BECOMING A WRRF
A STEPWISE PROCESS

MWEA Annual Conference
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DONOHUE
Agenda

- Why now? – Drivers
- Opportunities for Wastewater Utilities
- Where to Start – A Stepwise Approach
- Midwest Examples
- Take Aways
Why now? – Drivers
1. Shifting and Growing Population

Number of people living worldwide since 1700 in billions

- 1804: 1 bln
- 1927: 2 bln
- 1960: 3 bln
- 1974: 4 bln
- 1999: 6 bln
- 2012: 7 bln
- 2024: 8 bln
- 2048: 9 bln

Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung
2. Nutrients – P and N

- **Issue 1: Nutrient sources**
- **Issue 2: Global nutrient balance (or imbalance!)**
  - High input, limited recycling

Adding a LOT more nutrients to the environment

Environmental imbalance of nutrients

Lake Taihu, China

2. Nutrients – Phosphorus

Phosphate Rock: Non-renewable resource

Phosphate production has steadily increased

World Phosphate Rock Production (metric tons)
2. Nutrients – Nitrogen

Nitrogen limitation

Haber-Bosch: large natural gas requirement
3. Climate Change

Figure 3.1 Global average surface temperature from 1850 to 2006. Dots show individual years, and the black line with its blue uncertainty range shows decadal averages. The temperature changes on the left scale are given with respect to the average over the years 1961–90.
4. Water Sources

Figure 8.15 Projected changes in runoff by the end of this century, based on a suite of model simulations for the emission scenario A1B. Blues shows increased runoff, red decreased runoff (in %). This map points to serious future drought problems, e.g., in the Mediterranean region, southern Africa, the south-west of the United States and western Australia.
Resource Nexus: The Environmental Challenge of the 21st Century
Opportunities for Wastewater Utilities
## Opportunities for Wastewater Utilities

<table>
<thead>
<tr>
<th>Driver</th>
<th>Wastewater Utilities</th>
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<tbody>
<tr>
<td>World population increase and shift</td>
<td>Fertilizer production</td>
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<tr>
<td>Nutrients</td>
<td>Lower effluent nutrient requirements</td>
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<td>Economics of recovery</td>
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<td>Be paid for product</td>
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<td>Climate change and Energy</td>
<td>Reduced energy usage</td>
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<td>GHG emissions</td>
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<td>Power generation</td>
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<td>Water sources</td>
<td>Water quality protection and water reuse</td>
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N-E-W Paradigm

- Resource Recovery Facilities
  - Nutrient recovery
  - Energy independence
  - Water reuse

- Past: meet permit

- Future: recovering valuable resources while maintaining water quality standards
WEF believes that wastewater treatment plants are NOT waste disposal facilities, but rather water resource recovery facilities that produce **clean water**, **recover nutrients** (such as phosphorus and nitrogen), and have the potential to reduce the nation’s dependence upon fossil fuel through the production and use of **renewable energy**.
The Water Resources Utility of the Future: A Blueprint for Action (NACWA, WERF, and WEF)

“Clean water utilities are undergoing a remarkable transformation. They are evolving from wastewater treatment plants to resource recovery facilities...

Delivering maximum environmental benefits at the least cost to society”
Treating Wastewater: Responding to the “New Normal”

Waste Streams → Value Streams
Where to start – A Stepwise Approach
How Do We Get There?

- **Stepwise process**
  Incremental steps that make sense now

- **Establish vision for the future**

- **Reduce resource use**
Energy Roadmap Purpose

- **To help utility managers effectively plan and implement efforts to enhance energy sustainability**
- **Build off of the wealth of existing information**
### The WEF Energy Roadmap

<table>
<thead>
<tr>
<th>Strategic Management</th>
<th>Organizational Culture</th>
<th>Communication and Outreach</th>
<th>Demand Side Management</th>
<th>Energy Generation</th>
<th>Innovating for the Future</th>
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<tbody>
<tr>
<td><strong>ENABLE</strong></td>
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<tr>
<td>Set goal</td>
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<td>Develop vision, Team</td>
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<td><strong>INTEGRATE</strong></td>
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<tr>
<td>Gather support</td>
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<td>Communicate, take action</td>
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<td><strong>OPTIMIZE</strong></td>
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<td>Prioritize and implement</td>
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<td>Empower Team and staff</td>
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<td>Continuously evolve efforts</td>
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<tr>
<td>Implement changes</td>
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<tr>
<td>Maximize value</td>
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<td>Full-scale solutions</td>
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#### Key Steps:
- **Develop strategy**
- **Develop message**
- **Understand baseline**
- **Detailed evaluation**
- **Implement generation**
- **Research, partner, mitigate**
- **Evaluate existing**
- **Maximize value**
- **Full-scale solutions**
- **Enable**
- **Optimize**
- **Integrate**

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**Innovating for the Future**
- Set goal
- Develop vision, Team
- Develop strategy
- Understand baseline
- Develop goal/strategy
- Evaluate existing

**Communication and Outreach**
- Gather support
- Communicate, take action

**Demand Side Management**
- Prioritize and implement
- Empower Team and staff
- Continuously evolve efforts
- Implement changes

**Energy Generation**
- Full-scale solutions

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**Strategic Management**
- Develop vision, Team
- Develop strategy
- Understand baseline
- Develop goal/strategy
- Evaluate existing

**Organizational Culture**
- Gather support
- Communicate, take action
- Detailed evaluation
- Implement generation
- Research, partner, mitigate
Strategic Management

Strategic Direction • Financial Viability • Collaborative Partnerships • Towards Carbon Neutrality

Possible Goals
• 75% energy produced onsite
• 20% energy conservation
• 90% energy from renewables
• 50% employees on public transportation

Energy Use

<table>
<thead>
<tr>
<th>Time</th>
<th>Imported Energy</th>
<th>Renewable Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>0</td>
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</table>
Organizational Culture

Energy Vision • Energy Team • Staff Development & Alignment

Energy Champion

Operations Staff

Engineering Staff

Maintenance Staff

Planning Staff

Regulatory Compliance
Demand Side Management

Electricity Costs and Billing • Power Measurement & Control • Energy Management • Source Control

- **Review Data**
  - 2 years of bills

- **Analyze Costs**
  - Energy charges
  - Demand charges
  - Rate structure

- **Make Changes**
  - Rate structure
  - Shift loads

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**Electricity Costs and Billing**

- **Energy Demand Costs**
  - $2.65000/kW - $11.79000/kW

- **Energy Usage Costs**
  - $0.08351/kWh - $0.13965/kWh

**Total Electric Costs**

**Time of Use (TOU) Charges**

**Energy Usage Costs**

- $0.08351/kWh - $0.13965/kWh

**Total Electric Costs**

- $2.65000/kW - $11.79000/kW
Demand Side Management

Electricity Costs and Billing • **Power Measurement & Control** • Energy Management • Source Control

- **Analyze Baseline Energy Use**
- **Benchmarking by Process**
- **Real-time control**
Demand Side Management

Electricity Costs and Billing • Power Measurement & Control • Energy Management • Source Control

- Energy Audit
- Implement Changes
- Incorporate Energy into Future Designs

Reduce Energy Use of Key Equipment By:
- ✅ Shutting down
- ✅ Operate part time
- ✅ Operate with variable speed
- ✅ Operate at lower flows
- ✅ Operate at lower pressures
- ✅ Replace with more efficient equipment
CIP Based Plan

<table>
<thead>
<tr>
<th>Energy (kWh)</th>
<th>Annual Energy Cost ($)</th>
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</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>$2,208,690</td>
</tr>
<tr>
<td>HW Plant</td>
<td>$2,208,690</td>
</tr>
<tr>
<td>H2S Control</td>
<td>$2,208,690</td>
</tr>
<tr>
<td>BG Utilization</td>
<td>$2,208,690</td>
</tr>
<tr>
<td>DAF</td>
<td>$1,557,360</td>
</tr>
<tr>
<td>Heat Conservation</td>
<td>$1,517,360</td>
</tr>
<tr>
<td>20% Biogas Increase</td>
<td>$1,387,094</td>
</tr>
<tr>
<td>50% Biogas Increase</td>
<td>$1,191,695</td>
</tr>
<tr>
<td>100% Biogas Increase</td>
<td>$866,130</td>
</tr>
</tbody>
</table>

Legend:
- Purchased Electricity
- BG Electricity
- Purchased NG
- BG Heat
- Electricity Cost
- NG Cost
Example: Sheboygan

2002

2006

City Initiates High-Strength Waste Program

2008

2010

2012

Master Planning → Aeration Efficiency → Biogas Utilization → Biosolids Energy Master Planning → Phase I Biosolids Upgrades → Phase II Biosolids Upgrades

Sheboygan’s Energy Roadmap

2013: Average 90% of energy produced on site
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

- RWW Pumping (2005)
- Aeration I
- CHP I
- Aeration II
- Digestion and CHP II
- Biosolids Dryer (2013)
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

Motors and VFDs

Diffusers and High-Efficiency Blowers

RWW Pumping

Aeration I

Heat Utilization

CHP I

Aeration II

Digestion and CHP II

Biosolids Dryer

HSW Program

2005

2006

2010

2011

2013
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

- **Biogas Boilers + Piping Mods**
- **10 x 30-kW Microturbines**

Diagram:
- RWW Pumping (2005)
  - Aeration I
    - Heat Utilization
      - CHP I
        - Aeration II
          - Digestion and CHP II
            - Biosolids Dryer

Timeline:
- 2005: RWW Pumping
- 2006: Heat Utilization
- 2010: Aeration II
- 2011: Digestion and CHP II
- 2013: Biosolids Dryer

HSW Program
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

- RWW Pumping
- Aeration I
- Heat Utilization
- CHP I
- Aeration II
- Digestion and CHP II
- Biosolids Dryer

HSW Program

Automatic DO Control

- 2005
- 2006
- 2010
- 2011
- 2013
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

- RWW Pumping
- Aeration I
- Heat Utilization
- CHP I
- Aeration II
- Digestion and CHP II
- Biosolids Dryer

LM Digester Mixers
2 x 200-kW Microturbines

2005
2006
2010
2011
2013

HSW Program
Stepwise example: Energy Efficiency, HSW, and Biogas Utilization Projects

RWW Pumping → Aeration I → Heat Utilization → CHP I → Aeration II → Digestion and CHP II → Biosolids Dryer

- HSW Program

- Medium Temperature Belt Dryer

- 2005
- 2006
- 2010
- 2011
- 2013
Example Sheboygan: HSW and CHP II
Dramatically Reduced Electricity Purchases

Purchased Electricity (kWh/Mgal)

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2010</th>
<th>2012</th>
<th>2013</th>
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<tbody>
<tr>
<td>WFE</td>
<td>1760</td>
<td>1200</td>
<td>400</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td>1700</td>
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75% decrease from 1760 kWh/Mgal in 2003 to 450 kWh/Mgal in 2013.
Resource Recovery in the Midwest
Example Battle Creek: Provide Air More Efficiently

Opportunity: Improve Blower Reliability, Operating Efficiency and Turndown

Replacement of Aging Equipment

25% Reduction In Blower Energy Use
Turndown to Lowest Operating Requirement
Example Battle Creek: Combined Blower and Control Savings

Anticipated Savings:

45% Total Reduction in Aeration Energy Use

Total estimated savings of $220,000 annually

Additional 1,420,000 kWh per year
Example: City of Janesville WWTF; Janesville, WI

19 mgd municipal plant (Avg. flow 13.5 mgd)

130,000 cfd of biogas produced

Gas Compression/Moisture Removal

Siloxane Removal

Carbon Dioxide Removal

BioCNG™ System produces vehicle fuel

Turbines Producing 460KW
Example: Dayton
Creating Pipeline Quality Methane from Biogas

Guild Molecular Gate PSA System
City of Dayton, OH
Digester (Waste Water Plant)
700 SCFM (1125 nm3/hr) Feed
Product to Pipeline Quality (98% Methane)
Example: Madison Struvite Harvesting
Example: MWRD

- Calumet WRP – 430 mgd
- Public/Private Partnership
- Selected Illinois American
- Reuse to industrial users
- American will build and own distribution system
- Buy water from MWRD, sell to industry
Take Away

- Embrace the opportunity
- Lots of great resources
- Set a goal
- Gain buy-in from staff/leaders
- Keep it simple at first
- Don’t overlook operational changes
- Use savings to fund future projects
- Look for rebates
Any questions

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Thank you!