Catching Energy Thieves in your Pump Stations

Tom Walski
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
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

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

Pump Efficiency = Water Power/Motor Power
Calculating What Energy Cost Should Be

Don’t just calculate at Best Efficiency Point

Operation varies over the day, season, long term

\[ C = \int_{0}^{T} \frac{kQhp\gamma}{e_p e_m e_d} \, dt \]

Flow, Head, Price, Efficiencies
Head Characteristic Curve

System Head Curves

Operating Points

Efficiency Characteristics Curve

Best Efficiency Point (BEP)
Converting Energy to Cost

\[ \text{Kw-hr} \times \$/\text{kwhr} \]
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
**Missouri Service Area**

**Service Classification No. 3 (L)**

**Large General Service Rate**

### 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: 9.30c
  - Next 200 kWh per kW of Billing Demand: 7.30c
  - All over 350 kWh per kW of Billing Demand: 4.70c
- **Demand Charge** - per kW of Total Billing Demand: $4.36
- **Energy Efficiency Program Charge** - per kW (1): 0.05c

### 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: 5.66c
  - Next 200 kWh per kW of Base Demand: 4.34c
  - All over 350 kWh per kW of Base Demand: 3.41c
- **Seasonal Energy Charge** - Seasonal kWh: 3.41c
- **Demand Charge** - per kW of Total Billing Demand: $1.61
- **Energy Efficiency Program Charge** - per kW (1): 0.03c

(1) Not applicable to customers that have satisfied the opt-out provisions of Section 353.167R, RSMo.

### Optional Time-of-Day Adjustments

- **Additional Customer Charge** - per Month: $17.72 per month
- **Energy Adjustment** - per kWh:
  - **Summer kWh (June-September billing periods):** On Peak $0.00, Off Peak $0.00
  - **Winter kWh (October-May billing periods):** On Peak $0.33c, Off Peak $0.19c

(2) On peak and off peak hours applicable herein shall be as specified in Rider 1, paragraph A.

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

*Indicates Change.
## Tarifa Convencional Subgrupo A4

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## Tarifa Horossazonal Azul Subgrupo A4

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### Descontos Percentuais - Água, Esgoto e Saneamento - Grupo A
VSP vs. Constant

![Graph showing VSP vs. Constant performance](image-url)
VFD Efficiency
7 Configurations

2 Constant Speed

2 VSP

2 Constant + Hydropneumatic

3 Constant Speed

3 Variable Speed

2 Constant + 1 VSP

2 Constant + 1 jockey
View VSP Operating Points

- Poor Efficiency At Low Flow
- Good Efficiency At High Flow
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%
Modeling is not just for planning engineers

Many opportunities in operations
Fix Leaks
Control I&I
Pump Problem
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

![Diagram showing time-of-day pricing with water level and cost per kilowatt-hour (kwhr)]
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
Energy Studies

• Quick payback
• Reduce carbon footprint
Response

Calibrated EPS Model

Energy Bill

Cost Calculations

Compare

Savings Possible?

Change: Equipment Operations

Done

Disagree

Resolve Differences:
- Model error
- Operations
- Adjust curves
- Bill error

Agree
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?
Tanks