Baselines & Benchmarks
Metrics & Models

Michigan Water Environment Association

Sustainable Wastewater Treatment Conference

Holiday Inn Battle Creek

October 18, 2018

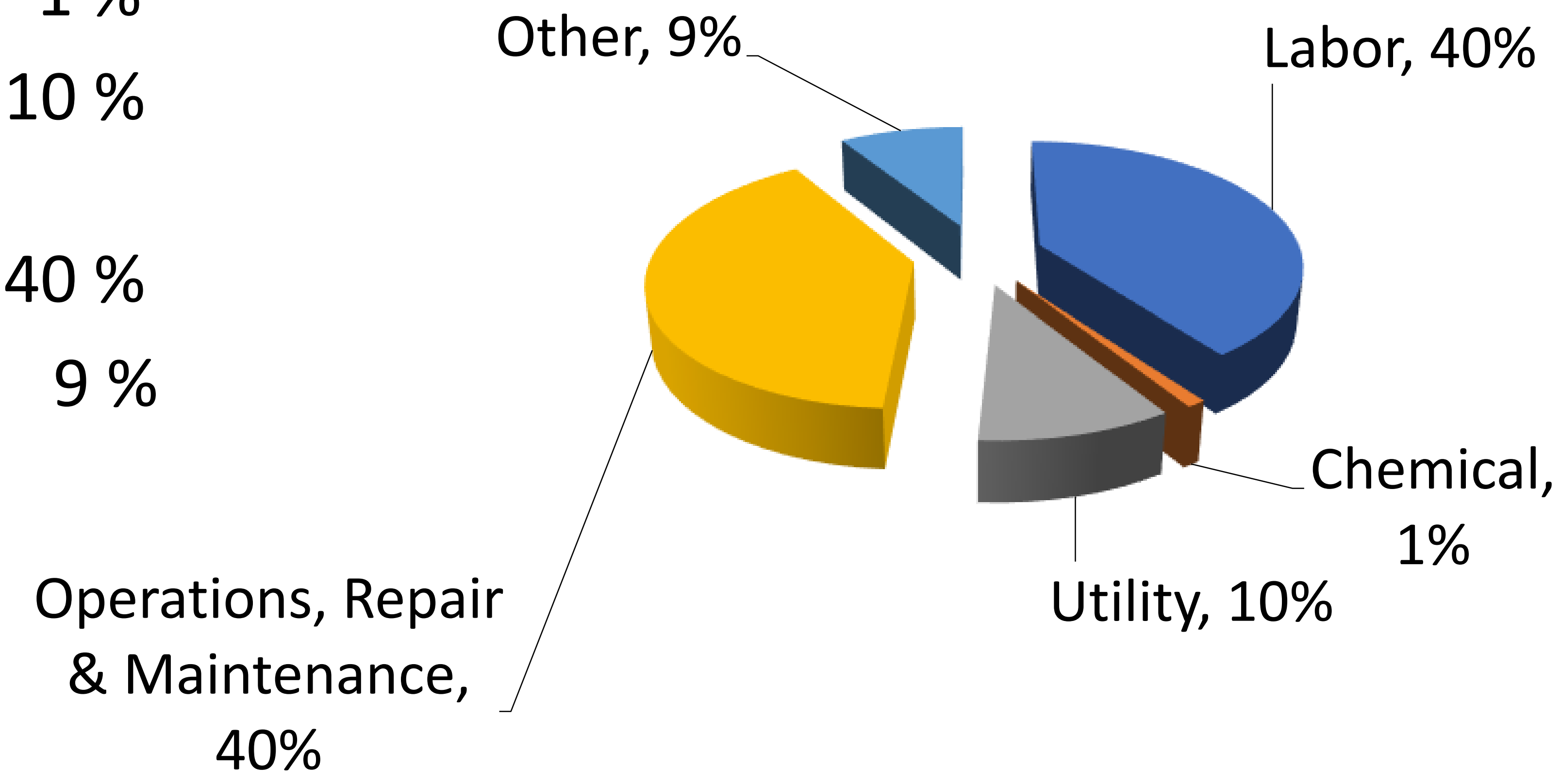
1:50 – 2:20 PM

GOALS

- Understand energy use patterns
- Explore useful metrics
- Develop a tool to allow operators to understand where energy is used on a monthly basis

Operating Cost Summary

• Labor	40 %
• Chemical	1 %
• Utility	10 %
• Operations, Repair & Maintenance	40 %
• Other	9 %



Potable Water

- Fixed Cost
- Volume
- Rate

Process Water

- Volume

Natural Gas

- Fixed Cost
- Volume
- Rate

Digester Gas

- Volume

Electricity

- Fixed Cost
- Volume (kWh)
- Demand (kW)
- Rate

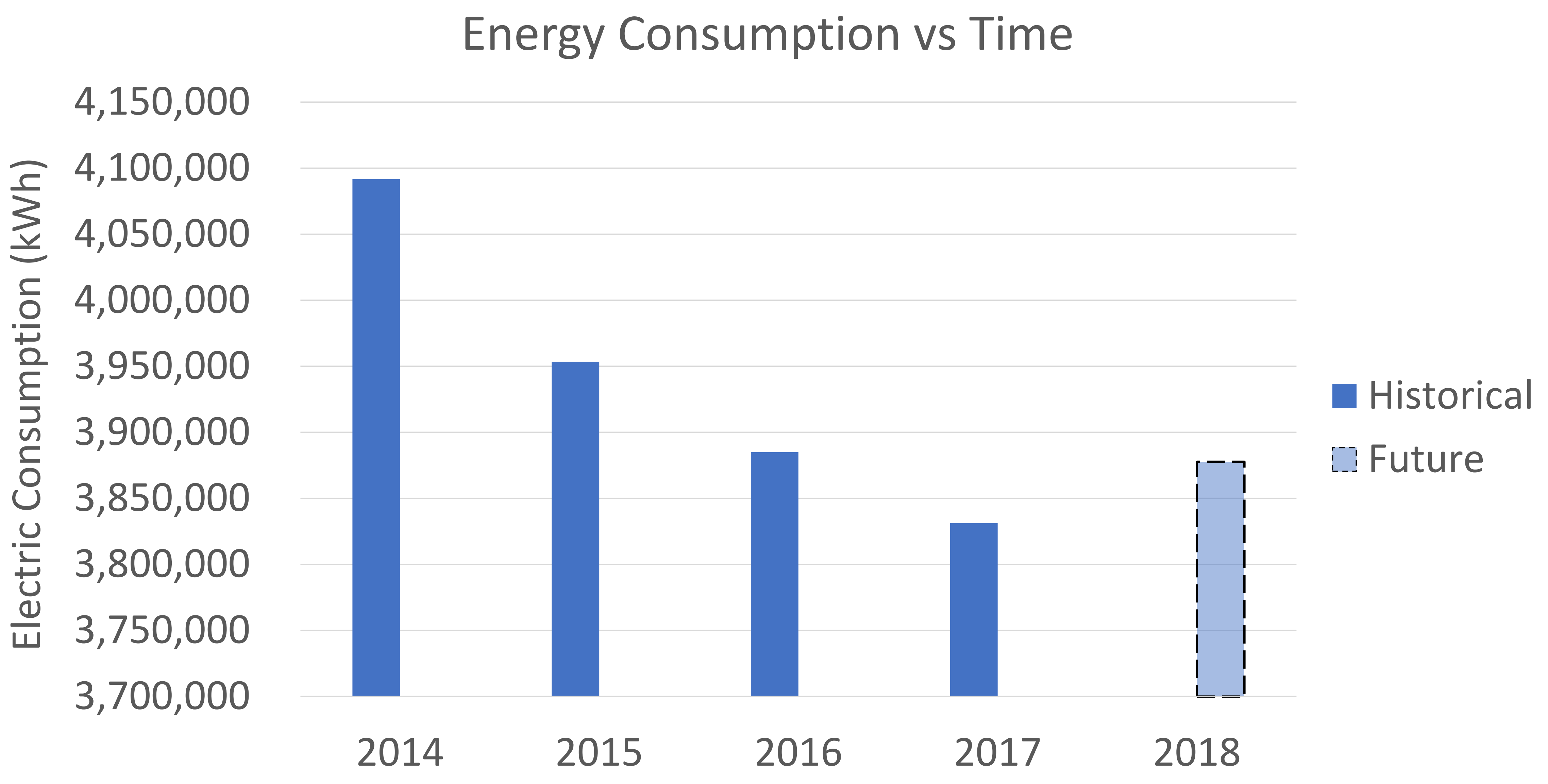
Baseline

https://leadershipfreak.files.wordpress.com/2012/04/starting-line.jpg

Baseline

- A baseline year is used to track energy performance.
- The baseline year (also known as baseline period, or year 0) is the first 12 months of energy and production data, as selected by the company [WRRF],
- It serves as the point of comparison for annual tracking and reporting purposes.

US Department of Energy, Better Plants, Energy Intensity Baselining and Tracking Guidance, February 2015 (Page 6 of 54)
https://www.energy.gov/sites/prod/files/2015/02/f20/Energy%20Intensity%20Baselining%20and%20Tracking%20Guidance.pdf



Dist 3 Elec mnth summry w adjustments 20181006

Baseline Adjustments

- Baselines may be adjusted
- Adjustment based on variables that affect the baseline
- Flow and temperature were considered
- Results were inconclusive
- Additional assessment of the data needed

Benchmark

http://www.socialbrite.org/wp-content/uploads/2011/11/geo-targeting1.png

Benchmarking

DOE defines benchmark as “The ability to compare the energy performance of one plant to the performance of another plant or group of plants.” (1)

(1) US Department of Energy, Better Buildings, Energy Data Management Manual, for the Wastewater Treatment Sector, December 2017

Benchmarking

- ***Each WRRF is unique***
- ***The energy intensity of WRRFs cannot be directly compared***
- ***The benchmark for a WRRF must be established based on the unit processes and operations in use at the facility.***

Benchmark Approaches

NYSERDA Metrics

- Developed based on surveys of New York WRRFs
- Presented in form of energy metric of kWh/MG

WERF Modeling

- Developed energy use data for a wide range of wastewater treatment facilities
- Based on extensive modeling for a large number of "types" of WRRFs
- A focus on developing energy benchmarks
- WERF project number ENER1C12

Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, Electric Power Research Institute, Water Research Foundation, November 2013.

EPRI Tables (WEF MOP 32)

- Energy intensity values for unit processes
- Based on calculations.
- Based on work from 1990's
- updated in 2013 - values from 2013 are higher
- Goal was to prepare a practical tool to help better understand the industry.

Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, Electric Power Research Institute, Water Research Foundation, November 2013.

MOP 32 Table C.4

- Four Tables
- Each represent a different type of WRRF
- Select the one that is the best fit for your facility

Table C.4
Electricity requirements for advanced wastewater treatment plants with nitrification

Item	Electricity use, kWh/d[a] (except where noted)					
	3 785- m^3/d 1-mgd[b]	18 925- m^3/d 5-mgd	37 850- m^3/d 10-mgd	75 700- m^3/d 20-mgd	189 250- m^3/d 50-mgd	378 500- m^3/d 100-mgd
Wastewater pumping	171	716	1402	2559	6030	11818
Grit Removal - Vortex	63	125	125	125	516	688
Aerated grit removal	49	87	134	250	600	1200
Primary clarifiers	15	78	155	310	776	1551
Aeration (diffused air)	532	2660	5320	10640	26600	53200
Biological nitrification	346	1724	3446	6818	16936	33800
Return sludge pumping	54	256	508	869	1952	3757
Secondary clarifiers	15	78	155	310	776	1551
Chemical addition	80	290	552	954	2187	4159
Filter feed pumping	143	445	822	1645	3440	6712
Filtration	137	247	385	709	1679	3295
Gravity thickening	6	15	25	37	75	138
Dissolved Air Flotation	na[c]	na	2,022	3,268	7,008	13,237
Aerobic digestion	1200	2400	na	na	na	na
Belt filter press	na	228	457	689	1385	2545
Chlorination	1	5	27	53	133	266
Lighting and buildings	200	400	800	1200	2000	3000
Totals (average day)	3,012	9,754	16,335	30,436	72,093	140,917
Average flow rate, mgd	1	5	10	20	50	100
Unit electricity use, kWh/mil. gal[d]	**3,012**	**1,951**	**1,634**	**1,522**	**1,442**	**1,409**
Energy recovery (from biogas combustion)	na	na	3500	7000	17500	35000
Net consumption[c]	3,012	9,754	12,835	23,436	54,593	105,917
Average flow rate, mgd	1	5	10	20	50	100
Unit net electricity use, kWh/mil. gal	3,012	1,951	1,284	1,172	1,092	1,059

MOP 32 Table C.4

- Add column(s) for the facility to be analyzed
- Add line items for additional unit processes
- Estimate kWh for each new unit
- Sum to establish the benchmark

Table C.4
Electricity requirements for advanced wastewater treatment plants with nitrification

Item	Electricity use, kWh/d[a] (except where noted)					
	3 785-m³/d					18 925-m³/d
	1-mgd[b]	4.19-mgd	4.19-mgd	4.19-mgd		5-mgd
		Biotowers No Cent	No Biotowers Cent	No Biotowers No Cent	Actual	
Screens / Preliminary Treatment	2	2	2	2	13	2
Wastewater pumping	171	606	606	606	661	716
Grit Removal - Vortex	63	63	63	63	37	125
Aerated grit removal	49					87
Aerated grit removal - remove from table	-49					-87
EQ Basins (pumps)		179	179	179	68	
Primary clarifiers	15	65	65	65	84	78
Biological P Removal		691	691	691	691	
Aeration (diffused air)	532	2229	2229	2229	1530	2660
Biological nitrification	346	1445	1445	1445	1530	1724
Oxidation Tower for Biological nitrification		45			153	
Return sludge pumping	54	215	215	215	741	256
Secondary clarifiers	15	65	65	65		78
Chemical addition	80					290
Filter feed pumping	143					445
Filtration	137					247
UV Disinfection	77	322	322	322	1136	384
Gravity thickening	6	13	13	13		15
Dissolved Air Flotation	na[c]	1298	1298	1298	451	na
~~Aerobic digestion~~	1200					2400
Anaerobic digestion	na	766	766	766	41	na
~~Belt filter press~~	na					228
Centrifuge			179			
Sludge Storage Pumps						
~~Chlorination~~	1					5
Chlorination - remove from table	-1					-5
Recycle Lift Station	21	73	73	73		86
Plant Water Pumps	21	73	73	73		86
Lighting and buildings	200	360	360	360		400
Totals (average day)	3011.664	**8507**	**8641**	**8462**		9754.328
Annual subtotal		**2,070,073**	**262,843**	**772,193**		
Annual total (Benchmark)			**3,105,109**			
Baseline			**3,831,277**			
Average flow rate, mgd	1	4.19	4.19	4.19		5
Unit electricity use, kWh/mil. gal[d]	**3,012**	**2,030**	**2,062**	**2,020**		**1,951**
Energy recovery (from biogas combustion)	na					na
Net consumption[c]	3011.664	8507	8641	8462		9754.328
Average flow rate, mgd	1	4.19	4.19	4.19		5
Unit net electricity use, kWh/mil. gal	3,012	2,030	2,062	2,020		1,951

District 3 Benchmark

Using this approach results in a benchmark of

3,105,000 kWh/year

Compared to a baseline of

3,831,000 kWh/year (2017)

Metrics

Energy performance enable plants to understand if they are improving and using less energy for the water they treat.

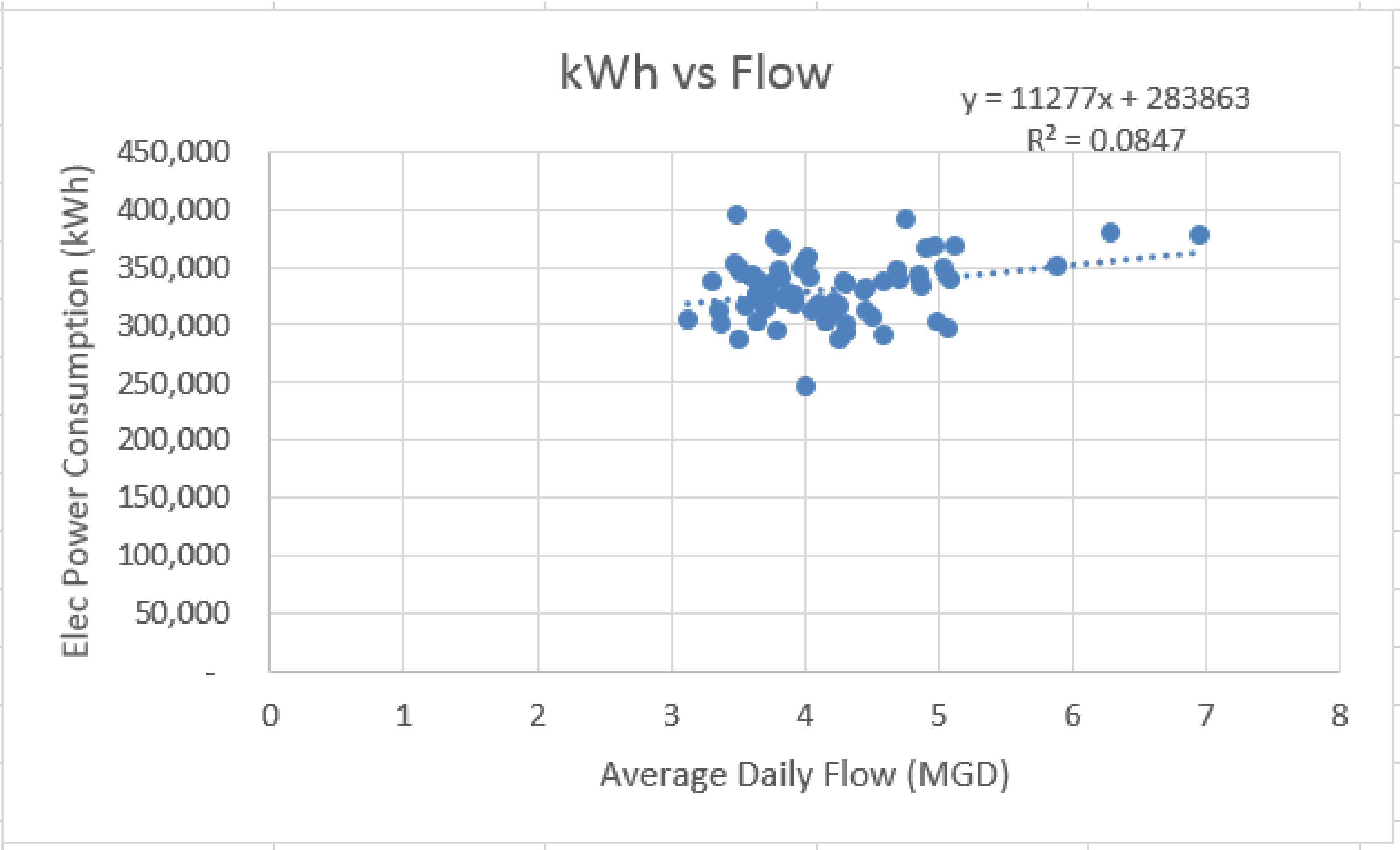
Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, Electric Power Research Institute, Water Research Foundation, November 2013. Page 110 of 194.

Metrics

- Amount of electricity used per unit of production
- Work performed by
  - Michigan DEQ / WEA Water Resource Recovery Initiative
  - Wisconsin Focus on Energy (FOE)
  - New York State Energy Research Authority
- kWh/MG treated is most commonly used in the US
  - It is a convenient metric
  - easily computed, and easily understood

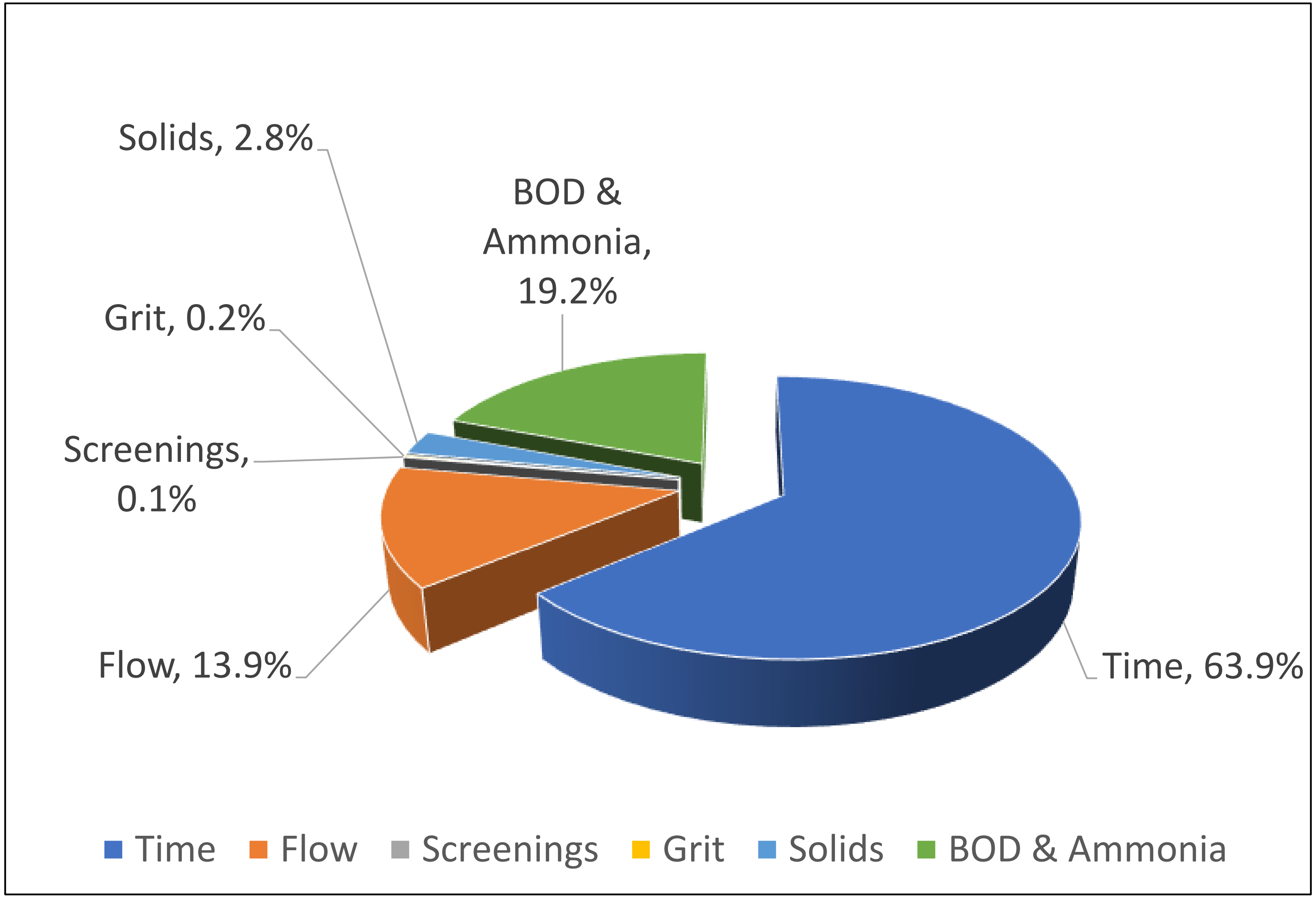
kWh/MG treated

The relationship between power consumed and volume of wastewater treated isn't always strong



Factors Affecting Energy kWh at District 3

- One reason might be the importance that run time has on determining energy consumption
- **Turning equipment off when not needed is the single most effective way to conserve energy**
- Then comes oxygen demand loading and flow



Energy Breakdown

Process (kWh %)	
Flow	15.4%
TSS	3.5%
AOR (BOD & Ammonia)	49.1%
Other	12.5%
Sub-Total	80.5%

Building (kWh %)	
Lighting	4.6%
HVAC	14.8%
Other	0.1%
Sub-Total	19.5%
Total	100.0%

Parameter Specific Metrics

Item	kWh	Parameter	Units	Metric	Units
Flow	591,197	1556	MG	380	kWh-flow / MG
TSS	133,727	3,403,317	LB	39	kWh-TSS/klb TSS
AOR	1,879,954	3,734,466	LB	503	kWh-AOR/klb AOR
Other Proc	477,695				
Building	685,083				
Sub-Total	3,829,241				

Parameter Specific Metrics

- Run time is the most important determinant of energy consumption at a WRRF
- Air Demand and Flow are the primary process factors
- Validates use of flow and BOD as primary metrics
- Where the relationship between flow and/or BOD and kWh is not strong, Parameter Specific Metrics may be a way to provide insight into energy consumption

Parameter Specific Metrics

- Need a way to accurately allocate kWh to each parameter
- Perhaps with modeling of power consumption based on equipment run time
- More work needed to assess Parameter Specific Metrics

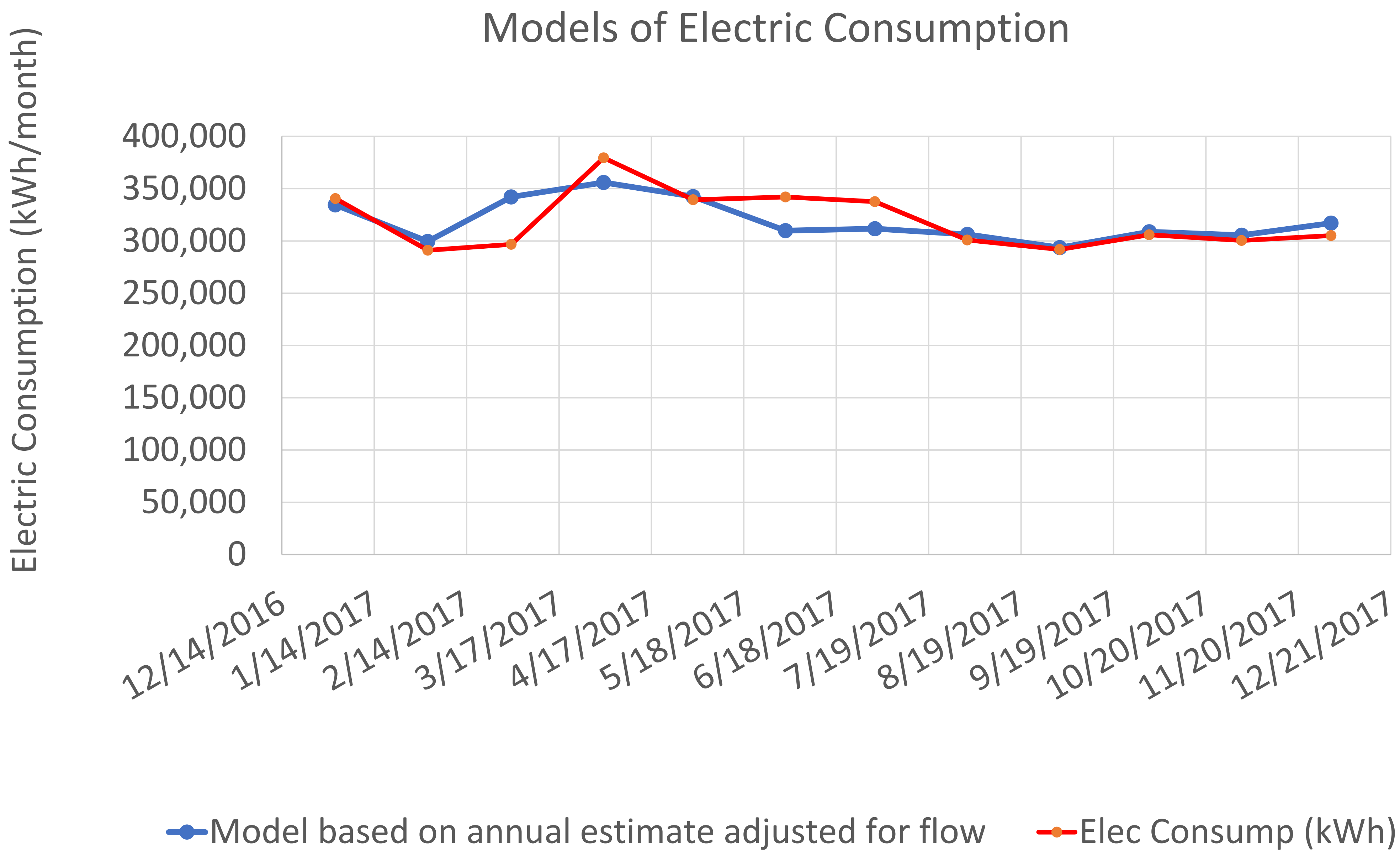
Energy Models

CAN WE PREDICT ENERGY PERFORMANCE WITH KEY METRICS?

...

Energy Models

- Used to measure and monitor energy performance data at WRRFs
- See DOE Energy Data Management Manual for comparison of
  - Portfolio Manager
  - EPA Energy Assessment Tool
  - DOE Energy Performance Indicator (EnPI)
- Key performance indicators
  - Flow
  - BOD
  - Temperature


Models of Electric Consumption
Electric Consumption (kWh/month)
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
12/14/2016
1/14/2017
2/14/2017
3/17/2017
4/17/2017
5/18/2017
6/18/2017
7/19/2017
8/19/2017
9/19/2017
10/20/2017
11/20/2017
12/21/2017
Model based on annual estimate adjusted for flow
Elec Consump (kWh)

What's Next?

Natural and Digester Gas

https://www.flickr.com/photos/todbaker/9148692/

Key Take Aways

Key Take Away

- This has resulted in looking at how the facility operates in a different light
- Review of run time has resulted in changes to how equipment is operated –
  - Why is equipment operating?
  - Turning equipment off is the quickest way to save energy
- Questions that have arisen …
  - Are we using the tools we have to gather data?
  - Are we gathering the right data?
  - Are we gathering the data correctly?

Key Take Away

- Establish baselines and benchmarks
- Doing so will result in asking questions
- Question the metrics you are using and why – how can they be changed to better represent operation at your facility?
- Consider ways to predict your energy use
- Keep working at even the small items

Actions you can take

- Apply for the MWEA Sustainable Energy Award
- Plan on attending the Effective Utility Management Workshop
- Use the Effective Utility Management Website (www.watereum.org)
- Apply for the MDEQ/MWEA Premier Utility Management Performance Recognition

Thank you

- For your attention
- MWEA Sustainable Energy & Process Committees for providing the opportunity for us to speak
- To Brian Ross and the operators at District 3 for their support in providing information for analysis

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References & Additional Reading

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Image: © educatorstechnology.com, 2014

References

- Genesee County, Linden District 3 WRRF, Operating Data
- Water and Wastewater Industries: Characteristics and Energy Management Opportunities. EPRI, Palo Alto, CA: September 1996. CR-106941.
- Electricity Use and Management in the Municipal Water Supply and Wastewater Industries, Electric Power Research Institute, Water Research Foundation, November 2013.
- US Department of Energy, Better Plants, Review of Wastewater Energy Intensity Metrics, Program Guidance, and Reporting Timelines, Webinar, January 7, 2016.
- US Department of Energy, Energy Data Management Manual for the Wastewater Treatment Sector, December 2017

References

- Michigan’s Wastewater Treatment Plants, Energy Survey and Estimate of Energy Baseline, April 15, 2017, https://www.mi-wea.org/docs/2._Energy_Survey_Document_Final_20170329.pdf
- Energy Best Practices Guide: Water & Wastewater Industry, 2016 Wisconsin Focus on Energy, https://focusonenergy.com/sites/default/files/WW-Best-Practices_web.pdf?_ga=2.231234842.449822995.1538954523-1505779340.1538954523

Additional Reading

- WERF project titled "Energy Balance and Reduction Opportunities, Case Studies of Energy-Neutral Wastewater Facilities and Triple Bottom Line (TBL) Research Planning Support" (WERF project number ENER1C12). The principal investigators were Steve Tarallo, P.E., and Paul Kohl, P.E.
- NYSERDA Water and Wastewater Technical Reports, https://www.nyserda.ny.gov/About/Publications/Research-and-Development-Technical-Reports/Water-and-Wastewater-Technical-Reports