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

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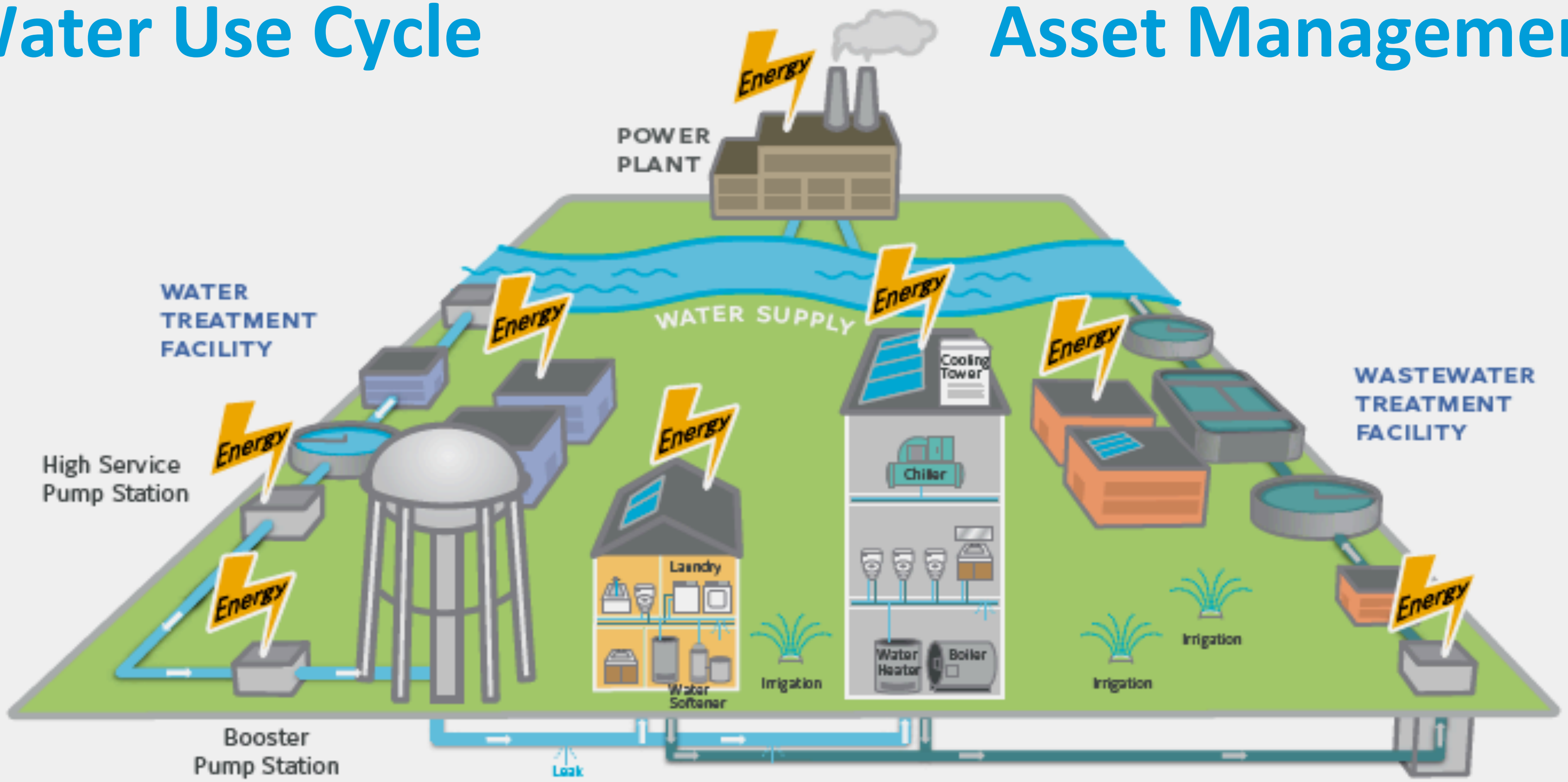
Municipal Water Solutions

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

ASCE – Infrastructure Report Card, 2017

US Municipal Water Infrastructure (MWI)

[ASCE (2012 and 2013), USEPA (2016), AWWA (2016)]

- Significant US infrastructure improvement(s) are required – Costs are estimated at $3.6trillion 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**.

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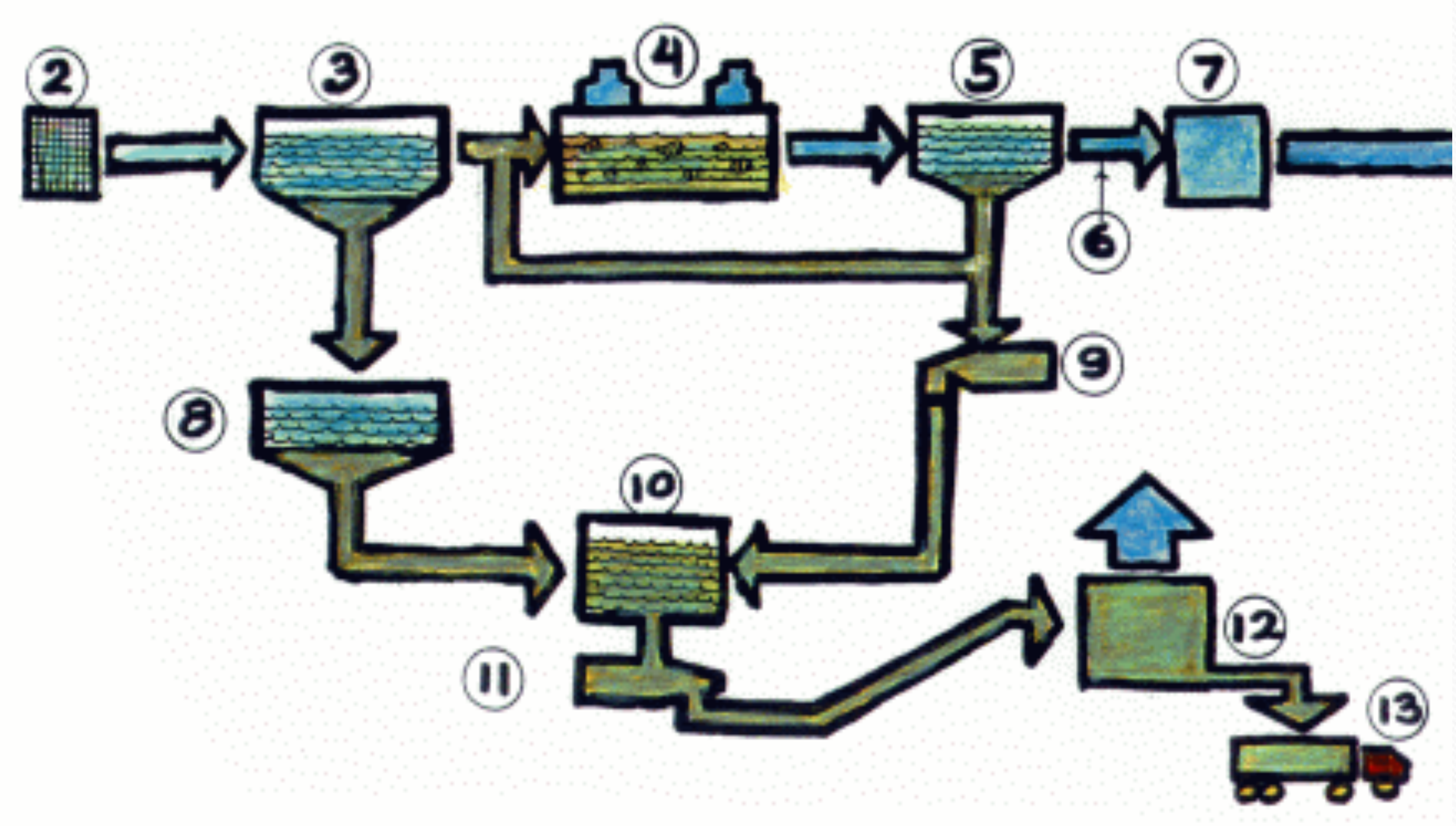
Atlantic County (NJ) – WRRF, schematic



(ref. ACUA, Wastewater 101, http://www.acua.com/wastewater101/, accessed 4/9/17)

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

WRRFs – Process & Energy Optimization cont'd.

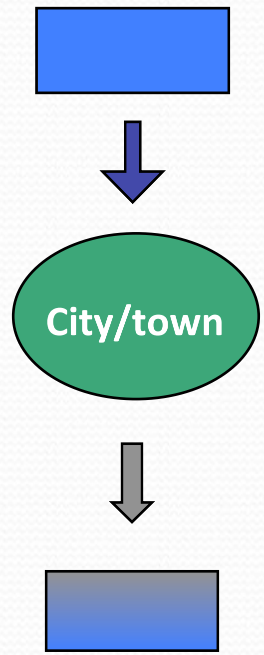
- (Bio)Solids Treatment Train
  - Solids Thickening
    - Chemical conditioner use and %solids-to-stabilization
    - Soluble-COD or Volatile-acids to support-BNR
  - Solids Stabilization
    - Aerobic or anaerobic
  - Solids Dewatering
    - %cake-solids; mg/L-TSS-filtrate; %solids-recovery
  - Solids Disposal
    - Class A or B; Solids-incineration; Biosolids/ash landfilling

Energy Usage – Municipal Water Processing

(some general information)

Water Intake, Treatment, & Distribution

900 – 3,000 kWh/MG



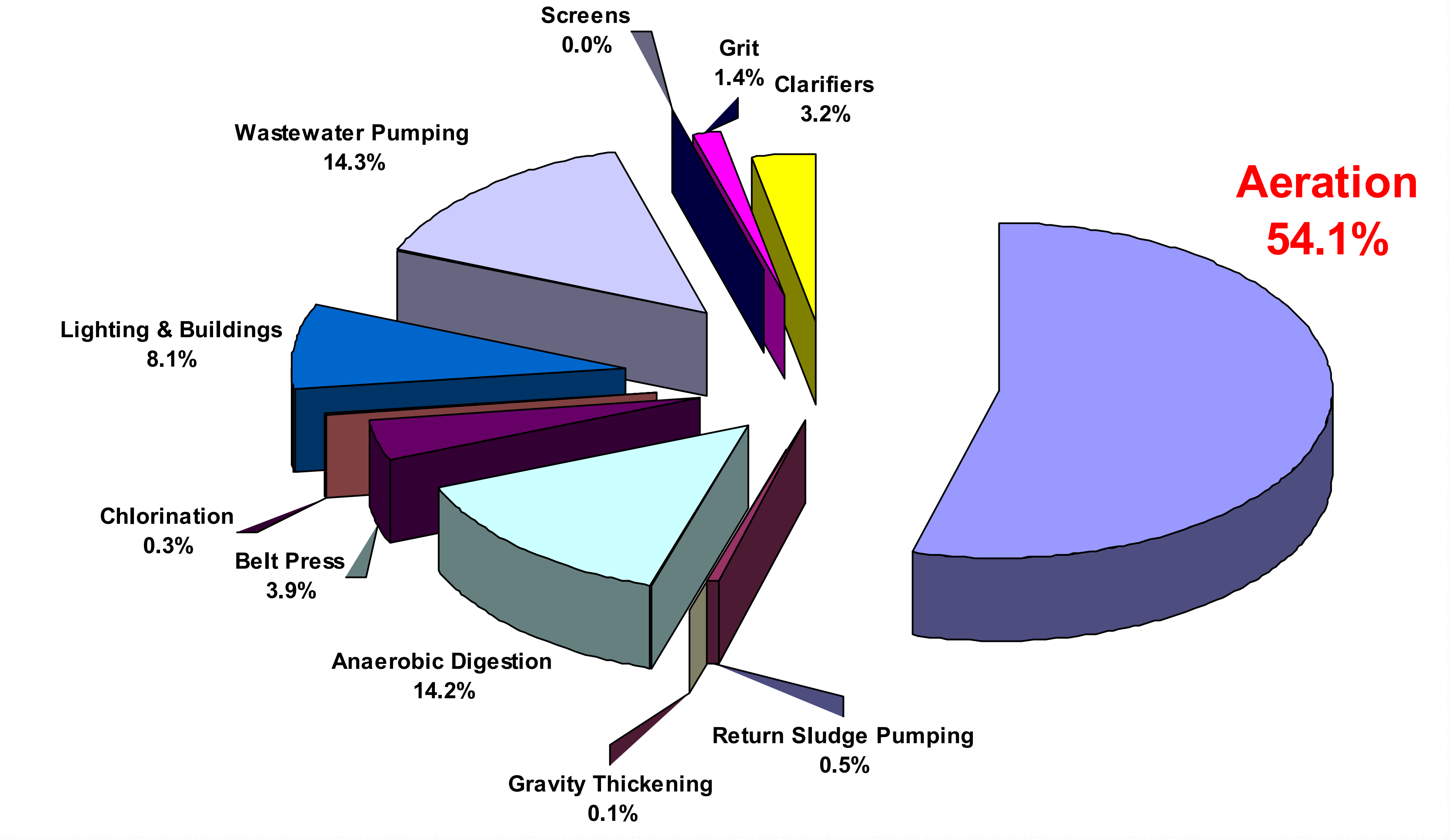
Wastewater Collection & Treatment

1,000 – 2,700 kWh/MG

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

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

- 40 CFR 136, Part B – Federal Energy Management and Planning Programs/Methods and Procedures for Energy Savings Performance Contracting.

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

Performance Infrastructure

Elements

- Mutually established energy and operations baseline
- Energy conservation, process efficiency, and renewable energy measures
- Savings (and other) support the improvements
- Well defined scope of work
- Training, and measurement and verification of savings

Benefits

Guaranteed Savings and Results

Fixed price project

Single point accountability

Fast-track project completion

Significant local, energy, and environmental improvements

Performance Infrastructure -- Business Case Financials – Process and Energy Efficiency Improvement Projects – An Example

Business Case Summary		Measured Utility Savings	Non-measured Savings: Utility Savings	Non-measured Savings: Operational Savings	Non-measured Savings: Rebate	Non-measured Savings: Capital Avoidance	Total Savings	Loan Payment	Performance Management	Balance
Performance Years	Year 7	$ 234,440	$ 5,014	$ 159,251	$ -	$ -	$ 398,705	$ 398,705	$ -	$ -
	Year 8	$ 243,772	$ 5,215	$ 165,621	$ -	$ -	$ 414,608	$ 414,608	$ -	$ -
	Year 9	$ 253,476	$ 5,424	$ 172,245	$ -	$ -	$ 431,145	$ 431,145	$ -	$ -
	Year 10	$ 263,568	$ 5,641	$ 179,135	$ -	$ -	$ 448,343	$ 448,343	$ -	$ -
	Year 11	$ 274,062	$ 5,866	$ 186,301	$ -	$ -	$ 466,228	$ 466,228	$ -	$ -
	Year 12	$ 284,974	$ 6,101	$ 193,753	$ -	$ -	$ 484,828	$ 484,828	$ -	$ -
	Year 13	$ 296,323	$ 6,345	$ 201,503	$ -	$ -	$ 504,170	$ 491,515	$ -	$ 12,655
	Year 14	$ 308,124	$ 6,599	$ 209,563	$ -	$ -	$ 524,286	$ 491,515	$ -	$ 32,771
	Year 15	$ 320,396	$ 6,863	$ 217,945	$ -	$ -	$ 545,204	$ 491,515	$ -	$ 53,689
	Year 16	$ 333,158	$ 7,137	$ 226,663	$ -	$ -	$ 566,959	$ 491,515	$ -	$ 75,444

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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

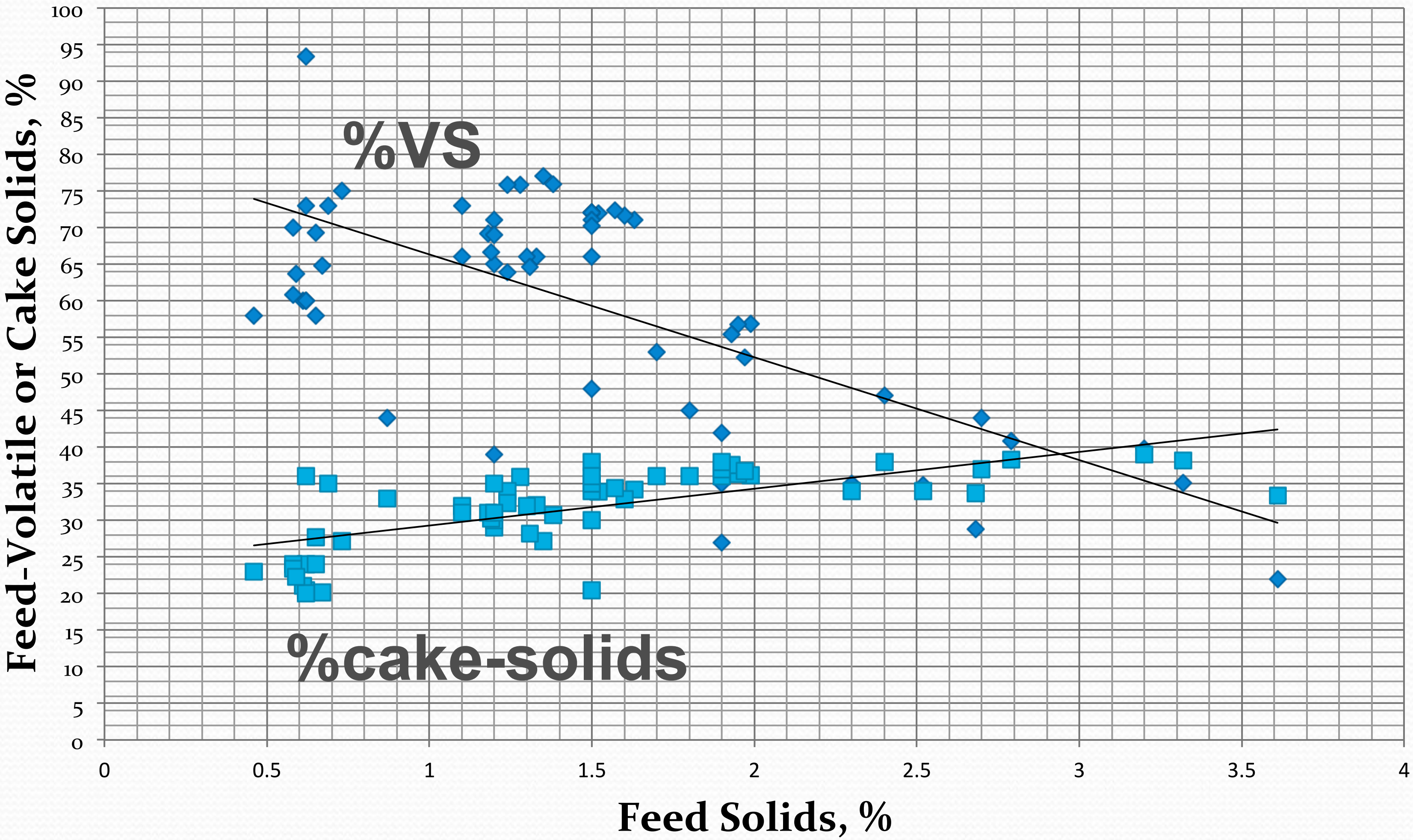
[Ref. Based on JCI-internal info.]

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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