Energy and Process Optimization at the Water Resource Recovery Facilities (WRRFs)

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Municipal Water Solutions

Johnson Controls
Objectives

- US Municipal Water Infrastructure (MWI) -- Asset Renewal
- MWI – Water Resource Recovery Facilities (WRRFs)
  - Energy-usage, Process Optimization, O&M, and Financials
- Performance Water Infrastructure
- Case Studies – Evansville IN
  - Energy & Water-processing Efficiency and Optimization
- Conclusions
Water Use Cycle

Asset Management

Water Supply

Wastewater Treatment Facility

Wastewater Collection

Lift Station

Booster Pump Station

Water Distribution

CONSUMER
- Residential & Commercial
  - Water heating
  - Water softening
  - Irrigation systems
  - Processing needs (sterilization, laundry)
- Metering
- Cooling
- Pool heating
- Rainwater harvesting

High Service Pump Station

Power Plant

Water Treatment Facility

Irrigation

Energy

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US Municipal Water Infrastructure (MWI)

- Significant **US infrastructure** improvement(s) are required – Costs are estimated at **$3.6 trillion by 2020**
- **US-MWI**: Spending-to-need ratio – 40% (2010) and projected decline to 26% (2040)
- Water systems and facilities
  - 54,000 community water systems
  - 15,000 wastewater treatment facilities
  - 20,000 wastewater pipe systems
- Sustainable, upkeep of the **US water infrastructure** -- costs
  - $655-blN; >$1-trillion; >$2-trillion, by 2030 . . .
Non-Revenue Water (NRW) -- Unaccounted for Water or the Water Loss

- **Real, Water Losses** - Physical loss of water from the distribution system
  - Leaks and breaks
  - Overflows
- **Apparent, Water Losses** – Water use that is not accounted for
  - Water meter inaccuracy
  - Not being a right size or type
  - Billing system mistakes/errors
  - Other, inaccurate estimation(s) – flushing, etc.

- **Revenue Losses** – significant; can be reduced.
Atlantic County (NJ) – WRRF, schematic

WRRFs – Process & Energy Optimization

- Building Facilities
- Liquid Treatment Train
  - Preliminary/Headworks – screening and grit removal
    - Soluble-COD, and no-grit escape are critical
  - Primary
    - BOD and TSS removal, and no-grit escape to secondary/ABs
    - Soluble-COD or the Volatile-acids to BNR
  - Secondary (ABs + clarifiers) and Tertiary
    - TN and TP removal focus
  - Disinfection
    - Chlorination/dechlorination, or UV
(Bio)Solids Treatment Train

- **Solids Thickening**
  - Chemical conditioner use and %solids-to-stabilization
  - Soluble-COD or Volatile-acids to support-BNR
- **Solids Stabilization**
  - Aerobic or anaerobic
- **Solids Dewatering**
  - %cake-solids; mg/L-TSS-filtrate; %solids-recovery
- **Solids Disposal**
  - Class A or B; Solids-incineration; Biosolids/ash landfilling
Energy Usage – Municipal Water Processing
(some general information)

Water Intake, Treatment, & Distribution

City/town

Wastewater Collection & Treatment

U.S., average of 5,000 kWh/MG, from water-intake to watershed-return (not a benchmark value)
WRRF Energy Usage

Energy consumed among a variety of processes and equipment

Ref. USEPA, Derived from the data from Water Environment Energy Conservation Task Force – *Energy Conservation in Wastewater Treatment*
Energy Usage and Process Efficiency Upgrades

**Water Treatment & Distribution**
- Unit operations and process systems
- Water metering & AMR/AMI
- Water loss Control
- Efficient and right-sized pumping systems
- Residuals Processing
- Renewable energy

**Water Resource Recovery Facilities**
- Unit operations and process systems
- I/I Control
- Efficient and right-sized pumping systems
- Biosolids Processing
- Renewable energy

**Buildings and Surrounding Facility Improvements**
- Lighting, HVAC, Fire, Security, Renewable Energy

[ref. ENERGY STAR: Water and Water Utilities, U.S. Environmental Protection Agency (EPA), 2009; Johnson Controls]
Performance Infrastructure

- A Regulated Project Delivery Model


- State of New Jersey – Title 52 of the Revised Statutes
  - Energy Savings, and Energy and Water Conservation Measures are defined.
## Performance Infrastructure

<table>
<thead>
<tr>
<th>Elements</th>
<th>Benefits</th>
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<tbody>
<tr>
<td>Mutually established energy and operations baseline</td>
<td>Guaranteed Savings and Results</td>
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<tr>
<td>Energy conservation, process efficiency, and renewable energy measures</td>
<td>Fixed price project</td>
</tr>
<tr>
<td>Savings (and other) support the improvements</td>
<td>Single point accountability</td>
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<tr>
<td>Well defined scope of work</td>
<td>Fast-track project completion</td>
</tr>
<tr>
<td>Training, and measurement and verification of savings</td>
<td>Significant local, energy, and environmental improvements</td>
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Performance Infrastructure -- Business Case Financials – Process and Energy Efficiency Improvement Projects – An Example

<table>
<thead>
<tr>
<th>Performance Years</th>
<th>Measured Utility Savings</th>
<th>Non-measured Savings</th>
<th>Loan Payment</th>
<th>Performance Management</th>
<th>Balance</th>
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<tbody>
<tr>
<td>Year 7</td>
<td>$234,440</td>
<td>$159,251</td>
<td>$398,705</td>
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<td>Year 8</td>
<td>$243,772</td>
<td>$165,621</td>
<td>$414,608</td>
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<td>Year 9</td>
<td>$253,476</td>
<td>$172,245</td>
<td>$431,145</td>
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<td>Year 10</td>
<td>$263,568</td>
<td>$179,135</td>
<td>$448,343</td>
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<tr>
<td>Year 11</td>
<td>$274,062</td>
<td>$186,301</td>
<td>$466,228</td>
<td>$-</td>
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<tr>
<td>Year 12</td>
<td>$284,974</td>
<td>$193,753</td>
<td>$484,828</td>
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<td>Year 13</td>
<td>$296,323</td>
<td>$201,503</td>
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<td>Year 14</td>
<td>$308,124</td>
<td>$209,563</td>
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<td>Year 15</td>
<td>$320,396</td>
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<td>$545,204</td>
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<td>Year 16</td>
<td>$333,158</td>
<td>$226,663</td>
<td>$566,959</td>
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Evansville IN -- Water Meters and WRRF Upgrades

- Approx. 64,000 water meters
- Biogas-to-energy with addition of FOG and CHP
- Primary clarification
- Sludge dewatering
- Engineering for additional energy and process efficiency measures, and
- Building facilities
Evansville IN -- Water Meters

Water Meters’ upgrade:
- new, Water-meters
  - 5/8” and 1-8” size meters
- Advanced metering infrastructure (AMI)
- Automated leak detection system (ALDS)

- Annual, project benefit – approx. $5MM

[Ref. Based on JCI-internal info.]
Evansville IN -- WRRF Upgrades

- The 14MGD WWTP’s electric spend – 1,593 kWh/MG
  - FOG and biogas-to-energy CHP will meet approx. 50% energy requirements and will provide supplemental-FOG-tipping-revenue.
  - This improvement will drive the plant toward net-zero.

- Primary Clarification, and

- Sludge Dewatering

EWSU FOG Program Benefits
- 472KW
- 3.9MM kWh
- $124k FOG tipping fees
- Net Savings = $278k

[Ref. Based on JCI-internal info.]
Sludge Dewatering – Review of Pilot/Field Data

- **Screw-press on raw PS+WAS, 2%feed, and 70%VS**
  - 30-35%cake-solids; 97-99%+recovery; <500 mg/L filtrate-TSS
  - vs. existing centrifuge(s) at 22-30%cake-solids to landfill
  - Mannich vs. twice-emulsion for similar results

- **Centrifuge on An.D PS+WAS, 1.2-1.5%feed, and 50-55%VS**
  - 28-30%cake-solids;
  - vs. existing BFPs at 17-19%cake-solids to landfill
  - Existing dry-polymer use
  - Originally designed BFP as back-up, with a centrifuge addition

- **Centrifuge on Raw PS+WAS, 0.5-2.7%feed, 30-78%VS**
  - 20-38%cake-solids; 82-99%recovery; <500 mg/L centrate-TSS
  - vs. existing BFPs at 16-19%cake-solids to incineration
  - Tested with existing emulsion polymer

[Ref. Based on JCI-internal info.]
Raw PS+WAS Feed and VS versus Centrifuges’ Cake-solids

Ref. Based on JCI-internal info.
Evansville IN: WRRF Upgrades

Biosolids Dewatering:
- Anaerobically digested biosolids
- BFPs to Centrifuge optimization
  - 18% to 28% cake-solids output
  - Reduced wet-tonnage to landfilling
- Annual, project benefit – approx. $175k

[Ref. Based on JCI-internal info.]
Municipal Water & Wastewater Processing Costs
(some general information, as noticed)

- Second to the employees’ salaries on the annual budgets of cities
  - More than 40% of that are energy costs
- Potable or Drinking Water Treatment -- $2/1,000-gal (flow based) (USEPA)
- Wastewater treatment -- $300/MG (10-100 MGD flow based) for energy and biosolids disposal . . . (unpublished data)
- Projected, Advanced water and wastewater treatment costs both CapEx and OpEx are significantly high:
  - Water – for example, usage of advanced systems for algal-bloom removal . . .
  - Wastewater – for example, TN to 3.0 mg/L, TP ≤ 0.1 mg/L
Atlantic County Utilities Authority (ACUA) – WRRF Operation & Management -- Notes

- 40-MGD, design capacity – serving 14-municipalities
  - Inflows include: septage, leachate, and sludges
  - Preliminary, primary, secondary-ASP, disinfection, and ocean-outfall discharge
  - Solids thickening, centrifuge-dewatering, solids-incineration, and ash-disposal to landfill
- Renewable Energy Use – Wind and solar-PV
  - Five (5), Wind-turbines -- 7.5 MW
  - Solar-PV – 500 kW
  - Effective pricing at <$0.10/kWh
- More than 60% of WRRF’s energy needs were met by the renewables

[ref. ACUA – Wastewater and Green Initiatives, websites accessed on 4/9/17; TPO (2009)]
Conclusions

• Current upkeep of the US municipal water infrastructure requires significant and immediate improvement measures, and the capital investment need is estimated at more than $1-trillion.
• Energy and process optimization is critical at WRRFs.
• Energy, chemical, and other allowable-savings need to be identified and verified for effective operation of water infrastructure, and be part of maintaining the annual budgets.
• Performance infrastructure includes effective installation of required improvement measures, with guaranteed savings and performance.
• The energy efficient and sustainable management of municipal water infrastructure would be required, in a life cycle to life cycle manner.
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Questions

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