Making Effective Decisions about

Energy Efficiency Improvements

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ISC Background

Industrial Systems and Control Ltd.

- ❒ Founded 1987, University spin out
- ❒ Control Engineering Consultancy and Training
- ❒ Initially marine & metals Industries
- ❒ Now process, power, utilities and automotive

Applied Control Technology Consortium

- ❒ Started in 1990 with (3 yrs.) DTI funding
- ❒ Large end-users of control – BP, Shell, RWE, British Energy, Scottish Power, BAE Systems

Overview

- Consider only energy savings from process / operations
  - From Simple operational changes to full optimisation
  - New equipment selection
  - "Moving" energy consumption

- How to decide what to do:
  - Top-level audits / energy mapping
  - Detailed analysis of process energy usage

Energy Audits

- Top-level Surveys
  - Identify energy usage – incl. buildings / people
  - Identify "quick wins"
  - Assessment of process itself maybe too complex
  - Can be free of charge !! e.g. Carbon Trust

- Routine Inspections:
  - Period inspection of air / steam leaks, lagging
  - Fix anything broken

Audit of Energy Users: Example

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- Compile list of energy consumers in process - mainly motors driving pumps and blowers
  - ❒ fixed or variable speed
  - ❒ on-off control or throttled flow
  - ❒ Rate by kW, duty, run-time
  - ❒ Calcs give crude estimate of energy savings (e.g. fixed speed to VSD)
- Can then prioritise energy users by potential savings

The "Affinity" Law

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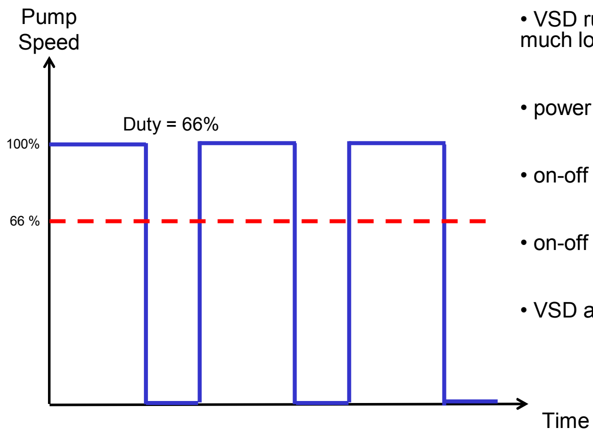
Savings Example: On-Off to VSD



- VSD runs at same average speed, but much lower average power
- power $\propto$ (speed)^3
- on-off ave speed = 66%
- on-off ave power = 0.66 * f.s. power
- VSD ave power = $(0.66)^3$ * f.s. power
  = 29% of f.s. power

Energy Saving: 56%

Throttled Flow Energy Losses

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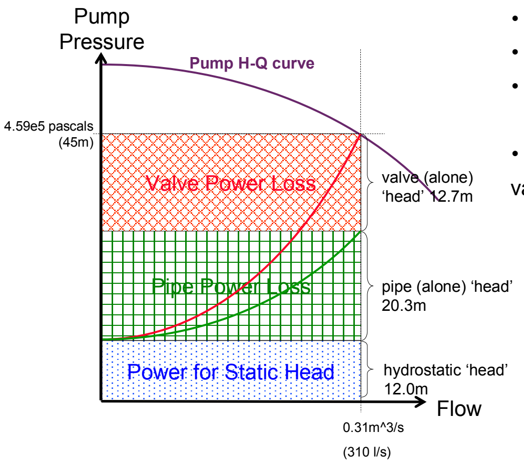
Savings Example: Throttled Flow to VSD



- Consider pressure drops
- Estimated from pipe-work dimensions
- VSD can only save 'Valve Power Loss'

- Saving can be calculated as:

valve loss kW = valve Δ press.*flow*1e-3

= (12.7*1e3*9.81)*0.31*1e-3

= **38.62 kW**

Energy Saving: 28%

Effect of Operating Point on Energy

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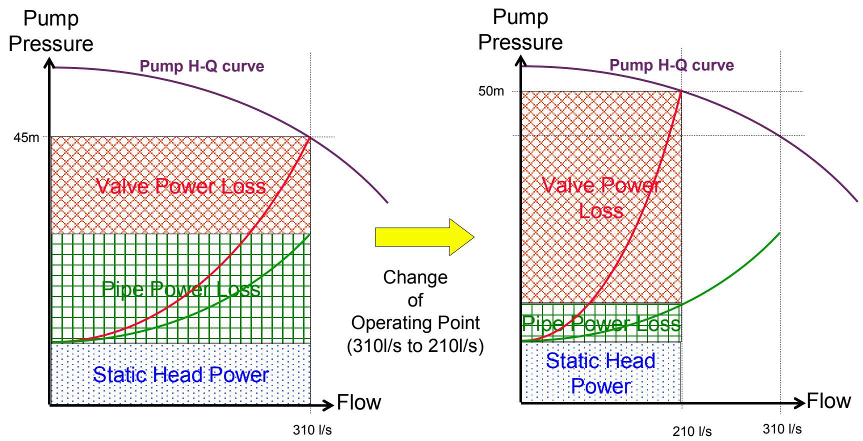

Note that as flow decreases…………

Typically - Valve Power Loss increases ……..

Which means Energy Savings potential increases

Energy Efficiency Audit Tools

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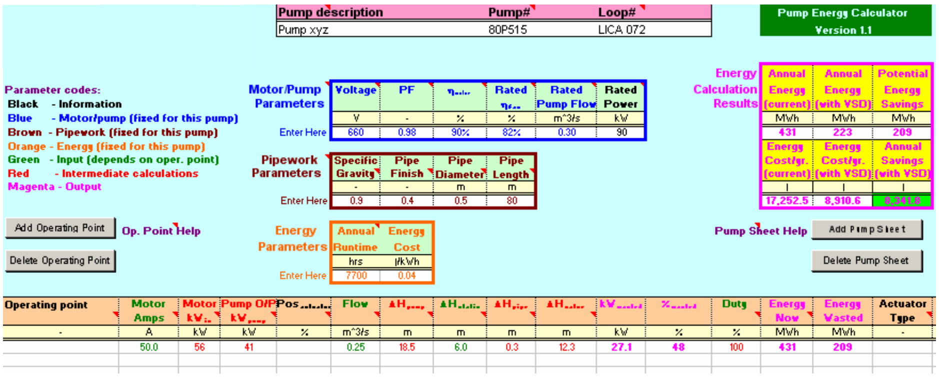
- ISC developed a spreadsheet for audits:



Detailed Analysis of Energy Use

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- Often need more detailed analysis:
  - For more accurate estimates of energy savings
  - When process is more complex – as usually is
  - Exploration of alternative scenarios

- Often simpler to use high-fidelity dynamic models
  - Use of static models (as simple audits) becomes cumbersome
  - Can identify new, optimal ways to operate
    - operations, control settings / strategies, new equipment

Simple Dual Pump Example

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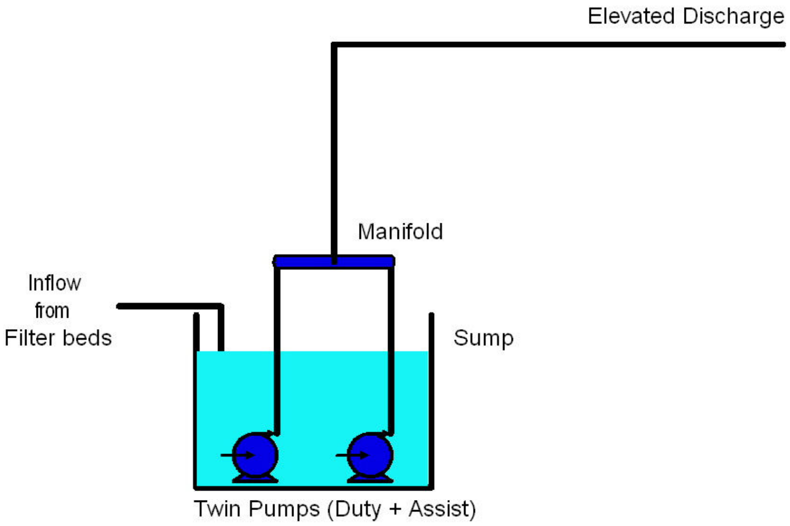

Mathematical Model

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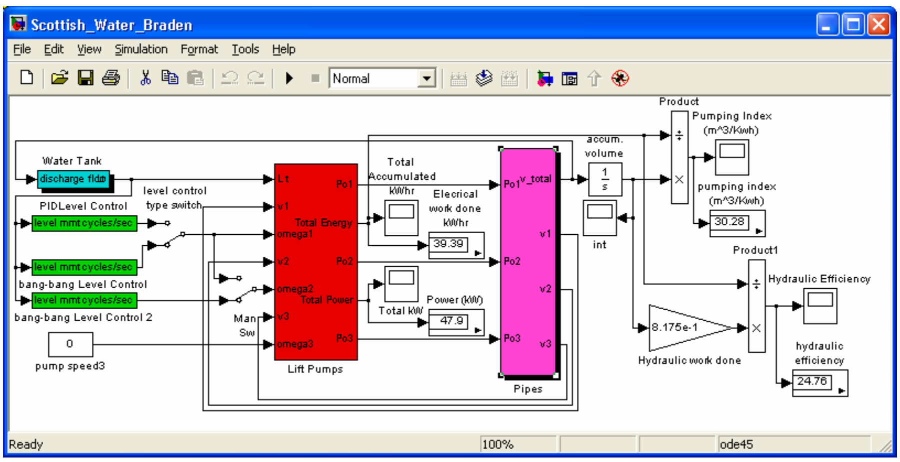
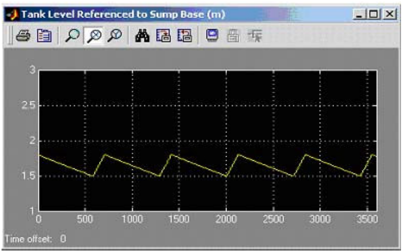
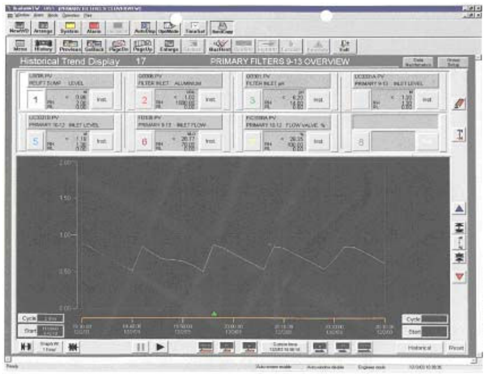


Model Validation



Model Tank Level Trend



Actual Tank Level Trend

Study and Practical Results

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	Model Prediction		Pumping Station Results	
Level Control Strategy	kWh Supplied (1 hour)	Energy Savings (%)	kWh Supplied (1 hour)	Energy Savings (%)
On-Off control	39.39 kWh		70 kWh	
Single pump VSD	29.2 kWh	25.6%		
Dual pump VSD	13.99 kWh	64.5%	26.5 kWh	62.2%

- Can explore additional “no cost” options:
  - Tighter level control – can raise average level – and so reduced lift

Detailed Energy Analysis

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- Advantages of using high-fidelity dynamic model:
  - Can look at any scenario
    - e.g. varying demands, varying tariffs
  - Look for other energy saving opportunities
    - e.g. effect of raising level SP in previous example
  - Can extend to much more complex processes
  - Can be used for any process, not just pumping

Example: Multiple Pumping

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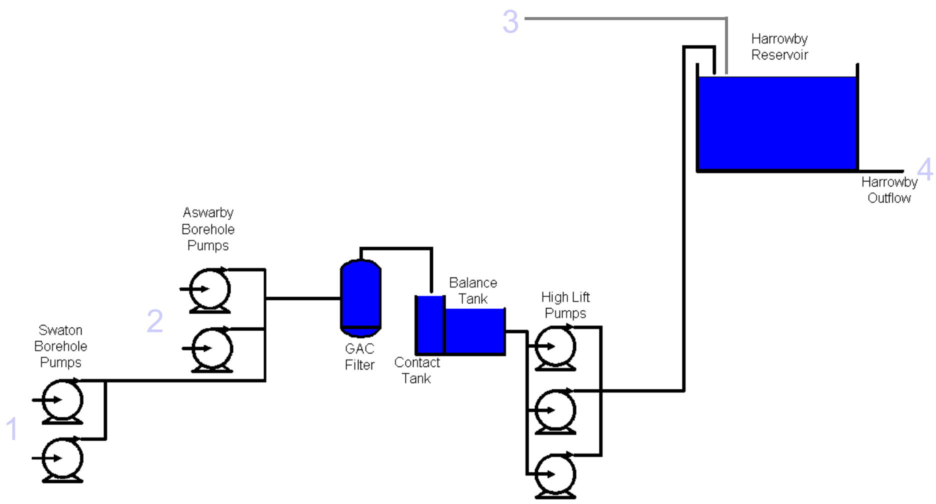

“What if?” Scenario Results

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Scenario	24 hr period Total Pump Energy (kWh)	Overall Energy Saving %
Current (validation model)	2786	-
Test #1 (BHP onoff, HLP PID)	2799	0.47% (higher)
Test #2 (all PID)	1905	32% (lower)
Test #3 (Asw & HLP PID, Swa off)	1883	32% (lower)
Test #5 (Swa & HLP PID, Asw off)	2197	21% (lower)
Test #6 (Swa & HLP PID, Asw onoff)	2551	8.4% (lower)
Test #7 (Asw & HLP PID, Swa onoff)	2328	16% (lower)
Test #8 (Asw & HLP onoff, Swa off)	2783	0.11% (lower)
Test #9 (BHP PID, HLP onoff)	2049	26% (lower)
Test #4 (bypass GAC plant)	2759	0.97% (lower)

Pumpsim Modelling Toolbox

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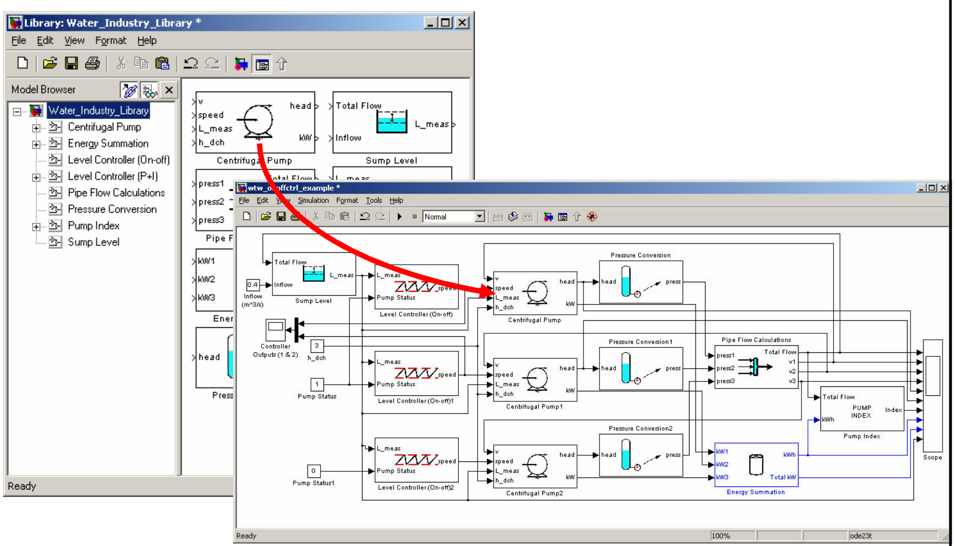

Other Energy Investigations

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- WWTP
  - investigate DO control strategies - 5-7% energy saving predicted (simple control changes), 20-30% if use MPC
- Steel Reheat Furnace
  - Trade-off between fuel-gas usage and production rates
  - Formal optimisation (using nonlinear MPC) estimated savings
- Coal-Fired Power Station
  - Benefits study of advanced control to give tighter temperature control
  - Allowing increase in superheater temp, increasing overall efficiency

Moving Energy Consumption

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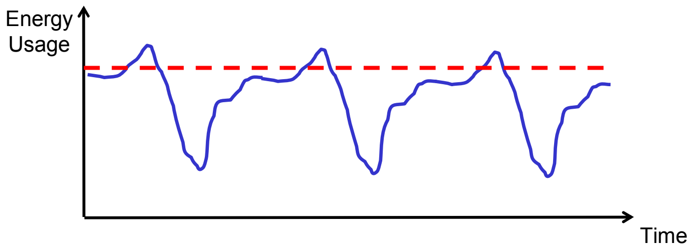
- Energy prices not constant:
  - If vary wrt time – move peak energy consumption to cheaper periods
  - If vary wrt consumption – use inventory in process to smooth demand
- Process needs to have predictable energy consumption



Concluding Message:

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- If energy savings are obvious:
  - Implement them!!
- Sometimes ROI / benefits are not clear:
  - Spend a bit of time considering options
  - Simple analysis can be useful
- Occasionally a detailed study needed:
  - e.g. when need more confidence or if complicated by other factors
  - call in outside help
  - factor in study cost into possible ROI

Contact Details

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