

Water and Wastewater Utility Energy Index

Project Overview

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Goals and Objectives

- Produce Industry-wide Energy performance metrics for
 - Water Utilities
 - Wastewater Utilities
- Useful for Energy Management
 - How does my utility compare to its peers?
 - How do my plants compare?
 - How do changes impact performance over time?
 - How do metric parameters impact energy use?

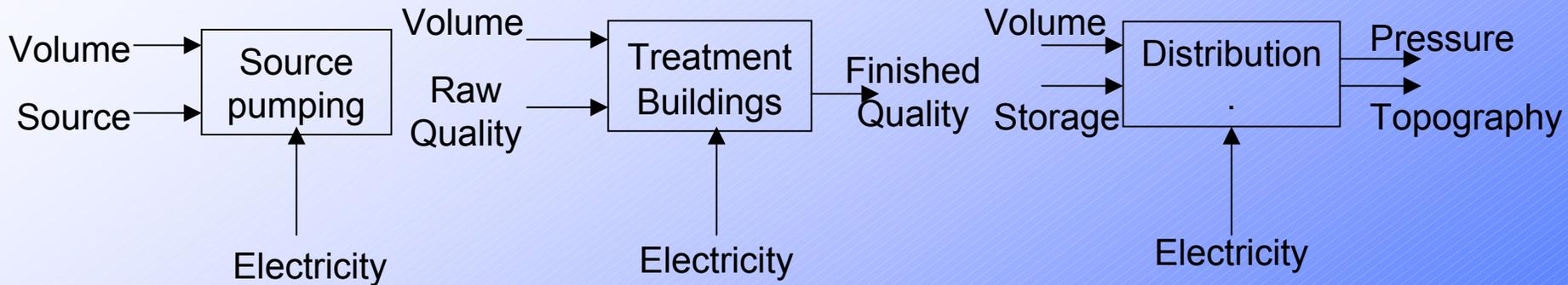
Background

- EPA Energy Star metrics
 - Comparing energy use of buildings
- Parameters
 - Utility Energy Use
 - Building Characteristics
 - Operational Characteristics

Methodology

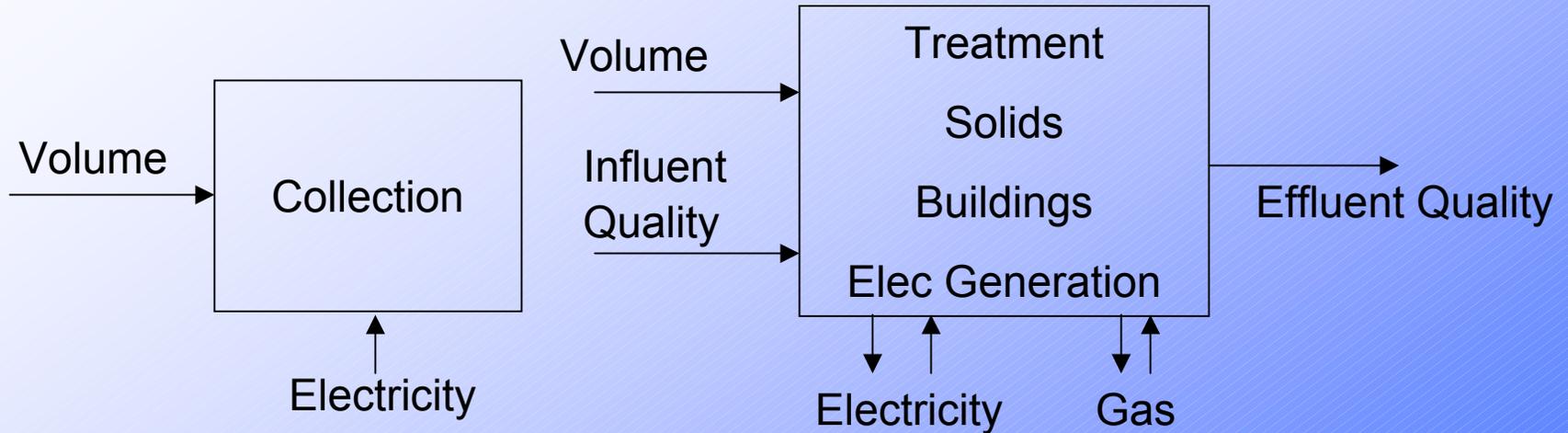
- Obtain representative data set
- Characteristic parameters
 - Configuration
 - Operating Conditions
- Predicted Energy = $f(\text{Parameters})$
 - Water Examples
 - Production volume
 - Water Source
 - Topography
 - Treatment
 - Wastewater Examples
 - Processed volume
 - BOD removed, TSS, nutrient removal
 - Secondary treatment type
 - Lift station capacity
- Apply data set parameters to regression model
- Form ranking from site parameters and regression model

Information Model - Water (multiple metrics)



- Requires energy data at process level consistently defined across industry
- Treatment
 - use quality parameters as main constraints
 - or use physical processes as proxy for quality (attractive because processes are assigned energy impact)

Information Model - Wastewater



- Treatment
 - Could use quality parameters as main constraints
 - or use physical processes as proxy for quality (attractive because processes are assigned energy impact)
 - Trickle Filtration, Aeration, Aeration plus nitrification could each be separate metrics (compare apples to apples)
- Effluent Quality
 - TSS, BOD loading, etc.

Task 1 – Literature Review

- Challenge
 - to collect data on parameters that impact energy use
 - Which characteristics?
- Review
 - Energy Use (kWh/gallons, etc)
 - Operation (treatment levels, etc)
 - Characteristics (water source, etc)
 - Often smaller scopes or little energy info
 - Other surveys/data sources
 - AWWA, AMSA, EPA, WERF
 - State Permits

Wastewater Existing Data

- EPA CWNS
 - Rich characteristics, no energy data
- EPA Water Discharge Permits (PCS)
 - Rich process characteristics, all utilities, no energy data
- AMSA
 - Characteristics and energy financial data (utility level), small sample (132)
- IOWA
 - Characteristics and energy data, sample dominated by small systems (lagoons), 355 total systems, noted 1150 kWh/MG treatment and 420 kWh/MG collection

Wastewater Classification - Size

- 3,200 of 16,255 utilities > 1 MGD
- represent 92% of total flow

Number of Treatment Facilities by Flow Range (from CWNS 2000)

Treatment Facilities in Operation in 2000

| Existing Flow Range (MGD) | Number of Facilities | Total Existing Flow (MGD) |
|---------------------------|----------------------|---------------------------|
| 0.001 to 0.100 | 6,583 | 290 |
| 0.101 to 1.000 | 6,462 | 2,339 |
| 1.001 to 10,000 | 2,665 | 8,328 |
| 10,001 to 100,000 | 487 | 12,741 |
| 100,001 and greater | 46 | 11,201 |
| Other | 12 | --- |
| Total | 16,255 | 34,899 |

Wastewater Classification – Treatment Level

- Classification Trade-off
 - Too Coarse – Wide variability
 - Too Detailed – Few Peers

Number of Treatment Facilities by Level of Treatment (from CWNS 2000)

| Treatment Facilities in Operation in 2000 | | | | |
|---|----------------------|-------------------------------|-------------------------|----------------------------|
| Level of Treatment | Number of Facilities | Present Design Capacity (MGD) | Number of People Served | Percent of U.S. Population |
| Less than Secondary | 47 | 1,023 | 6,426,062 | 2.3 |
| Secondary | 9,156 | 19,268 | 88,221,896 | 32.0 |
| Greater than Secondary | 4,892 | 22,165 | 100,882,207 | 36.6 |
| No Discharge | 1,938 | 2,039 | 12,283,047 | 4.5 |
| Partial Treatment | 222 | 563 | --- | --- |
| Total | 16,255 | 45,058 | 207,813,212 | 75.4 |

Wastewater Classification – Treatment Level

| Effluent Quality Category | Criteria: BOD5 (30 day average) NPDES permit level [mg/l] | |
|---|---|-------------|
| | Lower Limit | Upper Limit |
| Raw Discharge | Without any form of treatment | |
| Primary | >45 | - |
| | AND some preliminary or primary treatment | |
| Advanced Primary | >30 | <45 |
| | AND extensive primary treatment | |
| Secondary | >20 | <30 |
| | AND biological and/or chemical/physical treatment | |
| | OR the use of lagoons or trickle filters regardless of BOD5 | |
| Advanced Treatment I | >10 | < 20 |
| | AND biological and/or chemical/physical treatment | |
| Advanced Treatment II | - | <10 |
| | AND biological and/or chemical/physical treatment | |
| Added to above “With nutrient removal” | The use of any process to remove nutrients (e.g., nitrogen, phosphorus, etc) | |

Wastewater Classification – Process Use

- Trickle Filter (393 – 1,811 kWh/MG net)
- Activated Sludge (678 – 2,236 kWh/MG net)
- Advanced w/o nitrification (838 – 2,596 kWh/MG net)
- Advanced with nitrification (1,208 – 2,950 kWh/MG net)

Relative Energy Use projections for 20 MGD plant (adapted from Burton 1996)

| Trickling Filtration | | Activated Sludge | | Advanced without Nitrification | | Advanced with Nitrification | |
|-------------------------|-----|-------------------------|-----|--------------------------------|-----|-----------------------------|-----|
| Trickling filters | 30% | Aeration (diffused air) | 50% | Aeration (diffused air) | 40% | Aeration (diffused air) | 30% |
| Dissolved air flotation | 20% | Dissolved air flotation | 13% | Dissolved air flotation | 13% | Biological nitrification | 20% |
| Wastewater pumping | 20% | Anaerobic digestion | 12% | Anaerobic digestion | 10% | Dissolved air flotation | 10% |
| Anaerobic digestion | 14% | Wastewater pumping | 11% | Wastewater pumping | 10% | Anaerobic digestion | 10% |
| Lights & Buildings | 8% | Lights & Buildings | 5% | Filter feed pumping | 6% | Wastewater pumping | 8% |
| | | | | Lights & Buildings | 5% | Filter feed pumping | 5% |
| | | | | | | Lights & Buildings | 4% |

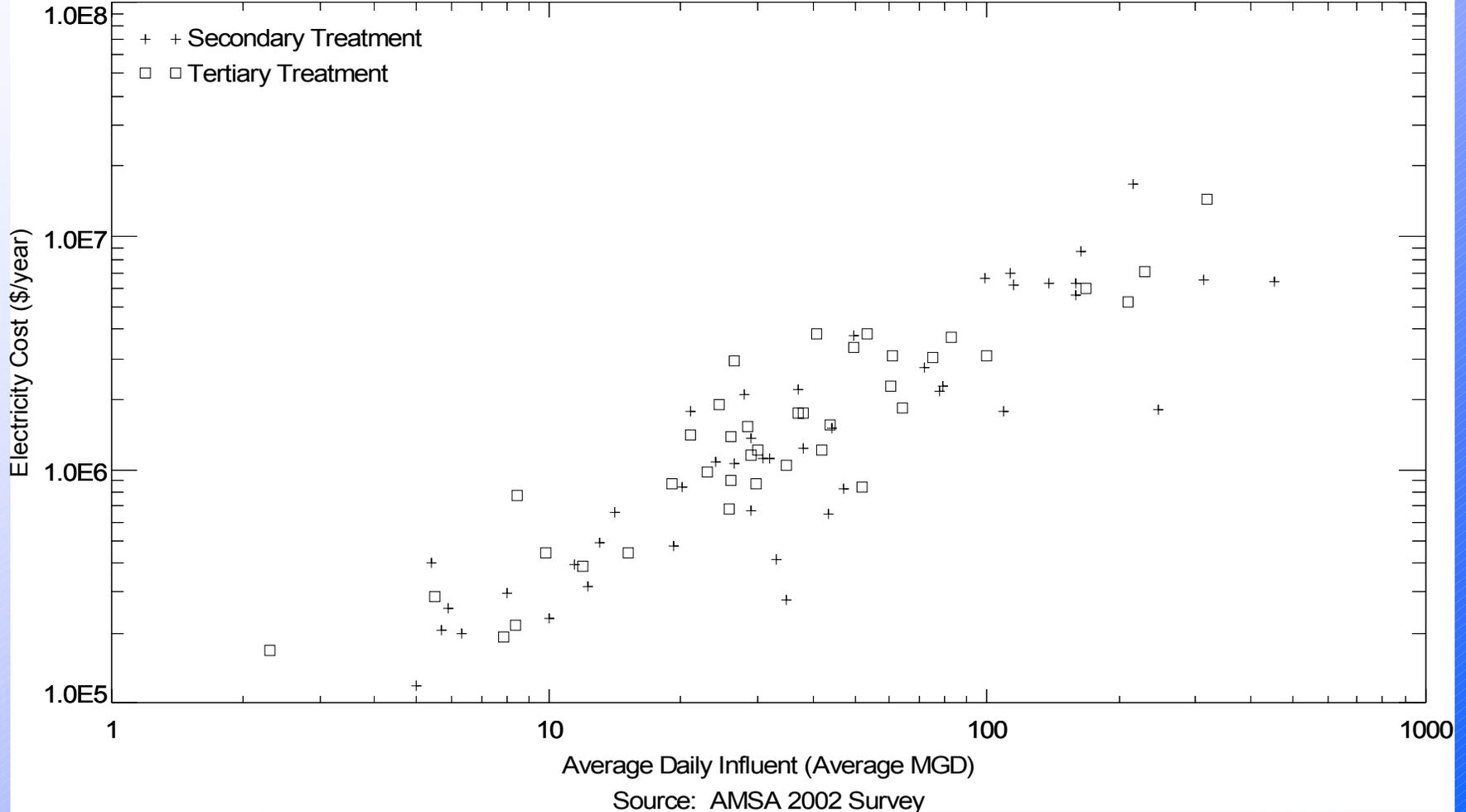
Wastewater Classification – Process Detail

Selected Process Frequency in EPA CWNS Database

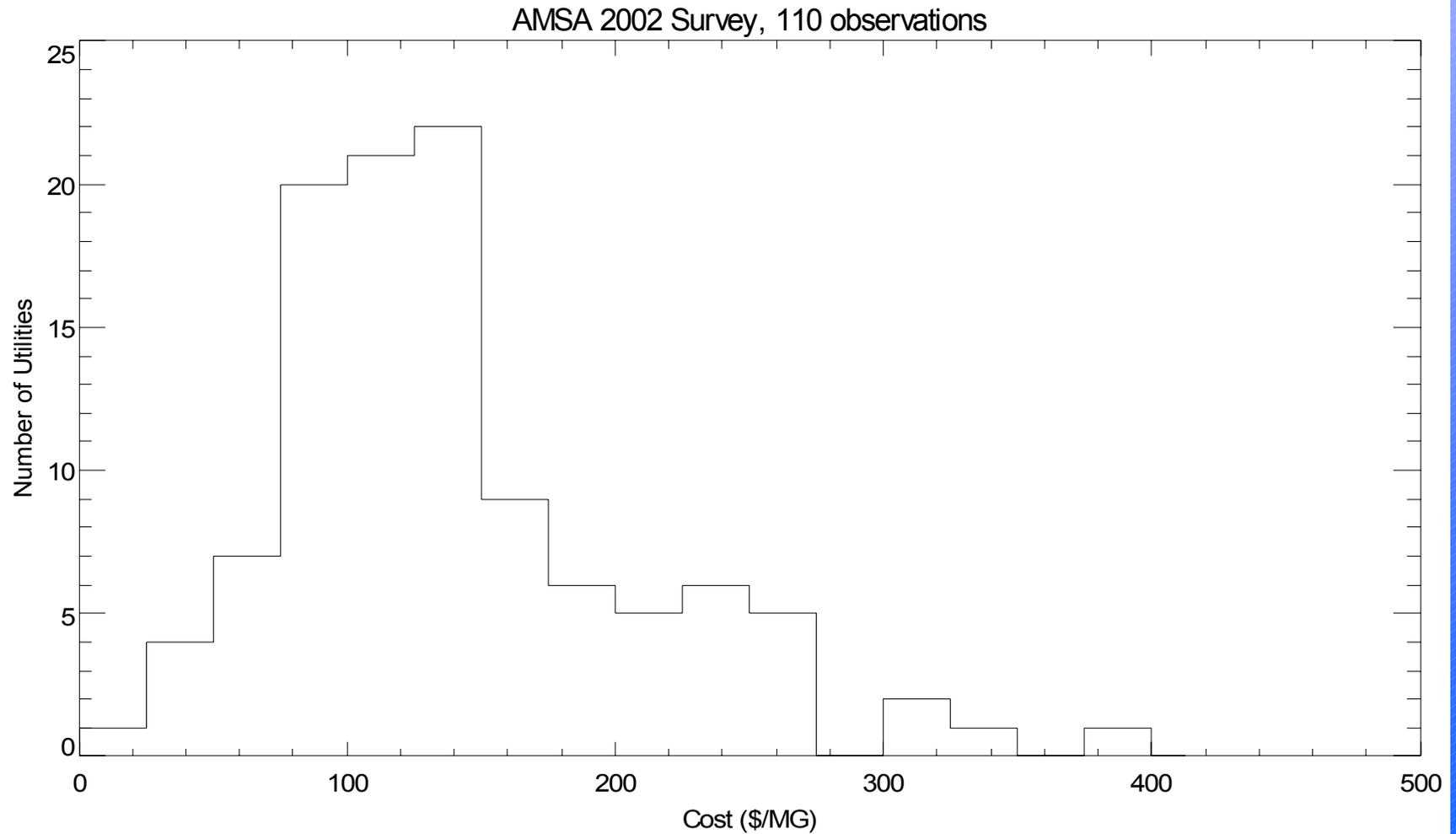
| Process | 3,198 plants > 1 MGD | 1,966 plants > 2 MGD | 906 plants > 5 MGD |
|--|--|--|--|
| Activated Sludge - Anaerobic/Anoxic/Oxic | 1 | 1 | 0 |
| Activated Sludge - Complete Mix | 7 | 6 | 3 |
| Activated Sludge - Contact Stabilization | 299 | 163 | 74 |
| Activated Sludge – Conventional | 1,174 | 835 | 443 |
| Activated Sludge - Extended Aeration | 364 | 189 | 65 |
| Activated Sludge - High Rate | 22 | 15 | 10 |
| Activated Sludge - Other Mode | 122 | 91 | 44 |
| Activated Sludge - Pure Oxygen | 107 | 99 | 69 |
| Activated Sludge - Step Aeration | 15 | 15 | 15 |
| Activated Sludge With Biological Denitrification | 6 | 5 | 2 |
| SUBTOTAL Activated Sludge | 2,117 | 1,419 | 725 |
| | 66% | 73% | 80% |
| | | | |

Wastewater Energy Data

Utility Electricity Cost Correlation to Influent Flow



Wastewater Energy Data



Water Existing Data

- EPA CWSS, DWNS, SDWIS
 - Rich characteristics, no energy data
- Awwa Water:\Stats
 - Rich characteristics, energy cost data
- WISCONSIN
 - Energy data, few characteristics
- IOWA
 - Energy data, dominated by small utilities
pop<10,000

Water Classification – Size

- 4,000 utilities serve 10,000+ = 85% of pop
- 9,000 utilities serve 3,300+ = 93% of pop

| Population | Number of Utilities |
|----------------|---------------------|
| 25-500 | 29,119 |
| 501-3,300 | 14,017 |
| 3,301-10,000 | 5,052 |
| 10,001-100,000 | 3,484 |
| 100,000+ | 514 |

Water Classification – Source/Treatment

Treatment Objectives
EPA 2000 Community Water System Survey

| Percentage of Plants with Each Treatment Objective | | |
|--|---------------------|----------------------|
| | Ground Water Plants | Surface Water Plants |
| Algae Control | 1% | 34% |
| Corrosion Control | 26% | 58% |
| Disinfection | 98% | 99% |
| Oxidation | 11% | 21% |
| Iron or Manganese Removal/Sequestration | 45% | 32% |
| Fluoridation | 21% | 49% |
| Taste and Odor | 8% | 49% |
| TOC Removal | 1% | 31% |
| Particulate/Turbidity Removal | 9% | 86% |
| Organic Contaminant Removal | 2% | 19% |
| Inorganic Contaminant Removal | 4% | 17% |
| Radionuclides Removal | 2% | 5% |
| Other | 15% | 18% |

Treatment Schemes
EPA 2000 Community Water System Survey

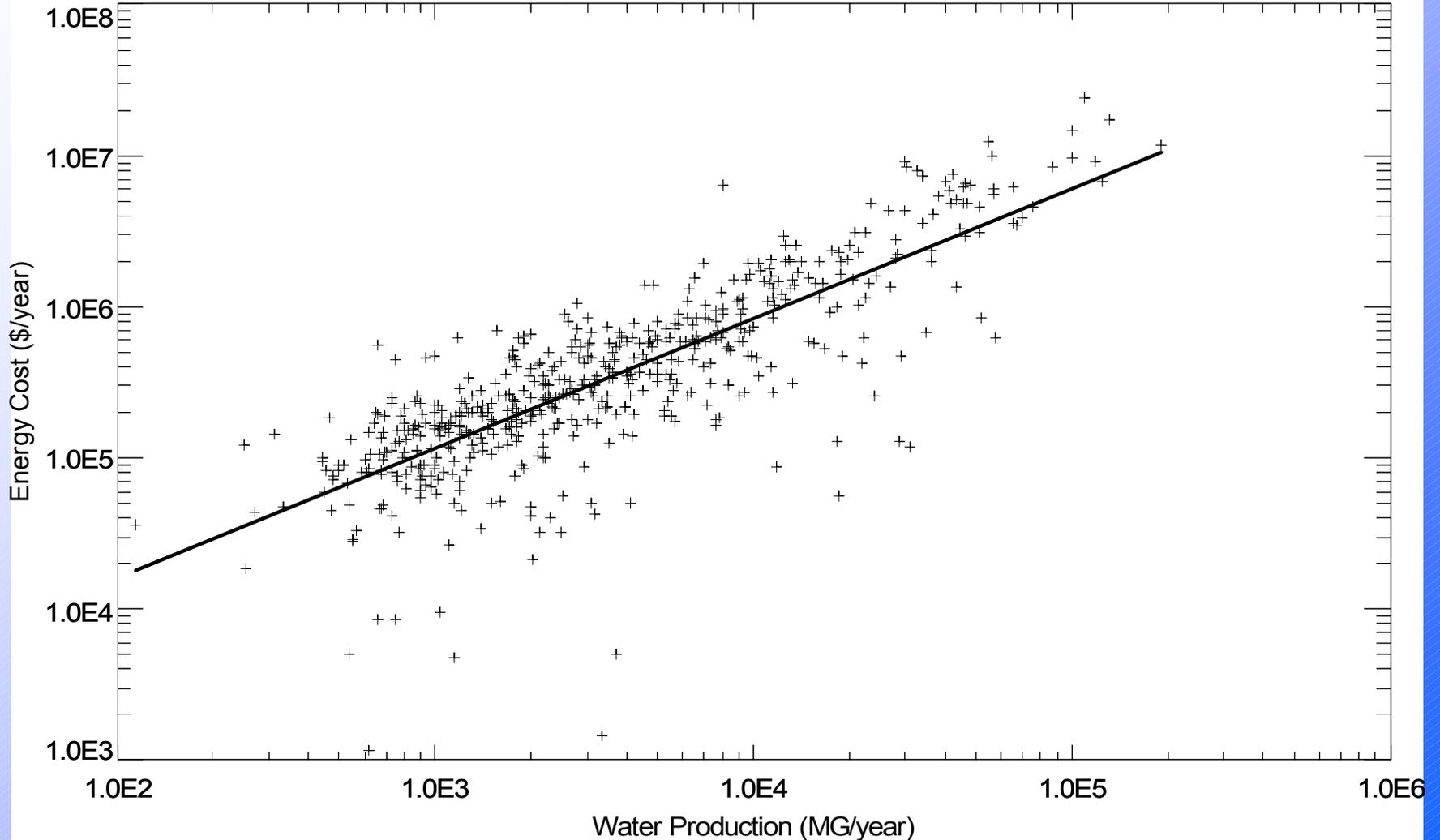
| Percentage of Plants Using Various Treatment Schemes | | |
|--|---------------------|----------------------|
| Treatment Practice | Ground Water Plants | Surface Water Plants |
| Disinfection Only | 55% | 11% |
| Disinfection and other Chemical Addition Only | 16% | 1% |
| IX, AA, Aeration | 14% | 4% |
| Filters | 8% | 12% |
| Direct Filtration | 0% | 14% |
| Conventional Filtration | 0% | 35% |
| Membrane Filters | 0% | 2% |
| Softening | 6% | 21% |

Water Classification - Distribution

- Little existing data
- Gravity vs pumping
- Pressure zones
- Total pumping horsepower
- Population density
- Storage volume
- Distribution main length

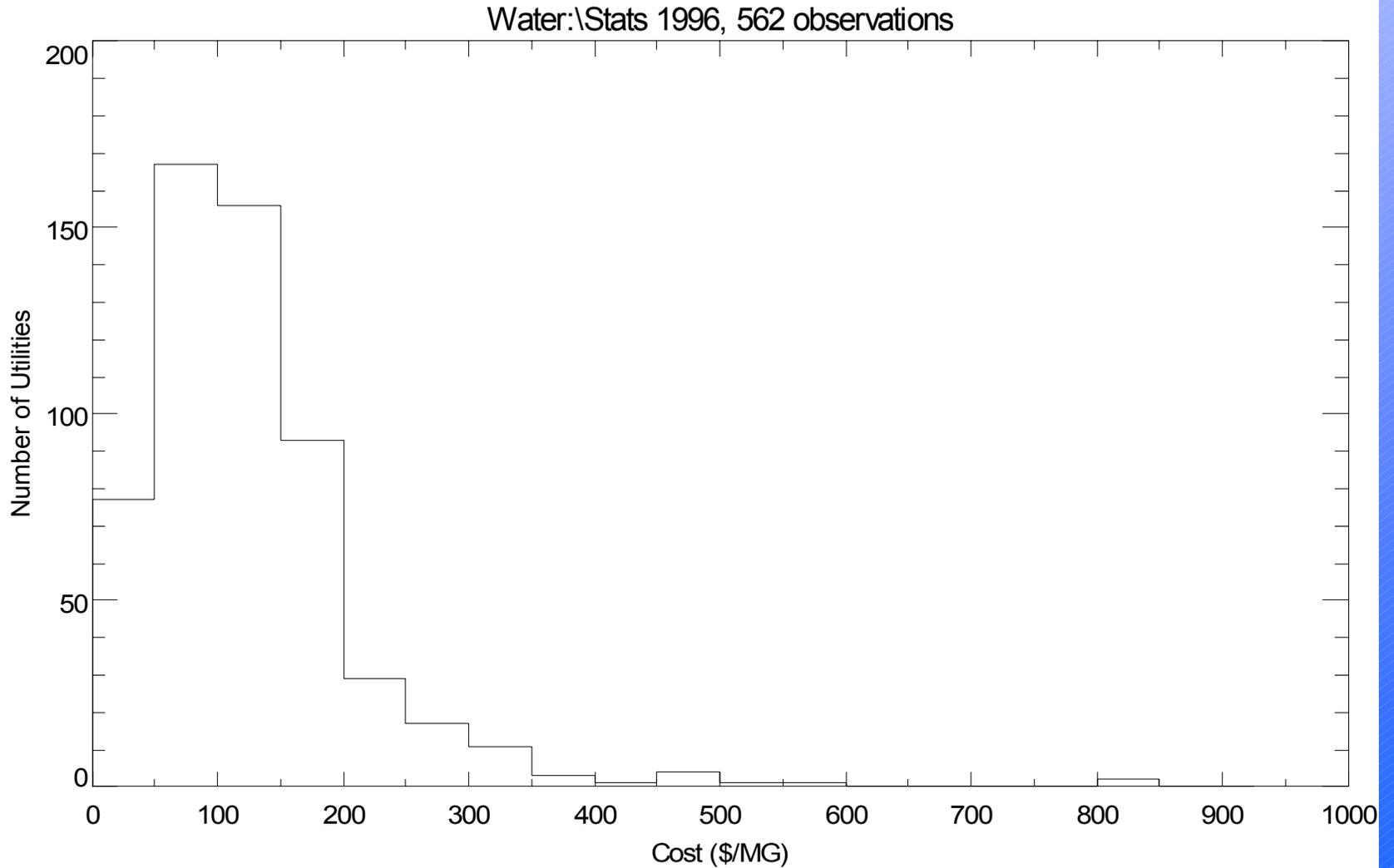
Water Energy Data

Utility Energy Cost Correlation to Water Production

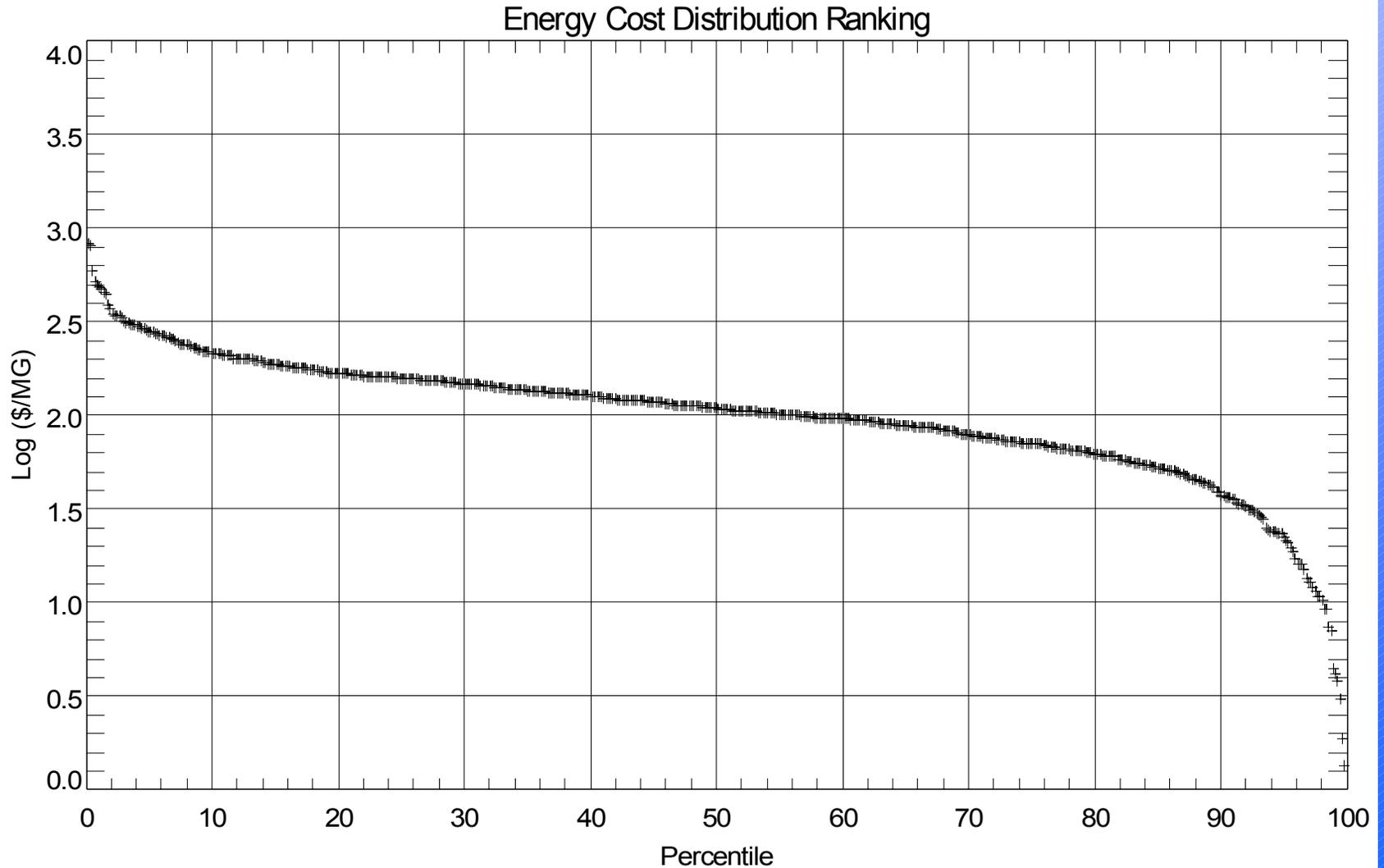


Source: Water:\Stats 1996, 562 observations

Water Energy Data



Water Energy Data



Source: Water:\Stats 1996, 562 observations

Task 2 - Assemble Data Sets

- Statistically representative survey of utilities
- Leverage Existing Surveys
 - Process characteristics
 - Water quality
- Currently Testing Survey
- Planned Spring Implementation

Task 3 – Data Analysis

- Identify parameters that explain energy use variation
- Define ranking distribution from data set
- Formulate comparison framework
- Late summer/fall

Task 4 /5 Metric Applications

- Demonstrate Metric Application
 - Types/sources of data needed
 - Parameters interpretations
 - Ranking
- Test Metric
 - Do poor rankings correspond to opportunities?
 - Do high rankings correspond to “Best Practice”?
- Sites
 - Participating Utilities
 - Outliers in Metric Rankings?

Task 6 Metric Roll-Out

- Demonstrate Usefulness to Utilities
- Example applications of Metric
- Conference Presentation