



Development of a Utility Energy Index

CEE
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Project Goals

- What?
 - Produce Industry-wide energy performance metrics for:
 - Water Utilities
 - Wastewater Utilities
- Why?
 - Comparison to Peers
 - Comparison to Ideal
 - Identify savings potential
 - Prioritize where to look for improvements
- How?
 - Mimic EPA Energy Star for Buildings Ratings
 - Building characteristics
 - Operating Characteristics

Larger Picture: Benchmarking - History

■ Business: Total Quality Management

"Benchmarking - a continuous, systematic process for evaluating the products, services, and work processes of organizations that are recognized as representing best practices for the purpose of organizational improvement."

Michael J. Spendolini, *The Benchmarking Book*, 1992

■ Identify actions to improve performance

- Identify issues (metrics)
- Collect Internal data (baseline)
- Collect External data (comparison framework)
- Analysis
- Implement change
- Monitor Impact

How am I doing? Compared to What?

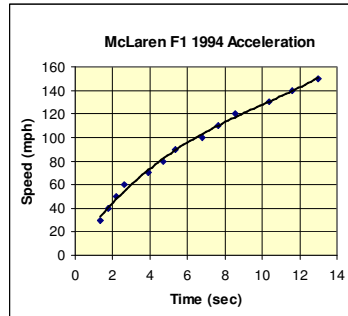
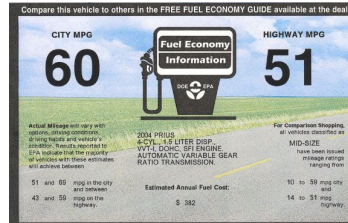
■ Energy Management Tool



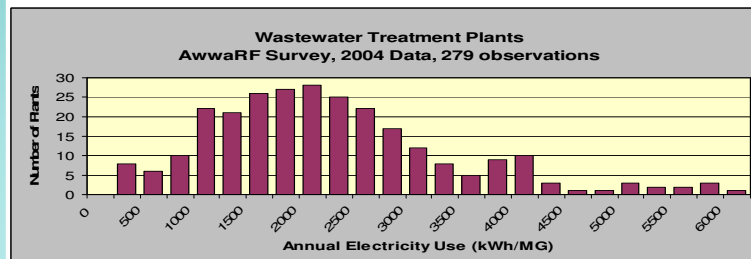
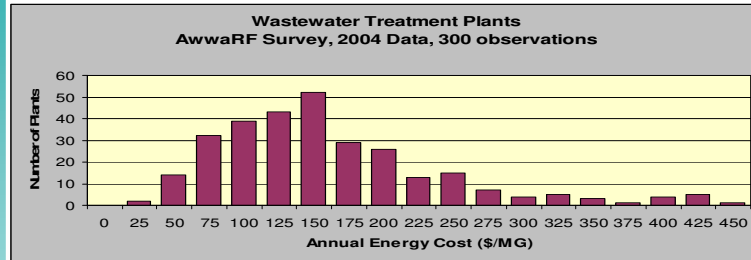
Define Performance: A Meaningful Metric



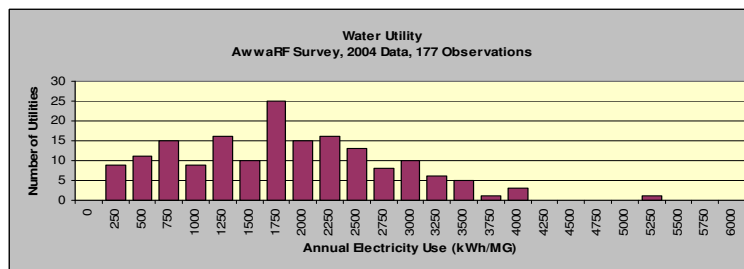
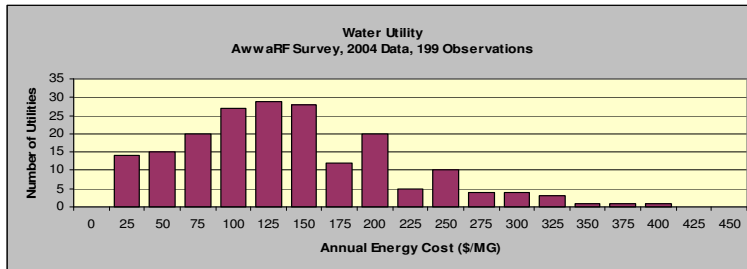
- Efficiency?
- Performance?
- Data Availability?
- Comparison Method?
 - Multiple factors
 - Flow
 - Loading
 - Treatment level
 - Processes
 - Unmanaged Factors
 - Imposed conditions



Single Parameter Comparisons Wastewater

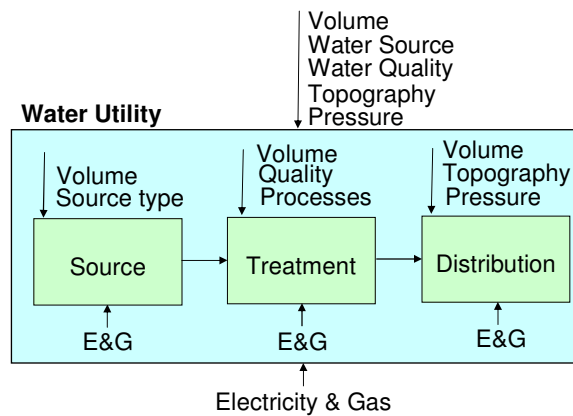


Single Parameter Comparisons Water



What Characterizes a Water Utility?

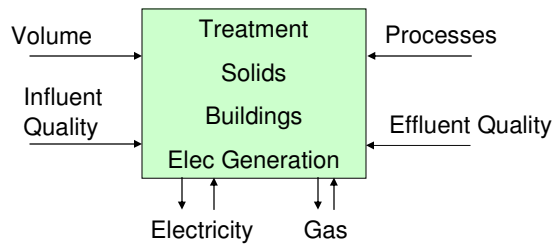
- Available energy use data?
- Factors impacting energy use?
- Exogenous vs Endogenous factors?



What Characterizes a Wastewater Treatment Plant?

Factors impacting energy use

- Load
 - Flow
 - Quality parameters (BOD, TSS, etc)
- Treatment level
 - Primary, Adv. Primary, Secondary, Advanced I, II
 - Nutrient removal
- Processes
 - Trickle Filtration, Aeration, UV disinfection, Digester gas use, etc.



What do we Already Know?

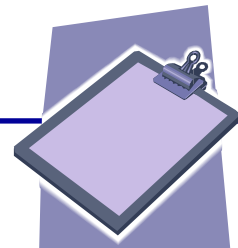
- Vast EPA Databases
 - Defines population
 - Characteristics
 - No energy data
- Water (51,000 MGD)
 - 52,000 Community Water Systems
 - 3,600 utilities serve pop>10,000 (85% of pop)
 - Little information on characterizing distribution
 - Total main length
- Wastewater (35,000 MGD)
 - 16,200 Treatment Plants
 - 3,200 plants >1.5 MGD (90% national flow)

Sample / Response



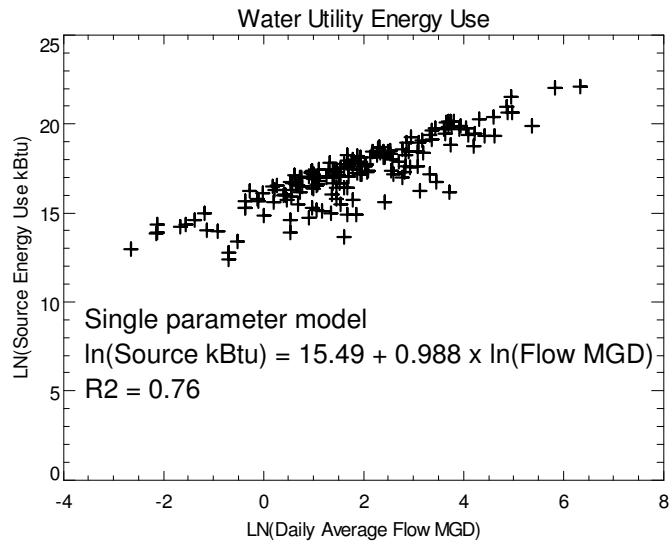
- **Water**
 - Pilot / survey refinement
 - 1,723 three page surveys mailed
 - SDWIS address and contact info incomplete
- **Results**
 - 217 responses (13%)
 - Additional NY surveys from State effort
- **Wastewater**
 - EPA Permit Compliance System (PCS) Database
 - 2,725 three page surveys mailed
- **Results**
 - 367 responses (14%)
 - Additional NY surveys from State effort

Survey

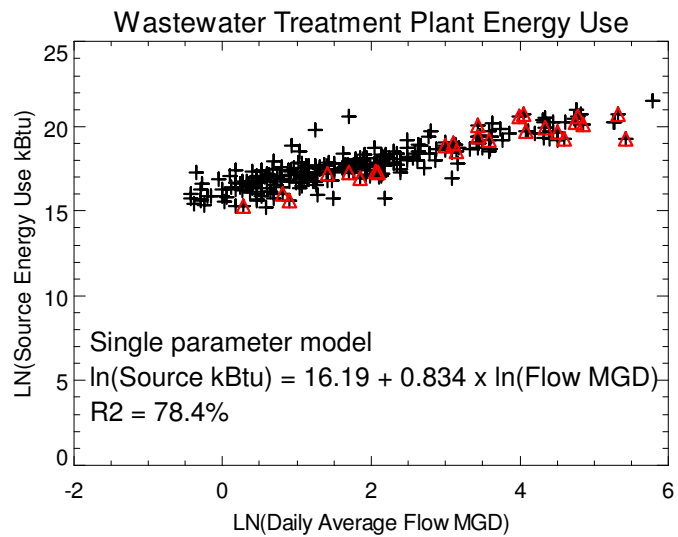


- **Water**
 - 97 parameters queried
 - Water Source
 - Treatment Objectives
 - Process Methods
 - Distribution System
 - Energy
- **Wastewater**
 - 65 parameters queried
 - Load
 - Process
 - Treatment Classification
 - Collection System
 - Energy

Analysis – Single Parameter



Analysis – Single Parameter



Multi-Parameter Model - Water

Flow (total & purchased)
Pumping Horsepower (total, raw, distribution)
Main Length

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	6	296.61614	49.43602	140.23	<.0001
Error	131	46.18114	0.35253		
Corrected Total	137	342.79727			

Root MSE	0.59374	R-Square	0.8653
Dependent Mean	17.72028	Adj R-Sq	0.8591
Coeff Var	3.35063		

Parameter Estimates					
Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > t
Intercept	1	8.63860	0.38143	22.65	<.0001
ln(flow)	1	0.53504	0.09018	5.93	<.0001
ln(p_flow)	1	-0.06773	0.01567	-4.32	<.0001
ln(total_hp)	1	0.24103	0.07650	3.15	0.0020
ln(raw_hp)	1	0.09625	0.02594	3.71	0.0003
ln(disrib_hp)	1	0.06563	0.02852	2.30	0.0230
ln(main_lngth)	1	0.26772	0.08316	3.22	0.0016

Improved from
0.76

Additional Data Characteristics

- Raw / Treatment / Distribution kWh isolation finds more related parameters

- n = 93 have two or more categories
- n = 35 have all three categories

Raw	Treatment	Distribution
<ul style="list-style-type: none"> Flow Raw HP Purchased flow Raw NTU Other energy Pressure filter 	<ul style="list-style-type: none"> Flow Distrib. Main Well depth Raw NTU Raw HP Distrib. Pressure Distrib. Storage Treat Oxidation Treat Recarbonation Treat Aeration Residual Sand Residual Gravity Pressure Filter 	<ul style="list-style-type: none"> Flow Distrib. HP Distrib. main length

Multi-Parameter Model - Wastewater

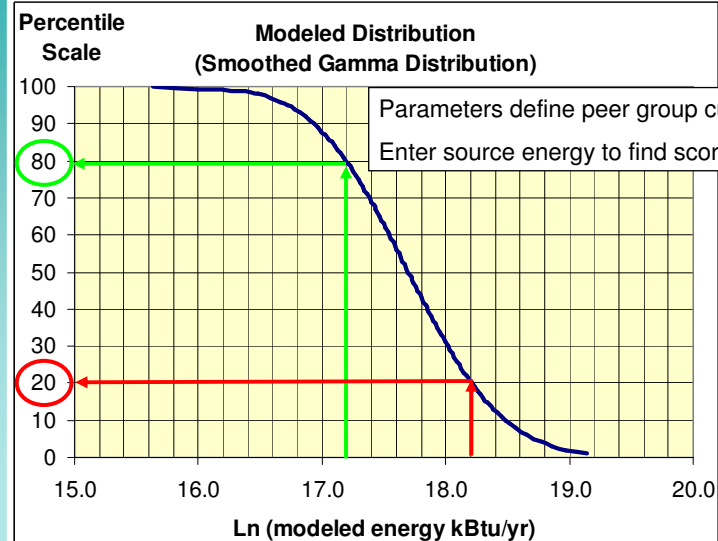
Parameter	Coefficient	Std Err	T-Value	p-value
Intercept	13.8359	0.390	35.47	0.0000
LN(Flow)	0.9035	0.025	35.71	0.0000
LN(In BOD)	0.5107	0.077	6.68	0.0000
LN(Out BOD)	-0.2005	0.043	-4.66	0.0000
Trickle Filtration	-0.2676	0.082	-3.25	0.0013
Nitrification	0.2502	0.070	3.59	0.0004
LN(Load Factor)	-0.0056	0.001	-4.43	0.0000
Land Application	0.2109	0.067	3.16	0.0018
Aerobic Digestion	0.1649	0.075	2.19	0.0291
On-Site Generation	-0.1528	0.077	-1.99	0.0477
Pure Oxygen	0.3069	0.152	2.02	0.0445

Analysis of Variance (Excerpt)

sum of squares for regression	389.92
sum of squares for error	59.81
total (corrected) sum of squares	449.73
adjusted R-squared (in percent)	86.17

Improved from
78%

Grading on a Curve



Metric Formulation – Utility Information

Utility Annual Energy Use

Please enter the annual energy use from all energy sources. If your utility generates power, please enter only purchased fuel.

Site Energy Type	Units	Site Energy Annual Use
Electricity	kWh	3,911,496
Natural gas	therms	-
Fuel oil #2	gallons	
Propane	gallons	

Energy use time period covered above:

Utility Characteristics

Please enter the following characteristics to describe the wastewater treatment plant.

Parameter	Units	Value
Design Daily Influent Flow	MGD	7.12
Average Daily Influent Flow	MGD	5.02
Average Influent BOD	mg/l	154.35
Average Effluent BOD	mg/l	2
Fixed Film - Trickle Filtration Process ?	yes (1) or no (0)	0
Treatment Includes Nutrient Removal ?	yes (1) or no (0)	0

Metric Formulation – Score and Distributions

Energy Metric

This wastewater treatment plant energy benchmark is based on a statistical representation of the energy use of treatment plants across the country. It includes the characteristics that were found to have the most impact in explaining energy use among various plants. The resulting score represents your plant's relative energy use within the distribution of plants with your characteristics.

Your Utility Benchmark Score:

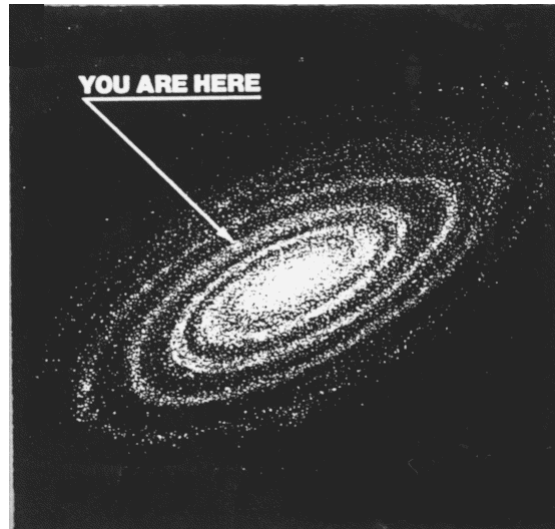
Total Source Energy Use (kBtu/yr):

Target Energy Use - Energy Metric Distribution

The following table shows the range in distribution of energy use for utilities with your characteristics. The percentages are relative to your use. The estimated site energy use is based on the proportions of site energy used at your plant.

Score	Source Energy Use		Estimated Site Energy Use			
	(kBtu/yr)	Percentage Difference (%)	Electricity (kWh/MG)	Natural Gas (therms/MG)	Fuel Oil (gallons/MG)	Propane (gallons/MG)
10	78,215,000	80%	3,846	0	0	0
25	58,451,000	35%	2,874	0	0	0
50	42,440,000	-2%	2,087	0	0	0
75	30,934,000	-29%	1,521	0	0	0
90	23,350,000	-46%	1,148	0	0	0

How to Use the Information?



Identify and Move Toward Best Practices

The metric isn't the destination,



Just the mile marker...
A hint that potential
improvements exists.

Still need to figure out where to go

- Apply expertise
- Investigate systems
- Devise changes
- Assess performance

