WWTP Sustainable Design Opportunities
A Case Study in Dubuque, Iowa

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Presentation Outline

- Background & History
- Project Drivers
- Major Project Elements
- Sustainability Drivers in Dubuque
- Sustainable Project Elements
Overview of the Water Pollution Control Plant

- Bypass Old Rock Filters
- Primary Clarifiers
- HPO Activated Sludge
- Final Clarifiers
- Chlorine Contact Tank
- Ash Settling Ponds
- To Incineration
- Biological Sludge
- Ash
- To Mississippi River
History of the Water Pollution Control Plant

1960s Construction
- Preliminary Treatment
- Primary Clarifiers
- Trickling Filters
- Sludge Incinerators
History of the Water Pollution Control Plant

1970s Construction
- HPO Activated Sludge
- Final Clarifiers
- Zimpro Added
History of the Water Pollution Control Plant

1990s Modifications
- Preliminary Treatment
- Decommission Zimpro
- HPO Modifications
- Clarifier Upgrades

- Odor Control
- Reduce O&M
Project Drivers - Concerns & Issues

1. Plant Age
2. Performance
3. Capacity/City Growth
4. Regulatory Changes
Project Drivers – Plant Age

- Systems and equipment 30-40 years old
- Reduced efficiencies; high maintenance
- Especially critical for incinerators
Dubuque WPCP Upgrade Project

1. Planning started in 2007
2. Facilities Plan approved December 2008
3. Design complete March 2010
4. Bid date May 20, 2010
5. Bid Amount: $50 million
6. Construction Completion: 2013
Major Project Elements

- TPAD Anaerobic Digestion
- Renovate Admin Bldg & Lab Addition
- Peak Flow Equalization Tank
- Replace HPO Equipment
- Backup Generation
- New Primary Clarifier and Weir Covers
- New Energy Dissipating Inlets
- Convert Chlorine Tank to UV
- Remove Ash Ponds
- New Cascade Aerator
- Cold Storage Building
- Renovate Incinerator & Maint. Bldgs
- New Screening and Grit Equipment
- Septage/HST Receiving
Sustainability Drivers

2006 program to establish Dubuque as a “Sustainable City”

2009 announcement to make Dubuque one of the first “smarter cities”

Energy Star rating for buildings, lighting, HVAC; possibly entire project/plant
Sustainable Dubuque

11 Sustainable Principles

- Regional Economy
- Smart Energy Use
- Resource Management
- Community Design
- Green Buildings
- Healthy Local Food
- Community Knowledge
- Reasonable Mobility
- Healthy Air
- Clean Water
- Native Plants & Animals
Smart City

• “Dubuque will be a living lab...to develop an international smarter sustainable city model and a set of reusable assets...”

  – Transit & Transportation
  – Energy
  – Housing & Urban Development
  – Social Engagement - Public Awareness
  – Health & Wellness
  – Parking - Transit optimization
Smart City

- Enhance the city’s and citizens’ understanding of energy consumption and water management
- Reduce costs and overall carbon footprint
- Implement an IBM platform for real-time integrated “sustainability monitoring”
- Energy management and energy use tracking within the electric grid - water system, WPCP, etc.
Energy Efficiency

• Portfolio Manager for WWTPs
  – Benchmark against other WWTPs

• Specific Incentives for Energy Efficiency Improvements and Elements
Sustainable Project Elements
Planning Phase

• Previous Planning in the 1980s (20 years ago):
  – Focused on incinerators
  – Air pollution was primary concern
  – “Protest” type opposition to incineration
Sustainable Project Elements
Planning Phase

• 2007-2008 Planning:
  – Air pollution still primary concern
  – Engaged public and interest groups
  – Discussion vs. protests
  – Two public informational meetings/workshops
  – Industrial/commercial presentation and outreach
  – City council workshops
  – Additional presentations by WPCP staff to interested groups
Sustainable Project Elements
Planning Phase

- Residuals Management Example
Example
Current Solids Management
Sludge Incineration

Primary Sludge

Biological Sludge

Centrifuges for Dewatering (installed 1993)

Two Incinerators (installed 1960s; rehabbed 1990s)

Ash to storage; reuse or landfill
## Example

**Solids Management Alternatives**

<table>
<thead>
<tr>
<th>RM1</th>
<th>Refurbish both incinerators</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM2a</td>
<td>Refurbish one incinerator; use lime system for backup</td>
</tr>
<tr>
<td>RM2b</td>
<td>One new incinerator; use lime system for backup</td>
</tr>
<tr>
<td>RM3</td>
<td>Redundant lime stabilization systems; land application</td>
</tr>
<tr>
<td>RM4</td>
<td>Anaerobic digestion; land application</td>
</tr>
<tr>
<td>RM5</td>
<td>Anaerobic digestion and composting</td>
</tr>
<tr>
<td>RM6</td>
<td>Anaerobic digestion and drying; land application</td>
</tr>
<tr>
<td>RM7</td>
<td>Drying; land application</td>
</tr>
<tr>
<td>Alternative</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Alt. RM1</td>
<td>Rehab Both Inc.</td>
</tr>
<tr>
<td>Alt. RM2a</td>
<td>Rehab. 1 Inc.; Lime Backup</td>
</tr>
<tr>
<td>Alt. RM2b</td>
<td>One new Inc.; Lime Backup</td>
</tr>
<tr>
<td>Alt. RM3</td>
<td>Lime Stabilization</td>
</tr>
<tr>
<td>Alt. RM4</td>
<td>Digestion &amp; Land App.</td>
</tr>
<tr>
<td>Alt. RM5</td>
<td>Digestion &amp; Composting</td>
</tr>
<tr>
<td>Alt. RM6</td>
<td>Digestion, Drying, and Land App.</td>
</tr>
<tr>
<td>Alt. RM7</td>
<td>Drying and Land App.</td>
</tr>
</tbody>
</table>
# Example

**O&M Costs**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>Opinion of Annual O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt. RM1</td>
<td>Rehab Both Inc.</td>
<td>$862,000</td>
</tr>
<tr>
<td>Alt. RM2a</td>
<td>Rehab. 1 Inc.; Lime Backup</td>
<td>$914,000</td>
</tr>
<tr>
<td>Alt. RM2b</td>
<td>One new Inc.; Lime Backup</td>
<td>$914,000</td>
</tr>
<tr>
<td>Alt. RM3</td>
<td>Lime Stabilization</td>
<td>$1,669,000</td>
</tr>
<tr>
<td>Alt. RM4</td>
<td>Digestion &amp; Land App.</td>
<td>$754,000</td>
</tr>
<tr>
<td>Alt. RM5</td>
<td>Digestion &amp; Composting</td>
<td>$790,000</td>
</tr>
<tr>
<td>Alt. RM6</td>
<td>Digestion, Drying, and Land App.</td>
<td>$1,062,000</td>
</tr>
<tr>
<td>Alt. RM7</td>
<td>Drying and Land App.</td>
<td>$1,391,000</td>
</tr>
</tbody>
</table>
## Example

### 20-Year Present Worth

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Description</th>
<th>Opinion of Present Worth</th>
<th>% of Lowest Present Worth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alt. RM1</td>
<td>Rehab Both Inc.</td>
<td>$37,624,000</td>
<td>126%</td>
</tr>
<tr>
<td>Alt. RM2a</td>
<td>Rehab. 1 Inc.; Lime Backup</td>
<td>$29,941,000</td>
<td>100%</td>
</tr>
<tr>
<td>Alt. RM2b</td>
<td>One new Inc.; Lime Backup</td>
<td>$45,469,000</td>
<td>152%</td>
</tr>
<tr>
<td>Alt. RM3</td>
<td>Lime Stabilization</td>
<td>$33,530,000</td>
<td>112%</td>
</tr>
<tr>
<td>Alt. RM4</td>
<td>Digestion &amp; Land App.</td>
<td>$35,601,000</td>
<td>119%</td>
</tr>
<tr>
<td>Alt. RM5</td>
<td>Digestion &amp; Composting</td>
<td>$36,054,000</td>
<td>120%</td>
</tr>
<tr>
<td>Alt. RM6</td>
<td>Digestion, Drying, and Land App.</td>
<td>$55,453,000</td>
<td>185%</td>
</tr>
<tr>
<td>Alt. RM7</td>
<td>Drying and Land App.</td>
<td>$43,838,000</td>
<td>146%</td>
</tr>
</tbody>
</table>
Example
40-Year Present Worth Costs

- City wished to look beyond the typical 20-year planning window to establish direction and evaluate long-term sustainability

- Anaerobic digestion alternatives had lowest 40-year present worth values
## Example

### Carbon Footprint

<table>
<thead>
<tr>
<th>Category</th>
<th>RM1</th>
<th>RM2</th>
<th>RM3</th>
<th>RM4</th>
<th>RM5</th>
<th>RM6</th>
<th>RM7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incin.</td>
<td>Incin.</td>
<td>Incin.</td>
<td>Lime</td>
<td>AD</td>
<td>AD</td>
<td>AD + Dry</td>
<td>Drying</td>
</tr>
<tr>
<td>Electricity, MWH/yr</td>
<td>1,614</td>
<td>1,614</td>
<td>834</td>
<td>686</td>
<td>686</td>
<td>1,289</td>
<td>603</td>
</tr>
<tr>
<td>Nat. Gas, MBTU/yr</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>24,500</td>
<td>45,900</td>
</tr>
<tr>
<td>Fuel Oil, gal/yr</td>
<td>18,300</td>
<td>18,300</td>
<td>6,000</td>
<td>1,280</td>
<td>1,280</td>
<td>230</td>
<td>430</td>
</tr>
<tr>
<td>GHG Emissions, Tons of CO$_2$e/yr</td>
<td>1,300</td>
<td>1,300</td>
<td>640</td>
<td>480</td>
<td>480</td>
<td>2,300</td>
<td>3,100</td>
</tr>
</tbody>
</table>

**Notes:**

- Carbon equivalents from electrical generation = 1.37 lbs CO$_2$/kWH.
- Carbon equivalents of natural gas use = 117 lbs CO$_2$/MBTU.
- Carbon equivalents of fuel oil use = 22.29 lbs CO$_2$/gallon.

**Source:** EPA Climate Change Website
Example
Sludge Processing Direction

- Anaerobic Digestion Selected
  - Lowest annual O&M cost
  - Lowest energy use
  - Potential for energy generation
  - Reasonable 20-year present worth cost
  - Lowest 40-year (and beyond) present worth cost
  - Most “Sustainable” solution
Sustainable Project Elements
Anaerobic Digestion

- **High-strength industrial wastes/FOG wastes**
  - Digestion facilities are designed to accommodate
  - Receiving station included

- **Food residuals (commercial, institutional)**
  - Preliminary design complete
Sustainable Project Elements
Renewable Energy

• **Thorough evaluation of renewable energy opportunities:**
  – Solar
  – Wind
  – Geothermal
  – Effluent heat recovery
  – Biogas
  – Food residuals
  – Micro Hydropower

• Include effluent heat recovery and biogas reuse; plan for others
### Sustainable Project Elements

**Cogeneration**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas Production at Design Conditions</td>
<td>260,000 ft³/day</td>
</tr>
<tr>
<td>Total Energy Content of Biogas</td>
<td>156 MMBTU/day</td>
</tr>
<tr>
<td>Electrical Generation Potential (kW)</td>
<td>400</td>
</tr>
<tr>
<td>(kW/H/day)</td>
<td>9,600</td>
</tr>
<tr>
<td>Net Electrical Generation Value @ $0.08/kWh</td>
<td>$768/day</td>
</tr>
<tr>
<td></td>
<td>$280,000/yr</td>
</tr>
<tr>
<td>GHG Emission Reduction Credit</td>
<td>4,800,000 lbs CO₂/yr**</td>
</tr>
<tr>
<td><em>(Biogas used to generate electricity)</em></td>
<td>~ 2,400 tons/yr</td>
</tr>
</tbody>
</table>

** 1 kWh ~ 1.37 lbs CO₂ equivalent.**
Sustainable Project Elements
Effluent Heat Recovery

Winter

OUTSIDE AIR

ENERGY RECOVERY UNIT

HEAT PUMP

Wastewater

EFFLUENT WATER

ROOM

HEATING MODE
Sustainable Project Elements
Effluent Heat Recovery

Summer

OUTSIDE AIR → ENERGY RECOVERY UNIT → WASTEWATER

HEAT PUMP

COOLING MODE
Sustainable Project Elements
Building Design

• Energy Star rating for the Administration Building
• Energy Star credits for process buildings
• Energy Star rating for plant?
Energy Efficiency (Thermal)

- **Building Shell R Values (non-process)**
  - $R = 50$ for roofs (typical design ~ 24)
  - $R = 24$ for walls (typical design ~ 14)
  - Specified wall panel system in lieu of standard infill

- **Available credits of $0.60/sq. ft. for thermal efficiency (occupied spaces)**
  - $6,000$ for Admin. Bldg.
Energy Efficiency (HVAC/Mechanical)

- HVAC Modeling
  - TRACE 700 modeling of all occupied spaces
  - Identify thermal bridging
- Mechanical/thermal efficiency > ~93% (equipment)
- Available credits of $0.60/sq. ft. for mechanical efficiency
  - Includes process buildings too
Energy Efficiency (Lighting)

• AGI32 Modeling of All Spaces
  – Interior and exterior lighting efficiency

• Available credits of $0.60/sq. ft. for lighting efficiency
  – Includes process buildings too
Sustainable Project Elements
Building Design

- Utility rebates - materials, appliances, etc. (≈$250,000)
- Very Significant Design Effort
- Design Verification After Construction
Sustainable Project Elements
Structure Re-Purposing

- Renovate Incinerator Bldg
- Convert Chlorine Tank to UV
- Peak Flow Equalization Tank
- Generator Bldg
Sustainable Project Elements
Site Design

Native Prairie Mix
Low Mow
Rain Garden
Rain Garden
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Sustainable Project Elements
Public Sharing/Education

- Plant operating data and energy use data sharing via the Internet.
Major Project Elements

- Peak Flow Equalization Tank
- Equalization Tank
- Renovate Incinerator & Maint. Bldgs
- Renovate Admin Bldg & Lab Addition
- New Screening and Grit Equipment
- Septage/HST Receiving
- New Primary Clarifier and Weir Covers
- TPAD Anaerobic Digestion
- Replace HPO Equipment
- Backup Generation
- New Energy Dissipating Inlets
- Convert Chlorine Tank to UV
- New Cascade Aerator
- Cold Storage Building
- Remove Ash Ponds
Alt. RM1 – Refurbish Both Incinerators

Primary Sludge

Biological Sludge Modifications

Centrifuges Dewatering

Refurbished Incinerators

Ash to storage; reuse or landfill
Alt. RM2a – Refurbish One Incinerator
Use Lime as Backup

Primary Sludge

Biological Sludge Modifications

Centrifuges Dewatering

Refurbished Incinerator

Ash to storage; reuse or landfill

Backup Lime System

Biosolids to Ag. Land
Alt. RM2b – One New Incinerator
Use Lime as Backup

- Primary Sludge
- Biological Sludge Modifications
- Centrifuges Dewatering
- New Incinerator
  - Ash to storage; reuse or landfill
- Backup Lime System
- Lime & Acid Addition
- Biosolids to Ag. Land
Alt. RM3 – Lime Stabilization and Land Application

Primary Sludge → Centrifuges Dewatering → Redundant Lime Systems → Biosolids to Ag. Land

Biological Sludge
Alt. RM4 – Anaerobic Digestion with Land Application

Primary Sludge → WAS Thickening → TPAD Anaerobic Digestion → Centrifuge Dewatering → Biosolids to Ag. Land

Biological Sludge
Alt. RM5 – Anaerobic Digestion with Composting

Primary Sludge

Biological Sludge

WAS Thickening

TPAD Anaerobic Digestion

Yard Trimmings ➔ Biosolids to DMASWA

Centrifuge Dewatering
Alt. RM6 – Anaerobic Digestion and Drying with Land Application
Alt. RM7 – Drying and Land Application

Primary Sludge

Biological Sludge

Centrifuge Dewatering

Redundant Sludge Dryers

Biosolids to Ag. Land