Demographics & Growth Impacts on Wastewater Inflow and How to Deal with Demand

Jen Muir
JKMuir
(860)249-0989
JKMuir.com
Demographics & Growth Impacts on Wastewater Inflow and How to Deal with Demand

- Past and projected wastewater flows.
- Increased flows and its effects on energy usage and cost.
- How to reduce energy usage, demand, and costs.
- Evaluating equipment efficiencies.
- Equipment to handle varying waste water flows.
“If we want to avoid extreme energy, we need extreme efficiency.”

—Daniel Gross, “Moneybox” column and senior editor at Newsweek

Goal: Reducing greenhouse gases to 80% of 2001 levels, by 2050

“Significant additional measures and breakthrough technologies.”
Water Use Per Capita

Average annual indoor household water use

22% DECREASE 1999-2016


- Total Withdrawals (billions of gallons per day)
- Population (millions)

Circular Economy of Wastewater

- Emissions from untreated sewage can represent a significant portion of cities’ global emissions.
- Carbon neutral power, such as biogas, can be produced from wastewater products.
- Moving closer to water treatment with net-zero emissions.
What are we designing for?

• Industrial & manufacturing flows
• Lean manufacturing
• Stormwater
• CSO regulations
• Bypass flows

• Green infrastructure
• Climate Change
• Sea level rise
U.S. Wastewater Treatment Growth

76% of the POPULATION rely on 14,748 TREATMENT PLANTS for wastewater sanitation

56 Million MORE PEOPLE are expected to connect to CENTRALIZED TREATMENT PLANTS by 2032
Varying Flowrates

![Flowrate Graph](image)

- **Months**: Mar-07 to Feb-08
- **Flowrate (ft³/s)**: 0.1 to 0.7
- **kWhs**:
  - Mar-07: 16,000
  - Apr-07: 14,000
  - May-07: 12,000
  - Jun-07: 10,000
  - Jul-07: 8,000
  - Aug-07: 6,000
  - Sep-07: 4,000
  - Oct-07: 2,000
  - Nov-07: 16,000
  - Dec-07: 14,000
  - Jan-08: 12,000
  - Feb-08: 10,000
Inflow & Infiltration Contributing to Increased Flow

- Contain it
- Pump it
- Treat it
- Store it
- Prepare for it
Equipment Sizing

Equipment needs to handle worst case scenario

Negative effects from oversized equipment.

Equipment as an Alternative

• Can be installed to handle low or average flow
• Design point will be closer to the actual BEP.
• Operating large equipment far from the BEP:
  ➢ Damage the equipment
  ➢ High demand charges
  ➢ Increase energy usage
Why Pumps?

Electrical motors account for 66% of North American Industrial Electricity usage & Pumping Systems = 25%

In municipal water systems pumping = 46%
Wastewater systems = 20 – 30%

Energy Costs = 75% of lifecycle costs
What happens when we operate outside BEP

- High temperature rise
- Low flow cavitation
- Reduced impeller life
- Low bearing and seal life
- Discharge recirculation
- Suction recirculation
- BEP
- Low bearing and seal life
- Cavitation
What affects Pump Efficiency?

- Wear
  - Bearings
  - Seals
  - Clearances
  - Surface roughness
  - Vibration/misalignment

- Impeller modifications
- Cavitation
Life-Cycle Cost

- Life cycle costing incorporates the less obvious savings:
  - Maintenance costs
  - Future replacement
  - Labor time requirements
  - System reliability

![Figure 1. Life-cycle cost of a typical wastewater pumping system](chart.png)
Maintenance Costs

Maintenance accounts for >25% of the total life cycle cost of a pump.

- Operating pumps far from BEP leads to:
  - Premature wear,
  - Equipment failure
  - Increased maintenance costs

- Regular observation can alert operators to potential losses in system performance.
  - Monitoring vibration, temperature, noise, flow rates, and pressure.
How to get Scale with Efficiency?

- Aeration and Blowers
- Pump System Optimization
- Pump Optimization
- Mixing
- Operation and Maintenance
- Demand Response
Pump System Efficiency

Energy Loss

Goal: Reduce kwh/MG
What Affects Pump System Performance?

• Hydraulic and System Conditions
  • Valves
  • Piping
  • Elevations
• Operational Sequencing
  • VFD Operation
  • Best Efficiency Point (BEP) & Best Eff. Range
  • Set-points
• Pump Efficiency
Size and Number of Units

- Multiple equally sized constant speed units
  - On/Off control strategy
  - Cycling

- Multiple varying sized constant speed units
  - Smaller equipment for typical daily flow
  - Larger equipment for higher flows

- Variable speed
  - Operating flexibility with fewer units
  - Energy losses through VFDs

- Added system storage
  - Flexibility of when to operate equipment
DOE’s New Pump Efficiency Legislation
DOE Standards for Pump Efficiency – Final Rule

• Energy Conservation Standards for Pumps
  (10 CFR Parts 429 – 431)
• Finalized in Jan 2016
• 1st Rule related to Pump System Efficiency
• Compliance begins in 2020
Pump Energy Index (PER) is a rating for pump efficiency. Minimally compliant PER is defined as the weighted average energy use over the load profile. Specific to a pump model, it considers unique characteristics such as specific speed, flow at Best Efficiency Point (BEP), and C value, which helps define the attainable efficiency. The rating is inclusive of motor and controls, and the PEI differentiates for nominal speed (1800/3600 rpm).

<table>
<thead>
<tr>
<th>Size (HP)</th>
<th>Flow (gpm)</th>
<th>Head (ft)</th>
<th>Speed (rpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-200</td>
<td>&gt;25</td>
<td>&lt;459</td>
<td>3600/1800</td>
</tr>
</tbody>
</table>

PEI < 1.0
- Pump is more efficient than standard requirements

PEI > 1.0
- Pump does not comply with DOE Standards
Hydraulic Institute Energy Rating Program

Two Label Options suitable for technical specs and/or direct product application

- Clearly Communicate Performance
- Linked to public database page
What The DOE Rule Does NOT Do:

- Prevent oversizing
- Control where on the curve pump operates (BEP)
- Address pump throttling
- Correct for misapplication of pumps
- Reduce friction loss
- Impact motor efficiency
- Improve system controls
- Control wear
How do we address sizing?

- Lifecycle Costs
- Is a VFD the right solution?
- Multiple size equipment
- Optimization of system operations
  - Wet Well Level Setpoints
  - Sequencing
- Commissioning
Is a VFD the Right Solution?
Pump Systems: Jockey Pumps Example

<table>
<thead>
<tr>
<th>Condition</th>
<th>kWh</th>
<th>Cost/Yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing Pump</td>
<td>1,987,989</td>
<td>$218,679</td>
</tr>
<tr>
<td>New Jockey Pump</td>
<td>1,328,487</td>
<td>$146,134</td>
</tr>
<tr>
<td><strong>Total savings</strong></td>
<td><strong>659,502</strong></td>
<td><strong>$72,545</strong></td>
</tr>
</tbody>
</table>

**Pump Hydraulic Efficiency vs System Head**

- **48%**
- **70%**
- **82%**
- **88%**
- **79%**
- **73%**

Data Label values = Pump Ef
How Important is Wet Well Level?

Potential Annual Savings:
- 590,000 kWh
- $40,000/ft
What is Commissioning?

Comprises:
• Procedures to check, inspect & test
• Instruments, equipment, & systems
• Guaranteeing operability
  • Performance
  • Reliability
  • Safety
  • Information traceability
Long Term Goals

- Energy efficiency
- Optimized set points
- Life cycle cost reduction
- Operator knowledge
Strategies for Start-Up & Commissioning

Commissioning During Design

- **SYPS** Approach: System Performance Specifications
- Manufacturer trips/timing
- Quality training sessions
- Information traceability
- Optimized for current conditions
Impacts of Peak Loads

- Peak load require more plants to be on-line:
  - Older
  - More expensive
  - Dirtier
  - Less efficient
- Pay plants to be “on-call”
- Construction of peaking plants
Benchmarking, Performance Monitoring & Smart Controls
The Internet of Pumps

- **CONVENTIONAL**: (Consultancy) • No intelligence or connectivity
- **INSTRUMENTED**: (On-site audit) • Connected data loggers • Provide external data (paper report)
- **SOFTWARE DEFINED**: (BMS/SCADA) • Some local intelligence (controller) to tune pump • Enhanced data feeds
- **SMART**: (Connected pump) • Active condition monitoring • Self optimization • Interact with ecosystem • Enhanced intelligence
- **AUTONOMOUS**: Internet of things by 2020* • 26 billion installed units, $263 billion new revenue and $1.9 trillion value-added services • Additional sensors • Real time diagnostics • Embedded execution • New business models • Performance guarantee • Customer loyalty • Connect everything

*Source Gartner, Forecast The Internet of Things worldwide
What’s Next

Consider Life Cycle Costing

Quantify cost of oversized equipment

Financial

Business case

ROI

Funding

Equipment performance & condition:

Asset Management

Capital Improvements

Commissioning
Thank You

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