UCI WEX Center
Research at the Water-Energy Nexus

EPL
ENVIRONMENTAL PROCESS LAB

# CHOOSING THE APPROPRIATE METRIC FROM SMALL TO LARGE FACILITIES


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# 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?

# FOR YOUR INSTIGATION

- 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

LOCATION MAP

SITE MAP

LIST OF DRAWINGS

- 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

INYOKERN
COMMUNITY SERVICES DISTRICT

APPROVED, PRESIDENT OF THE BOARD OF DIRECTORS
PETE LINDSTROM

USE OF DOCUMENTS

SCALES

INYOKERN COMMUNITY SERVICES DISTRICT
INYOKERN, CALIFORNIA

LOCATION AND SITE MAPS, DRAWING LIST, AND APPROVALS

Bebee et al (2015) *Proc. WEF Water & Energy Conference*, DC

# ENERGY FOOTPRINT: 20MGD

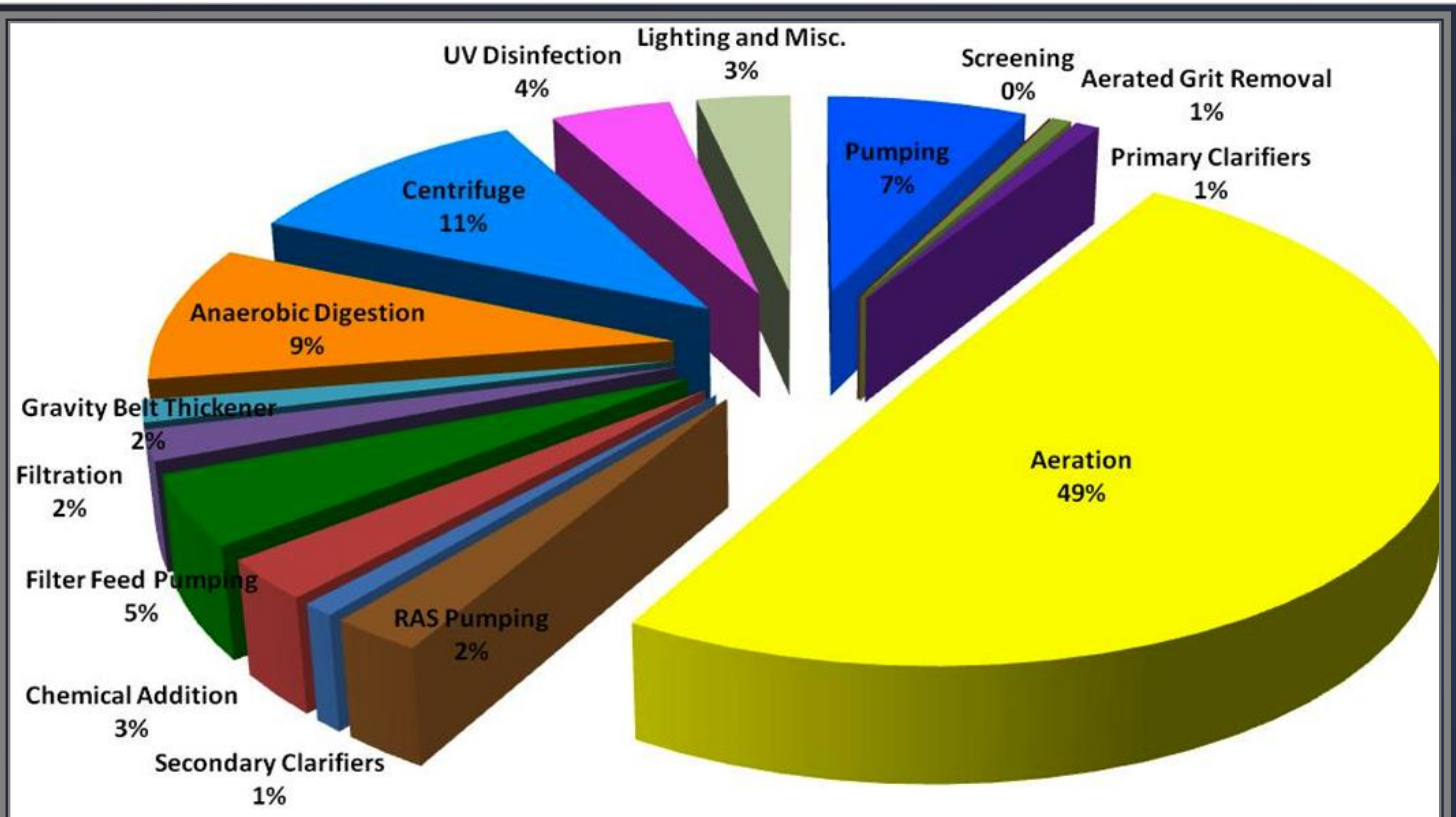
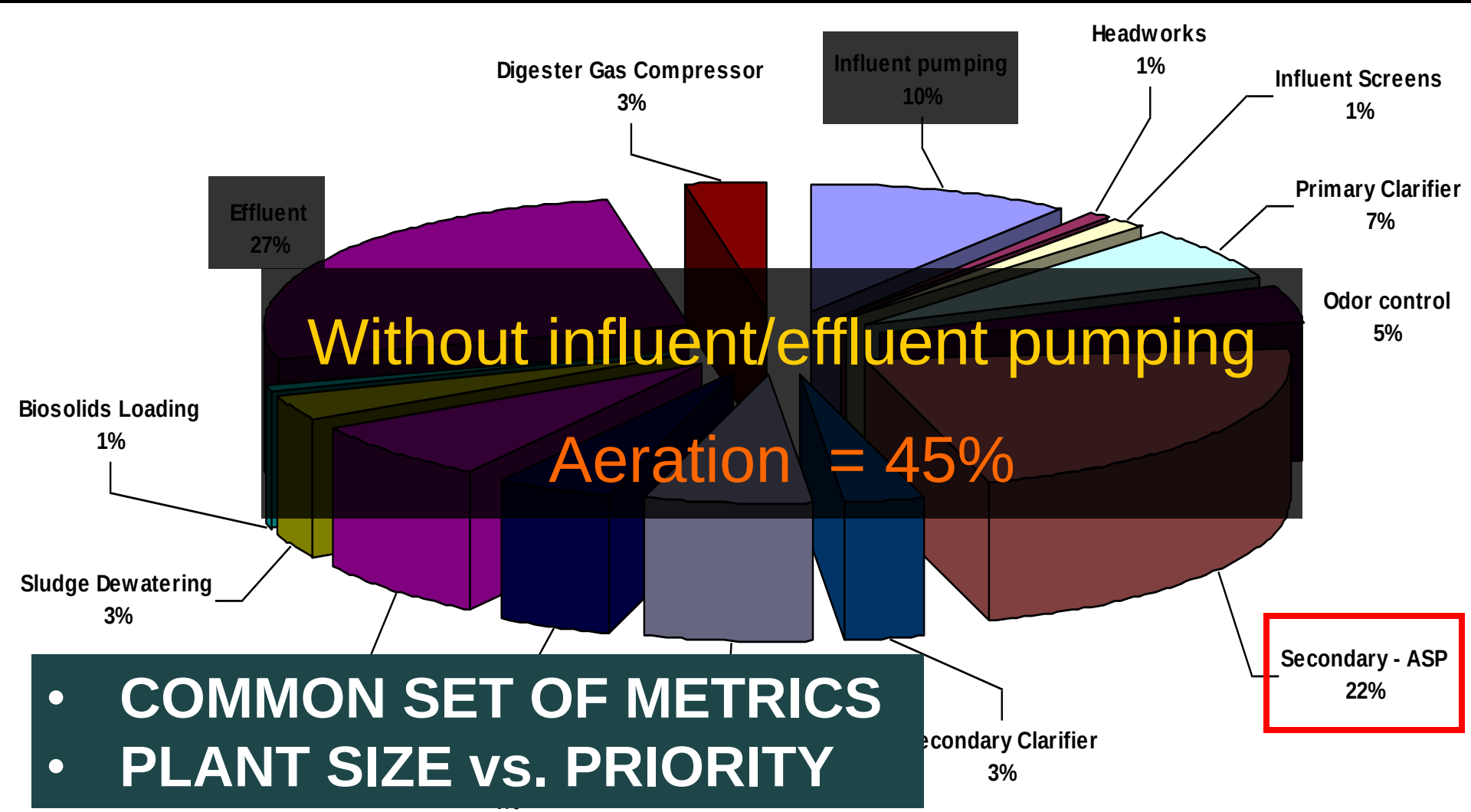



**Figure 1.** Estimated power usage for a typical 20MGD activated sludge facility performing wastewater treatment with nitrogen removal in the United States (MOP32, 2009).

**Aeration cost = 45-75% of plant energy (w/o influent/effluent pumping)**

**Rosso and Stenstrom (2005) *Wat. Res.* 39: 3773-3780**

# ENERGY FOOTPRINT: 200MGD




Without influent/effluent pumping

Aeration = 45%

- COMMON SET OF METRICS
- PLANT SIZE vs. PRIORITY

# BIG CHALLENGES

WATER RESEARCH 81 (2015) 113–123

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/watres


## 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

$$eFP_{TOT} = \sum_{i=1}^{n} eFP_i = \sum_{i=1}^{n} \sum_{j=1}^{m} n_j \times p_j \times \eta_j \times t_j$$

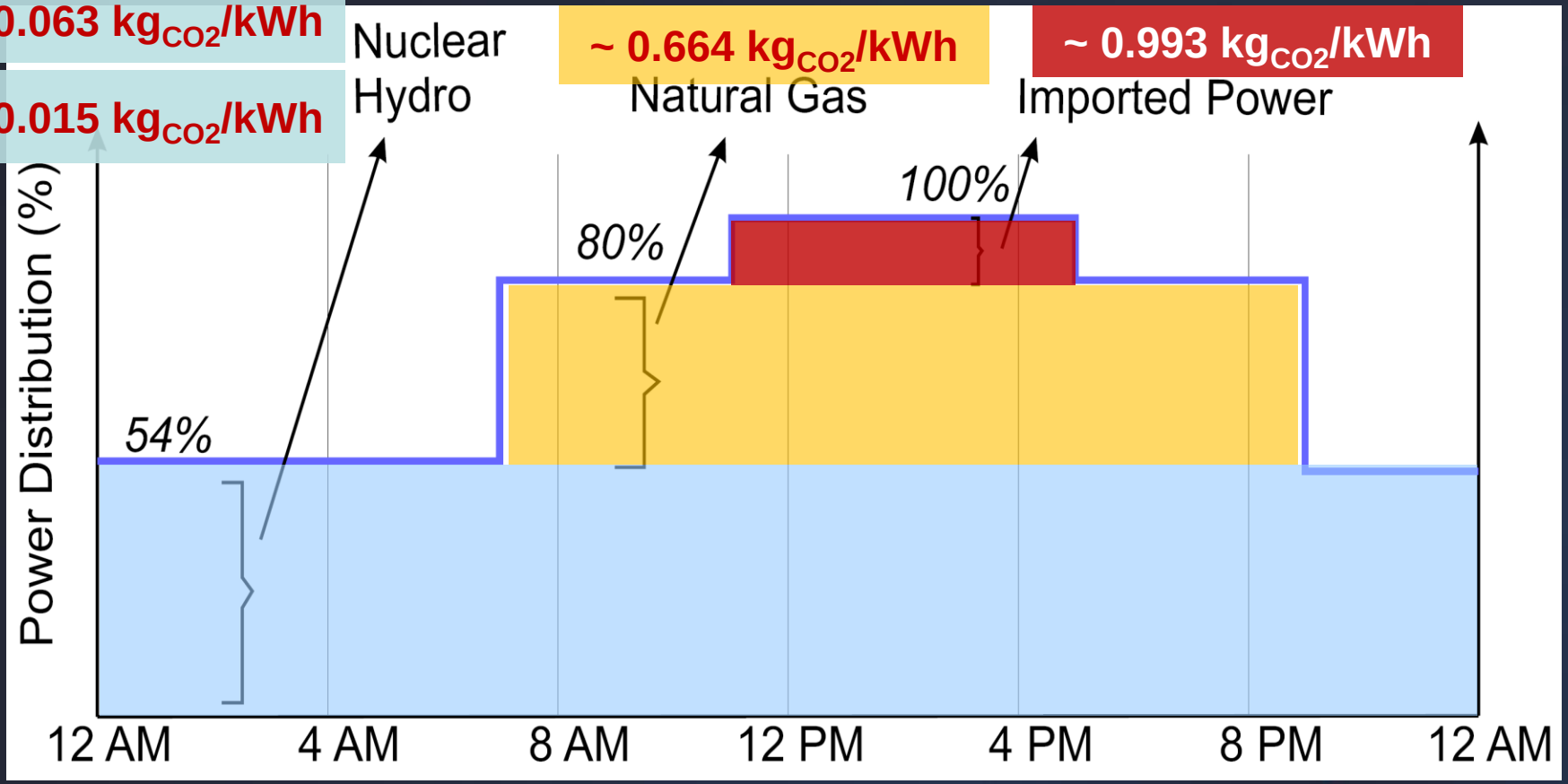
#units power efficiency time in operation

Rosso et al (2012) Wat. Practice Technol.

| Information Available | Modelling Nature | Difficulty to Gather | Margin for Improvement | Data Availability |
|---|---|---|---|---|
| Power bill | Cumulative | Easy | Small | Very common |
| Power by unit | Static | Moderate | Moderate | Rare |
| Po<br>Tim<br>( | | | | are |

**STANDARD vs. ADVANCED PROCEDURES/TECHNIQUES/PRACTICES**

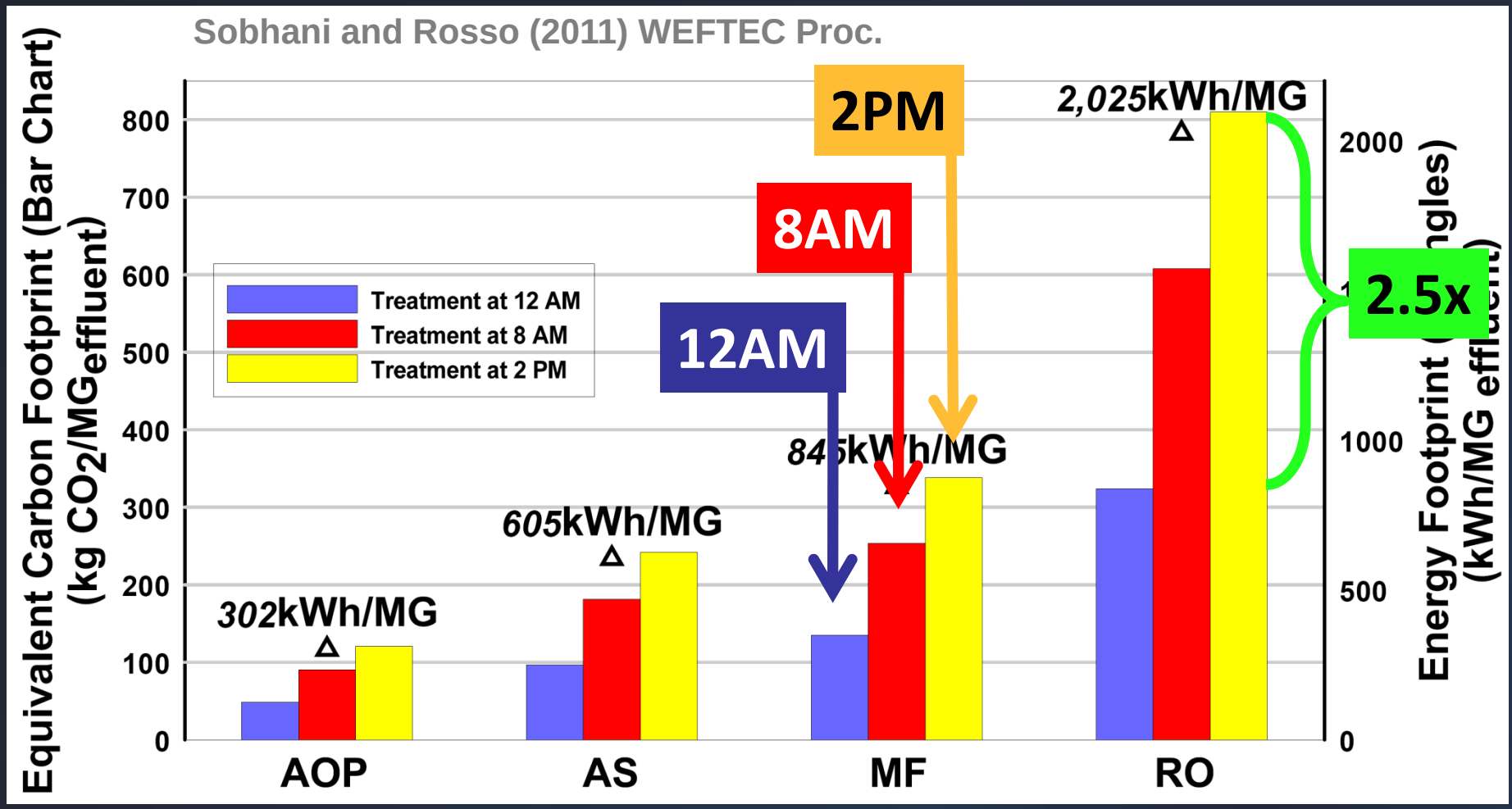
# Carbon Output Rate ($kg_{CO2}$ / kWh)




Power distribution portfolio over the diurnal cycle for Southern California (SCE, 2010)

**Q: WHAT ABOUT CARBON FOOTPRINT AS AN INDICATOR?**

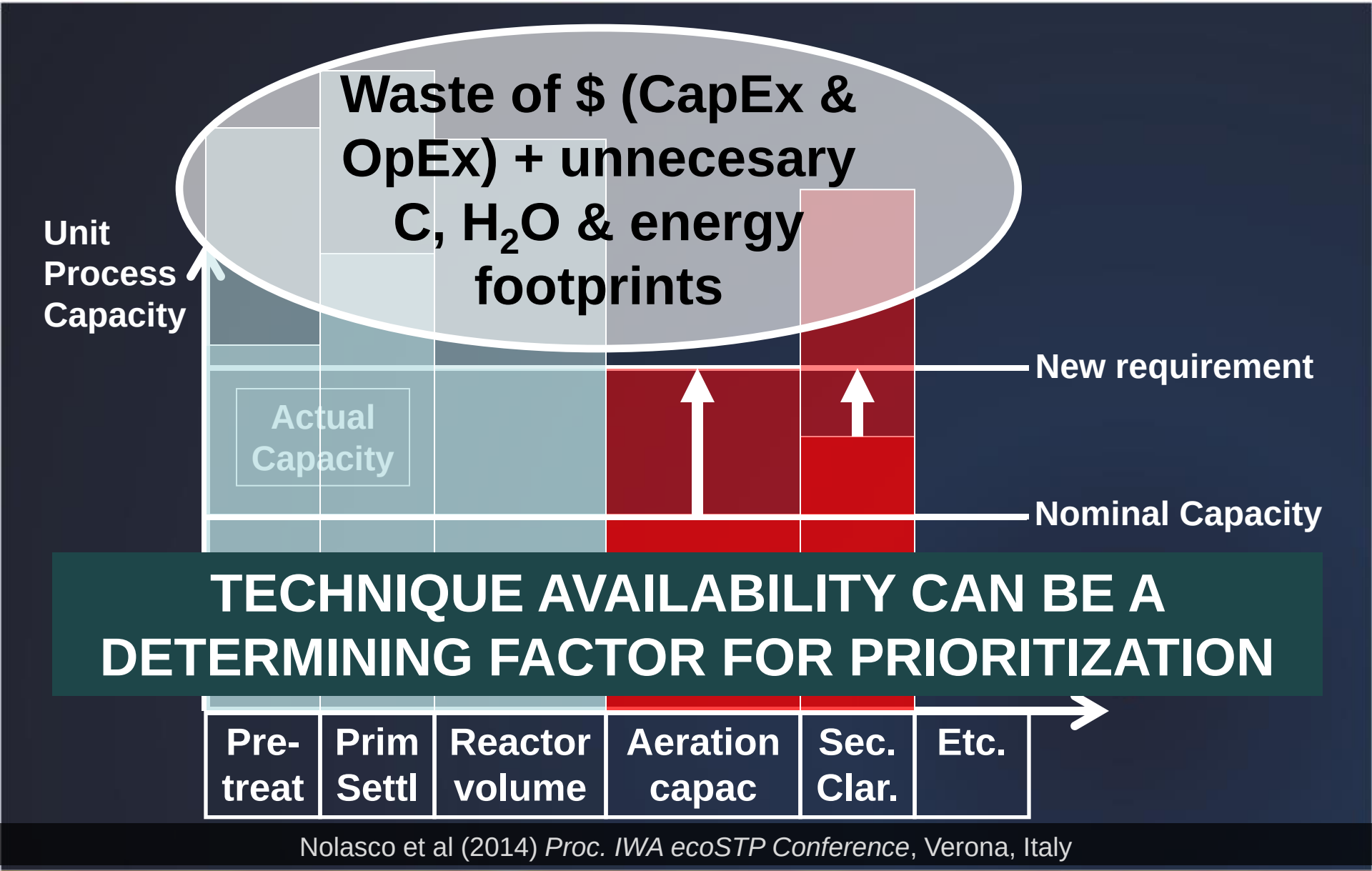
# Energy Intensity in Water Reuse




**NORMALIZED METRICS DO NOT NECESSARILY REFLECT ACTUAL IMPACT**

# PROCESS ANALYSIS AND AUDITS

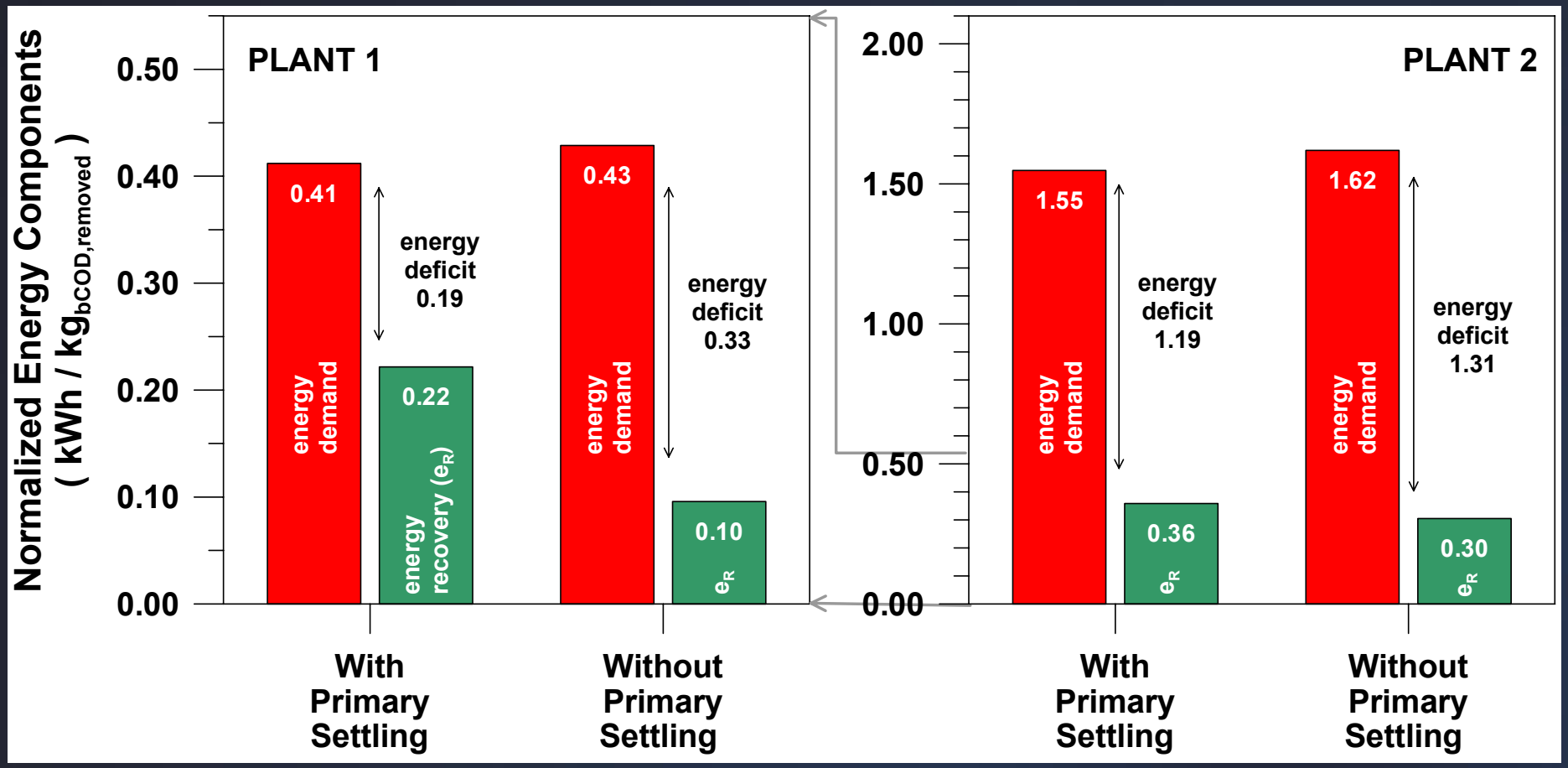
# CAPEX QUESTION: DO WE EVALUATE OUR WRRF BEFORE EXPANSION?




Nolasco et al (2014) *Proc. IWA ecoSTP Conference*, Verona, Italy

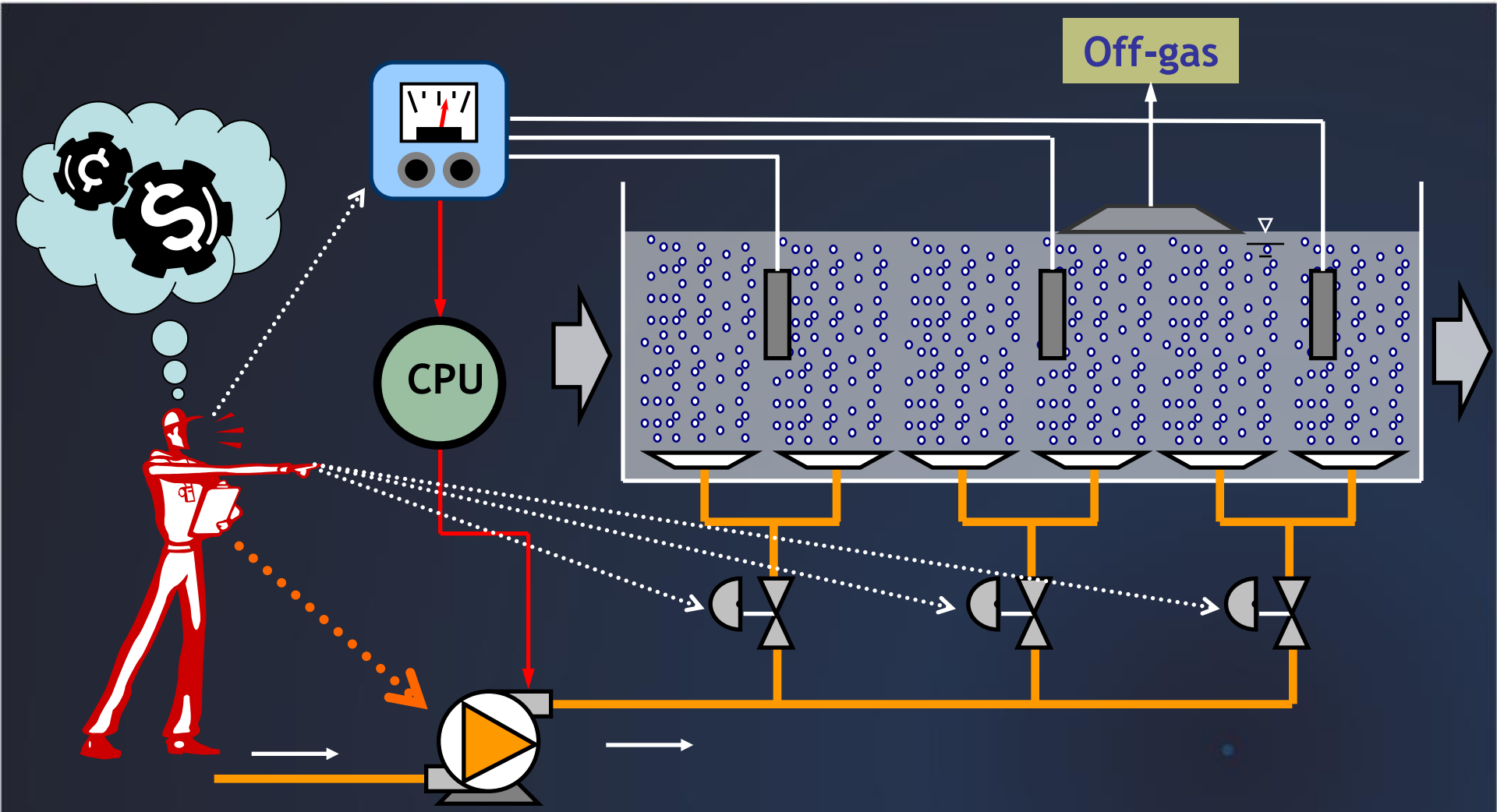
# The cost of inefficient primaries

Gori et al (2013) Wat. Sci. Technol.



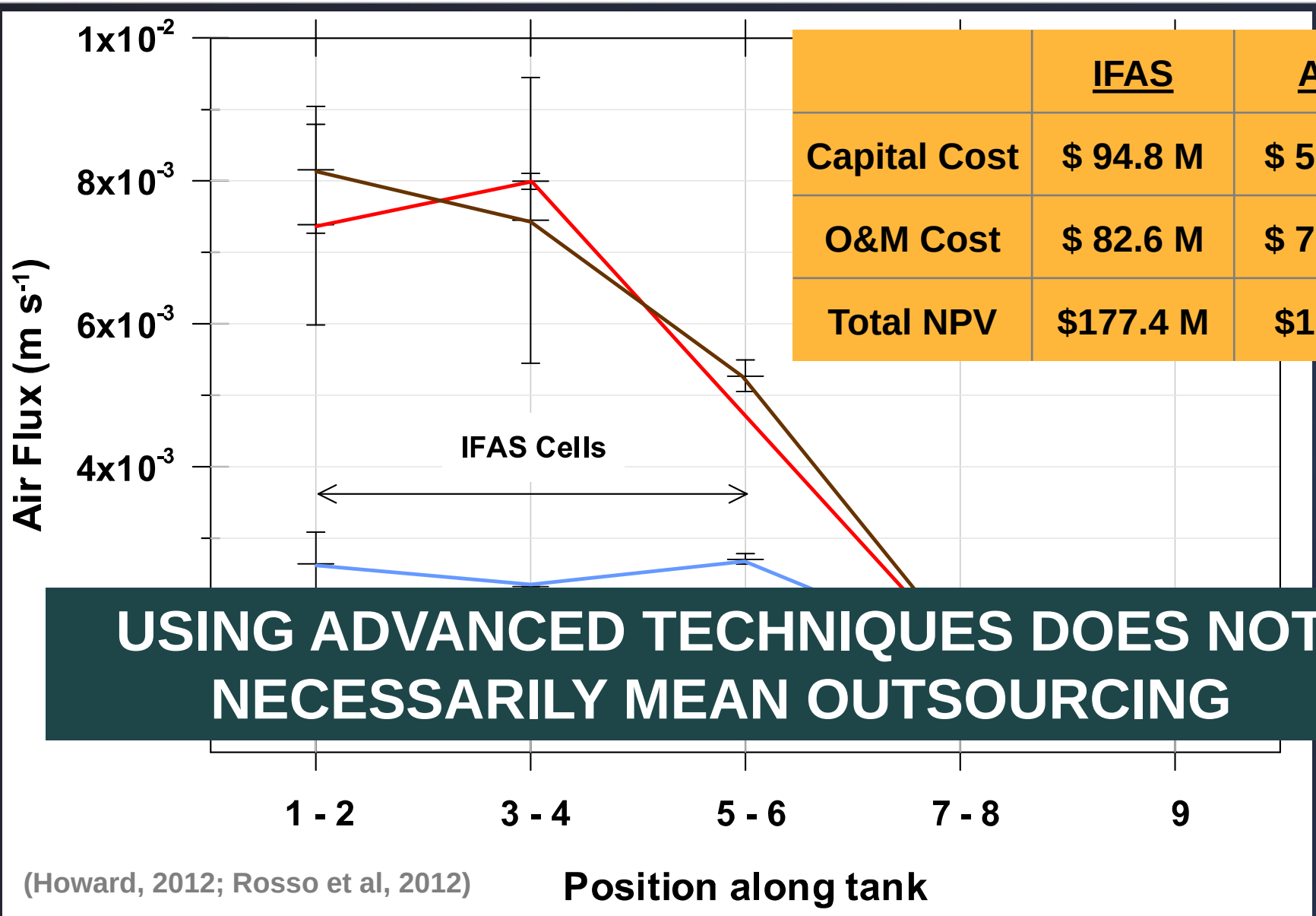

**The cost being inefficient is directly reflected in an energy deficit.**
**Treatment plants pose as potential energy and water factories,**
**i.e. Taking "Waste" out of "WasteWater" [Grant et al (2012) Science]**

# AERATION EFFICIENCY TESTING




$$OTR = (k_L a \cdot V)\,[C_{sat} - (DO_{exc} + DO_{needed})] = kg_{O_2}/d = \$\$\$/d$$

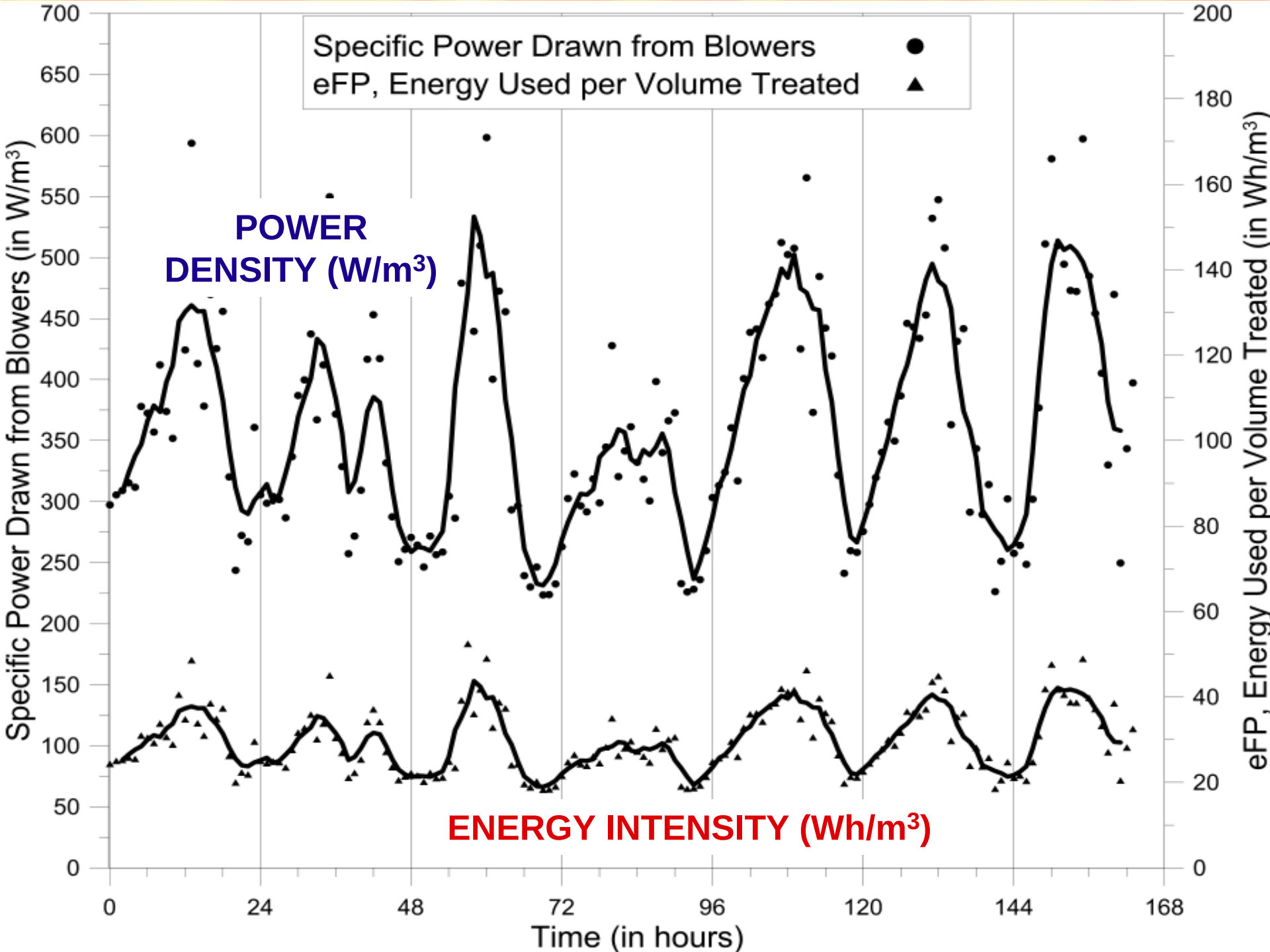
# AERATION ANALYSIS:
## Process selection of IFAS vs. ASP



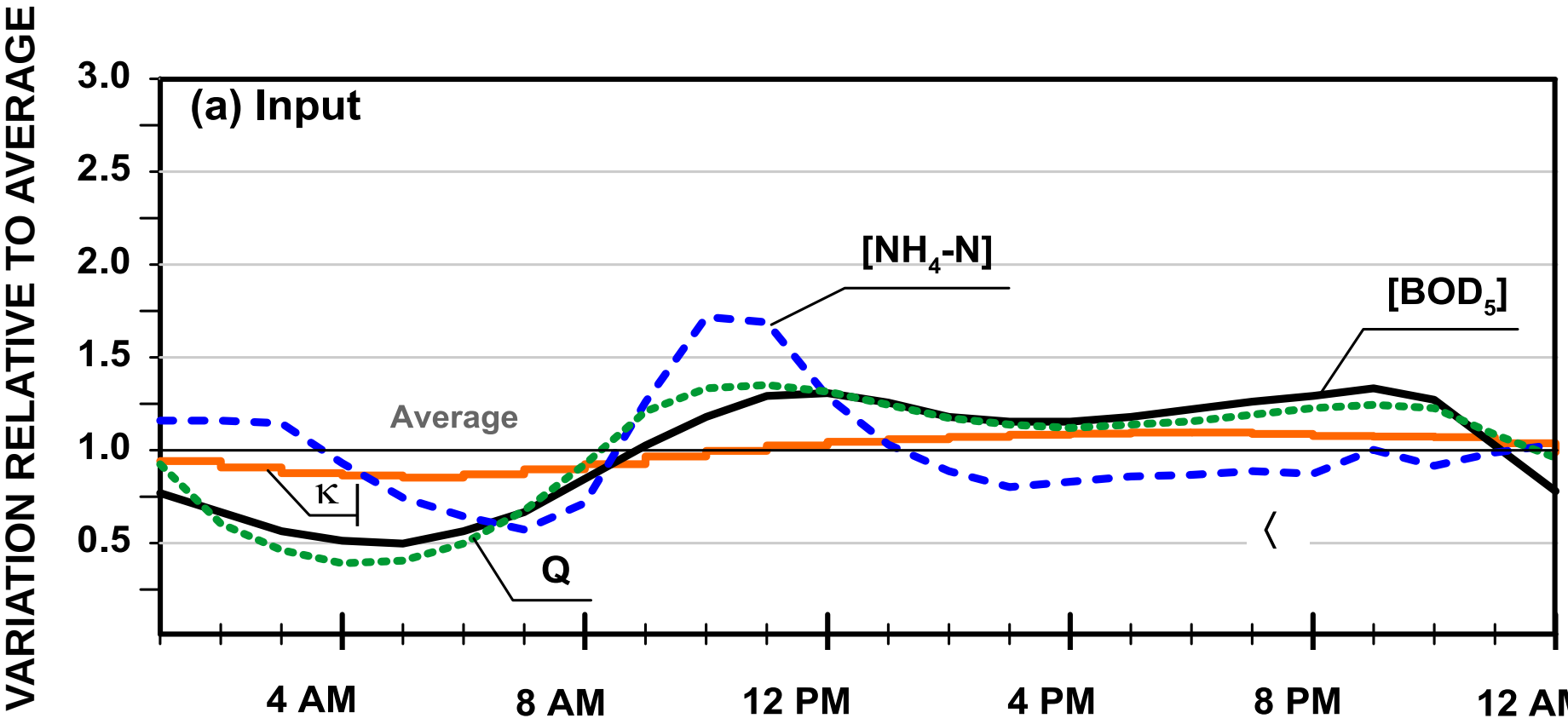

| | IFAS | ASP |
|---|---|---|
| Capital Cost | $ 94.8 M | $ 56.9 M |
| O&M Cost | $ 82.6 M | $ 70.1 M |
| Total NPV | $177.4 M | $127 M |

**USING ADVANCED TECHNIQUES DOES NOT NECESSARILY MEAN OUTSOURCING**

(Howard, 2012; Rosso et al, 2012)


Specific Power Drawn from Blowers
eFP, Energy Used per Volume Treated
POWER DENSITY (W/m³)
ENERGY INTENSITY (Wh/m³)
Specific Power Drawn from Blowers (in W/m³)
eFP, Energy Used per Volume Treated (in Wh/m³)
Time (in hours)
0
24
48
72
96
120
144
168
50
100
150
200
250
300
350
400
450
500
550
600
650
700
20
40
60
80
100
120
140
160
180

# Activated Sludge Process: Diurnal Dynamics




**IMPORTANCE OF PROCESS DYNAMICS: POWER vs. ENERGY**

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## PITCH:

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