Opportunities and Barriers In Applying Optimization To Reduce Energy Use in Pumping Systems

VR&D User Conference, Monterey, CA
Presenter: Trey Walters, P.E.
October 27, 2014

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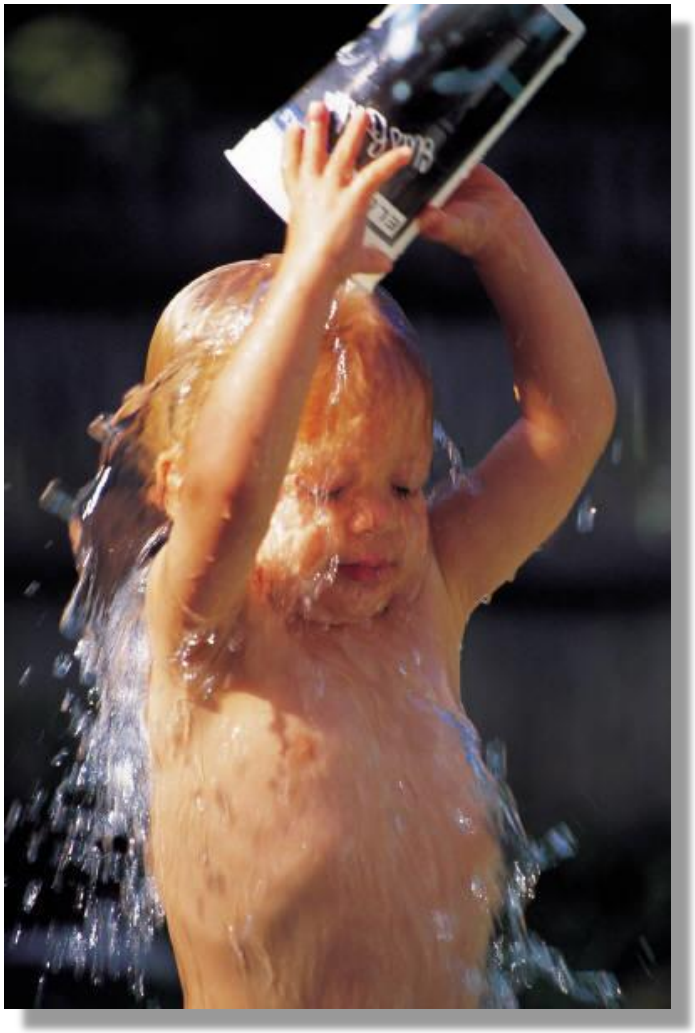
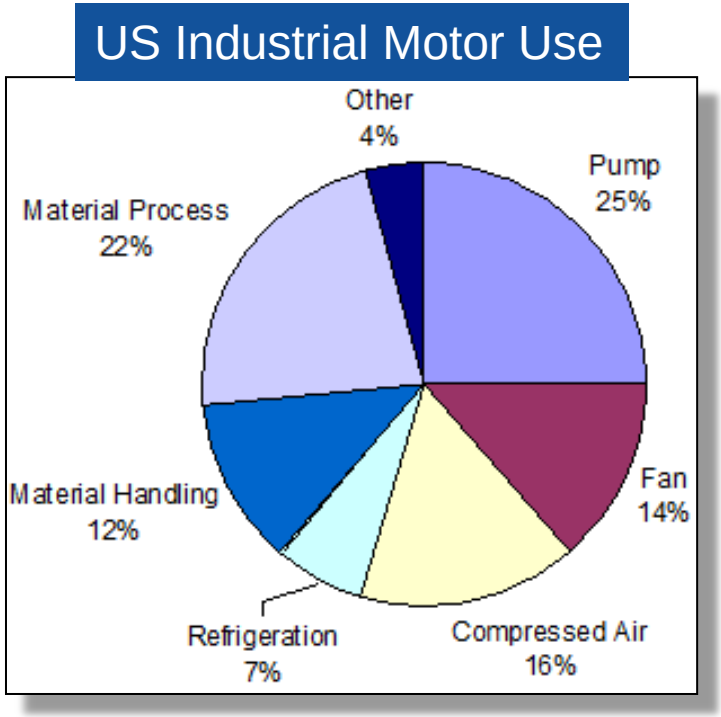
Fluids Are an Integral Part of Life



The Cost of Moving Fluids

- Pumping systems account for nearly 20% of the world's electrical energy demand [1]
- Compressor and fan systems consume more energy than pumping systems [2]



(1) *Pump Life Cycle Costs: A Guide to LCC Analysis for Pumping Systems,* Europump and Hydraulic Institute, Parsippany, NJ, 2001

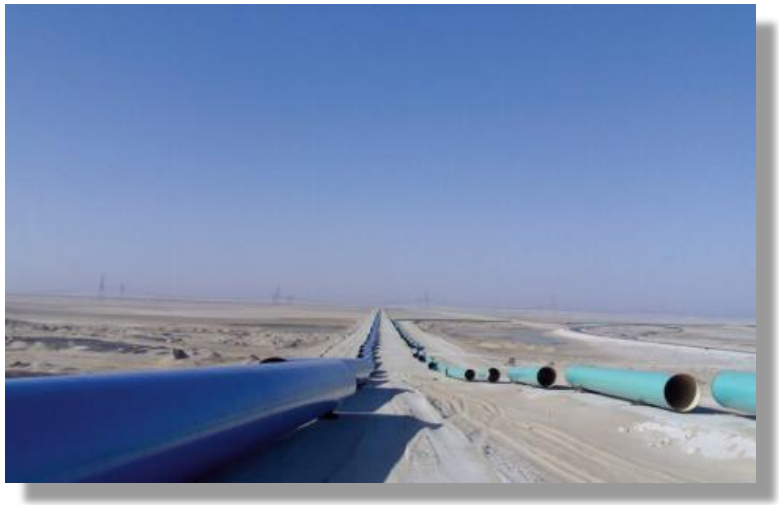
(2) *Energy-Efficient Motor Systems*, Second Edition, Nadel, S., R.N. Elliott, M. Shepard, S. Greenberg, G. Katz, and A.T. de Almeida. 2002. Washington, D.C., American Council for an Energy-Efficient Economy

The Cost of Moving Fluids (2)

- In 2008 world electricity consumption was 20,000+ TW-hr
  - 20×10^{12} kW-hr
- At $0.10 per kW-hr, that costs $2+ trillion per year
- Pumps, fans and compressors cost about $1 trillion per year

Optimization Saves Oil Company $100 Million

- 145 km pipeline carrying seawater for oil field injection [1]
  - First cost savings:
    - **$37 million**
  - Life cycle cost savings:
    - **$104 million**
  - Effort?
    - Six weeks starting from a well engineered design
- How many copies of the software were purchased by the client?



(1) *Application of Numerical Optimization of Seawater Pumping Systems,* Thorp, J.M, and Olsen, J.A., 24th International Pump Users Symposium, 2008

Opportunities for Using Optimization in Moving Fluids?

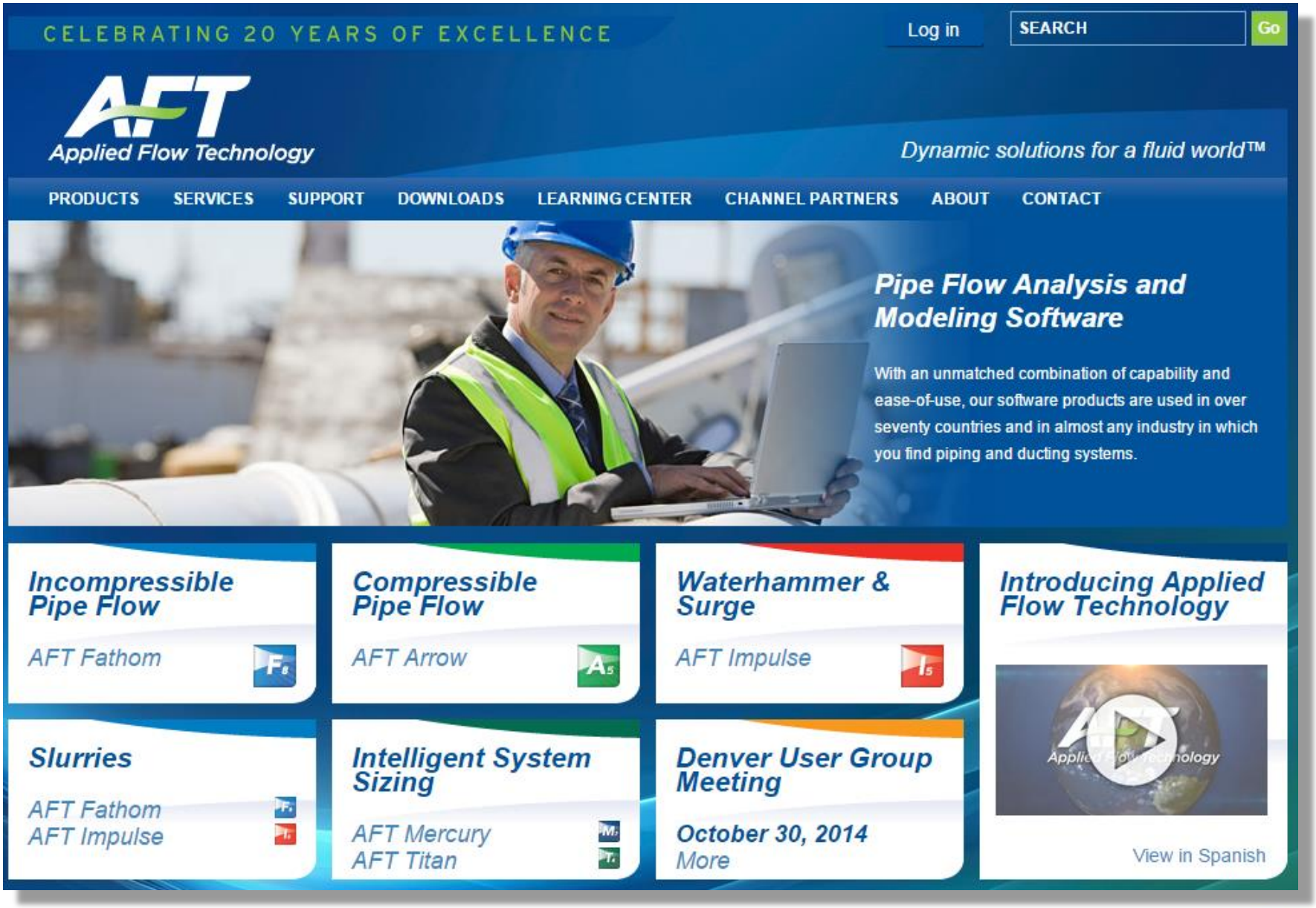
Agenda

- My background in fluid mechanics and optimization
- My experiences in starting two companies
- My experiences in developing commercial tools to apply optimization methods in fluid systems
- My experiences and lessons learned in selling and applying optimization tools
- Trends in energy use and pump efficiency legislation
- The future of optimization in fluid transfer systems?

My Background

- Early education in optimization
  - Studied optimization under Gary Vanderplaats at the University of California at Santa Barbara in 1985
- Career in fluid mechanics
  - Cryogenic rocket design
    - General Dynamics (San Diego, CA)
  - Steam/water equipment design
    - Babcock & Wilcox (Alliance, OH)
- Started two companies
  - Applied Flow Technology (1994)
    - Pipe flow simulation software developer
  - Purple Mountain Technology Group (2007)
    - Fluid system consulting

Creating a Culture Open To New Ideas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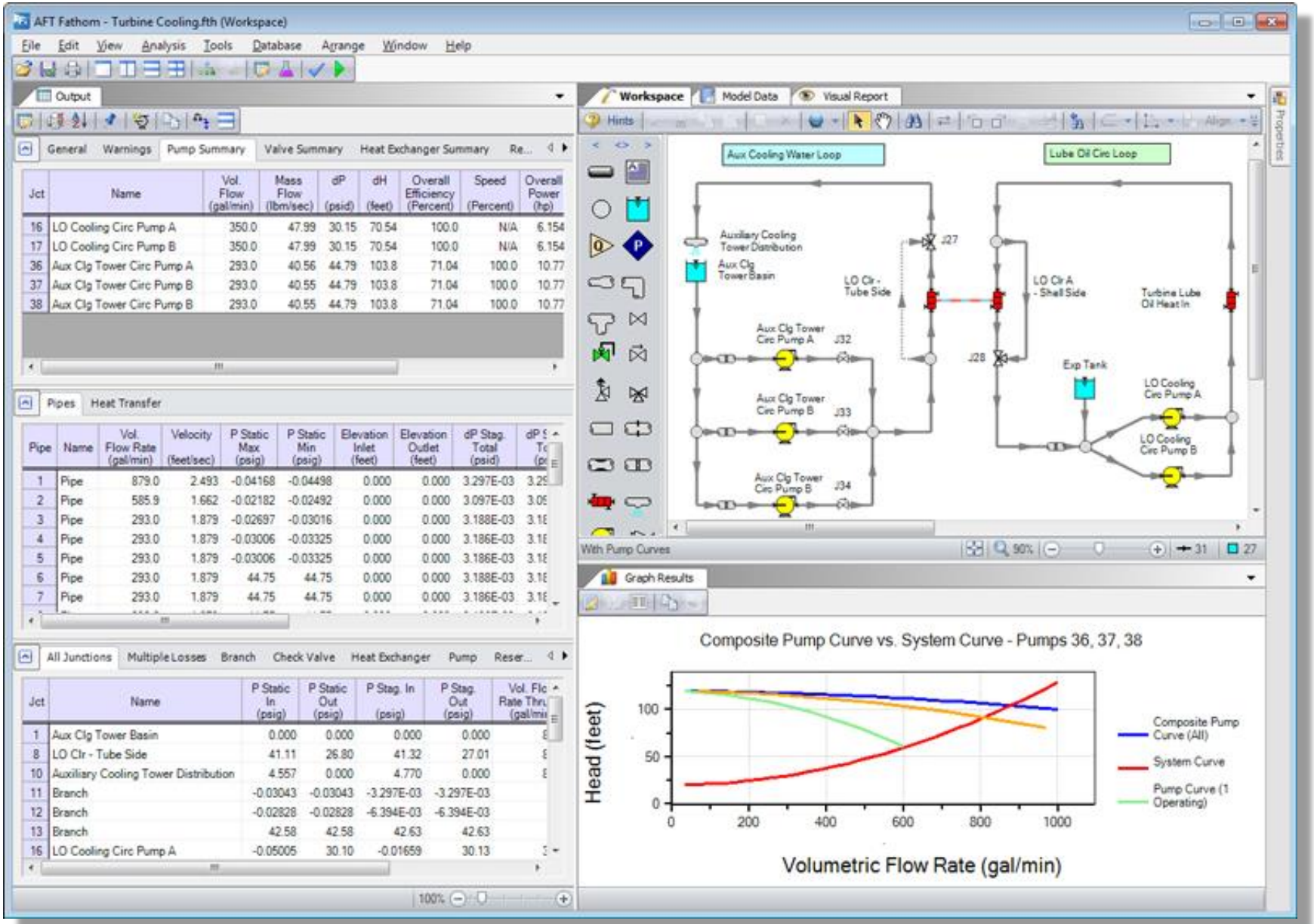

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AFT Commercial Product History

- Conventional Tools
  - AFT Fathom™
    - Released in 1994
    - Conventional incompressible flow pipe system simulation tool
    - First graphical tool of its kind for Microsoft Windows
- Optimization Tools
  - AFT Mercury™
    - Released in 2001
    - Built entirely on AFT Fathom with the addition of an optimizer
    - First and only commercial tool for optimizing piping systems
  - AFT Fathom GSC Module
    - Add-on module which performs multi-variable goal seeking
    - Released in 2004 with AFT Fathom 6.0

The Cost of Moving Fluids

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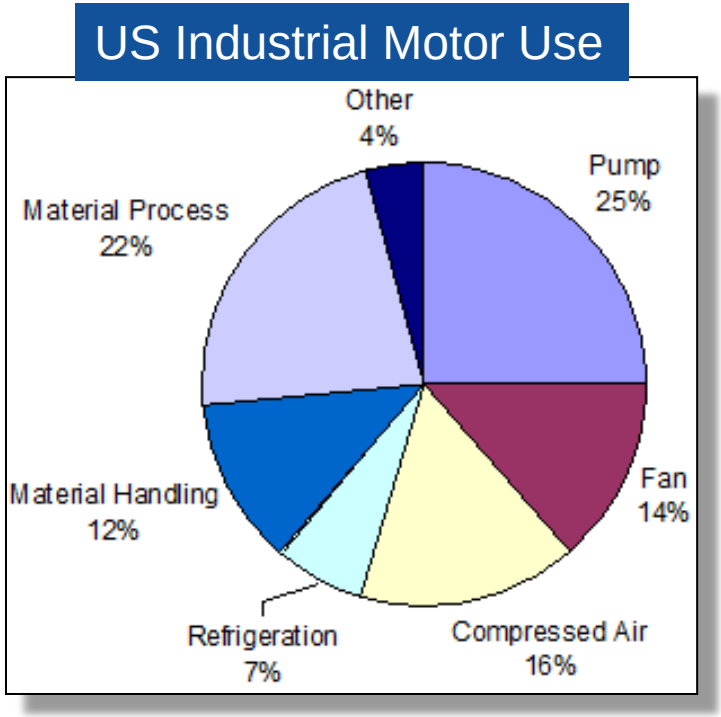

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How Many Pumps Are There in the World?

- It is estimated that there are 10 billion pumps in the world [1]
  - Pumps are the second most common piece of machinery in the world (behind electric motors)

(1) *2012 Pump Appreciation Day*, ITT Goulds Pumps website

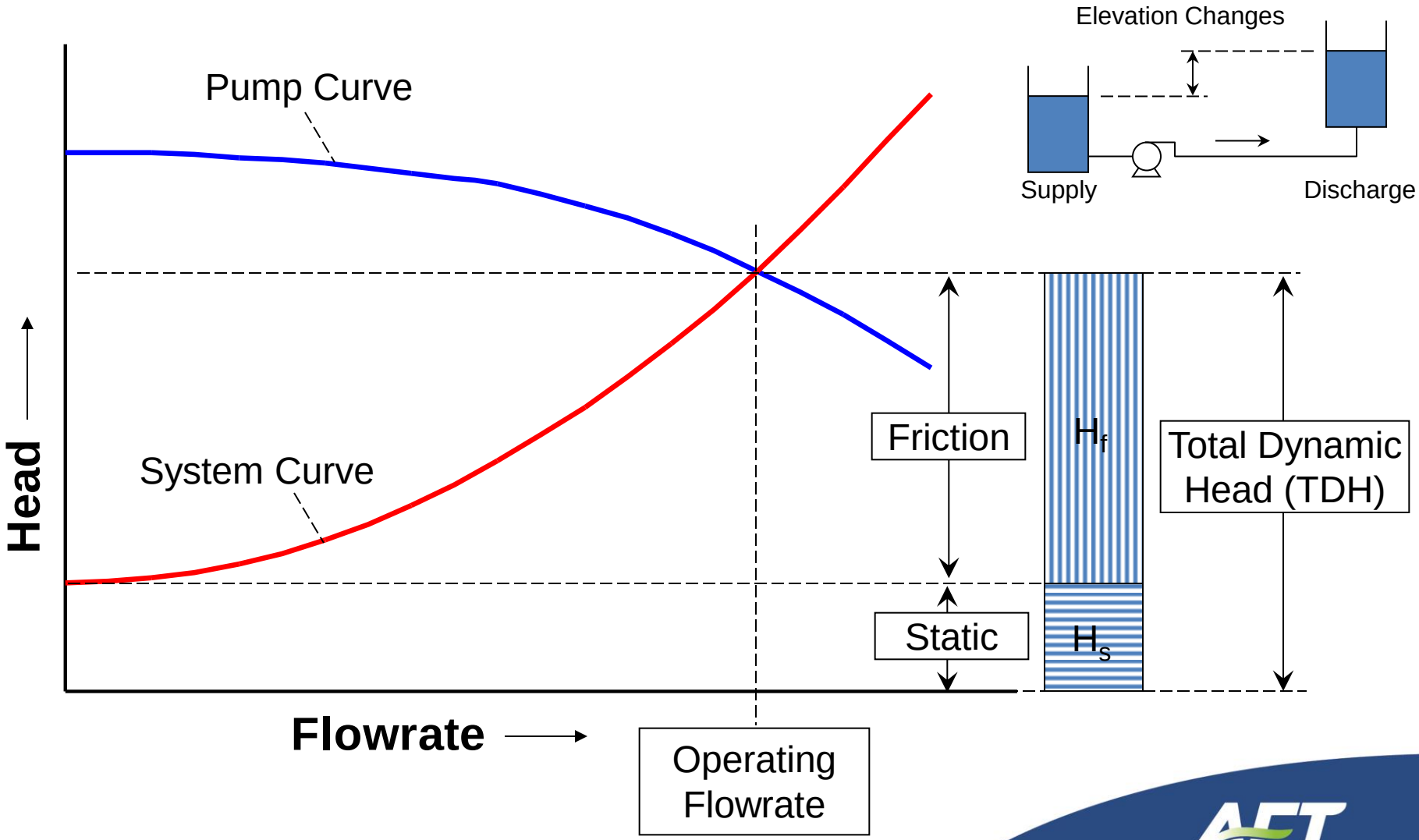
How Many Pump Systems Are There in the World?

- Since many pump systems have multiple pumps, it is fair to say there are 2-5 billion pump systems in the world

Global Infrastructure Development

- As the global economy grows, so will the need for infrastructure
  - Power plants
  - Water treatment plants
  - Water and natural gas distribution to communities
- The number of fluid transfer systems is only going to grow

What is a Pump-System Curve?



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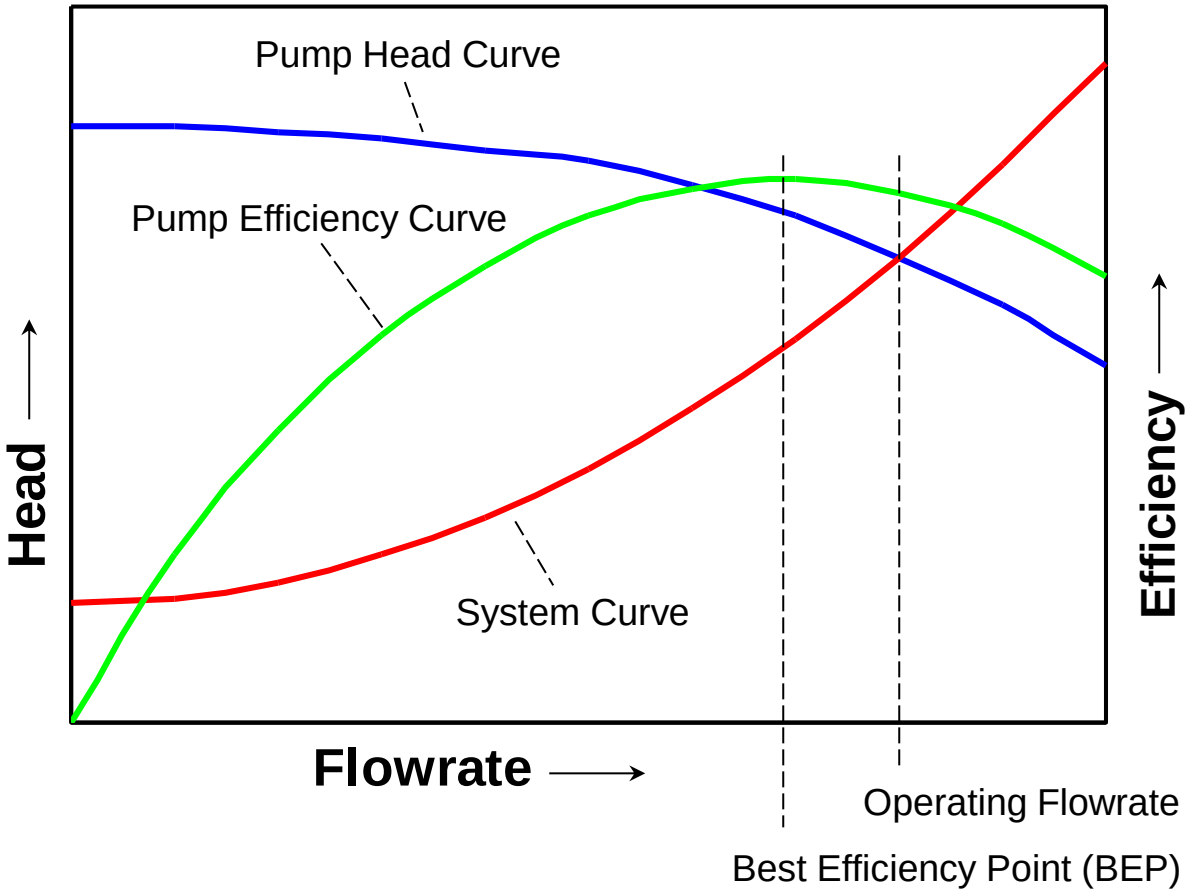
Pump Efficiency and BEP



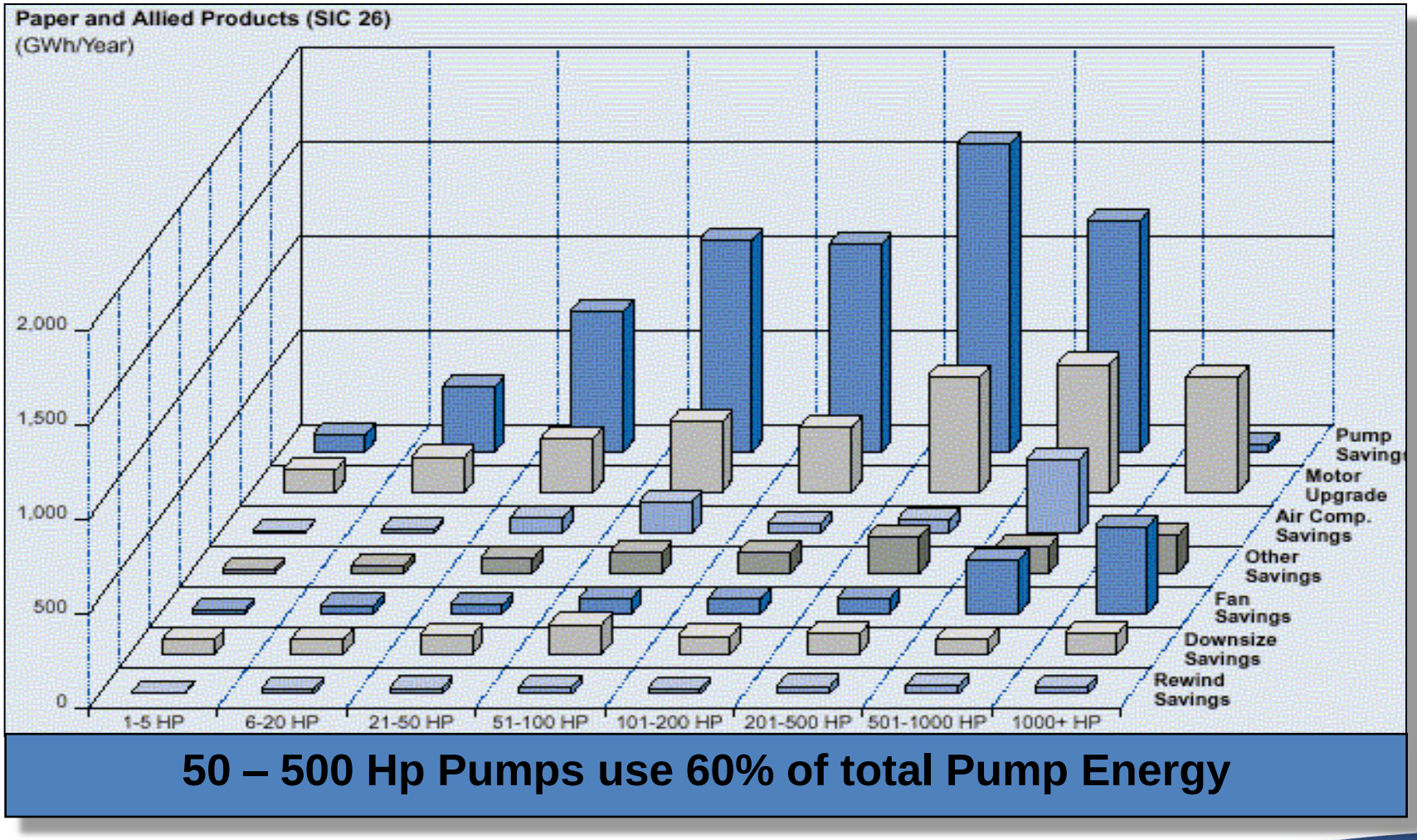
Finnish Technical Research Center Report

- "Expert Systems for Diagnosis of the Condition and Performance of Centrifugal Pumps”
- Evaluation of 1690 pumps at 20 process plants:
  - Average pumping efficiency is below 40%
  - Over 10% of pumps run below 10% efficiency
  - Major factors affecting pump efficiency:
    - throttled valves
    - pump over-sizing

How To Reduce Energy in Pumping Systems

- For new designs
  - Match the pump to the system at the design stage
    - Allow for changes in the pump and/or system over time
      - » Pump degradation
      - » System fouling
      - » Changes is operational requirements
  - Optimize using energy costs as part of the Objective Function
- For existing systems
  - Optimization is of little help unless owner is open to replacing the piping
  - Conventional pipe flow modeling can be very useful to understand root cause of inefficient operation

Example: Pump Energy Savings Potential



50 – 500 Hp Pumps use 60% of total Pump Energy

Barriers to Using Optimization in Fluid Transfer Systems

- Structural
- Cultural
- Relational

Structural Barriers

- Most fluid transfer systems are designed by companies who will never own the system
  - These are called EPC's (Engineering/Procurement and Construction firms)
  - EPCs have little incentive to optimize designs
- Most fluid transfer systems are owned by companies with minimal expertise in system design
  - These are called O/O's (Owner/Operators)
  - O/O's are stuck with non-optimal systems for the life of the system – which can be decades
- Perversely, O/O's award contracts on a lowest first cost basis
  - This results in increased energy usage

Structural Barriers (2)

- To reduce costs in fluid transfer systems, monetary costs must be an integral part of the optimization
- In large EPC companies, engineers do not estimate costs
  - a separate *cost estimating* group performs this task

Cultural Barriers

- Engineers are afraid of change
- Engineers are afraid that they will be labeled as poor engineers
  - if it is discovered their designs could have been better
- Engineers truly think they already “optimize” their designs
- The risk/reward of using optimization does not favor the engineer
  - If an optimization tool fails, the engineer will be blamed
  - If an optimization tool succeeds, the engineer will receive little or no reward

Relational Barriers

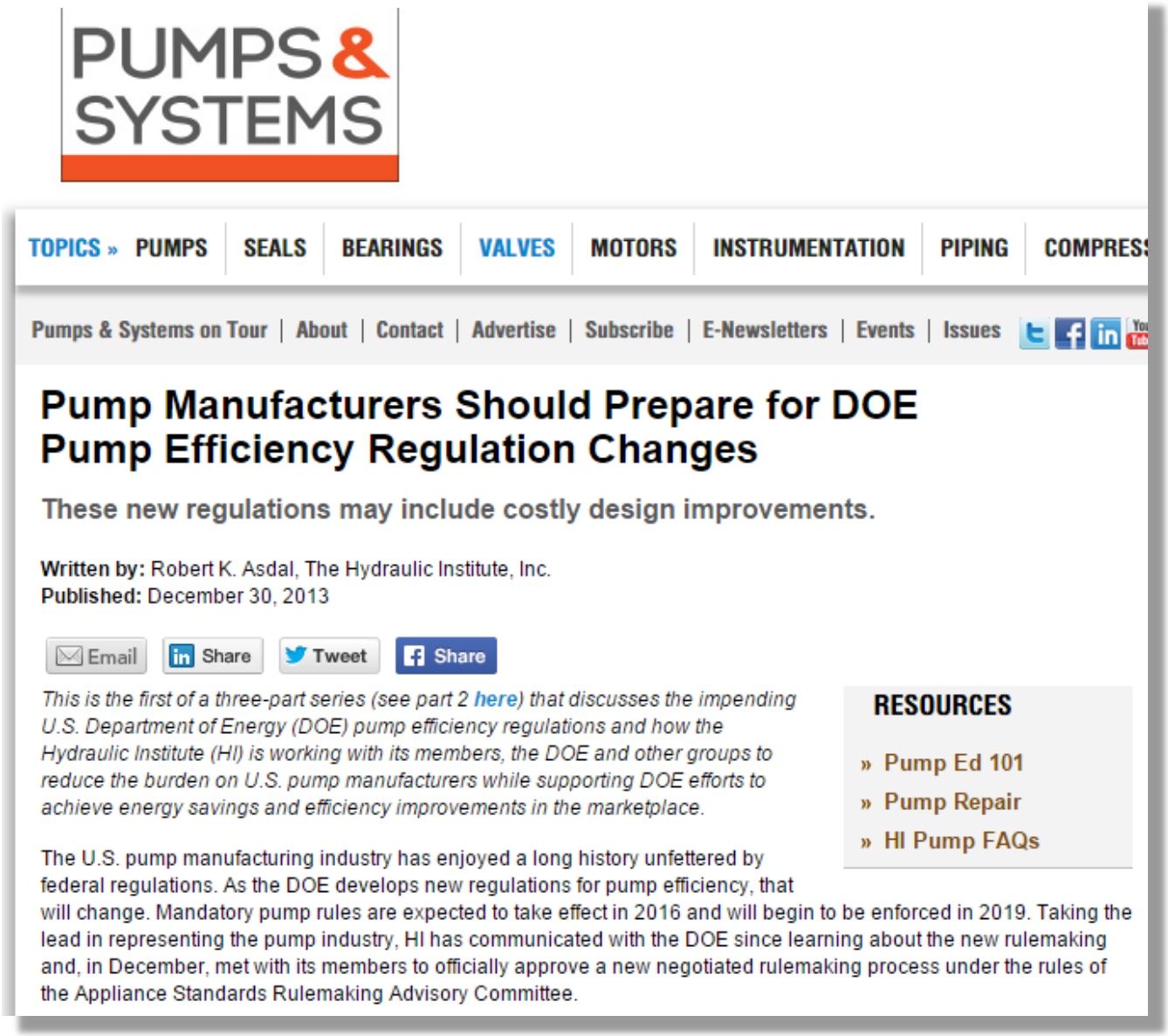
- Engineering modeling tools are typically sold “bottom up”
  - Sold to engineers
- Cost reduction tools (e.g., optimization) are typically sold “top down”
  - Sold to management
- In order to sell optimization tools for fluid transfer systems, new high level contacts must be developed at each EPC

Lessons Learned in Developing and Selling Optimization Tools

- Don’t use the word “optimization”
  - AFT calls it *Intelligent System Sizing* ®
- Give greater sales effort to system *owners* rather than system *designers*
- KISS – Keep It Simple Stupid
  - Make the optimization capabilities as simple as possible for the engineer/user
    - User interface design
    - Simplified terminology
- Technical Support
  - Optimization is still too complicated for the average engineer
  - Give significant effort to supporting users

Trends in Energy Regulations and Standards

- Force pump manufacturers to improve pump efficiency through regulatory action
  - In the United States
    - "Prepare for DOE Pump Efficiency Regulations", Pumps & Systems magazine, three part article, January/February/March 2014
  - In Europe
    - Regulations already in place (see Europump website)
- Standards have been developed by ASME on energy



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Pump Manufacturers Should Prepare for DOE Pump Efficiency Regulation Changes

These new regulations may include costly design improvements.

Written by: Robert K. Asdal, The Hydraulic Institute, Inc.
Published: December 30, 2013

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This is the first of a three-part series (see part 2 here) that discusses the impending U.S. Department of Energy (DOE) pump efficiency regulations and how the Hydraulic Institute (HI) is working with its members, the DOE and other groups to reduce the burden on U.S. pump manufacturers while supporting DOE efforts to achieve energy savings and efficiency improvements in the marketplace.

RESOURCES

» Pump Ed 101
» Pump Repair
» HI Pump FAQs

The U.S. pump manufacturing industry has enjoyed a long history unfettered by federal regulations. As the DOE develops new regulations for pump efficiency, that will change. Mandatory pump rules are expected to take effect in 2016 and will begin to be enforced in 2019. Taking the lead in representing the pump industry, HI has communicated with the DOE since learning about the new rulemaking and, in December, met with its members to officially approve a new negotiated rulemaking process under the rules of the Appliance Standards Rulemaking Advisory Committee.

Pump & Systems magazine, 3 part series, Jan.-Mar. 2014

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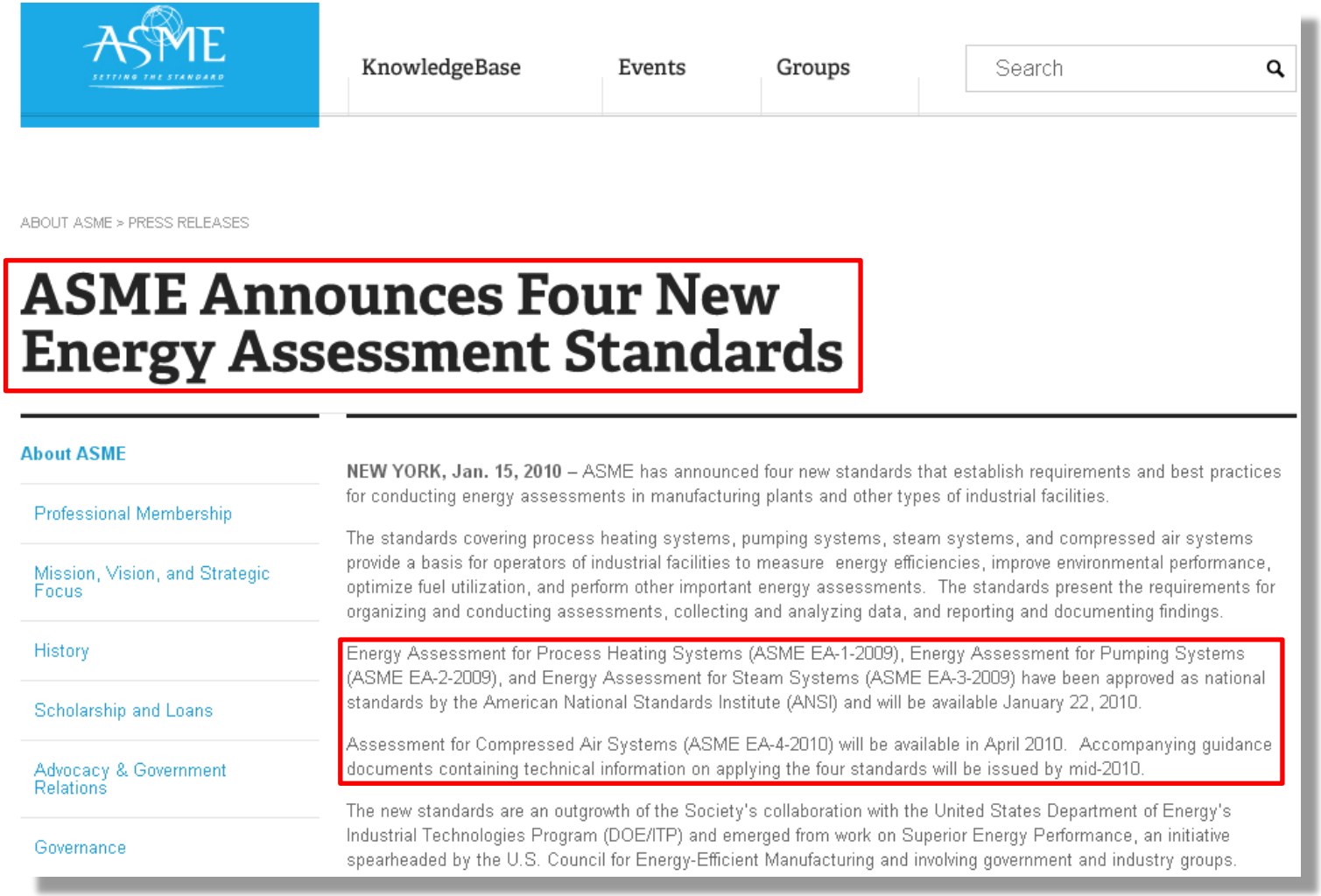

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ASME Announces Four New Energy Assessment Standards

About ASME

- Professional Membership
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NEW YORK, Jan. 15, 2010 – ASME has announced four new standards that establish requirements and best practices for conducting energy assessments in manufacturing plants and other types of industrial facilities.

The standards covering process heating systems, pumping systems, steam systems, and compressed air systems provide a basis for operators of industrial facilities to measure energy efficiencies, improve environmental performance, optimize fuel utilization, and perform other important energy assessments. The standards present the requirements for organizing and conducting assessments, collecting and analyzing data, and reporting and documenting findings.

Energy Assessment for Process Heating Systems (ASME EA-1-2009), Energy Assessment for Pumping Systems (ASME EA-2-2009), and Energy Assessment for Steam Systems (ASME EA-3-2009) have been approved as national standards by the American National Standards Institute (ANSI) and will be available January 22, 2010.

Assessment for Compressed Air Systems (ASME EA-4-2010) will be available in April 2010. Accompanying guidance documents containing technical information on applying the four standards will be issued by mid-2010.

The new standards are an outgrowth of the Society's collaboration with the United States Department of Energy's Industrial Technologies Program (DOE/ITP) and emerged from work on Superior Energy Performance, an initiative spearheaded by the U.S. Council for Energy-Efficient Manufacturing and involving government and industry groups.

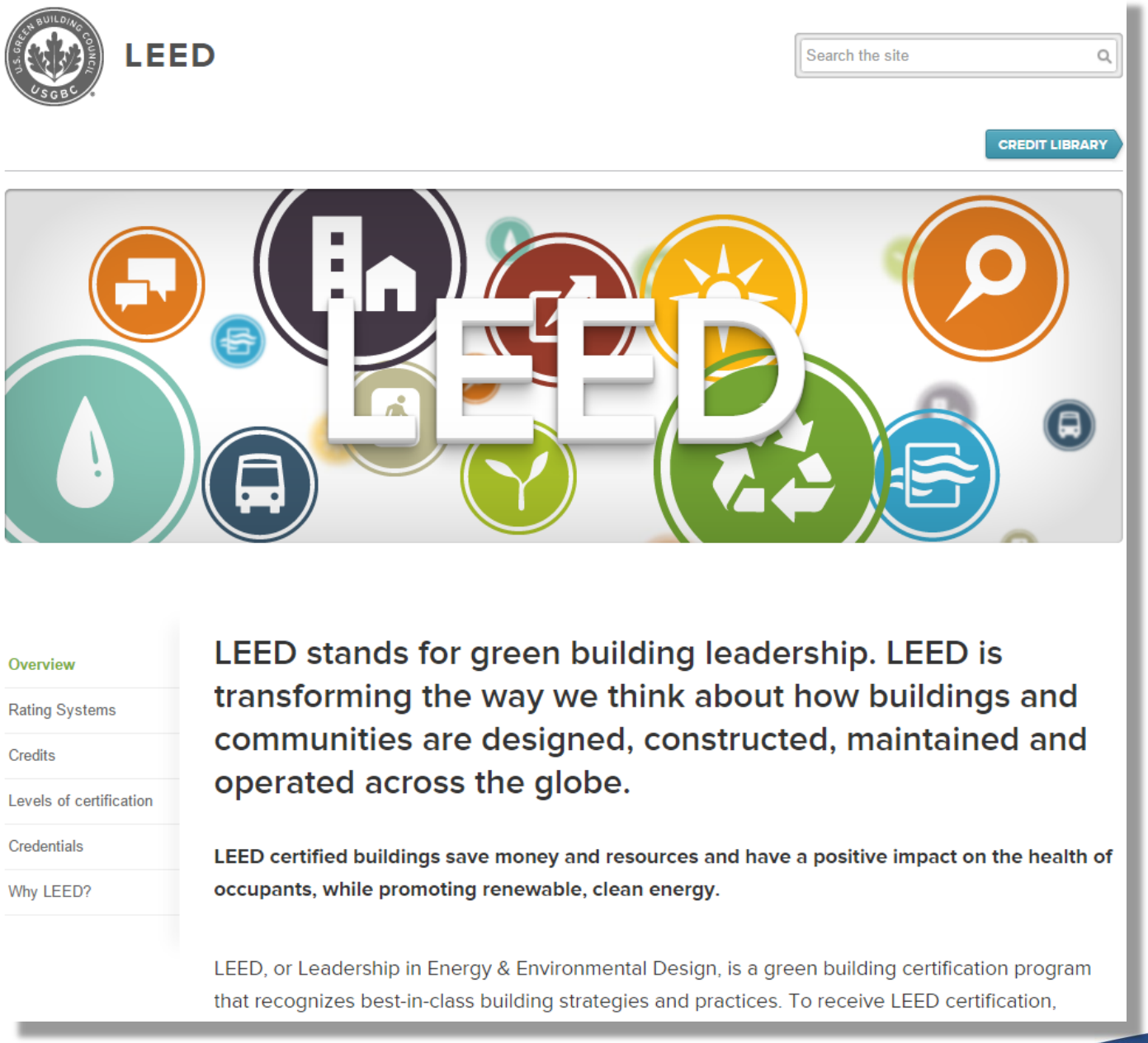
ASME press release, Jan. 2010

The Future of Optimization in Fluid Transfer Systems?

- Market driven future:
  - Unless energy costs increase dramatically it is doubtful the market will accept optimization in fluid transfer systems
  - Without energy being an issue, the structural issues in how industrial projects are executed will prevent optimization being used
  - It is possible a “killer app” may still open the door

The Future of Optimization in Fluid Transfer Systems? (2)

- Regulatory driven future:
  - Energy
    - There is reason to believe that energy regulation may force changes in how energy is prioritized in engineering design
    - Example is LEED certification on buildings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LEED certified buildings save money and resources and have a positive impact on the health of occupants, while promoting renewable, clean energy.
LEED, or Leadership in Energy & Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices. To receive LEED certification,

The Future of Optimization in Fluid Transfer Systems? (3)

- Regulatory driven future:
  - Energy
    - There is reason to believe that energy regulation may force changes in how energy is prioritized in engineering design
    - Example is LEED certification on buildings
  - Environment
    - Carbon dioxide emissions are increasingly on the radar screen of state, national and international regulatory agencies
    - CO2 reduction may put pressure on designing systems with less energy intensity
    - California is an important influence within the United States

Trey Walters, P.E., President
Applied Flow Technology

QUESTIONS?