CHOOSING THE APPROPRIATE METRIC FROM SMALL TO LARGE FACILITIES

Diego Rosso
University of California, Irvine
Department of Civil & Environmental Engineering
Department of Chemical Engineering and Material Science
Water-Energy Nexus Research Center
CHARGE QUESTIONS

a) What will we be able to achieve with a common set of metrics?

b) What is an appropriate set of common metrics that should be measured across a national test bed network and reported for all technologies that impact the performance of a wastewater resource recovery and treatment technologies?

c) What standard procedures exist to measure these metrics?
• What might be appropriate for different size plants

• or it just does not matter

• Priority = f(size)

• Should the priority list be dictated by the availability of techniques?

• How about surrogate metrics?

• What should be done in-house vs. by an external “expert”
ENERGY & WRRF
FACULTATIVE LAGOON (pop. 1090)

INYOKERN COMMUNITY SERVICES DISTRICT
WASTEWATER TREATMENT PLANT
INYOKERN, CALIFORNIA

- Population 1090
- 310 urban connections
- 50,000 gal/d
- 2x7.5HP on-grid mixers
- 1 solar-powered mixer
- POWER BILL DOMINATED BY AERATION ENERGY USE & POWER DEMAND

Aeration cost $= 45\text{-}75\%$ of plant energy (w/o influent/effluent pumping)


**Figure 1.** Estimated power usage for a typical 20MGD activated sludge facility performing wastewater treatment with nitrogen removal in the United States (MOP32, 2009).
ENERGY FOOTPRINT: 200MGD

- Effluent: 27%
- Biosolids Loading: 1%
- Sludge Dewatering: 3%
- Solid Digesters: 7%
- DAF Thickening: 4%
- Trickling Filter: 6%
- Secondary Clarifier: 3%
- Secondary - ASP: 22%
- Primary Clarifier: 7%
- Influent Screens: 1%
- Headworks: 1%
- Odor control: 5%
- Influent pumping: 10%
- Digester Gas Compressor: 3%

Without influent/effluent pumping

Aeration = 45%

• COMMON SET OF METRICS
• PLANT SIZE vs. PRIORITY
The difference between energy consumption and energy cost: Modelling energy tariff structures for water resource recovery facilities

- IS ENERGY INTENSITY A GOOD INDICATOR?
- WHAT ABOUT POWER DENSITY?
- SHOULD THE OVERALL ENERGY COST BE THE METRIC?
- SURROGATE METRICS?
INFORMATION IS POWER

\[ eFP_{TOT} = \sum_{i=1}^{n} eFP_i = \sum_{i=1}^{n} \sum_{j=1}^{m} n_j \times p_j \times h_j \times t_j \]


<table>
<thead>
<tr>
<th>Information Available</th>
<th>Modelling Nature</th>
<th>Difficulty to Gather</th>
<th>Margin for Improvement</th>
<th>Data Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power bill</td>
<td>Cumulative</td>
<td>Easy</td>
<td>Small</td>
<td>Very common</td>
</tr>
<tr>
<td>Power by unit</td>
<td>Static</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Rare</td>
</tr>
<tr>
<td>Power</td>
<td>Time</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STANDARD vs. ADVANCED PROCEDURES/TECHNIQUES/PRACTICES...
Power distribution portfolio over the diurnal cycle for Southern California (SCE, 2010)

Q: WHAT ABOUT CARBON FOOTPRINT AS AN INDICATOR?
Energy Intensity in Water Reuse


Normalized metrics do not necessarily reflect actual impact.

Increasing water quality.

INCREASING WATER QUALITY

NORMALIZED METRICS DO NOT NECESSARILY REFLECT ACTUAL IMPACT
PROCESS ANALYSIS AND AUDITS
CAPEX QUESTION: DO WE EVALUATE OUR WRRF BEFORE EXPANSION?

Waste of $(\text{CapEx & OpEx}) + \text{unnecessary C, H}_2\text{O & energy footprints}$

TECHNIQUE AVAILABILITY CAN BE A DETERMINING FACTOR FOR PRIORITIZATION

PRE-TREAT | PRIM SETTL | REACTOR VOLUME | AERATION CAPAC | SEC. CLAR. | ETC.
The cost of inefficient primaries

The cost being inefficient is directly reflected in an energy deficit. Treatment plants pose as potential energy and water factories, i.e. Taking “Waste” out of “WasteWater” [Grant et al (2012) Science]
AERATION EFFICIENCY TESTING

\[ \text{OTR} = (k_L a \cdot V) \left[ C_{\text{sat}} - (\text{DO}_{\text{exc}} + \text{DO}_{\text{needed}}) \right] = \text{kg} \text{O}_2/\text{d} = $$$/\text{d} \]
AERATION ANALYSIS: Process selection of IFAS vs. ASP

Using advanced techniques does not necessarily mean outsourcing.
Specific Power Drawn from Blowers

- Dot marker: eFP, Energy Used per Volume Treated
- Triangle marker:

**POWER DENSITY (W/m³)**

**ENERGY INTENSITY (Wh/m³)**

Time (in hours)
Activated Sludge Process: Diurnal Dynamics

Variation relative to average

Importance of process dynamics: Power vs. Energy
PITCH:

- Common set of metrics?
- Standard procedures/techniques?
- Priority = f (size)
- Priority = f (technique availability)
- Surrogate metrics?
- In-house vs. outsourcing