Building Leadership Excellence

Holistic Pump System Designs:

Optimizing Pump & Process Efficiency

May 1-4
PaperCon 2011
Northern Kentucky Convention Center

RETHINK PAPER:
Lean and Green

Industrial Process **Energy Performance Services**

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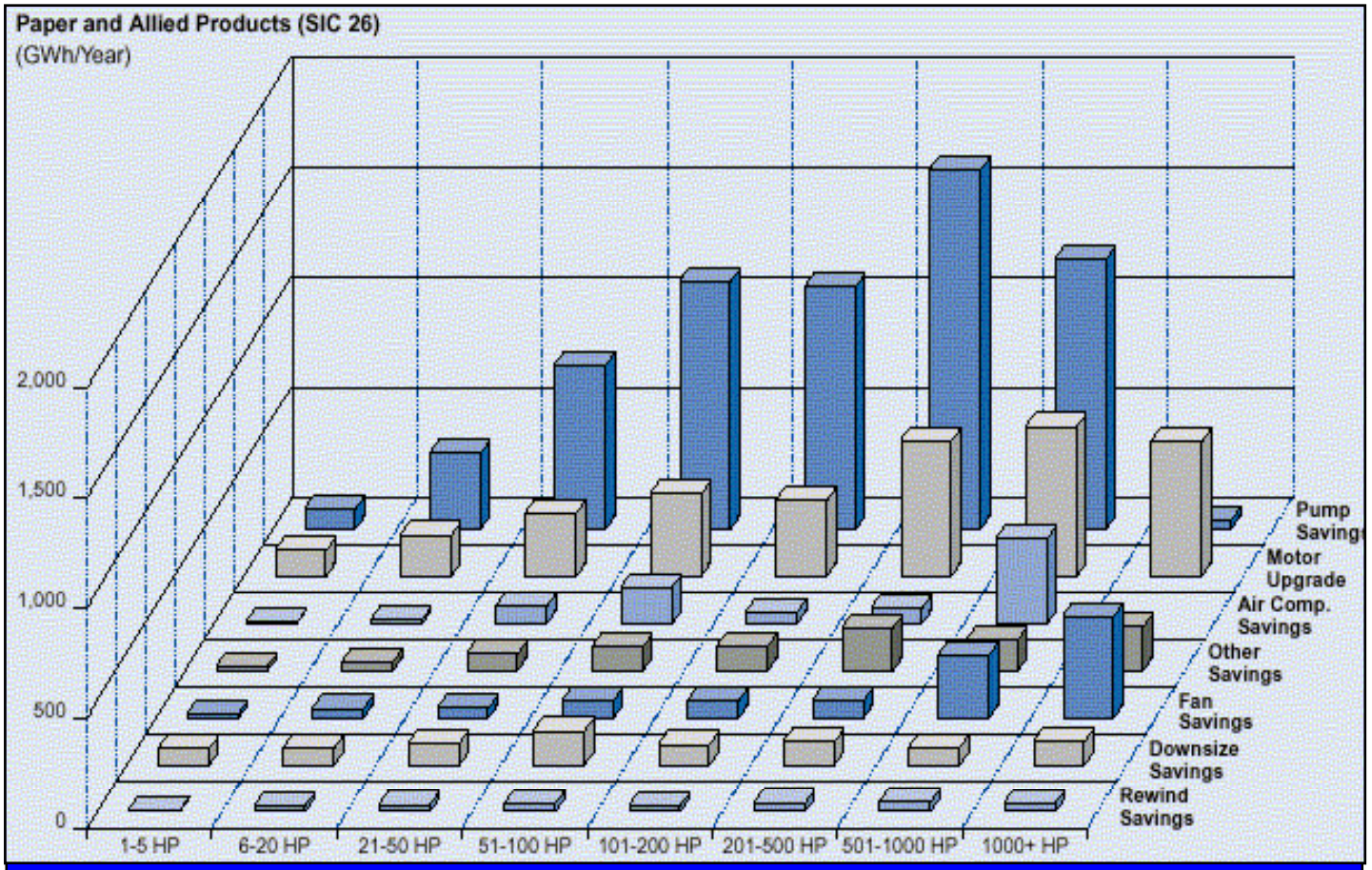
Pumping Systems Are Energy Intensive

Industry Type	Pump Energy (% Total Motor Energy Usage)
Petroleum	60%
Forest Products	30%
Chemicals	25%
Food Processing	20%
Primary Metals	10%

A 200 Hp Pump uses ≈ $50,000 / Yr in Electricity

- MECS 1994, Bureau of Economic Analysis 1997
- Census of Manufacturers, 1993

Pump Energy Savings Potential



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

Energy savings help justify reliability projects!

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**
- **Seal leakage causes highest downtime and cost**

Excessive Valve Throttling is Expensive

- **Higher energy consumption**
- **Lower process reliability**
- **Poor process control**
  - increased variability
  - manual operation

Control engineers need to consider the pumping system as an integral part of the automation architecture

Processes Often Are Not Well Controlled

…process variability exists, in many cases, not because of the raw materials or variations due to natural causes, but because process variability has been introduced into the process through design selection or the adjustment of process and control equipment."

Source: EnTech Report V11.2
www.emersonprocess.com/entechcontrol/download/

Processes Often Are Not Well Controlled

"Unfortunately, the tendency to oversize control valves has not changed significantly. With each design engineer applying an extra safety margin to avoid the possibility of undersizing

….. most valves end up being too big and operate as low as 15% open on startup…usually makes good process control nearly impossible."

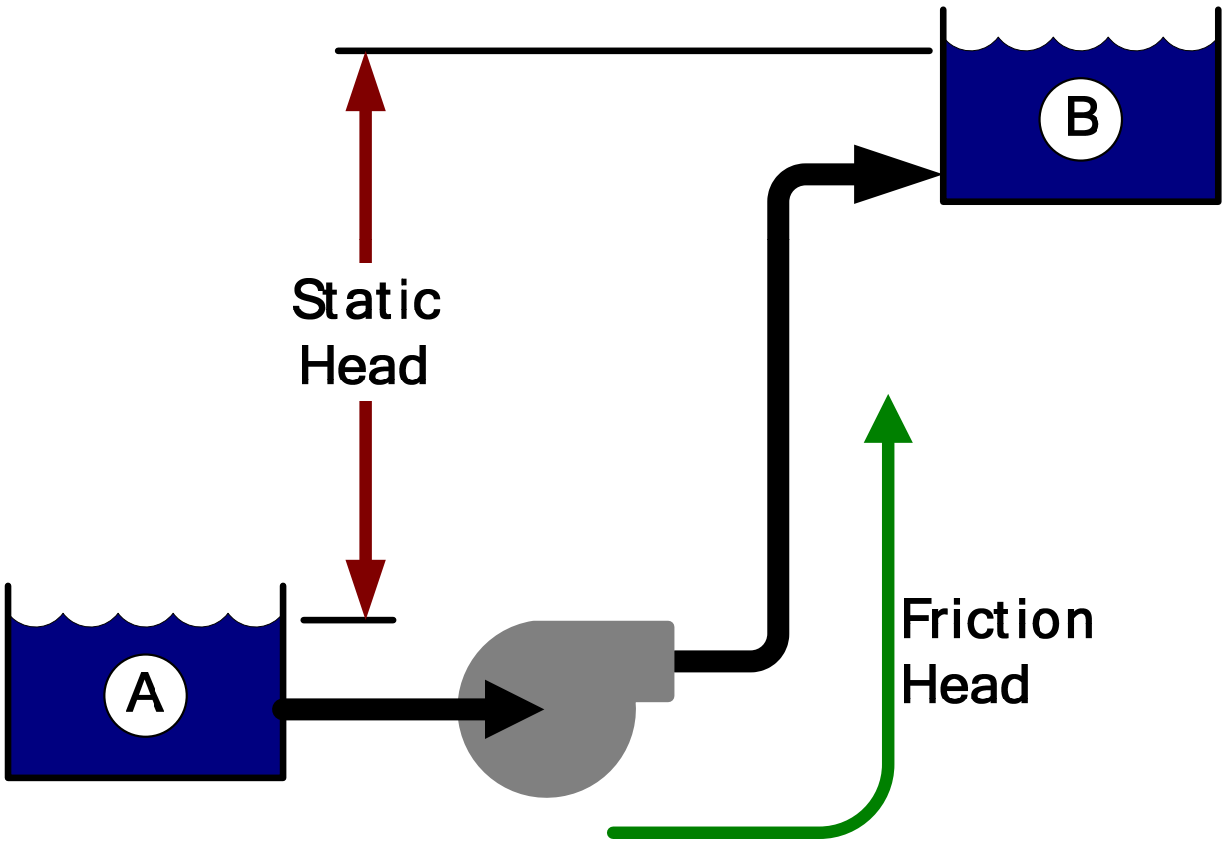
Source: EnTech Report V11.2

www.emersonprocess.com/entechcontrol/download/

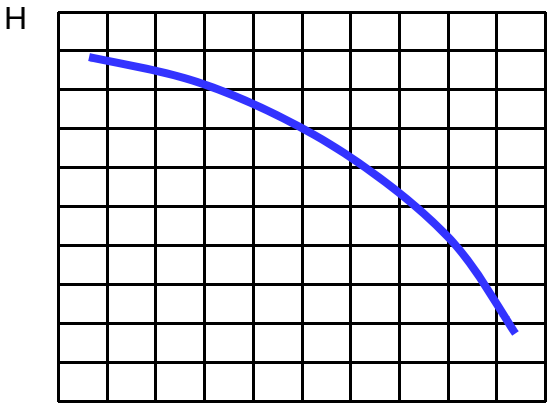
Some Fundamentals

Fixed vs. Variable Speed Pumping

Hydraulic System



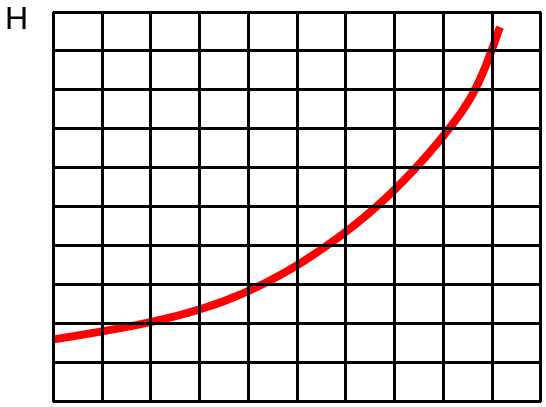
Basic Pump Curves



Pump Curve:

- Motor Speed

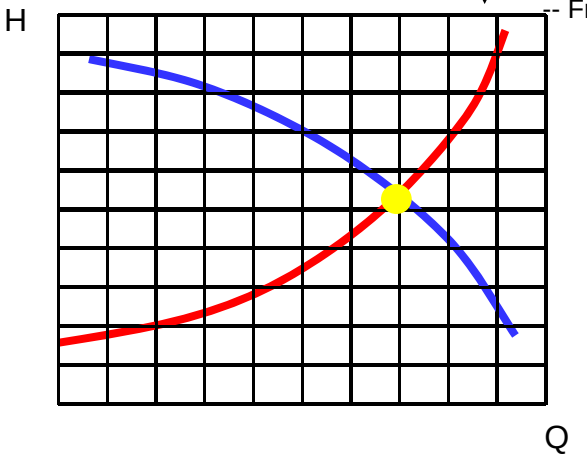
-- Impeller Diam.



System Curve"

- Static Head

-- Friction Head

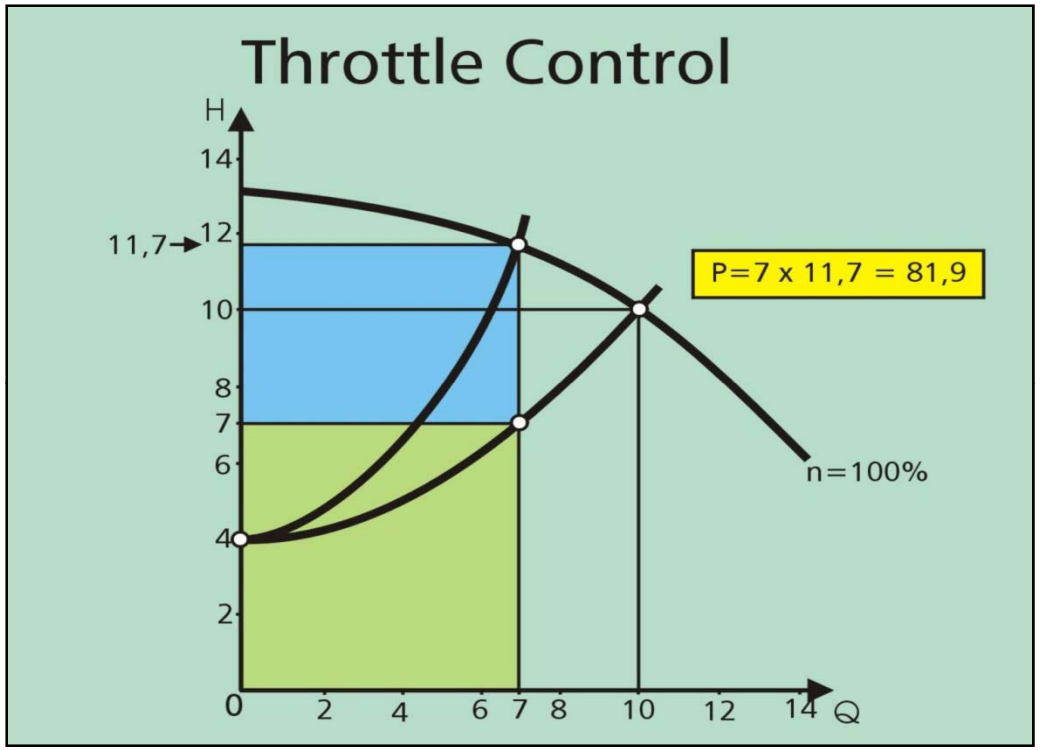


The operating point is at the intersection of the pump and system curves.

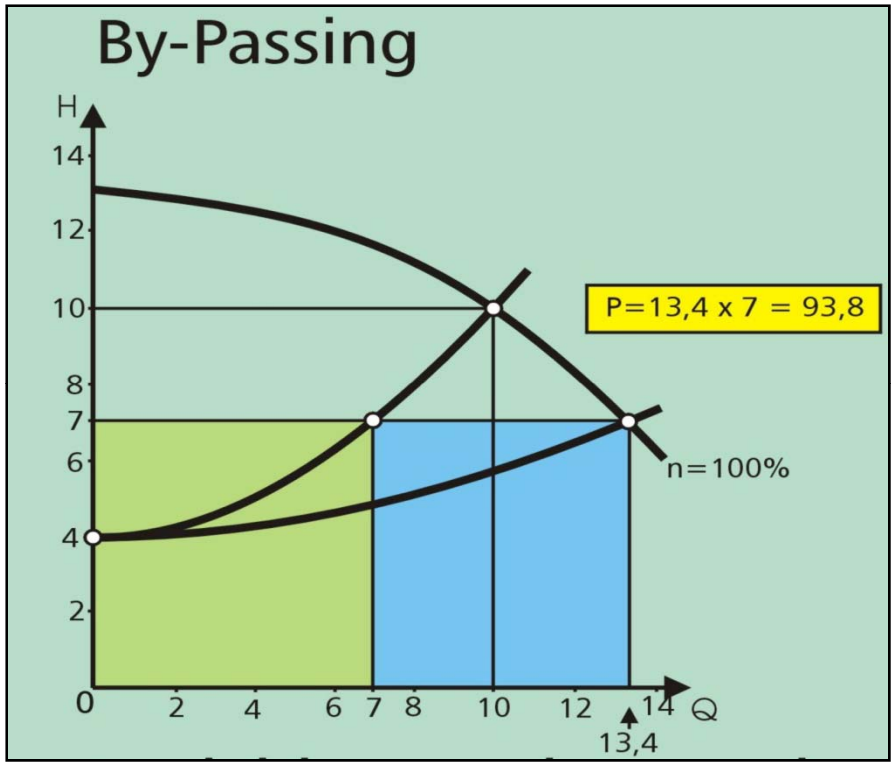
H = Head

Q = Flow

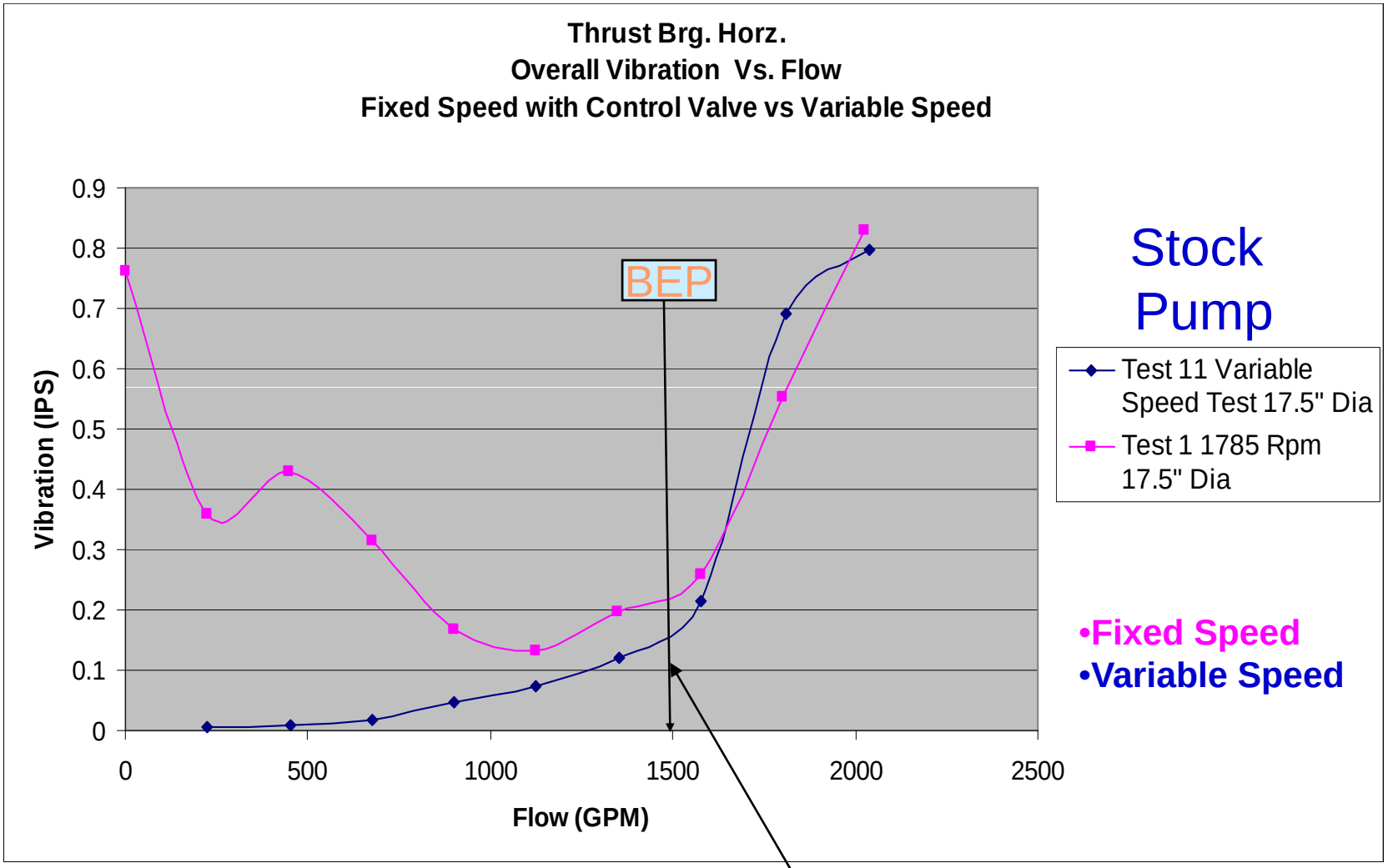
● = operating point



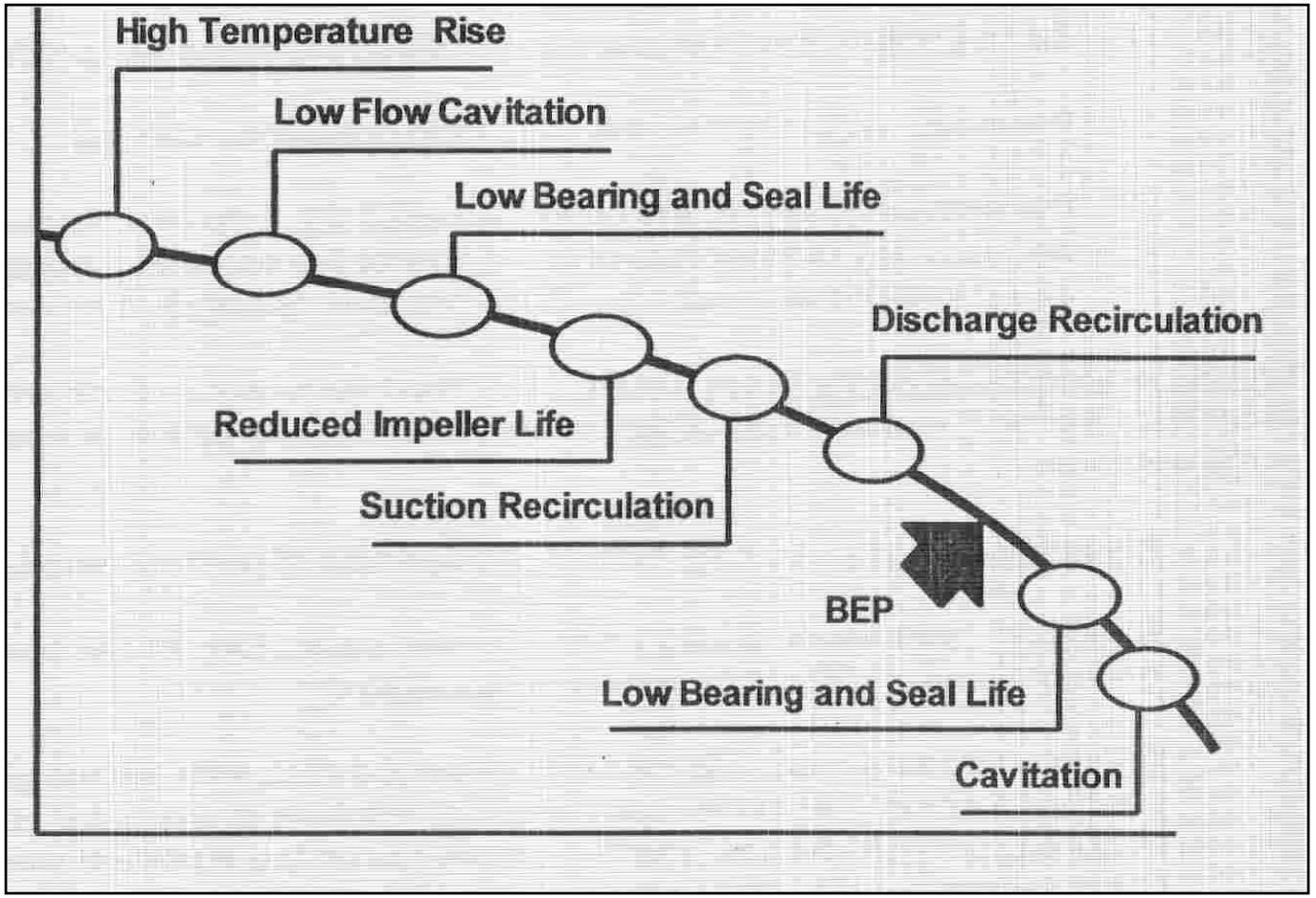
- Valve throttling results in excess power consumption
- Excess energy noted in blue area.



- Bypass lines consume excess power consumption.
- Excess energy noted in blue area.

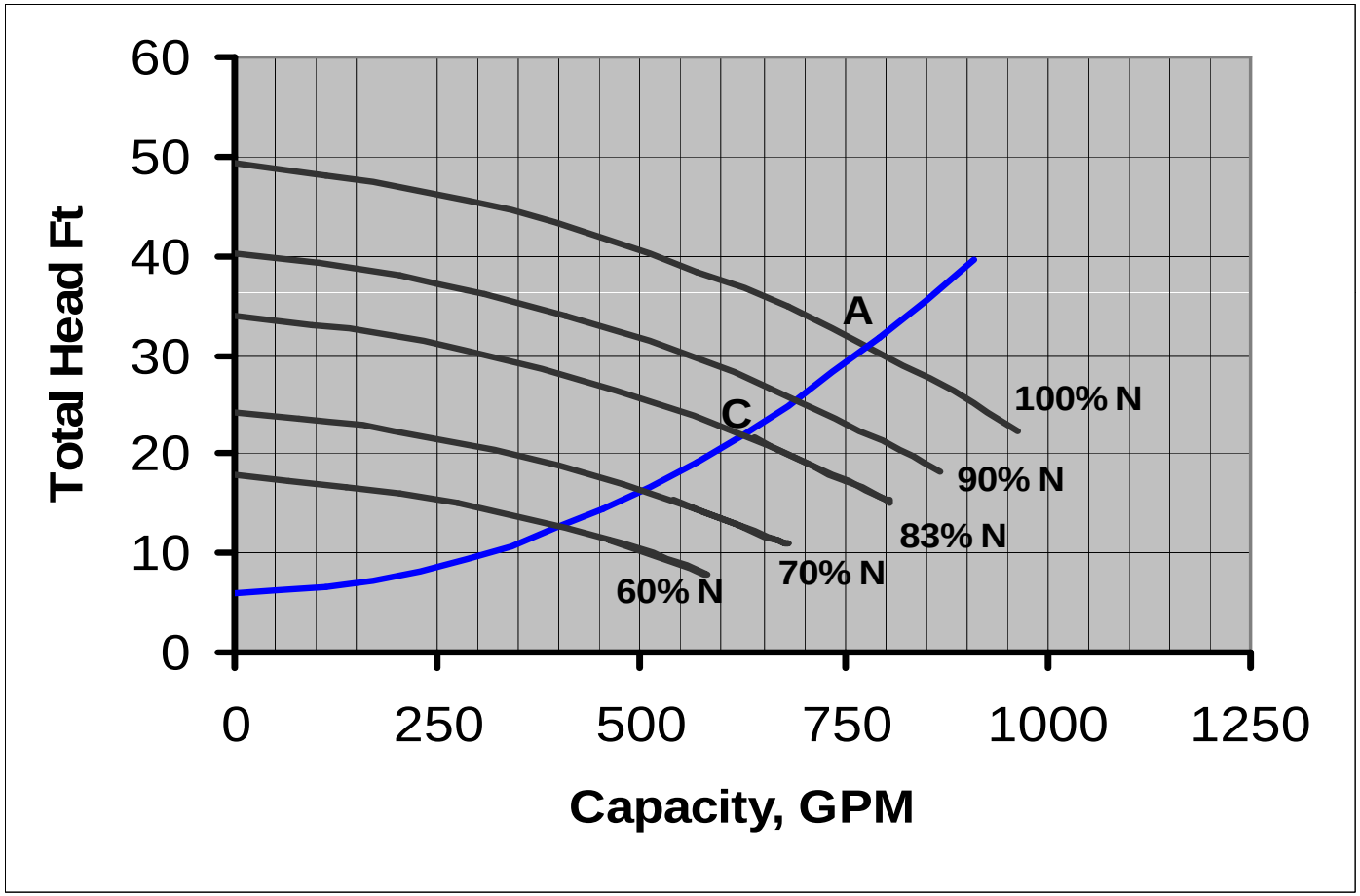

Thrust Brg. Horz.
Overall Vibration Vs. Flow
Fixed Speed with Control Valve vs Variable Speed
Vibration (IPS)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
500
1000
1500
2000
2500
Flow (GPM)
BEP
Stock Pump
Test 11 Variable Speed Test 17.5" Dia
Test 1 1785 Rpm 17.5" Dia
•Fixed Speed
•Variable Speed
BEP = 1500 GPM

Reliability Issues Relative to BEP

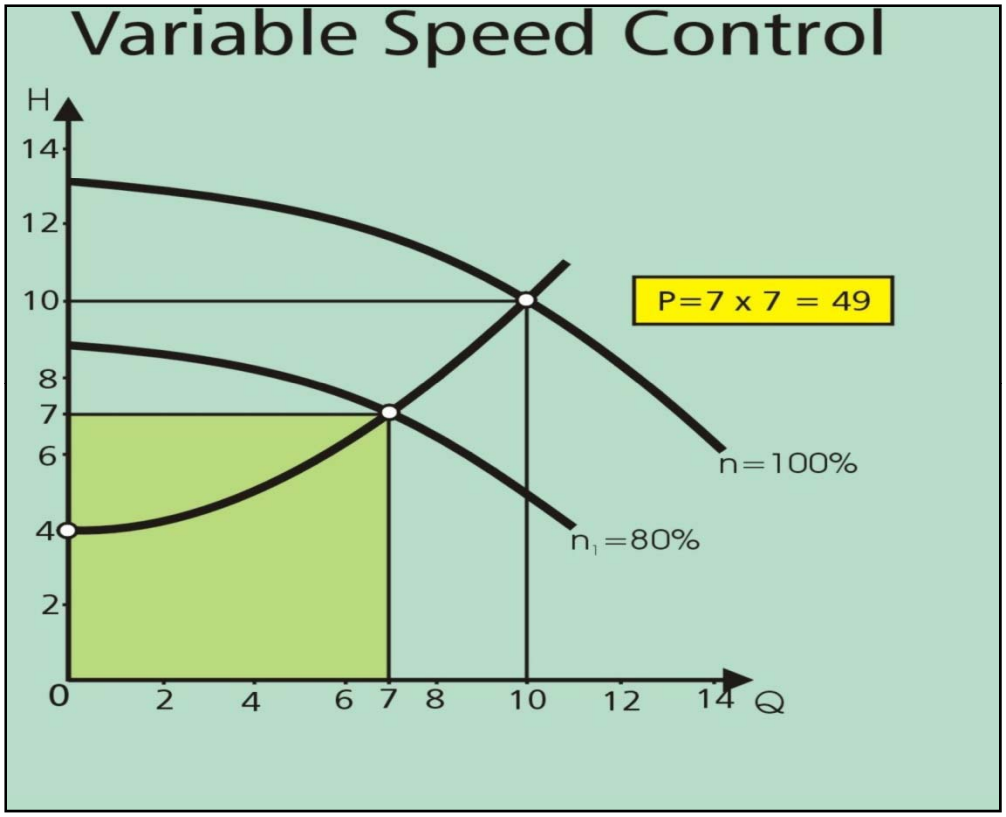


Pump Performance Curve

Variable Speed: *Maximizes HQ Flexibility*

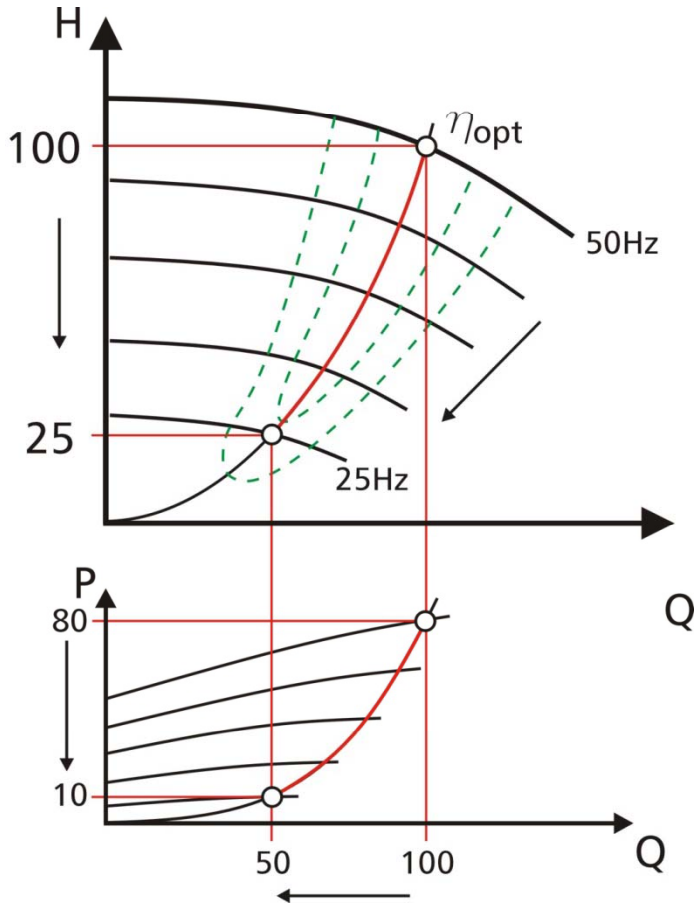


N = Speed



- Variable speed control meets the exact flow and head requirements
- No excess energy is consumed!

Affinity Laws in Action



P = Power

Energy savings are possible because of affinity laws.

Speed reduction provides significant energy savings at partial load.

The reduction of the speed provides:

- **Flow reduction according to the <u>linear</u> function**
- **Head reduction according to a <u>square</u> function**
- **Power reduction according to a <u>cubic</u> function!**

Variable Speed Control

Opportunities and Benefits

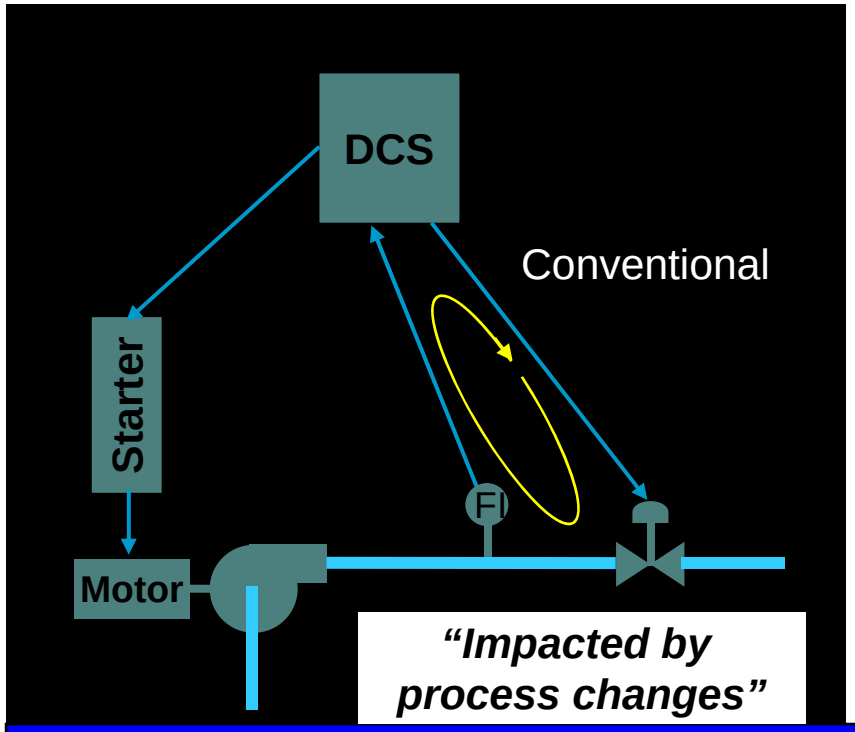
U.S. Motor Systems
Market Opportunity Assessment

"Motor systems equipped with VSD's account for only 4% of motor energy usage, compared to the potential for application on 18 - 25% of the total energy used…"

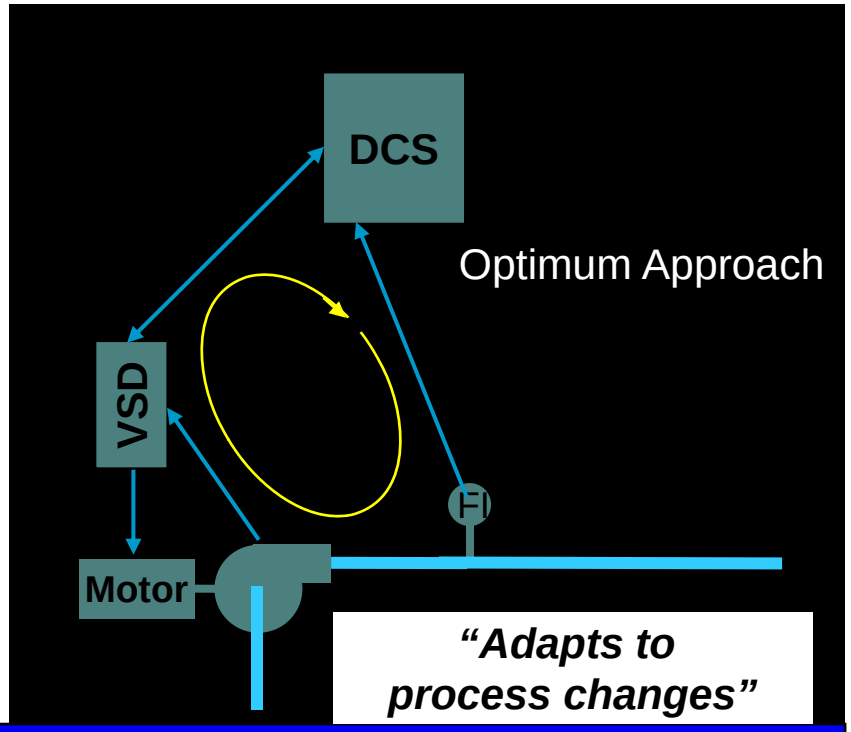
Source: DOE-Office of Industrial Technology

Pumping System Elements

Traditional Pumping System
(Fixed speed pump, control valve, transmitter)



Variable Speed Drive Pumping System

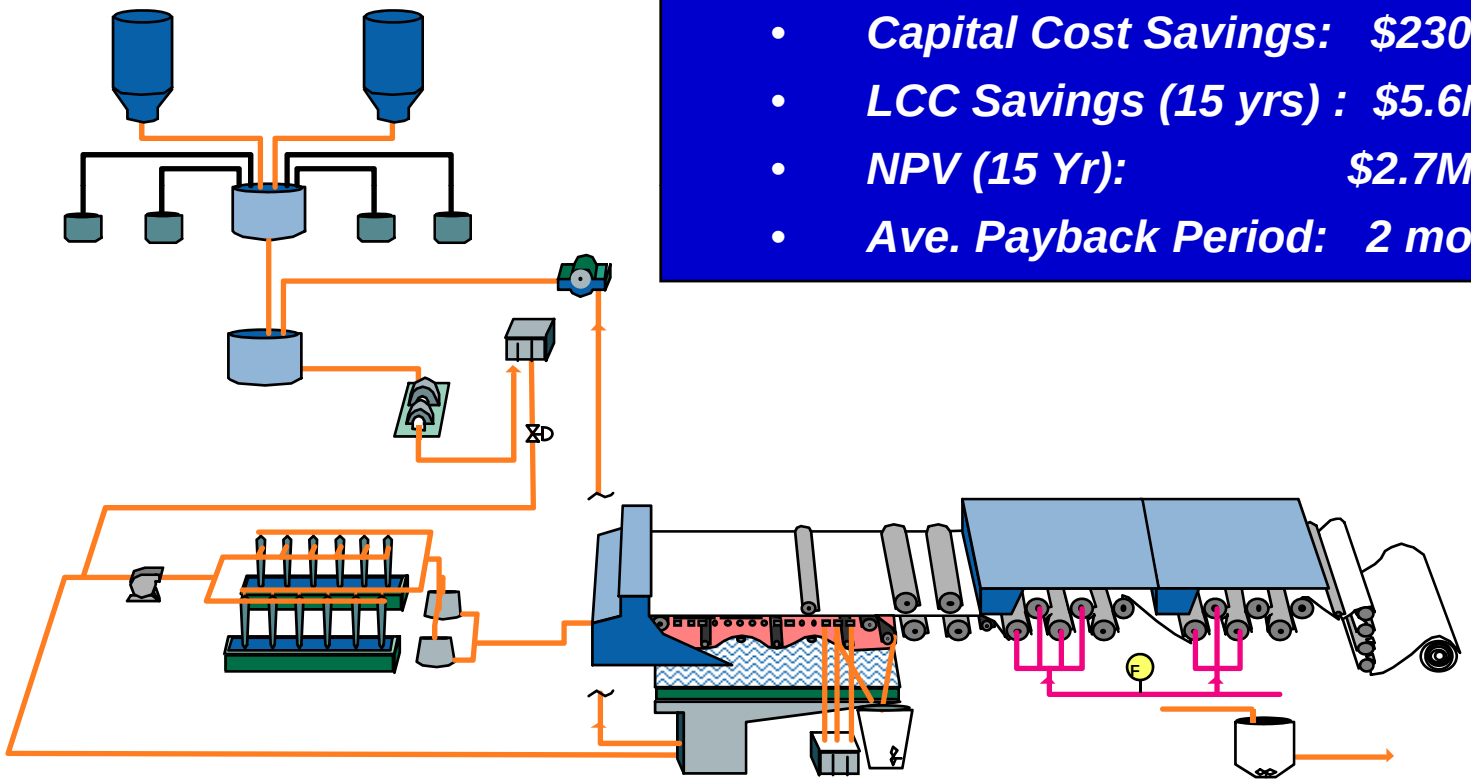


Control loops are tightly associated with pumping systems

Paper Machine Rebuild
VFD Savings Potential for 30 Pump Systems

LCC Analysis of 30 pumps w/VFD:

- ***Capital Cost Savings: $230K U.S.***
- ***LCC Savings (15 yrs) : $5.6M***
- ***NPV (15 Yr): $2.7M***
- ***Ave. Payback Period: 2 months***



"Motor and Valve Performance Can Make or Break Your Bottom Line"

Fine Paper Machine Rebuild Project

30 Applied VFDs / Life Cycle Performance Savings

11/18/2002

Service	Initial Capital Savings	Installation Savings	Total Installed Cost Savings	(15 yr) Energy Savings	(15 yr) Maintenance Savings	(15 yr) Total Savings	Payback (months)	Net Present Value (NPV)
Dilution Pump From No 3 PM	$1,206	$14,006	$15,212	$57,169	$31,748	$88,917	Immediate	$53,956
Uncoated Broke Storage	$1,316	$10,116	$11,432	$44,571	$34,855	$79,426	Immediate	$46,271
HW Chest Pump	($794)	$8,006	$7,212	$43,221	$30,377	$73,598	1.9	$39,857
HDHW Storage	($91)	$8,708	$8,617	$49,398	$35,811	$85,209	0.2	$46,383
Couch Pit Trim	$316	$7,116	$7,432	$36,138	$33,946	$70,084	Immediate	$38,458
Transfer Pump	($208)	$20,952	$20,744	$289,295	$35,889	$325,184	0.1	$165,852
Coated Broke to Mix Chest	($2,450)	$6,350	$3,900	$125,788	$35,576	$161,364	2.7	$77,205
Refined Kraft Chest Pump	($3,304)	$5,496	$2,192	$122,433	$30,642	$153,075	3.9	$71,462
Reel Pulper Pump	($7,229)	$21,788	$14,559	$355,976	$4,382	$360,358	3.6	$176,622
Saveall WW Pulper Dilution	($7,229)	$13,571	$6,342	$322,546	$28,301	$350,847	3.7	$164,967
SW Storage Diluted	($3,304)	$5,496	$2,192	$127,465	$25,081	$152,546	3.9	$71,222
White Water Cleaner Feed	$316	$7,116	$7,432	$19,859	$37,735	$57,594	Immediate	$32,787
Press Feed	($2,208)	$14,952	$12,744	$128,675	$25,481	$154,156	2.6	$81,053
Couch Pit Pump	($2,208)	$14,952	$12,744	$128,675	$25,481	$154,156	2.6	$81,053
White Water Chest Pump	$696	$17,496	$18,192	$132,562	$34,990	$167,552	Immediate	$92,321
SWHD Storage	($2,104)	$6,696	$4,592	$94,648	$37,020	$131,668	2.9	$63,885
Silo Cleaner Dilution Recirc	($450)	$12,350	$11,900	$94,432	$35,677	$130,109	0.6	$66,608
SiloPump to Cleaner Dilution	($37,453)	$3,347	-$34,106	$626,382	$28,852	$655,234	10.3	$267,063
Cleaner Final Stage Feed	($109)	$4,691	$4,582	$29,485	$35,397	$64,882	0.3	$33,551
Cleaner Stage 4 Feed Pump	($1,304)	$11,496	$10,192	$130,776	$25,529	$156,305	1.5	$80,071
GW Storage Diluted	($3,304)	$5,496	$2,192	$124,475	$31,669	$156,144	3.8	$72,869
Cleaner Stage 3 Feed Pump	($3,319)	$12,881	$9,562	$211,210	$22,916	$234,126	3	$114,309
Cleaner Stage 2 Feed Pump	($21,352)	$3,448	-$17,904	$565,067	$23,794	$588,861	6.5	$251,351
Stuff Box pump	($1,012)	$15,788	$14,776	$162,036	$31,487	$193,523	0.9	$101,063
Machine Chest Pump	($1,012)	$15,788	$14,776	$148,141	$27,267	$175,408	1	$92,838
Mix Chest Pump	($1,012)	$15,788	$14,776	$133,530	$29,814	$163,344	1.1	$87,360
Coated Broke Chest Pump	$1,316	$10,117	$11,433	$43,268	$36,905	$80,173	Immediate	$46,612
Saveall Chest pump	$891	$7,691	$8,582	$13,536	$30,045	$43,581	Immediate	$27,451
Saveall Filtrate Pump	($208)	$20,952	$20,744	$200,571	$35,184	$235,755	0.2	$125,246
GWHD Storage	($3,304)	$5,496	$2,192	$124,475	$31,699	$156,174	3.8	$72,869
Totals Installation Cost Savings	**($98,911)**	**$328,146**	**$229,235**					
Totals LCC Savings				**$4,685,803**	**$913,550**	**$5,599,353**		
Mean Payback Period							**1.7**	
Total Net Present Value (NPV)								**$2,742,615**
Mean Net Present Value (NPV)								**$94,572**

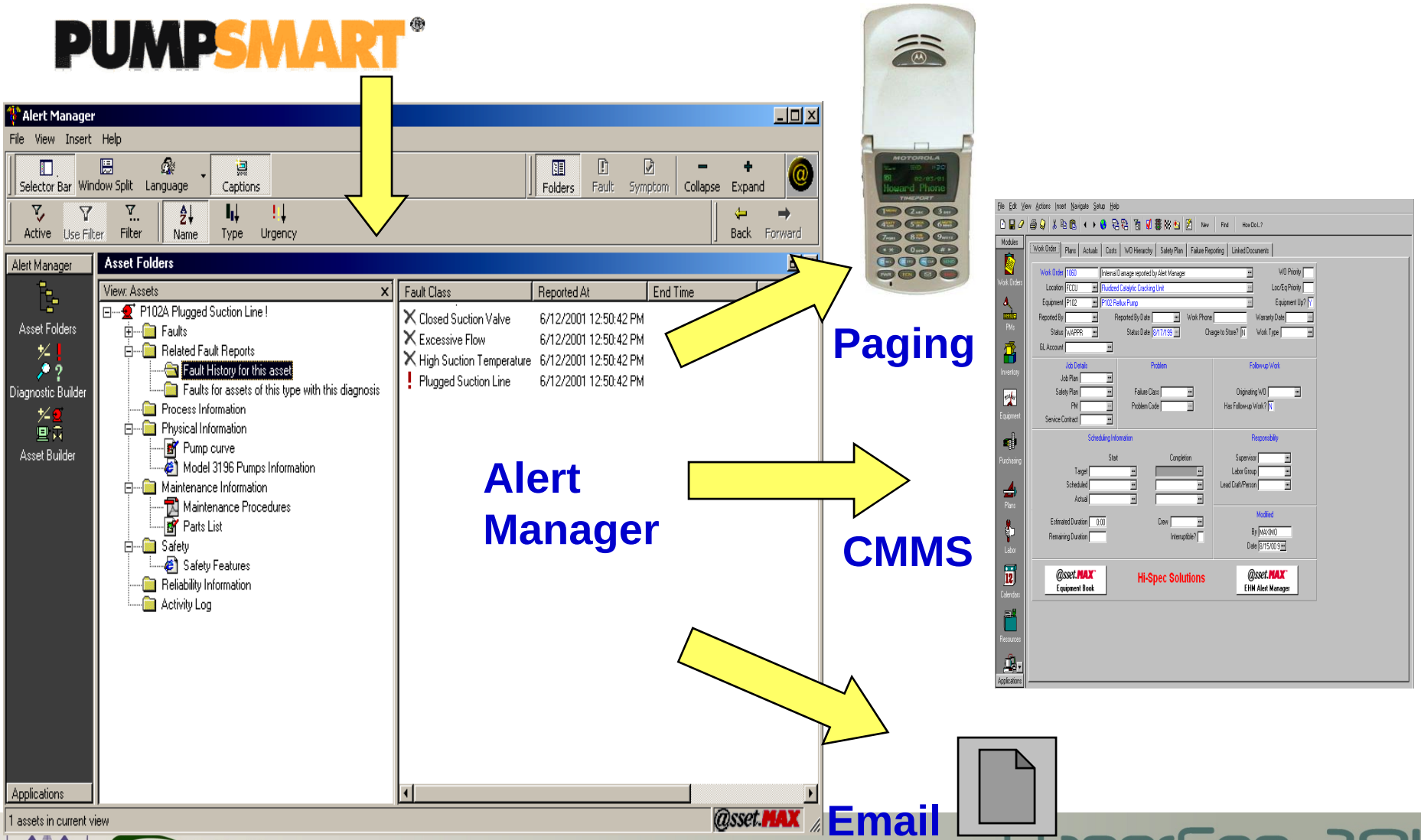
Asset Management

utilizing

Pump Intelligence

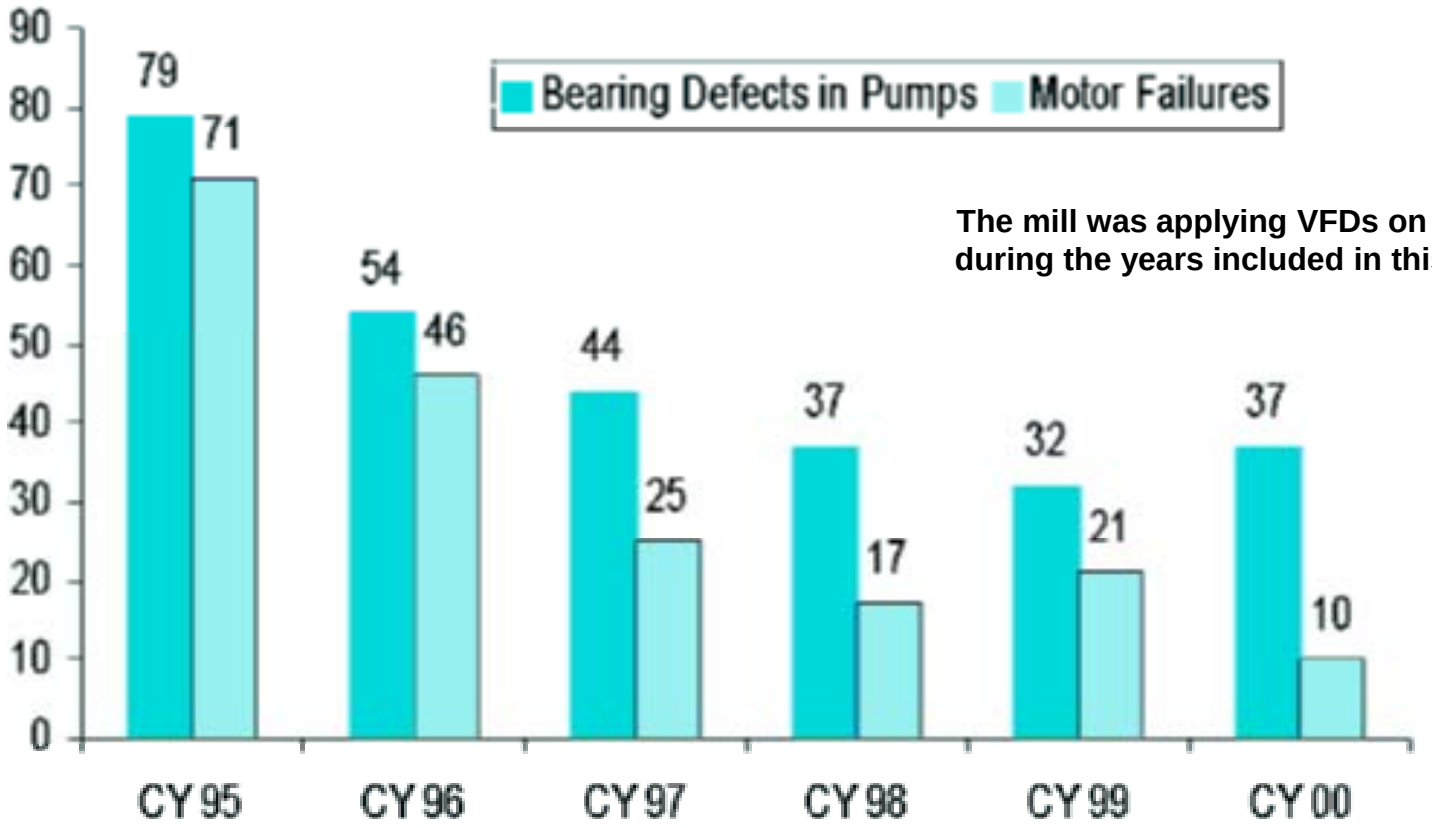
Asset Management Software

Operations, Maintenance and Engineering Support



PIMA TAPPI PaperCon 2011

RCM Reduced Pump Bearing and Motor Failures



The mill was applying VFDs on pumps during the years included in this study

TAPPI Solutions! Magazine: GP Old Town
September 01, 2001 Vol. 01, No. 01

RCM Steadily Increased Plant Availability

The mill was applying VFDs on pumps during the years included in this study

TAPPI Solutions! Magazine: GP Old Town
September 01, 2001 Vol. 01, No. 01

Building Leadership Excellence

Optimizing Pump System Performance

A Systems Design Approach

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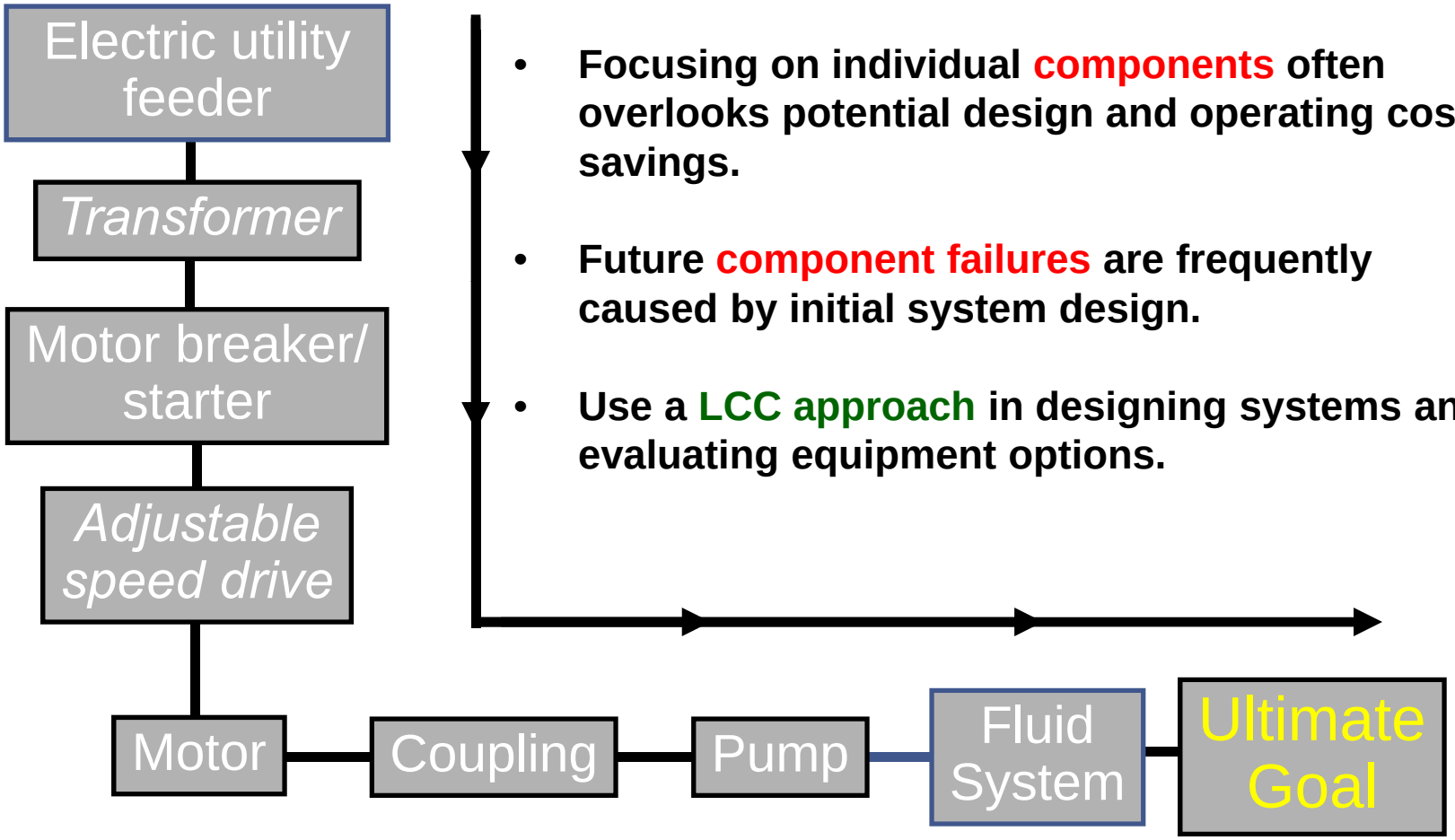
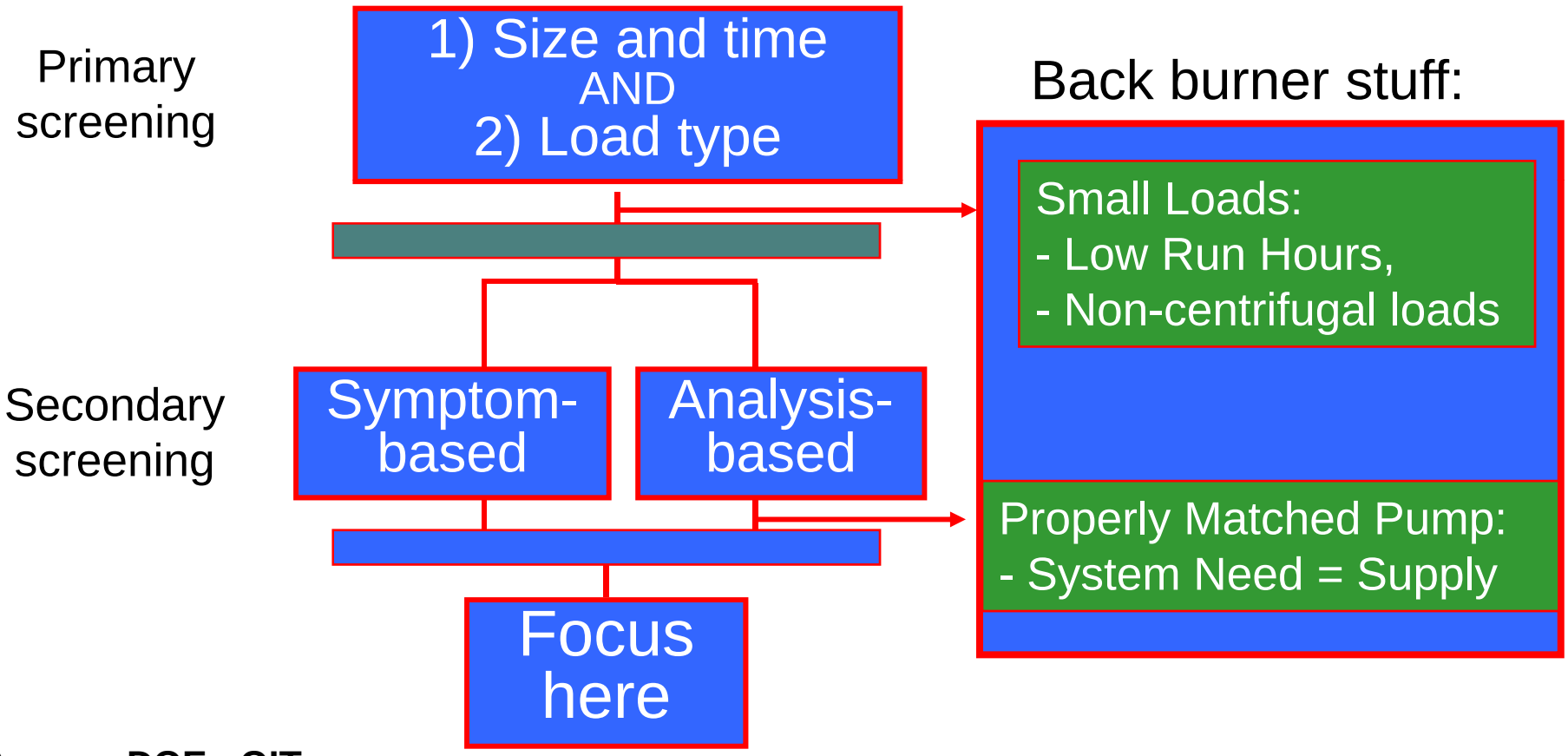
The Systems Approach



- **Focusing on individual components often overlooks potential design and operating cost-savings.**
- **Future component failures are frequently caused by initial system design.**
- **Use a LCC approach in designing systems and evaluating equipment options.**

Prescreening Methodology

First: Can it be turned off?



Source: DOE - OIT

Pump Symptoms that Indicate Potential Opportunity

- Throttled 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 process or frequent cycle operation in a continuous process
- Presence of cavitation noise (at pump or elsewhere in the system)

Energy Savings Methods

Action	Saving
Replace throttling valves with speed controls	10 - 60%
Reduce speed for fixed load	5 - 40%
Install parallel system for highly variable loads	10 - 30%
Equalize flow over product cycle using surge vessels	10 - 20%
Replace motor with more efficient model	1- 3%
Replace pump with more efficient model	1- 2%

Source: DOE - Office of Industrial Technology

Pump Optimization Benefits Summary

- Reduce Energy and Maintenance Cost
- Improve Pump and Process Reliability
- Increase Process Uptime and Throughput
- Improve Process Control & Quality
  - less variability
  - higher % of loops in automatic
- Reduce Fugitive Emissions

High Reliability Impact VFD Applications

- Mill Water Supply
  - Pressure control
- Seal Water Supply
  - Pressure control
  - Reduce process downtime
- Stock Blending
  - Consistency control
  - Improve product quality
- WW Dilution
  - Consistency control
- Machine Chest
  - Basis Weight MD control
  - Improve PM performance
- Broke Chest
  - Reduce Energy & Maintenance
- Repulper Chest
  - Reduce Energy & Maintenance

"There are many high impact applications that improve bottom line performance"

Holistic Pump System Designs

Thank You!

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