Catching Energy Thieves in your Pump Stations

Tom Walski

Bentley Advancing Infrastructure

Which pump is wasting energy?

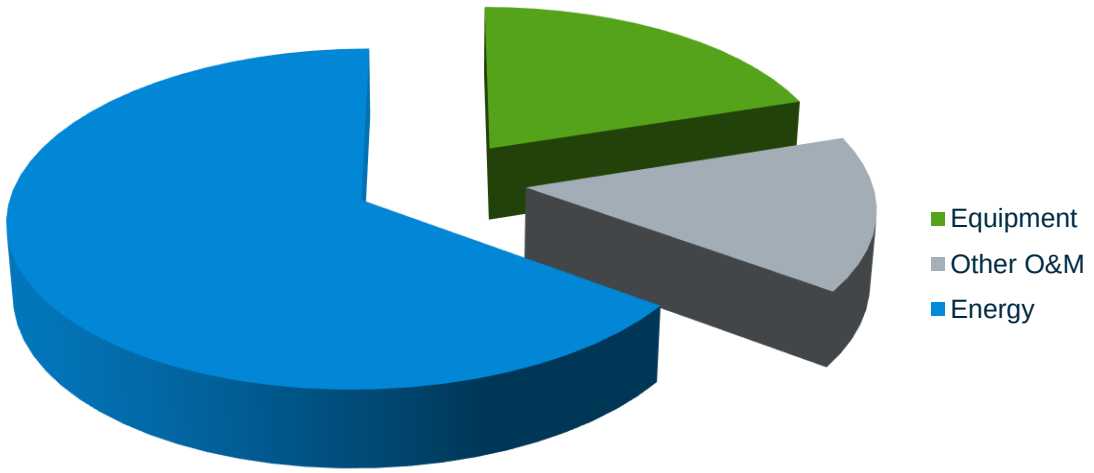
Energy

- Pump energy can be major O&M cost
- Major portion of life-cycle cost
- Depends on type of system
- Energy savings are achievable

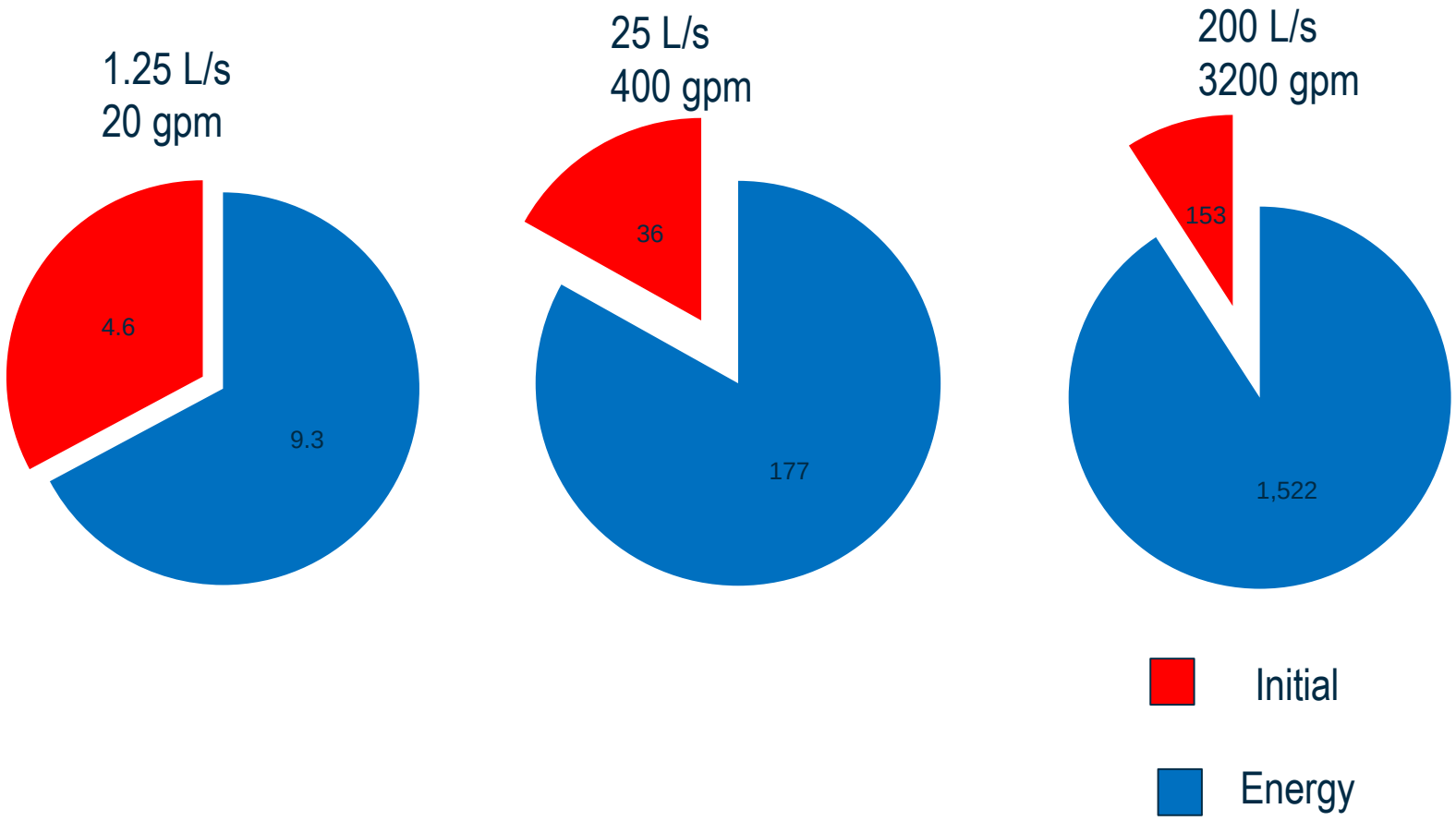
Bentley Advancing Infrastructure

Base Pump Selection on Life-Cycle Costs

Cost = Equipment + spwf (Energy + O&M)



Relative Energy vs. Initial Cost



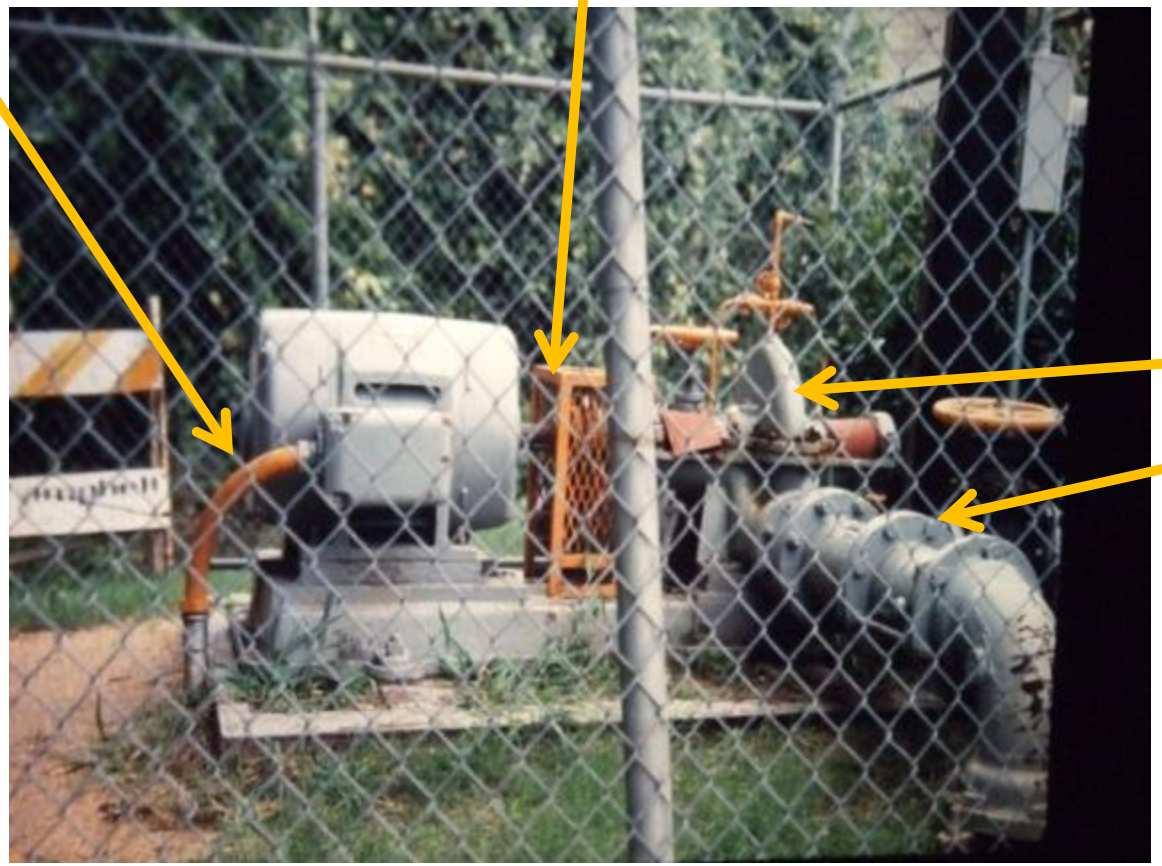
H = 130 ft, 40 m, Cost average over configurations

Energy Savings

- Design-Pump Selection
  - Base on life-cycle costs
  - Tradeoff between piping and pumping
  - Don’t just analyze design point
  - Consider range of operation
- Operation
  - Analyze pumping strategies
  - Minimize demand charges
  - Beware of bad combinations
  - Monitor energy bills

Wire Power In

Brake (Motor) Power



Water Power Added

Overall (wire-to-water) Efficiency = Water Power/Input Power

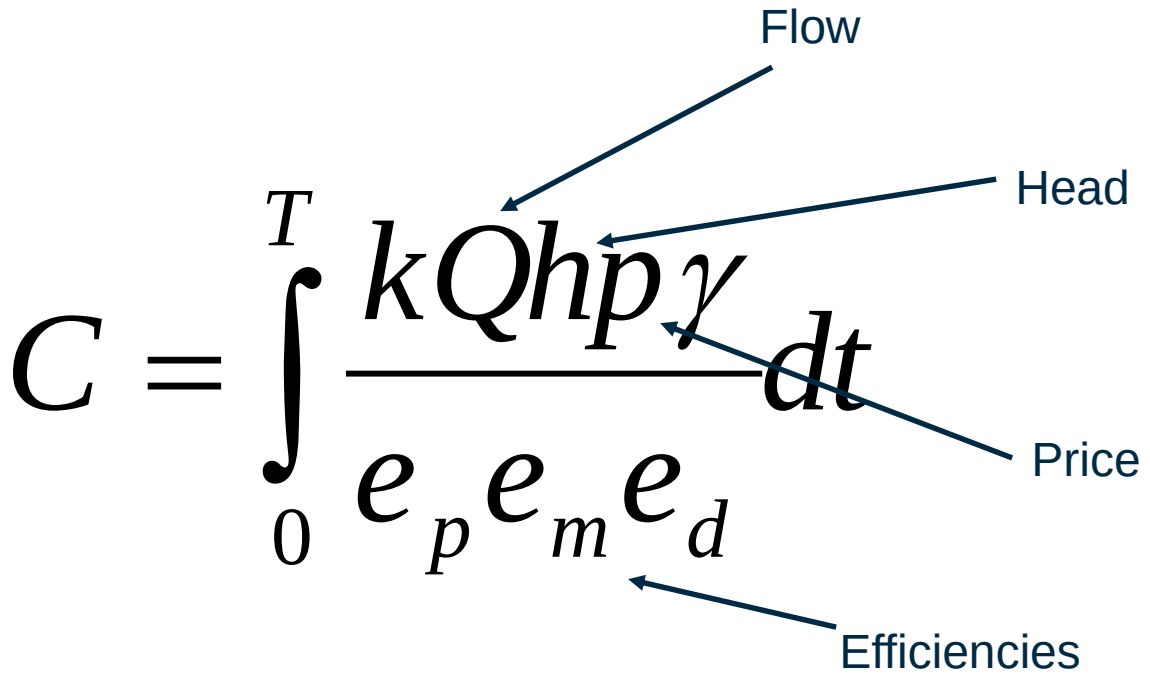
Pump Efficiency = Water Power/Motor Power

Bentley Advancing Infrastructure

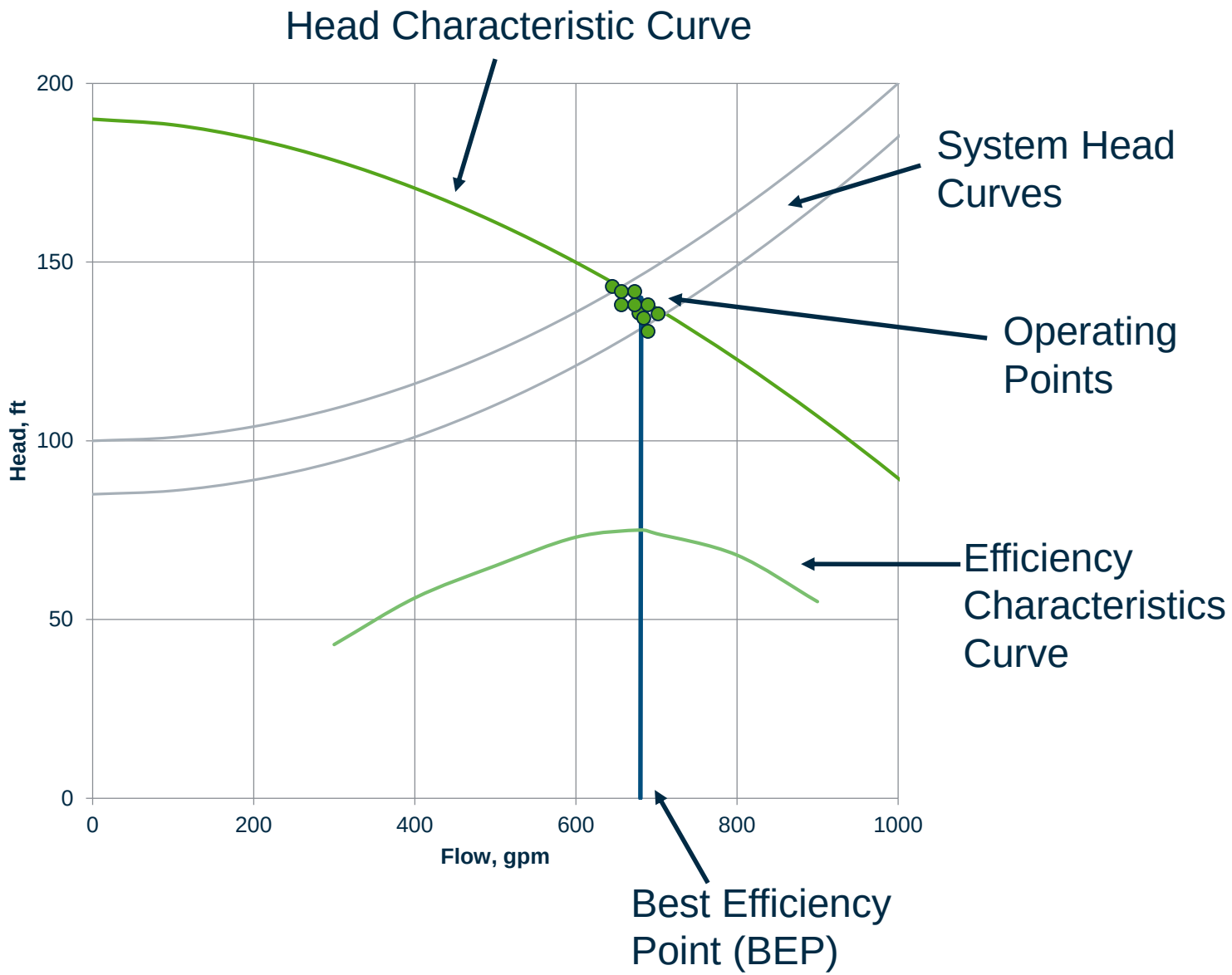
Calculating What Energy Cost Should Be

Don’t just calculate at Best Efficiency Point

Operation varies over the day, season, long term



$$C = \int_0^T \frac{kQhp\gamma}{e_p e_m e_d} dt$$



Converting Energy to Cost

Energy Cost

- More than kwh x $/kwh
- Energy pricing complicated
- Complicating factors
  - Peak demand charge
  - Time-of-day pricing
  - Block rates
  - Block rates as function of peak
  - Multiple rates
  - Seasonal rates
  - Multiple energy providers
  - Take or pay conditions
  - Open energy market

Bentley Advancing Infrastructure

CANCELLING MO.P.S.C. SCHEDULE NO. 5 — 29th Revised — SHEET NO. 34

APPLYING TO MISSOURI SERVICE AREA

SERVICE CLASSIFICATION NO. 3(M)
LARGE GENERAL SERVICE RATE

* Rate Based on Monthly Meter Readings

Summer Rate (Applicable during 4 monthly billing periods of June through September)

Customer Charge - per month	$83.04
Low-Income Pilot Program Charge - per month	$ 0.50
Energy Charge - per kWh	
First 150 kWh per kW of Billing Demand	9.30¢
Next 200 kWh per kW of Billing Demand	7.00¢
All Over 350 kWh per kW of Billing Demand	4.70¢
Demand Charge - per kW of Total Billing Demand	$ 4.34
Energy Efficiency Program Charge - per kWh (1)	0.05¢

Winter Rate (Applicable during 8 monthly billing periods of October through May)

Customer Charge - per month	$83.04
Low-Income Pilot Program Charge - per month	$ 0.50
Base Energy Charge - per kWh	
First 150 kWh per kW of Base Demand	5.86¢
Next 200 kWh per kW of Base Demand	4.34¢
All Over 350 kWh per kW of Base Demand	3.41¢
Seasonal Energy Charge - Seasonal kWh	3.41¢
Demand Charge - per kW of Total Billing Demand	$ 1.61
Energy Efficiency Program Charge - per kWh (1)	0.03¢

(1) Not applicable to customers that have satisfied the opt-out provisions of Section 393.1075, RSMo.

Optional Time-of-Day Adjustments

Additional Customer Charge - per Month $17.72 per month

Energy Adjustment - per kWh	On-Peak Hours (2)	Off-Peak Hours (2)
Summer kWh (June-September billing periods)	+1.10¢	-0.62¢
Winter kWh (October-May billing periods)	+0.33¢	-0.19¢

(2) On-peak and off-peak hours applicable herein shall be as specified in Rider I, paragraph A.

Fuel and Purchased Power Adjustment (Rider FAC). Applicable to all metered kilowatt-hours (kWh) of energy.

*Indicates Change.

Issued pursuant to the Order of the Mo.P.S.C in Case No. ER-2011-0028.

DATE OF ISSUE July 18, 2011 DATE EFFECTIVE July 31, 2011

ISSUED BY Warner L. Baxter (NAME OF OFFICER) President & CEO (TITLE) St. Louis, Missouri (ADDRESS)

Bentley® Advancing Infrastructure

COPEL
Companhia Paranaense de Energia

Vigência Para Adimplentes de 23/06/10 em diante

Os valores das tarifas não consideram os 15% desconto

TARIFA CONVENCIONAL SUBGRUPO A4			% Dif. Tarifa Anterior
Consumo	145,22	R$/MWh	-11,66
Demanda	32,82	R$/kW	28,28
Demanda Ultrapassagem	98,46	R$/kW	28,28

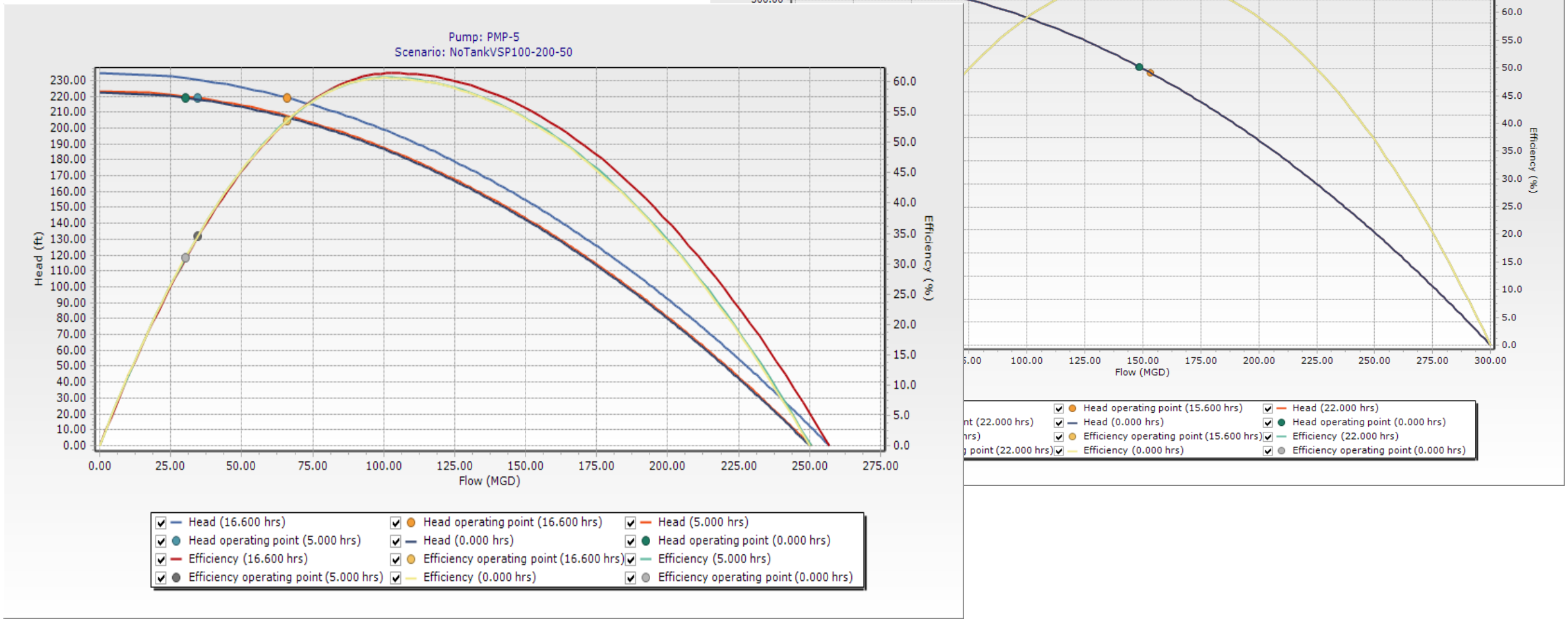
TARIFA HOROSSAZONAL AZUL SUBGRUPO A4			
Consumo Ponta Seca	222,21	R$/MWh	-6,60
Consumo Ponta Úmida	202,17	R$/MWh	-5,93
Consumo Fora de Ponta Seca	143,29	R$/MWh	-2,88
Consumo Fora de Ponta Úmida	131,66	R$/MWh	-1,96
Demanda Ponta	33,89	R$/kW	9,00
Demanda Fora de Ponta	8,42	R$/kW	10,81
Demanda Ultrapassagem Ponta	101,67	R$/kW	9,01
Demanda Ultrapassagem Fora de Ponta	25,26	R$/kW	10,85

TARIFA HOROSSAZONAL VERDE SUBGRUPO A4			
Consumo Ponta Seca	1009,17	R$/MWh	15,48
Consumo Ponta Úmida	989,13	R$/MWh	5,96
Consumo Fora de Ponta Seca	143,29	R$/MWh	-2,88
Consumo Fora de Ponta Úmida	131,66	R$/MWh	-1,96
Demanda	8,42	R$/kW	10,81
Demanda Ultrapassagem	25,26	R$/kW	10,85

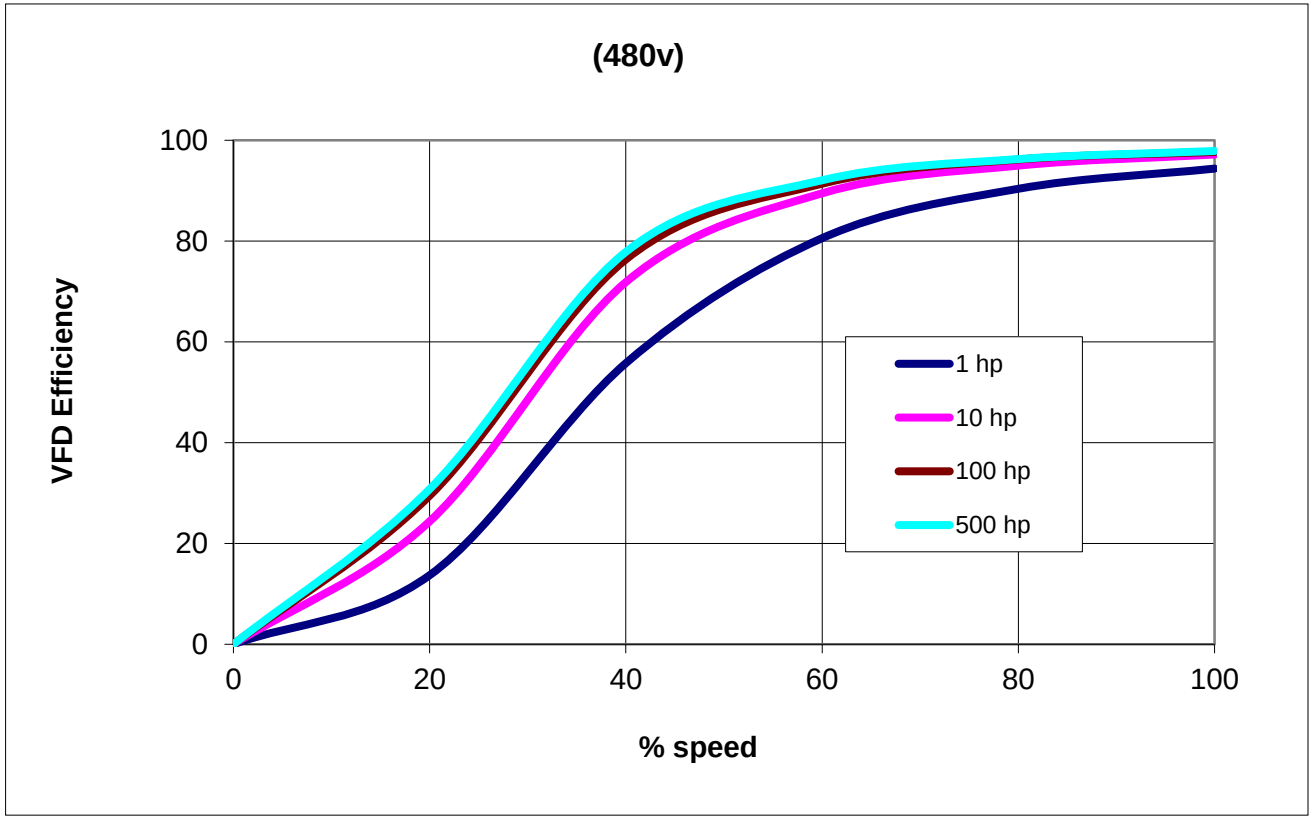
Descontos Percentuais - Água, Esgoto e Saneamento - Grupo A			media	6,20
Consumo	15	%		
Demanda	15	%		

Bentley® Advancing Infrastructure

VSP vs. Constant



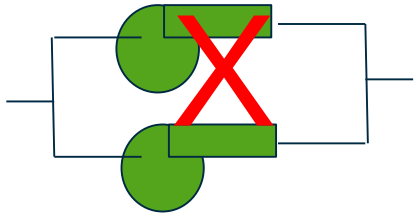
VFD Efficiency



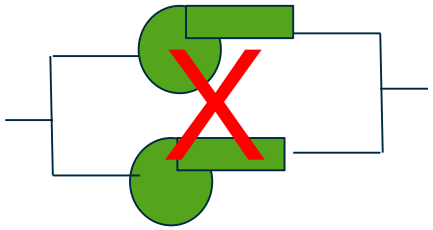
Bentley® Advancing Infrastructure

7 Configurations

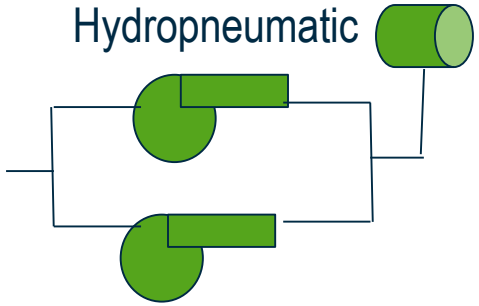
2 Constant Speed



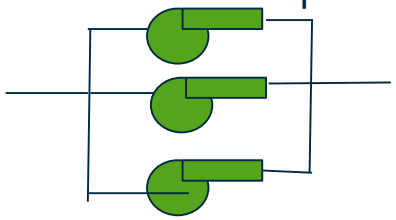
2 VSP



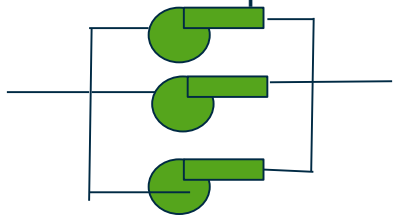
2 Constant + Hydropneumatic



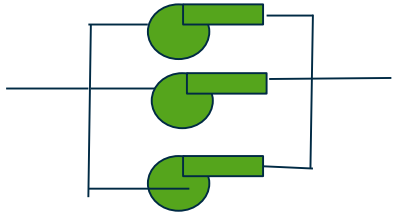
3 Constant Speed



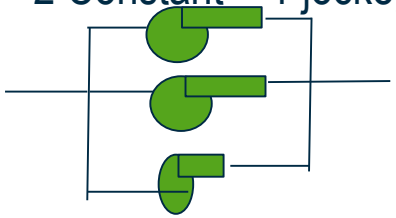
3 Variable Speed



2 Constant + 1 VSP



2 Constant + 1 jockey

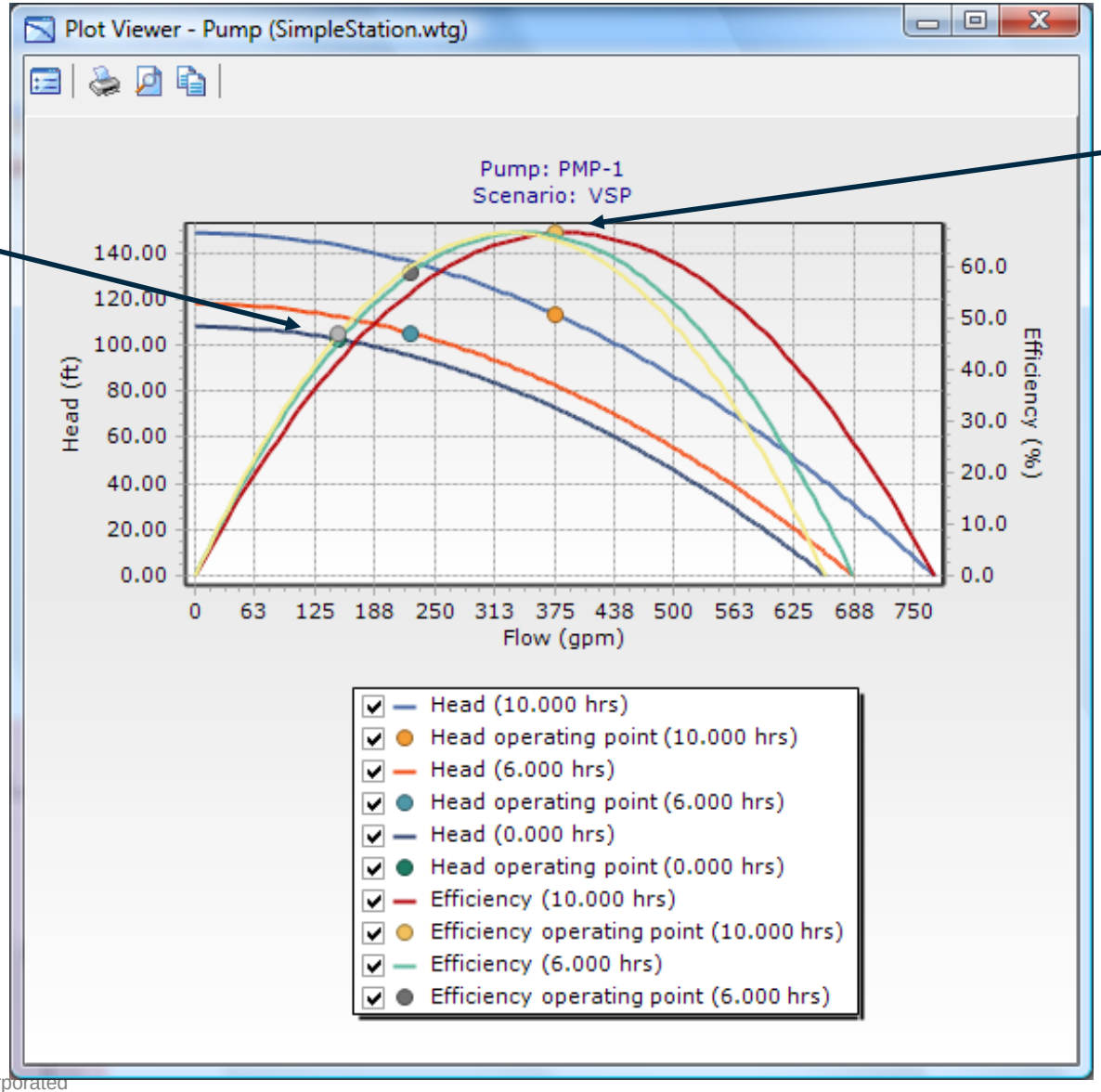


Bentley Advancing Infrastructure

View VSP Operating Points

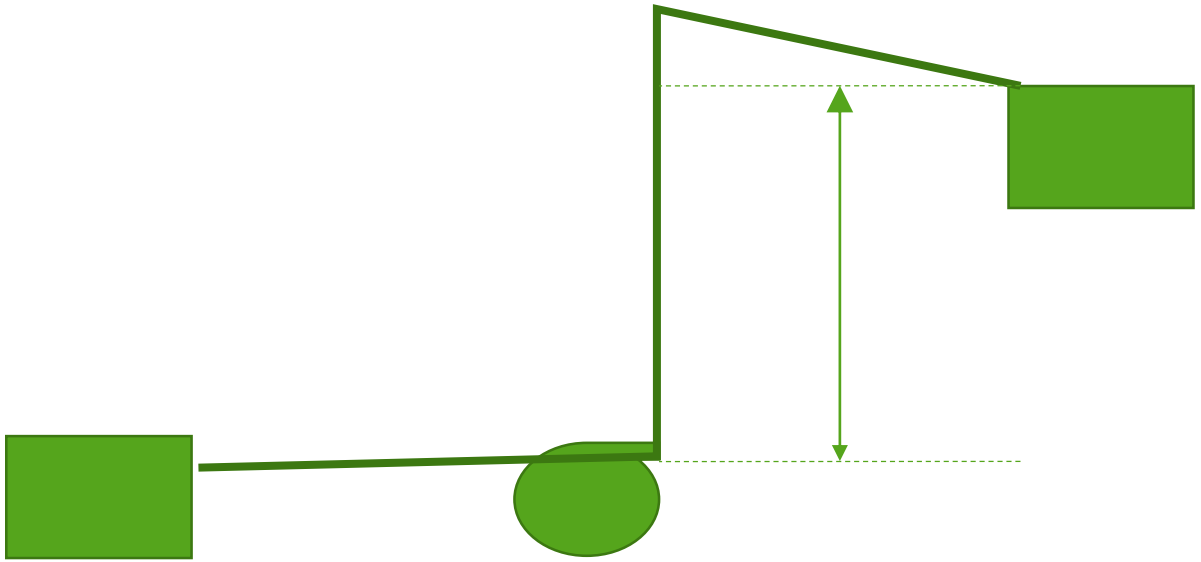
Poor Efficiency At Low Flow

Good Efficiency At High Flow



Bentley Advancing Infrastructure

Topography



Lift

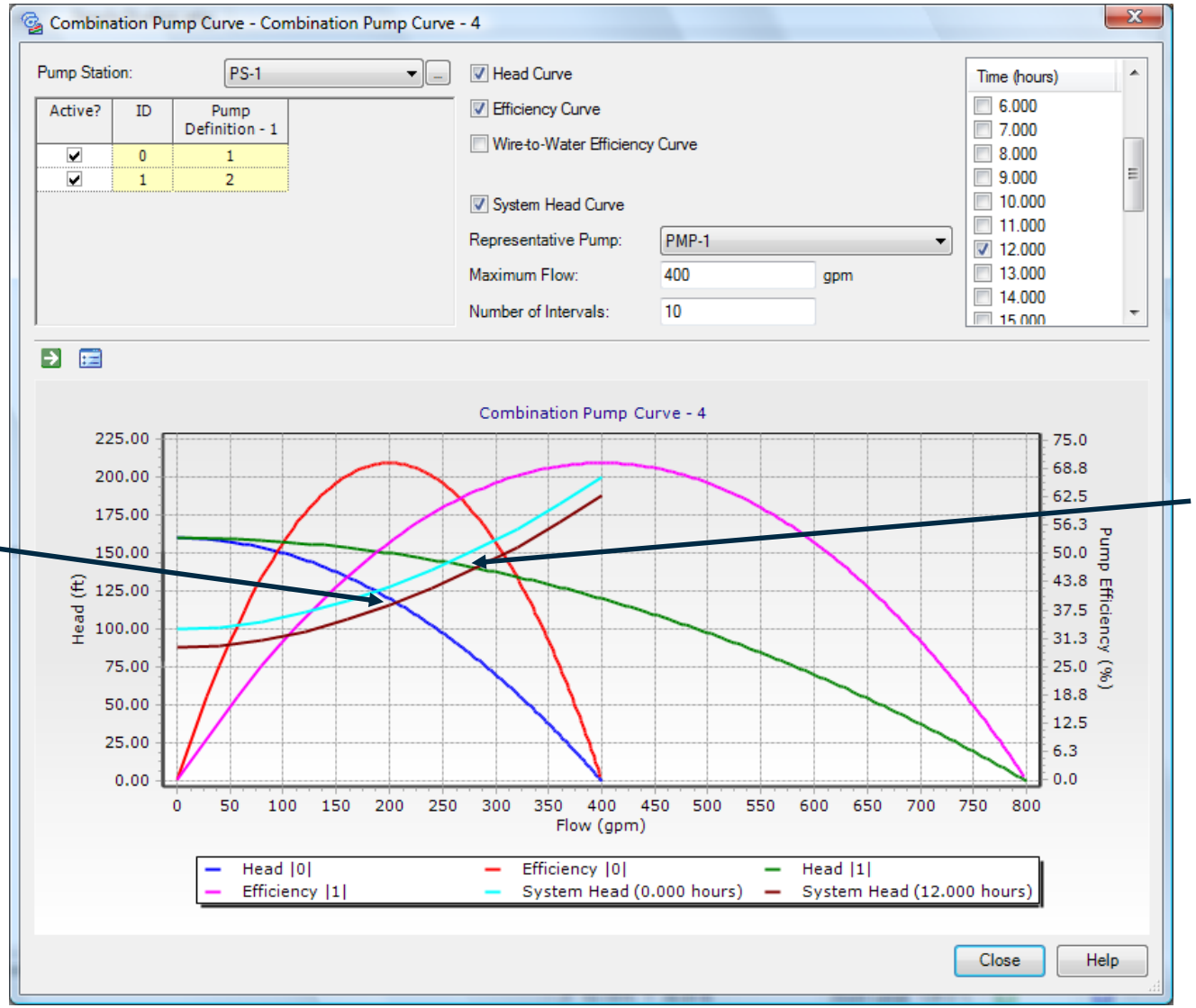
Friction

Hydropneumatic Tank Considerations

- Small (tiny) Systems
- Low/zero flow periods
  - Camp grounds
  - Ski resorts
  - Stadiums
  - Golf courses

Identifying Poor Capacity

One Pump
200 gpm
70%



Two Pumps
270 gpm
62%

Bentley Advancing Infrastructure

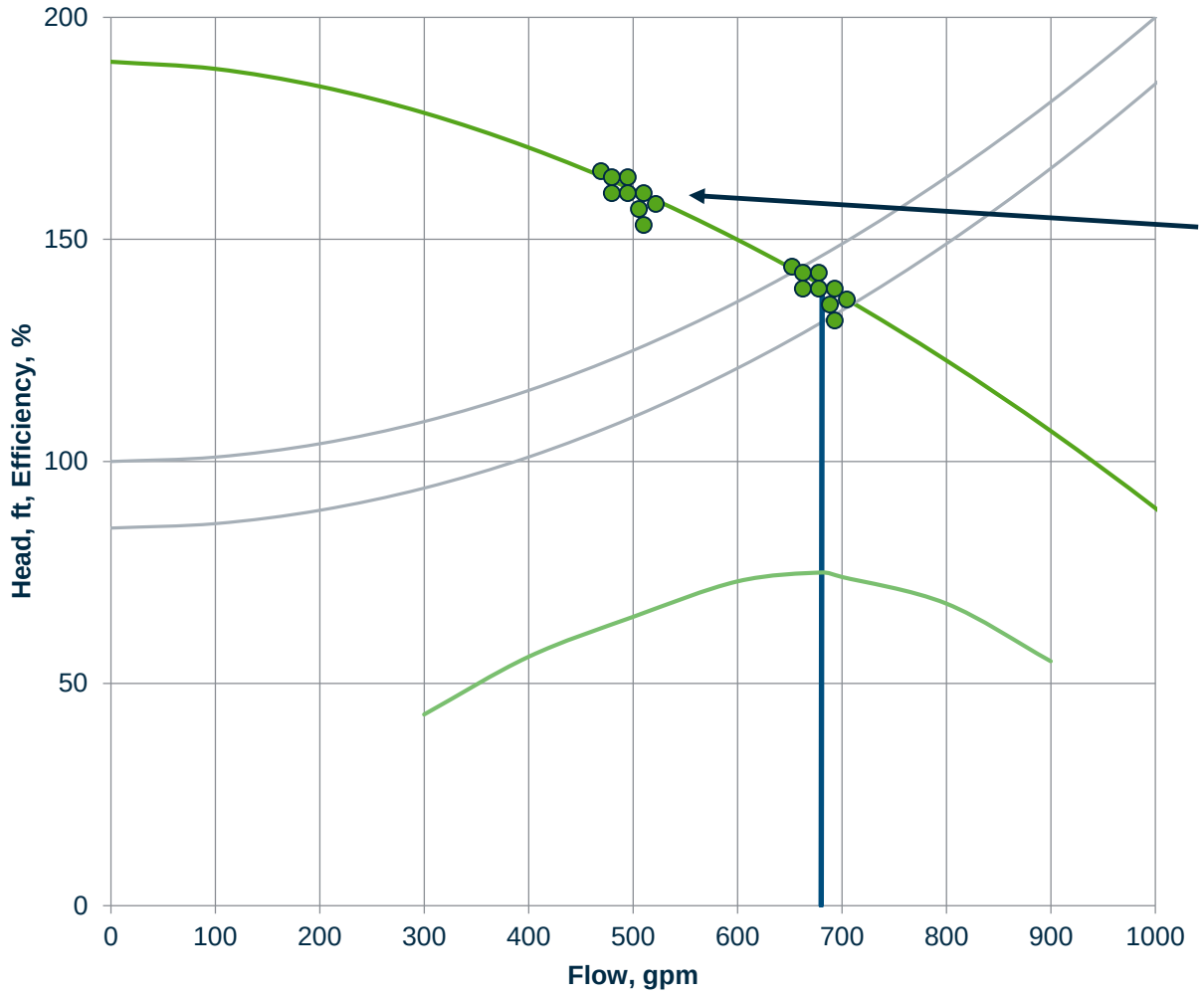
Modeling is not just for planning engineers

Many opportunities in operations

21

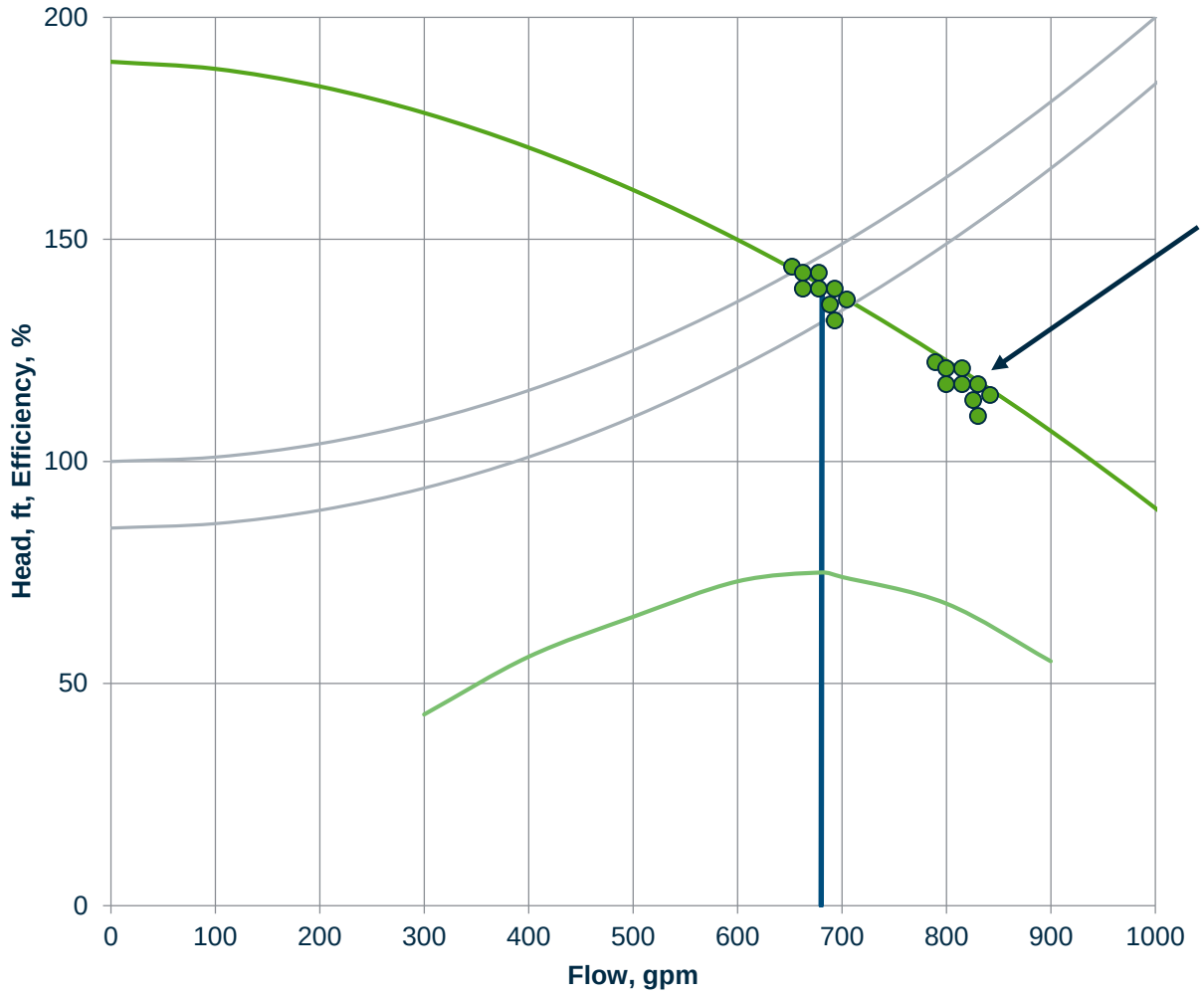
Fix Leaks

Control I&I



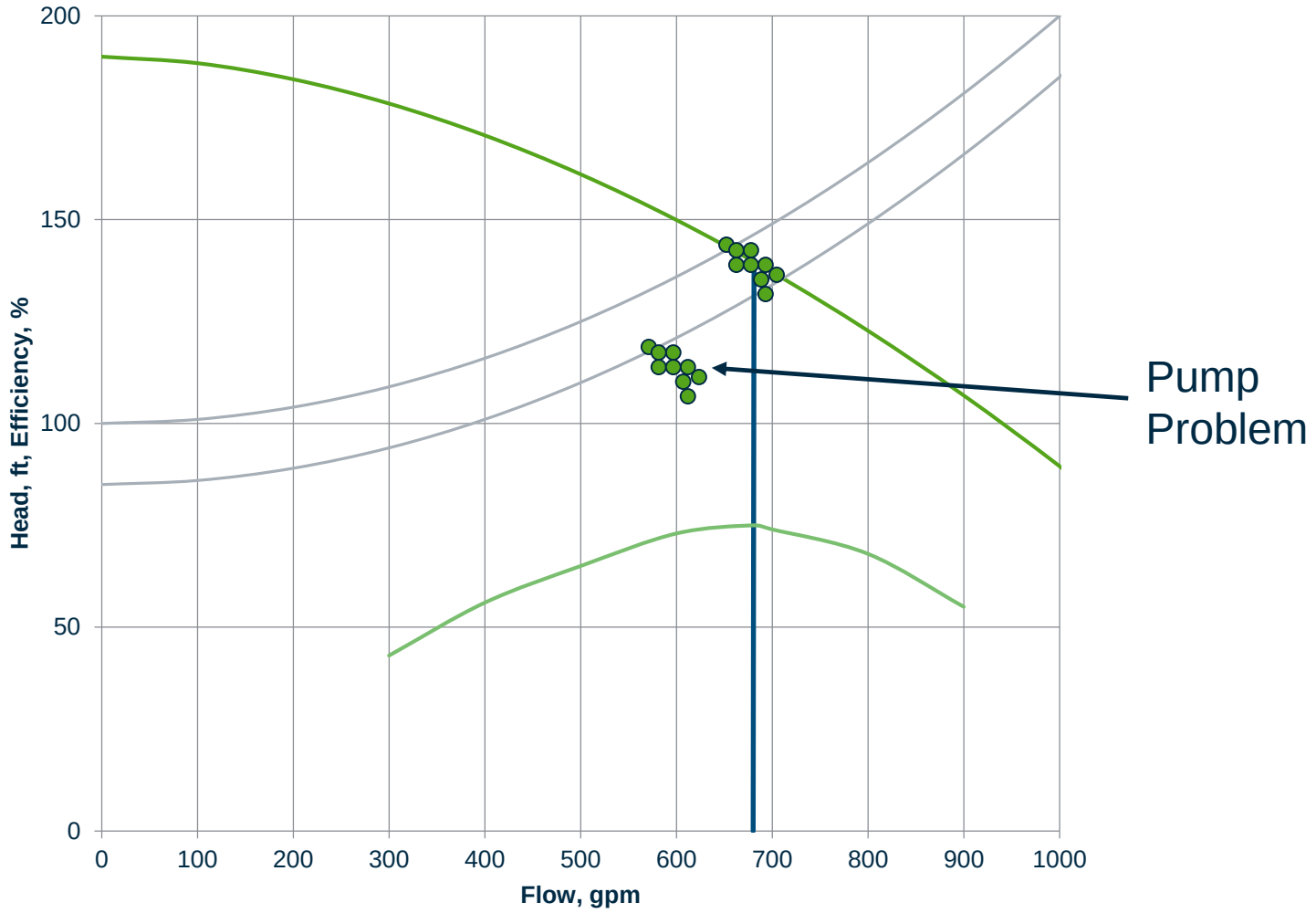
Pump/System Problem

Bentley® Advancing Infrastructure



Pump/System Problem

Bentley® Advancing Infrastructure



Bentley® Advancing Infrastructure

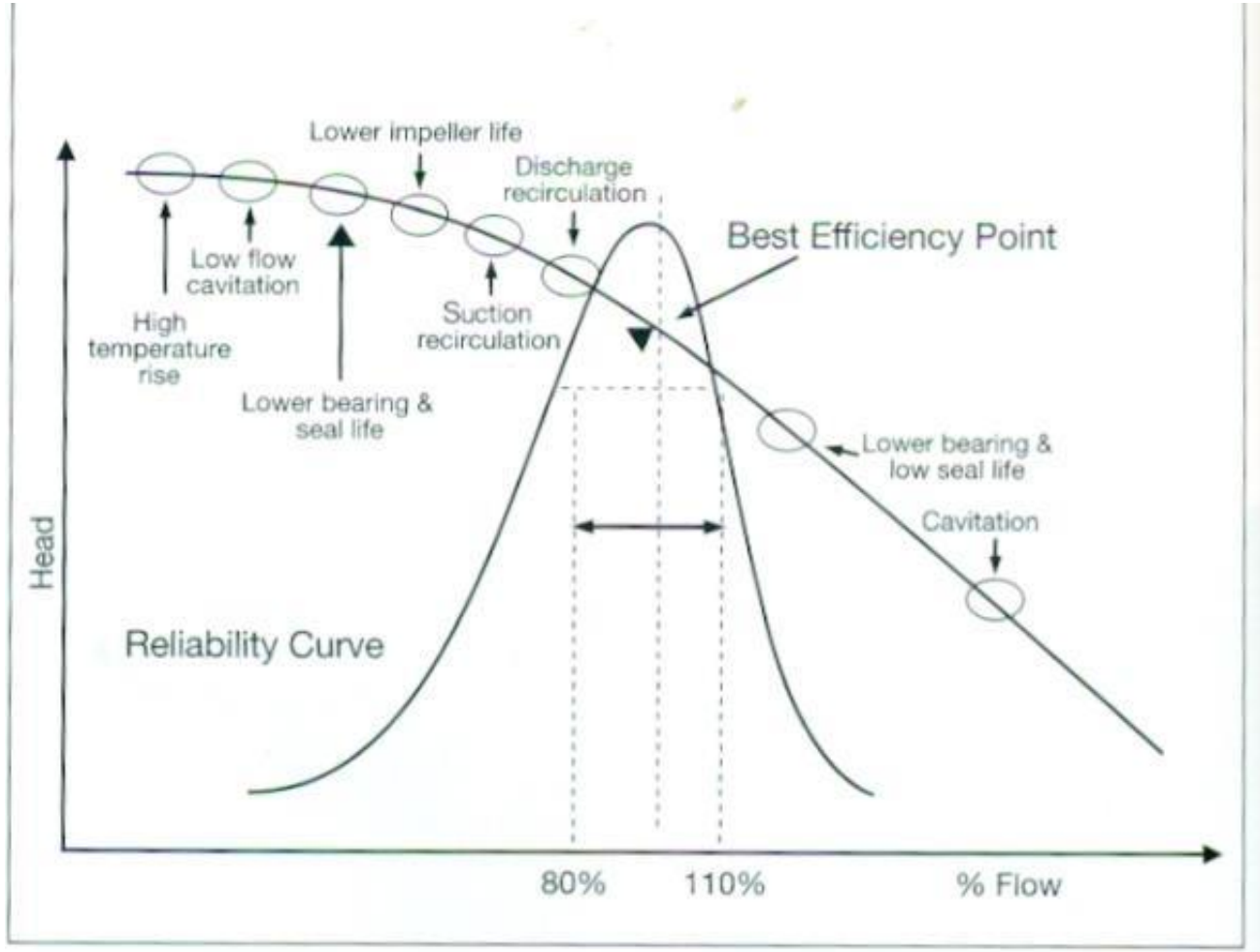


Figure 1. Adverse effects of operating away from the BEP (reproduced from Ref. 2, courtesy of Allweiler AG).

Braun, E. and Leiber, W, 2007, "The right pump lowers total cost of ownership," World Pumps, 491, 30-33.

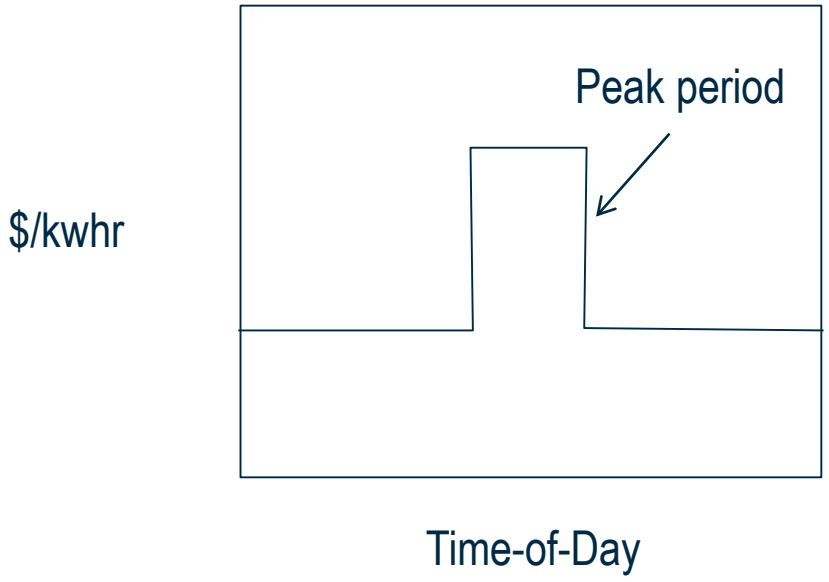
Bentley Advancing Infrastructure

Peak Demand Charge

- Based on peak kw use in some period
- Must understand period
  - 15 min, 1 hr
  - Seasonal
  - Time of day
  - Coincident peak
- Ratchet effect of peak (billing demand)
  - Current billing period
  - Year
- Includes non-pumping power
- Must educate operators

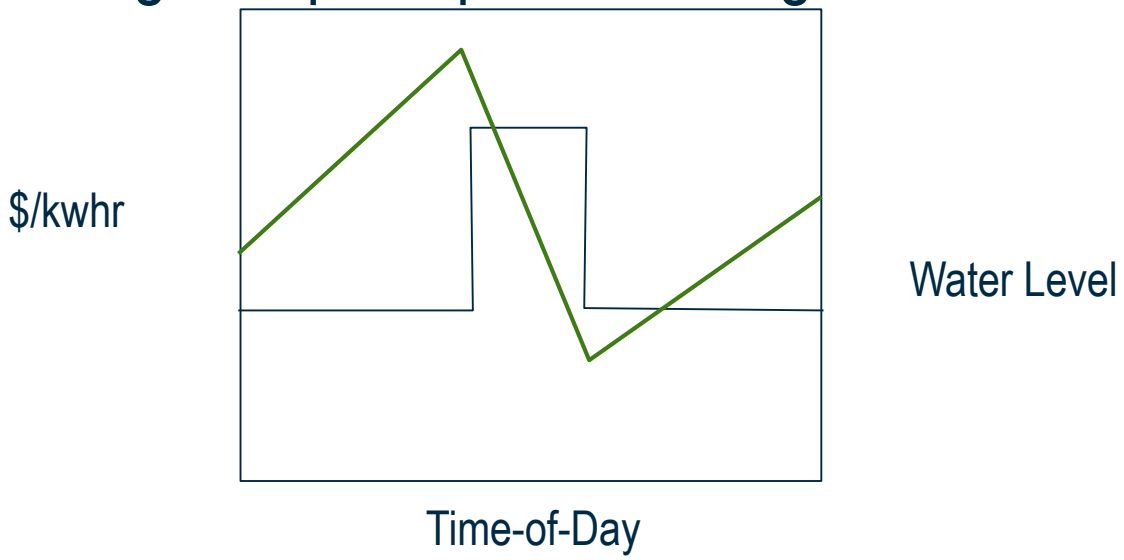
Time-of-Day Pricing

- Can store water – Can't store electricity
- Lower energy pricing during off-peak hours
- May only apply in peak season or other peak period
- Store energy by pumping water during off-peak hours

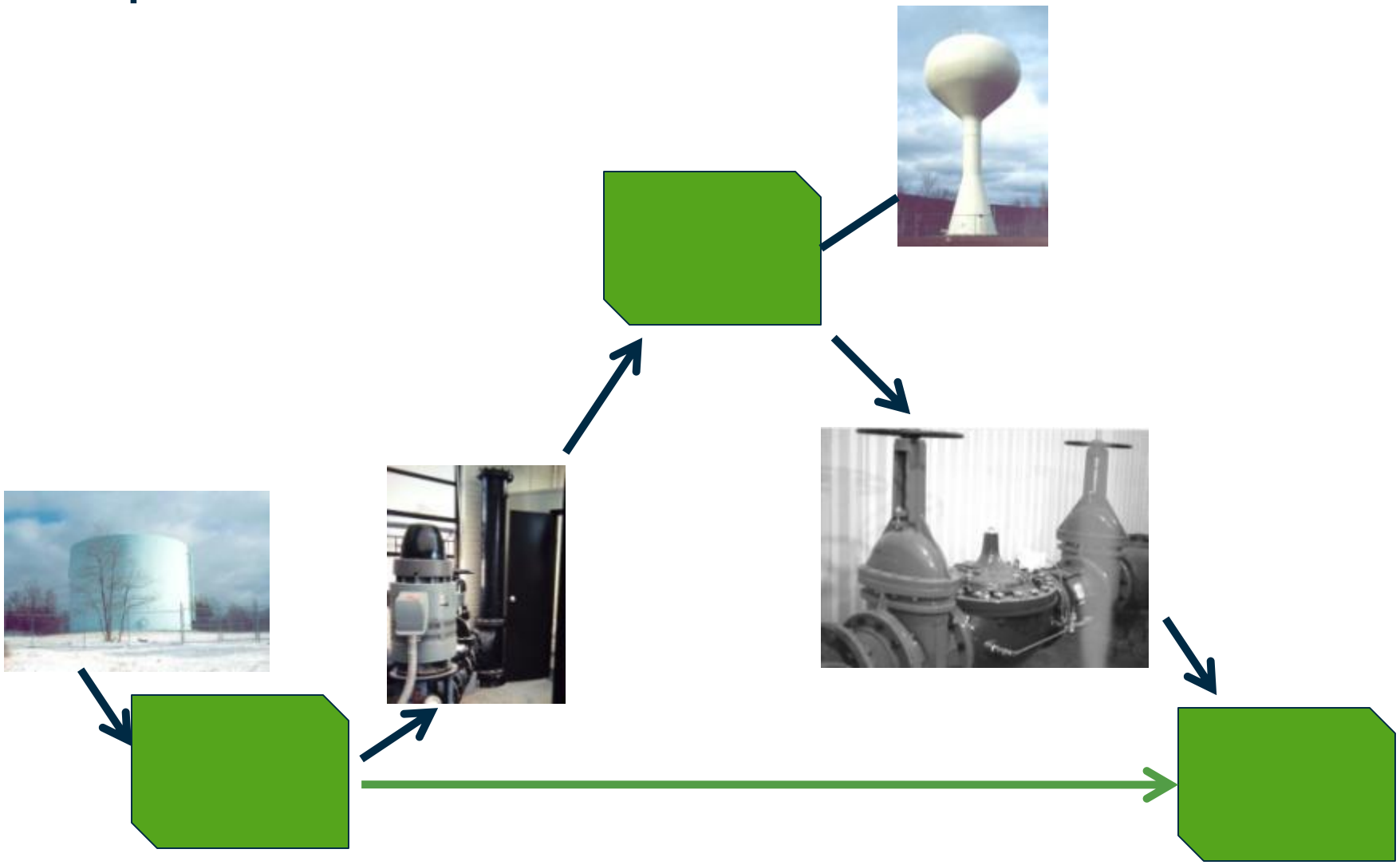


Time-of-Day Pricing

- Store energy by pumping water during off-peak hours
- Identify best operating rules
  - Change on-off during peak periods
  - Start peak period full
- Identify additional storage for peak period storage



Don’t Pump into PRV

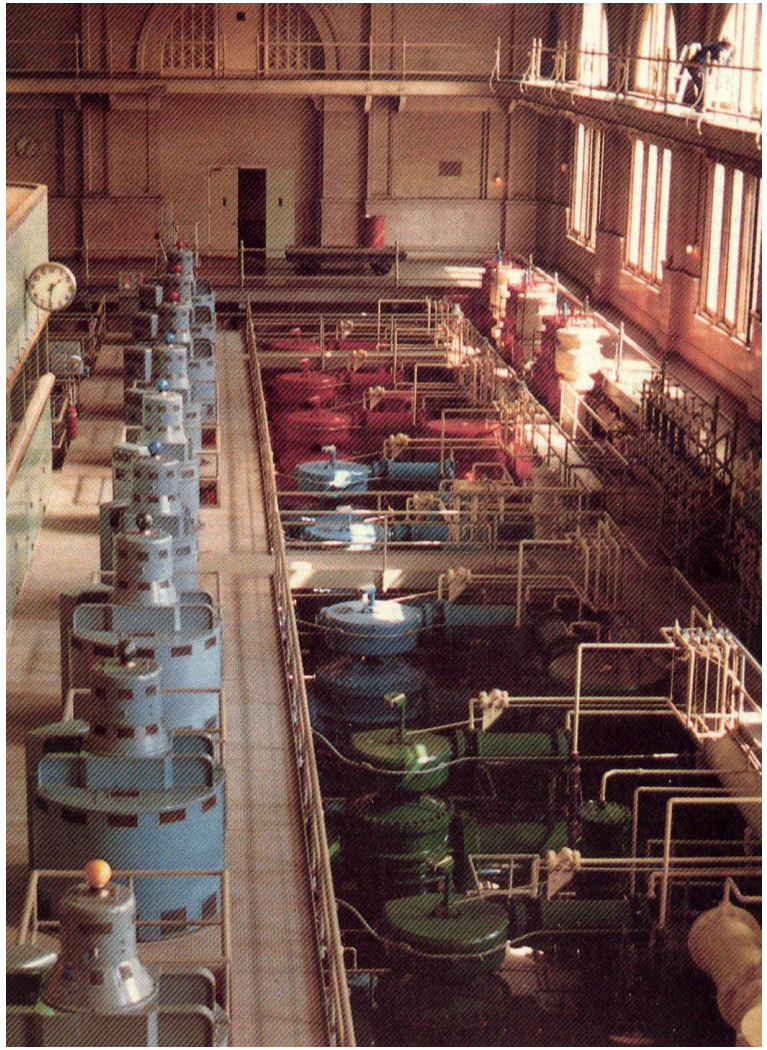


Check Net Positive Suction Head

- NPSH(available) > NPSH (required)
- Prevent cavitation

Pump Scheduling

- Optimal scheduling
- Uncertainty in demand pattern
- Many good solutions
- Online vs. Offline calculations

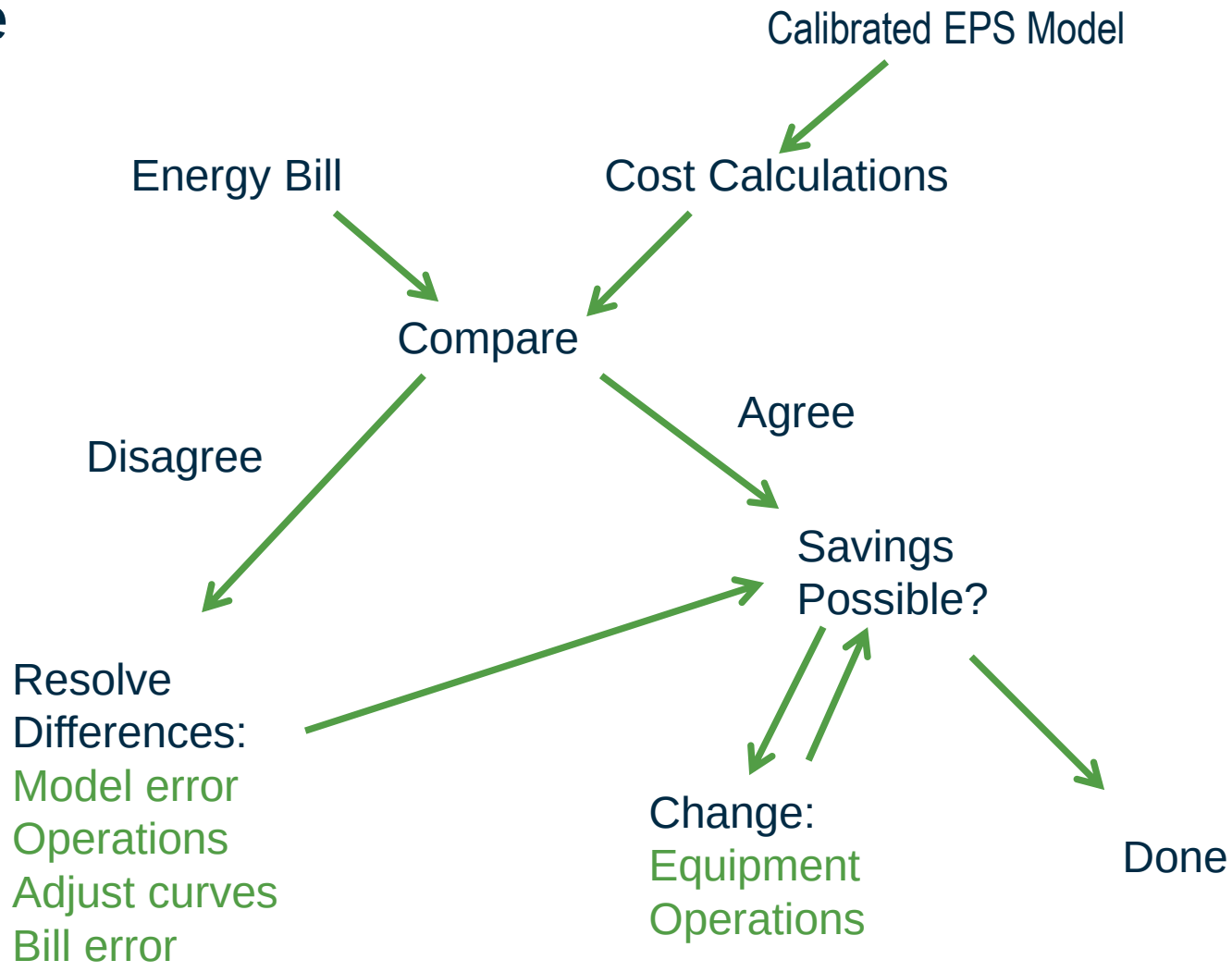


Bentley Advancing Infrastructure

Energy Studies

- Quick payback
- Reduce carbon footprint

Response

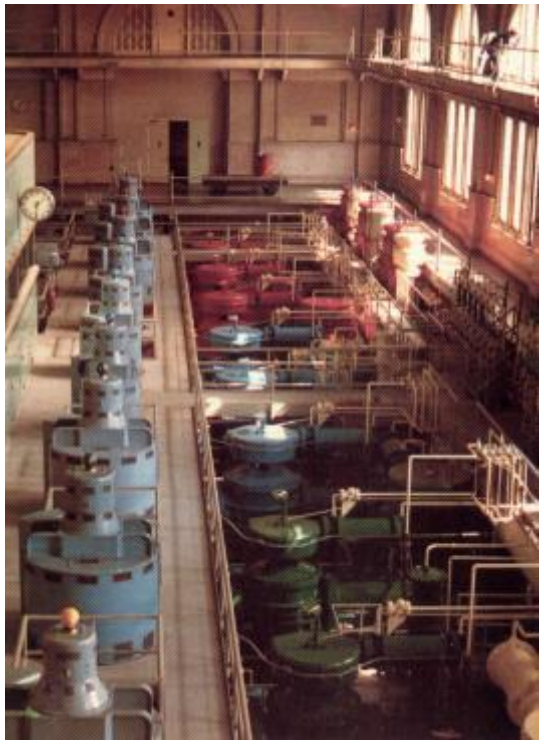


Take Home Points

- Energy and carbon emission savings possible
- Need to look for savings
- Can be good payback
- Hydraulic model can help

You won’t catch energy thieves unless you look for them

Which pump is inefficient?



Bentley® Advancing Infrastructure

Tanks

Bentley Advancing Infrastructure