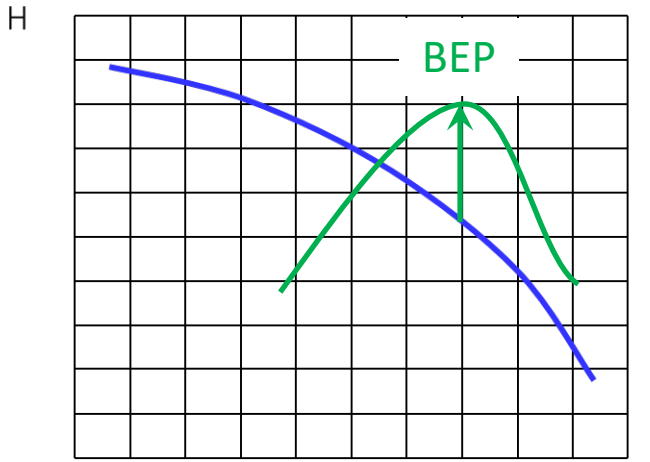


Illustration of
Suction Recirculation

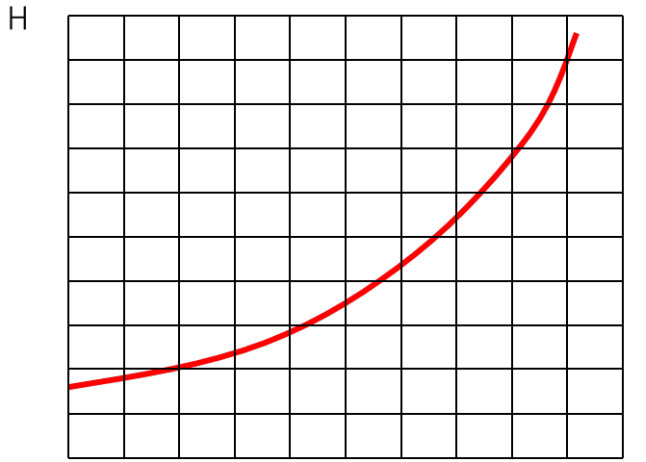


System Curve

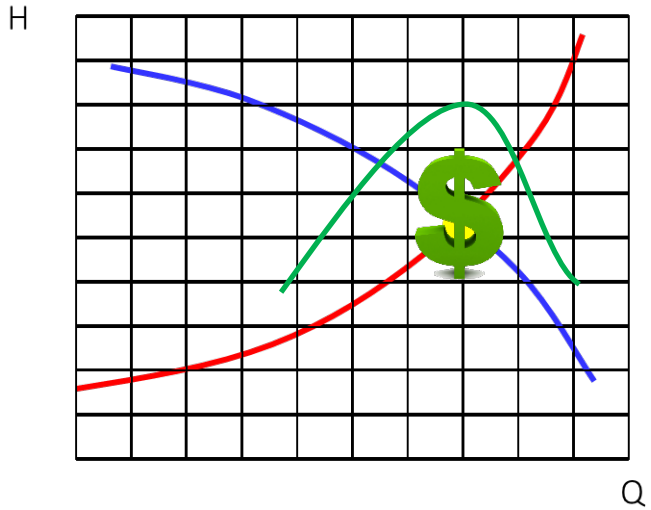
Pump + System Curves



Pump Curve
-Speed
-Impeller Dia.



System Curve
-Static Head
-Friction



H = Head
Q = Flow
● = operating point

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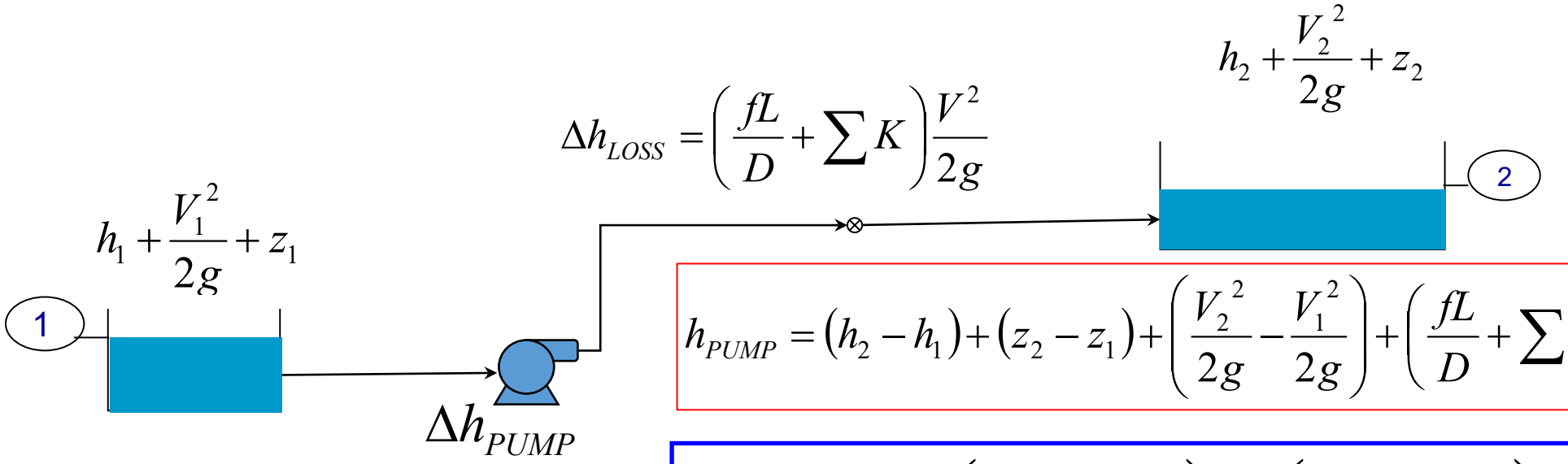
System Equation: View from the Pump



$$h_{PUMP} = (h_2 - h_1) + (z_2 - z_1) + \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right) + \left(\frac{fL}{D} + \sum K\right)\frac{V^2}{2g}$$

$$h_{PUMP} = (h_2 - h_1) + (z_2 - z_1) + CQ^2$$

$h_1 = h_2$

$$h_{PUMP} = (z_2 - z_1) + CQ^2$$

$z_1 = z_2$

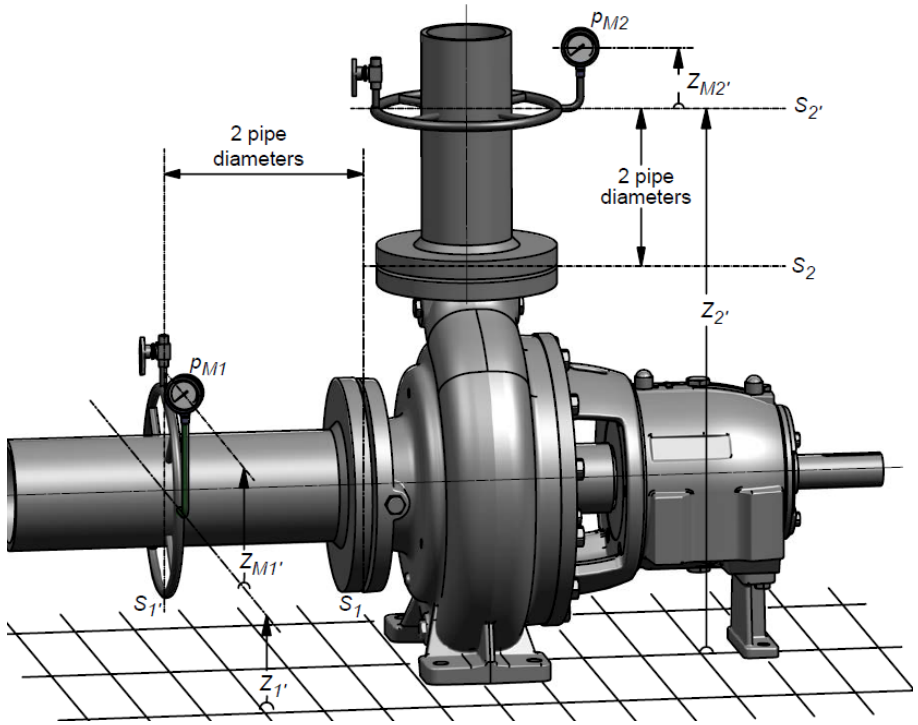
$$h_{PUMP} = CQ^2$$

Pump Efficiency

Pump Efficiency:

Pump efficiency is ratio of pump output power and pump input power expressed as a percent.

$$\eta = \frac{\mathrm{Pw}}{\mathrm{P}} \times 100$$



Where

- Pw = Pump output power
- P = Pump input power
- η= Pump efficiency

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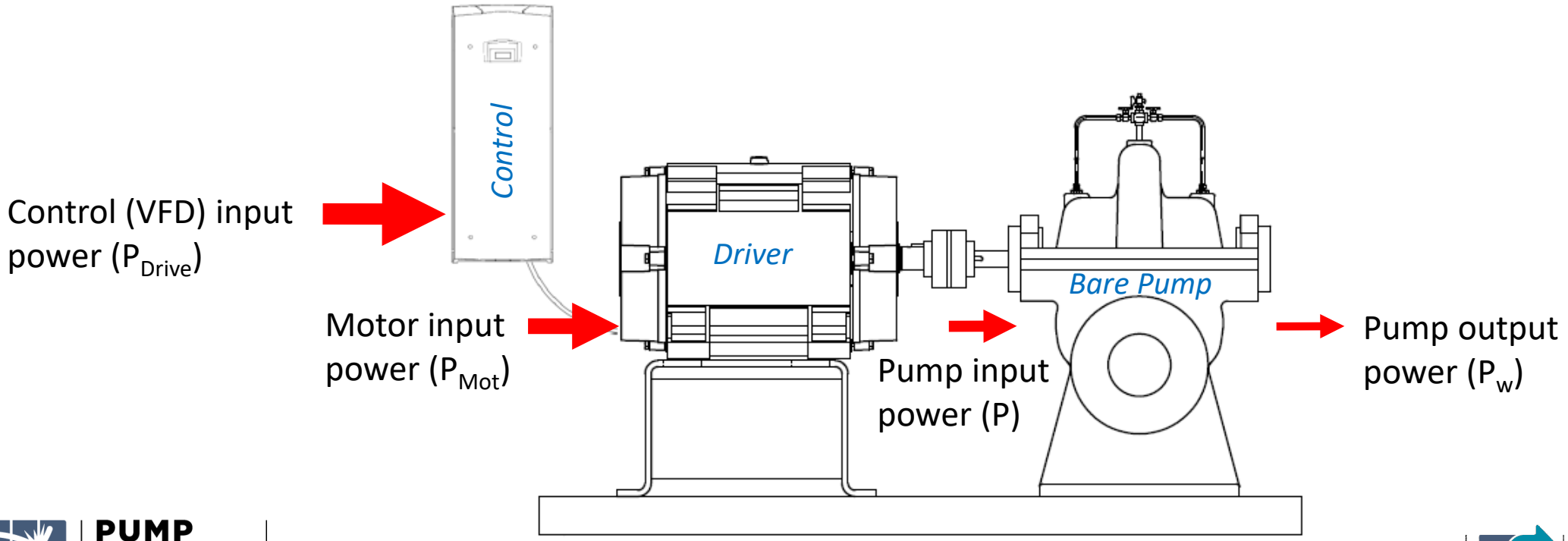
What is a pump and how does it consume power?

Pump means equipment that is designed to move liquids (which may include entrained gases, free solids, and totally dissolved solids) by physical or mechanical action and includes at least a bare pump and, if included by the manufacturer at the time of sale, mechanical equipment, driver, and controls.



Each power decrease by the component efficiency

What about the Motor & Drive

Efficiency is the ratio of output power to input power

Pump Efficiency

$$\eta = \frac{Pw}{P} \times 100$$

Motor Efficiency

$$\eta_{Mot} = \frac{P}{P_{Mot}} \times 100$$

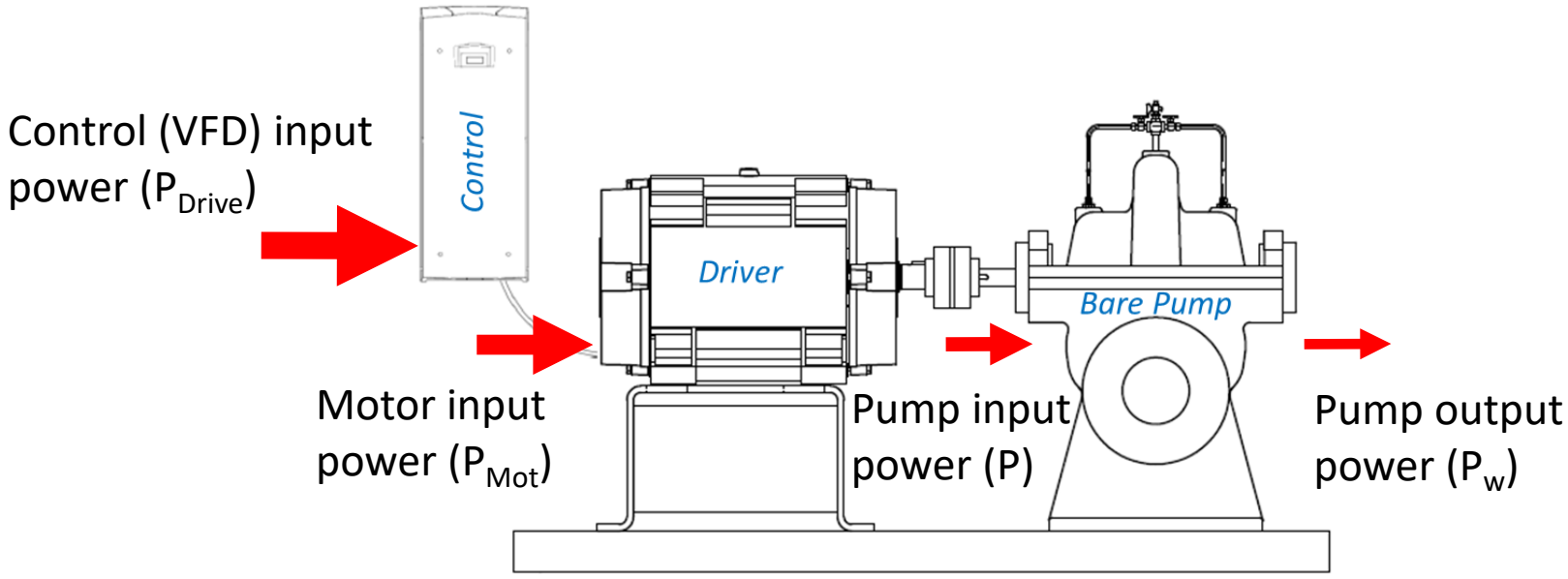
Drive Efficiency

$$\eta_{Drive} = \frac{P_{Mot}}{P_{Drive}} \times 100$$

Overall Efficiency

$$\eta_{OA} = \frac{P_W}{P_{Mot}} \times 100, \textit{ or}$$

$$\eta_{OA} = \frac{P_W}{P_{Drive}} \times 100$$



Pump System Optimization

Pump System Optimization

What is System Optimization?

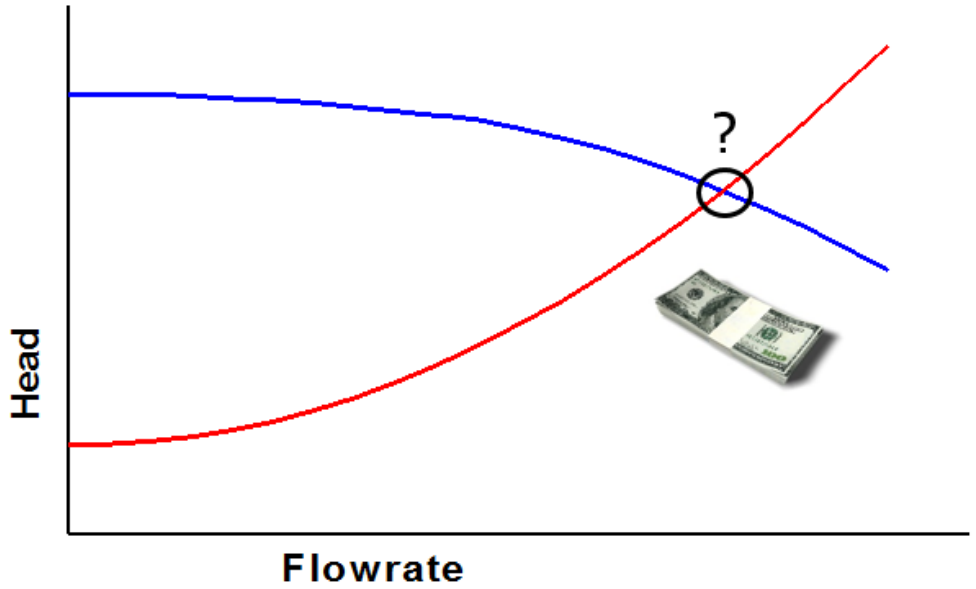
"The process of identifying, understanding and cost effectively eliminating unnecessary losses while reducing energy consumption and improving reliability in pumping systems, while meeting process requirements, minimizes the cost of ownership over the economic life of the pumping systems."

Ultimately minimizing the cost of ownership over the economic life of the pumping systems

Opportunities in New Design / Existing Design

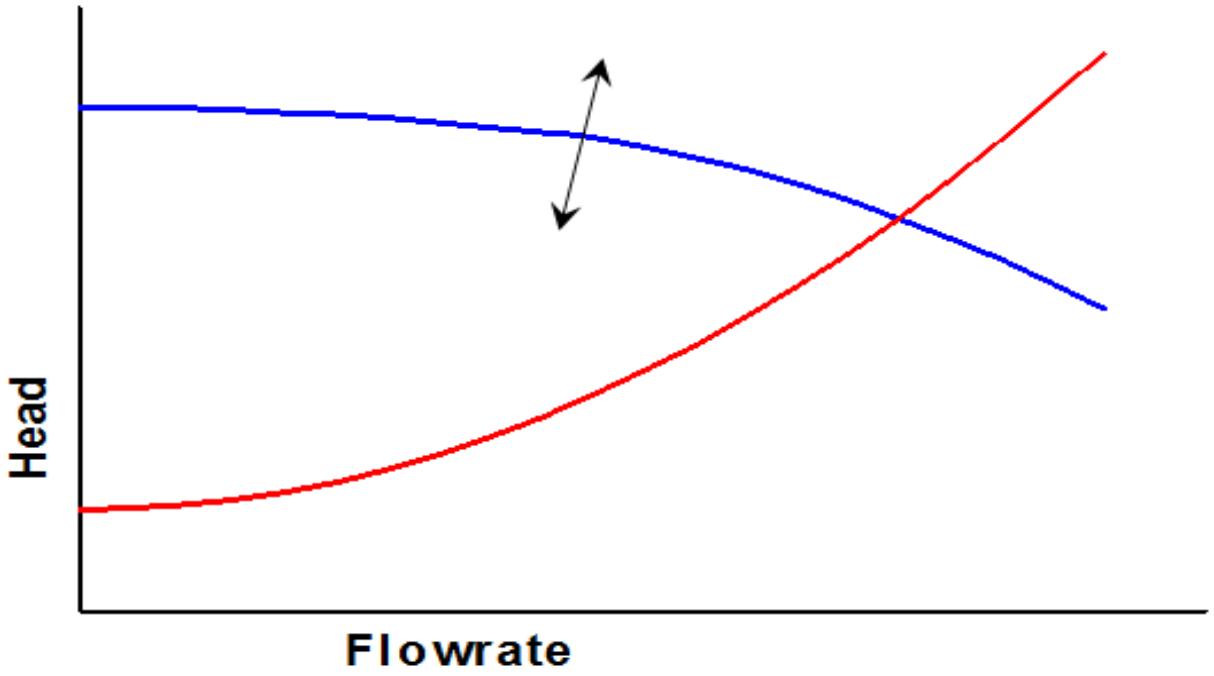
- Opportunities exist in new/existing systems
- New – More items can be addressed cost effectively
- Existing – Generally controls and pump upgrades. System (i.e. piping) changes limited to address reliability/safety

- Operating points have costs
- Is this the most cost-effective operating point for the system (energy & reliability)?



Effecting Cost Reduction: Pumps

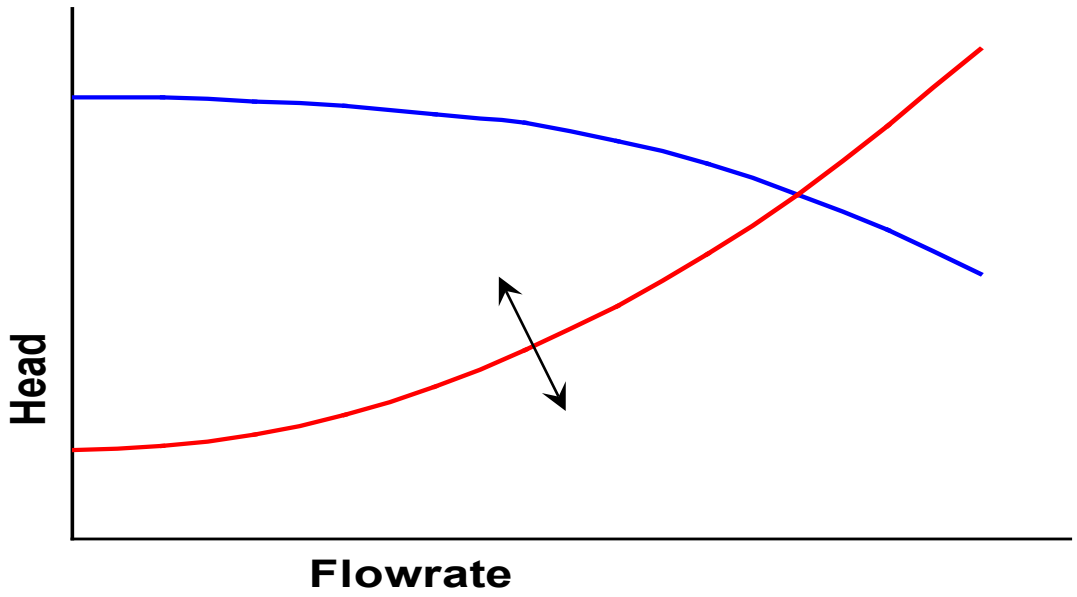
- By choosing different pumps, the pump curve can be adjusted
  - The pump efficiency and BEP also adjust
- The pump curve can also be changed by changing the impeller size or (fixed) speed



Effecting Cost Reduction: System

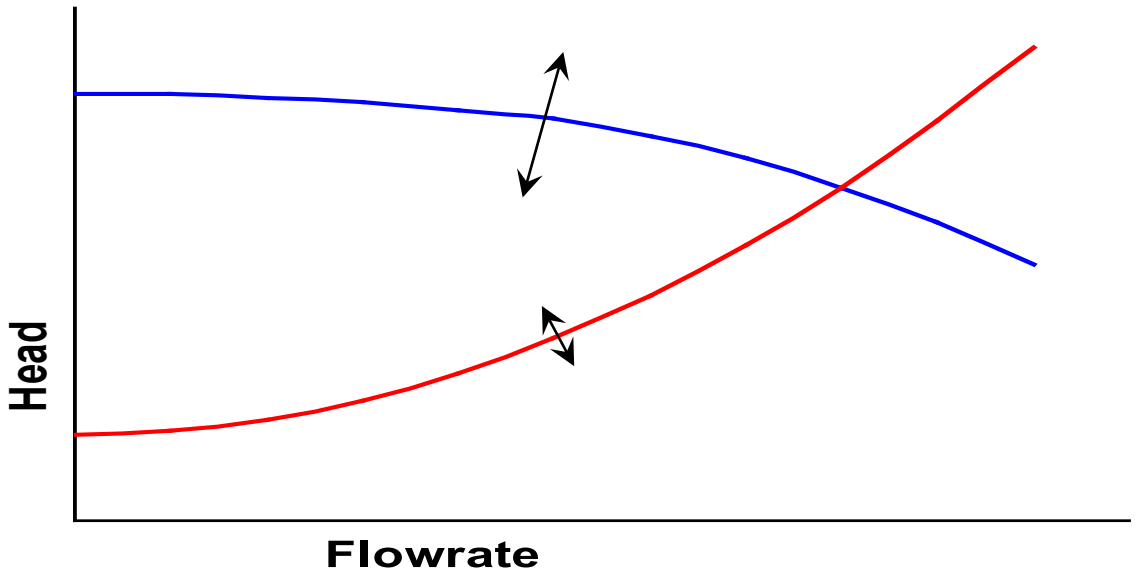
The system curve can be adjusted by using:

- Different pipe sizes
- Different layout
- Different pipe material
- Different components
- Etc.



Effecting Cost Reduction: Controls

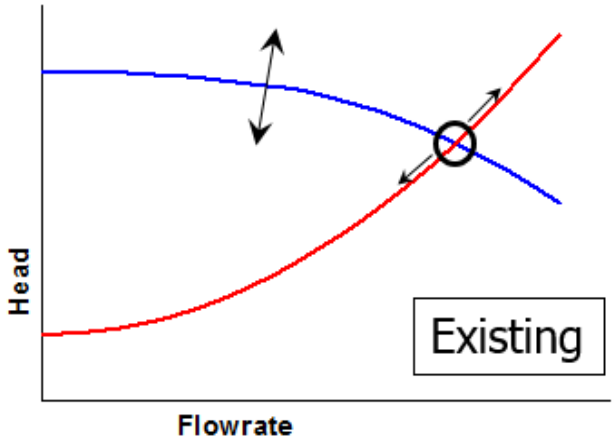
- The pump curve can be adjusted using variable speed control
- The system curve can be adjusted (to a limited degree) by decreasing pressure drop across high pressure drop components



Opportunities in Existing vs. New Systems

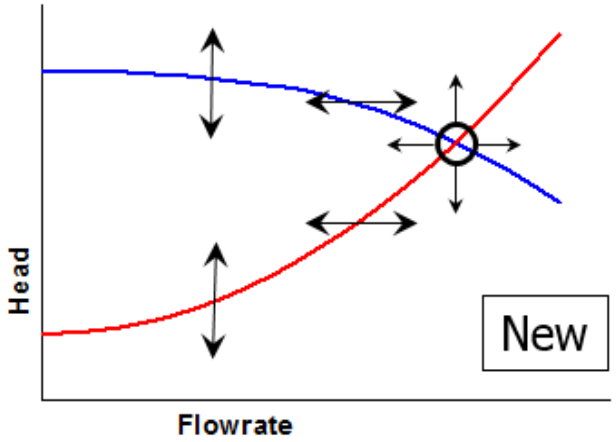
Existing systems

- Opportunities typically reside in changing the pump curve
  - Repair pump
  - Impeller size change
  - Controls (VFD)
  - New pump

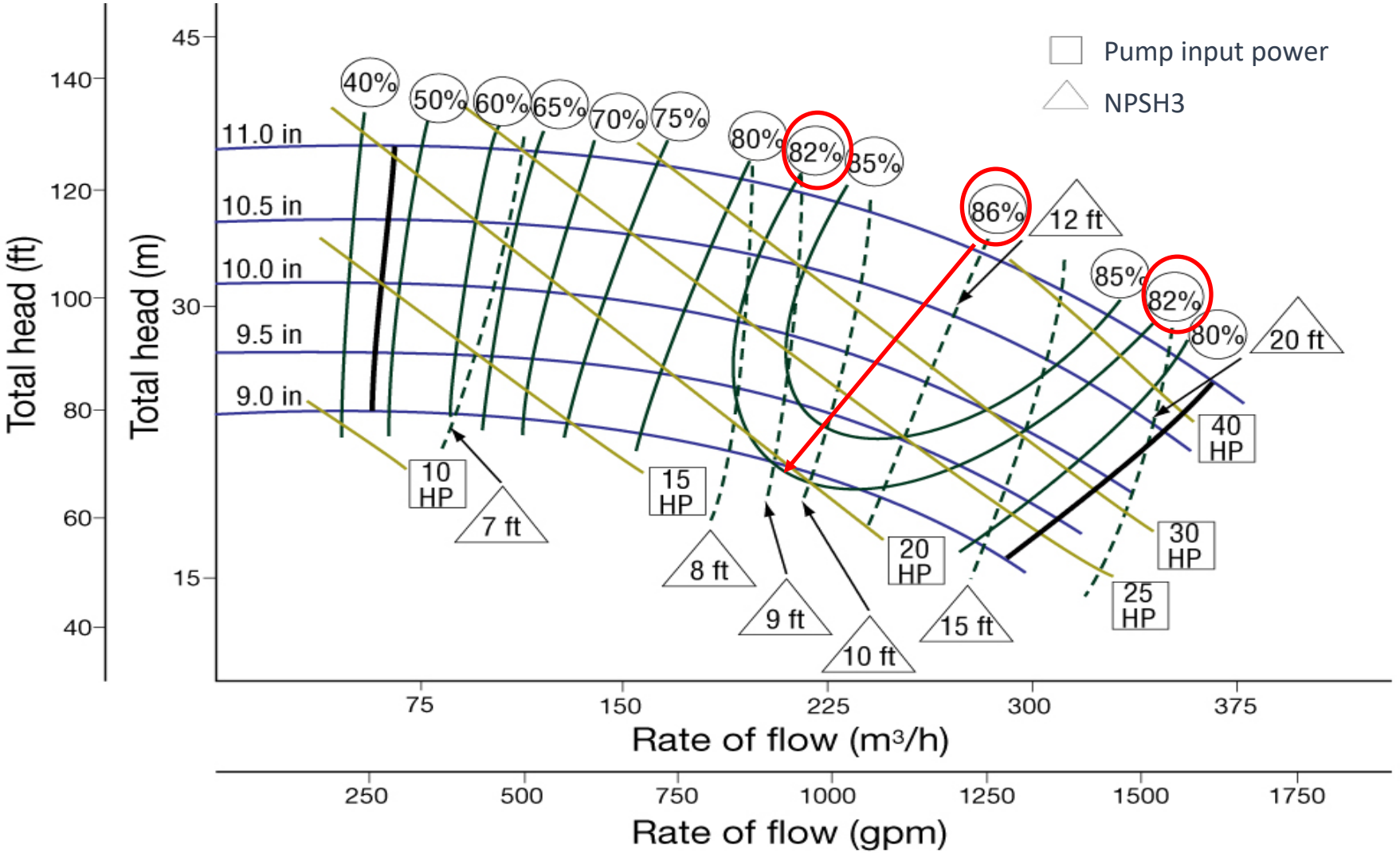


New systems

- Opportunities reside in changing anything
  - The operating point itself can be changed
  - The cost reduction opportunity is much larger



Additional Factors - Impeller Trimming



For this example, the efficiency at BEP decreases from 86% at maximum diameter to 82% at minimum diameter.

Consult ANSI/HI 14.3 regarding other considerations related to impeller trimming.

Pump System Assessment

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Pump System Assessment Action Plan

1. Screen and prioritize your pumping systems to identify good performance improvement candidates
   - Step 1a - Get management support for improving the highest priority pumping systems
2. Work with appropriate pumping system specialist and/or in-house team to gather and analyze additional data
3. Identify and economically validate improvement opportunities
4. Document actions and report results to management
5. Perform post implementation assessment
6. Repeat ***Action Plan*** process for other good candidate systems

Pump System Assessment Professional (PSAP) Certification

The certification for pump system professionals

- Outlines domains, tasks and knowledge requirements
- Comprehensive exam to confirm knowledge
- Experience requirements
- Tests the knowledge of candidates related to knowledge requirements.
- Provides assurance that candidates have experience and knowledge required to conduct pump systems assessments

More Information at:

https://www.pumps.org/certification

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DOE Regulations / HI Energy Rating

DOE Regulations for Pumps – IT'S THE LAW

PEI used to calculate power savings

What does the regulation mean to you?

Certain clean water pumps manufactured or imported into the US must comply to minimum performance levels

Generally, covers 5 types of clean water pumps within certain performance criteria.

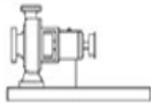
The rules use a holistic approach considering the pump, motor and VFD (when applicable)

Based on new "Pump Energy Index (PEI)" metric

- Constant Speed Pumps – PEI_{CL}
- Variable Speed Pumps – PEI_{VL}
- $PEI_{CL/VL} \leq 1.00$ required to comply

$$PEI_{CL} = \frac{PER_{CL}}{PER_{STD}}$$

$$PEI_{VL} = \frac{PER_{VL}}{PER_{STD}}$$

Diagram	Nomenclature (DOE)/[Industry]
	End Suction Frame Mount (ESFM) [OH0, OH1]
	End Suction Close Coupled (ESCC) [OH7]
	In-line (IL) [OH3, OH4, OH5]
	Radially Split multi-stage vertical in-line diffuser casing (RSV) [VS8]
	Vertical Turbine Submersible (ST) [VS0]

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Learn more - Free Webinar: https://training.pumps.org/

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What is HI Energy Rating?

The Energy Rating (ER) represents the percent power savings over the base case

$$\boldsymbol{ER} = (1.0 - \boldsymbol{Rated\ PEI_{CL/VL}}) * \boldsymbol{100}$$

Power savings easy to calculate

$$\boldsymbol{Power\ Savings} = \frac{ER}{100} * \boldsymbol{Motor\ Power}$$

$$\boldsymbol{Power\ Savings} = \frac{ER_1 - ER_2}{100} * \boldsymbol{Motor\ Power}$$

What & Why?

- Direct calculation from DOE representative PEI metric
- ER is a simple representation of percent power savings
- Incorporates extended product when DOE PEI may not
- Power savings easily calculated

HI Energy Rating Label

Additional data available in the Energy Rating Database

er.pumps.org

HYDRAULIC INSTITUTE ENERGY RATING

Brand XYZ	**ESCC Pump Type**
Model #: **84**	**- Motor**
Nominal Speed: **3600**	**- Continuous Controls**

VARIABLE LOAD PEI_{VL}: 0.40

ENERGY RATING

60

Most Consumptive — RANGE — Least Consumptive

Power savings over the baseline can be estimated by multiplying ER by motor input power (kw) and dividing by 100. Multiplying power savings by operating hours and cost of energy will yield estimated cost.

H23R19 er.pumps.org Jun 2017

1. BASIC INFORMATION
Pump brand, model number, nominal speed, equipment type, motor and controls (if applicable).

2. PUMP ENERGY INDEX
Calculation comparing the pump's efficiency to the minimum standard. Lower values are better.

3. ENERGY SAVINGS
Number indicating the percent of power savings over the baseline set by Department of Energy. The higher the energy rating, the more efficient the pump.

4. ESTIMATED SAVINGS
Illustrates the method for using the ER rating to determine actual savings.

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Hydraulic Institute and PSM Free Tools and Training Resources

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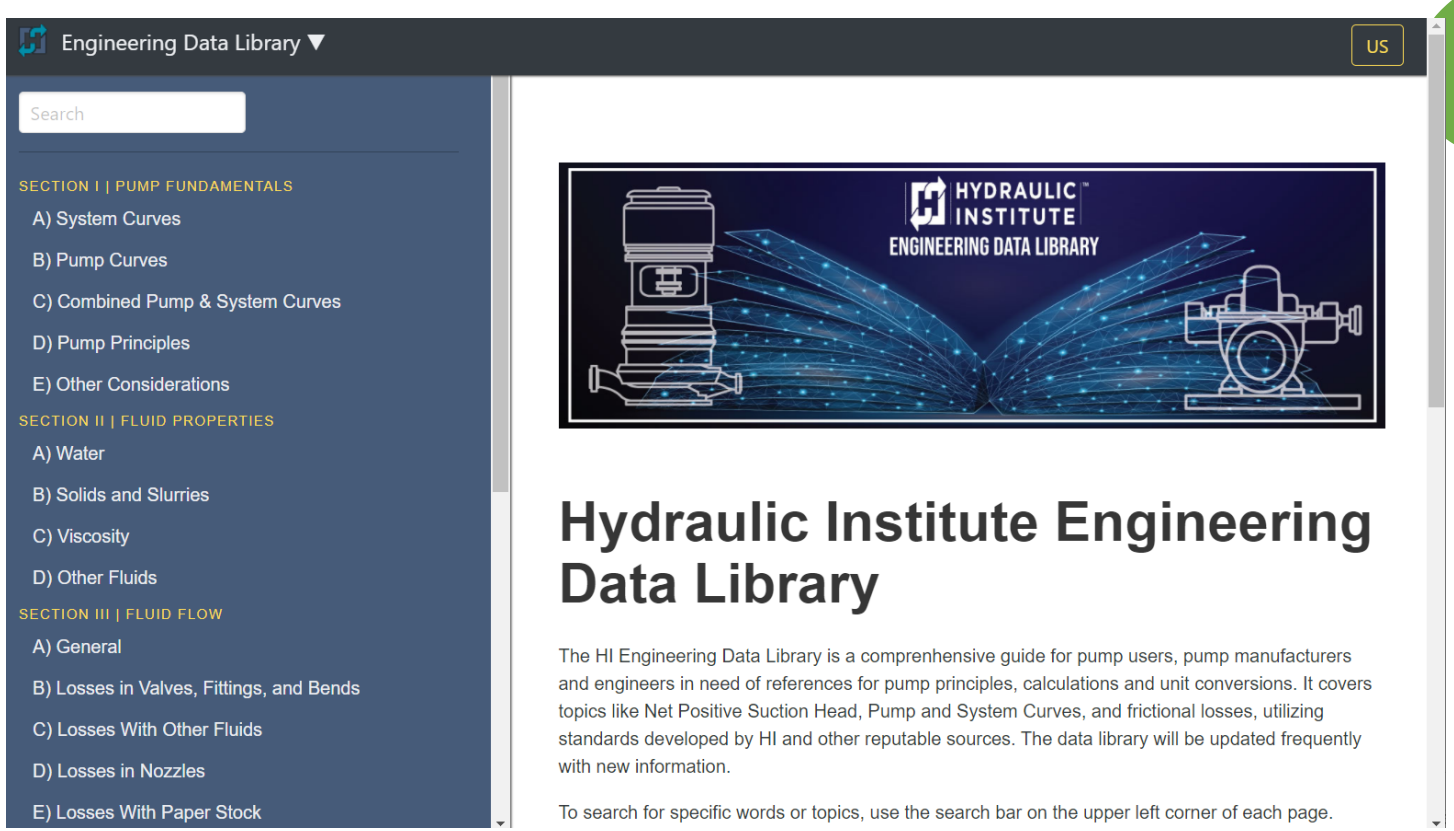
NEW Engineering Data Library & toolbox with software, training & calculators



MEASUR

PUMP SAVINGS CALCULATOR

BASIC TRAINING

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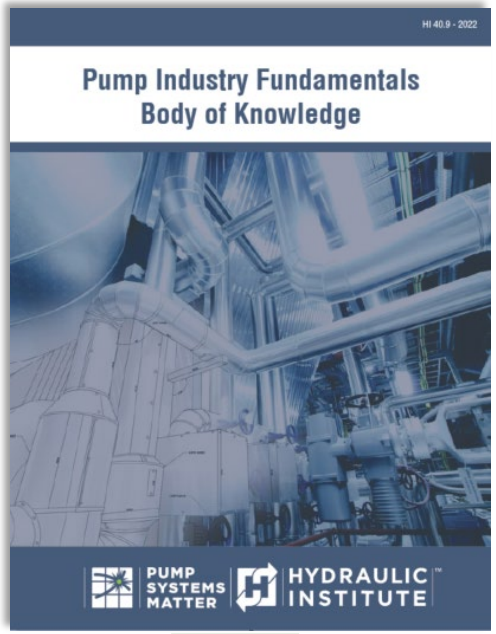
Industry Knowledge Path



Pump System Fundamentals

Pump System Optimization

Pump System Assessment

PUMP SYSTEMS ASSESSMENT PROFESSIONAL

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Pump Systems Assessment Professional Certification

1. PSAP is the benchmark for industry professionals.
2. Use PSAP credential to better position employees and the organization.
3. Assure clients of your expertise and differentiate yourself from your competitors.
4. PSO/PSA training provides the knowledge and tools to interact with customers on a service based engagement.
5. Implement proven methodologies to advance your position.