Agenda

- Mega trends
- Impacts on wastewater utilities
- The N-E-W paradigm
- Existing infrastructure examples
What Is a Mega Trend?

- Trend: short term, next five years
- Mega Trend: tendencies expected for 10 to 20 years and beyond
1. Shifting and Growing Population

Number of people living worldwide since 1700 in billions

Source: United Nations World Population Prospects, Deutsche Stiftung Weltbevölkerung
1. Shifting and Growing Population

Rural & Urban Populations vs. Time

- Rural population (thousands)
- Urban population (thousands)

Changing Environmental Pressures
2. Nutrients

Phosphate Rock: Non-renewable resource

Phosphate production has steadily increased

World Phosphate Rock Production (metric tons)
2. Nutrients

Nitrogen limitation

Haber-Bosch: large natural gas requirement
2. Nutrients

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

Together with nitrogen and potassium, phosphorus is a crucial ingredient in fertilizer. It is extracted from phosphorus-rich rock in the form of phosphate. **Morocco, China, South Africa and the U.S.** hold 83 percent of the world's easily exploitable phosphate rock and contribute two thirds of the annual phosphorus production (**circles, below**). At current rates of extraction (**bars, below**), known U.S. reserves are projected to last 40 years. Globally about 90 years' worth of phosphorus remains. Once the resource starts running out, less economical supplies may have to be tapped, which could result in higher prices and market disruptions. Already production has been declining despite the incentive of increasing prices (**graph, right**); last year the price spiked up because of tight supply and increased demand.
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.

Archer and Stefan (2010) *The Climate Crisis*
4. Water Sources

Red: Less Water
Blue: More water

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.

Archer and Stefan (2010) The Climate Crisis
Resource Nexus: The Environmental Challenge of the 21st Century
# Impact on Water Utilities

<table>
<thead>
<tr>
<th>Megatrend</th>
<th>Wastewater Utilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>World population increase and shift</td>
<td>Urban population: centralized treatment</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Lower effluent nutrient requirements Economics of recovery?</td>
</tr>
<tr>
<td>Climate change</td>
<td>Reduced energy usage GHG emissions</td>
</tr>
<tr>
<td>Water sources</td>
<td>Water quality protection and water reuse</td>
</tr>
</tbody>
</table>
A N-E-W Paradigm: shifting to Resource Recovery Facilities
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**
Check List is Divided into Three Categories

1. Environmental
2. Community/Social
3. Economic

The Triple Bottom Line
Treating Wastewater: Responding to the “New Normal”

Waste Streams → Value Streams
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.
Utility of the Future

- 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"
Utility of the Future

THE GENESIS AND EVOLUTION OF ACTIVATED SLUDGE TECHNOLOGY

James E. Alleman, Professor
School of Civil Engineering
West Lafayette, IN 47907-1284

"These newly devised waste conduits were subsequently recognized as a prime commodity for entrepreneurial gain, and a cottage industry of wastewater alchemists quickly emerged intent on extracting the nutrient essence of sewage for monetary gain."
How Do We Get There?

- **Stepwise process**
  - Incremental steps that make sense now
  - Establish vision for the future

- **One of first steps:** reduce resource use

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**WEF Technical Publication**

Moving Toward Resource Recovery Facilities

Detailed Chapter Outlines

- **Chapter 1** What Resources Can We Recover?
- **Chapter 3** The Case for Resource Recovery: Part 2—Regional Trends in the Water, Energy, Nutrient Landscape
- **Chapter 4** Recovery Technology Approaches and Opportunities
- **Chapter 5** Case Studies of Recovery Technology Applications around the Globe
- **Chapter 6** General Guidance for Applying Resource Recovery
- **Chapter 7** Resource Recovery: The Utility Management Perspective
- **Chapter 8** Where Do We Go and How Do We Get There?
- **Chapter 9** The Next Generation of Resource Recovery Technologies

Publication scheduled for July 2014

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**WEF Note:** WEF publications no longer refer to “wastewater treatment plants” but use “water resource recovery facilities”
Energy Roadmap Purpose

- To help utility managers effectively plan and implement efforts to enhance energy sustainability
- Build off of the wealth of existing information
What will the **N-E-W Utility** look like: **Linear vs. NON-Linear** systems
What Will this Utility Look Like?

- **Current:** linear, compartmentalized water and energy system
What Will this Utility Look Like?

- Future: Watershed approach
Resource Recovery in the Midwest
Nutrient Recovery

Current Fertilizer Production

Nutrient Recovery

Image Source: Ostara
Nutrient Recovery
Struvite: MAP: Magnesium Ammonium Phosphate

MgNH$_4$PO$_4$
Struvite Harvesting

- Baseline needs (with current technology)
  - Definite: Biological phosphorus removal
  - Most of the time: Anaerobic digestion
Struvite Harvesting

- Produce slow release fertilizer from wastewater
- Operational benefits in anaerobic digestion systems
- Excellent PR...
Struvite Harvesting

- Emerging, hot topic

- Current: only for plants with anaerobic digestion (which is required for the energy part...)

Madison: Startup in September 2014
Example: Madison Reactor and recycle pump
Example: Madison Harvest and Dewatering
Example: Madison Dryers and classifier
Example Madison:
Bagging and shipping
Energy Reduction/Recovery
Example: Delhi Township
Example: Sheboygan Regional WRRF

- Design Average Flow = 18 mgd
- Average Flow = 11 mgd
Example: Sheboygan

- 2002: Master Planning
- 2006: City Initiates High-Strength Waste Program
- 2008: Aeration Efficiency
- 2010: Biogas Utilization
- 2012: Biosolids Energy Master Planning

Sheboygan’s Energy Roadmap

2013: Average 90% of energy produced on site
HSW and CHP II Dramatically Reduced Electricity Purchases

Purchased Electricity (kWh/Mgal)

<table>
<thead>
<tr>
<th>Year</th>
<th>Purchased Electricity</th>
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<tbody>
<tr>
<td>WFE</td>
<td>1760</td>
</tr>
<tr>
<td>2003</td>
<td>1700</td>
</tr>
<tr>
<td>2010</td>
<td>1200</td>
</tr>
<tr>
<td>2012</td>
<td>400</td>
</tr>
<tr>
<td>2013</td>
<td>450</td>
</tr>
</tbody>
</table>

↓75%
## Favorable Cost-Benefit

<table>
<thead>
<tr>
<th>Category</th>
<th>Annual</th>
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<tbody>
<tr>
<td>Electrical Savings</td>
<td>$452,000</td>
</tr>
<tr>
<td>Natural Gas Savings</td>
<td>$135,000</td>
</tr>
<tr>
<td>HSW Revenue</td>
<td>$400,000</td>
</tr>
<tr>
<td><strong>Savings</strong></td>
<td><strong>$987,000</strong></td>
</tr>
</tbody>
</table>

Payback – under 6 years
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)
Compressed Natural Gas Vehicles
UK's first 'poo bus' hits the road
Britain’s first ‘Bio-Bus’ powered entirely by human and food waste takes to the streets

"Is Bristol’s biomethane-powered city bus a bold new move towards sustainable transport, or just hot air?Ajit Niranjan catches the No 2 (really) to find out"
Example: PersigoWWTF; Grand Junction, CO

12.5 MGD municipal plant (Avg. flow 8 MGD)
100 scfm of biogas produced
Time Fill for CNG-Fueled collection trucks and city buses
5.8 mile pipeline from the wastewater facility to the fueling facility
142,000 gallons of gasoline diverted = CO2 emissions reduction of 3 million pounds/year

Unison Solutions
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

Unison Solutions
Condition-Energy Nexus

Capital Prioritization

Condition Replacement
- Aging Infrastructure
- Safety Concerns
- Reliability
- Decreased Demand

Energy Efficiency
- Increased Production
- Potential Benefits

Payback = \( \frac{\text{Capital}_{\text{Energy Efficient}} - \text{Capital}_{\text{In-kind}}}{\text{Energy}_{\text{In-kind}} - \text{Energy}_{\text{Energy Efficient}}} \)
What about Water?

- Midwest: a lot of water is available

- Other areas:
  - Direct potable reuse
  - Irrigation
  - Power plants
  - Industrial uses
Drivers
Typical California Groundwater Recharge Reuse Requirements

- Micro filtration/reverse osmosis/AOP
- *Monitoring for pharmaceuticals, endocrine disruptors, wastewater indicators*
  - Turbidity < 0.2 NTU 95%, < 0.5 NTU max.
  - Total Nitrogen < 5 mg/L
  - TOC < 0.5 mg/L / max. average RWC
  - RO permeate conductivity < 300 uS/cm
  - pH 6.5 to 8.5
  - Not exceed CDPH MCLs for drinking water
  - Limits on lead, copper and mineral constituents
Internal Reuse at WRRF’s

- Gravity Belt Thickener
- Washdown Water
- Carrier Water
- Cleaning and Flushing
- Odor Control
- Yard Hydrants
Example: Muskegon County

5100 acres
55 mgd
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
Beginning a Journey
N-E-W Paradigm

- Utilities are beginning the journey
- Plan today for tomorrow
Energy Efficiency, HSW, and Biogas Utilization Projects

- RWW Pumping (2005)
- Aeration I
- CHP I
- Aeration II
- Digestion and CHP II (2010)
- Biosolids Dryer (2011)

HSW Program (2013)
Energy Efficiency, HSW, and Biogas Utilization Projects

- **Motors and VFDs**
- **Diffusers and High-Efficiency Blowers**

**Projects**

1. **RWW Pumping**
2. **Aeration I**
3. **Heat Utilization**
4. **CHP I**
5. **Aeration II**
6. **Digestion and CHP II**
7. **Biosolids Dryer**

**Timeline**

- 2005: RWW Pumping
- 2006: Aeration I
- 2006: Heat Utilization
- 2010: CHP I
- 2011: Aeration II
- 2013: Digestion and CHP II
- 2013: Biosolids Dryer
Energy Efficiency, HSW, and Biogas Utilization Projects

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

RWW Pumping

Aeration I

Heat Utilization

CHP I

Aeration II

Digestion and CHP II

Biosolids Dryer

HSW Program

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

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

Automatic DO Control

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

- LM Digester Mixers
- 2 x 200-kW Microturbines

- 2005
- 2006
- 2010
- 2011
- 2013
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

Year:
- 2005
- 2006
- 2010
- 2011
- 2013
Thank you!!

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