Better Plants
U.S. DEPARTMENT OF ENERGY

Review of Wastewater Energy Intensity Metrics, Program Guidance, and Reporting Timelines

Webinar
January 7, 2016

U.S. DEPARTMENT OF ENERGY

Scope of Webinar

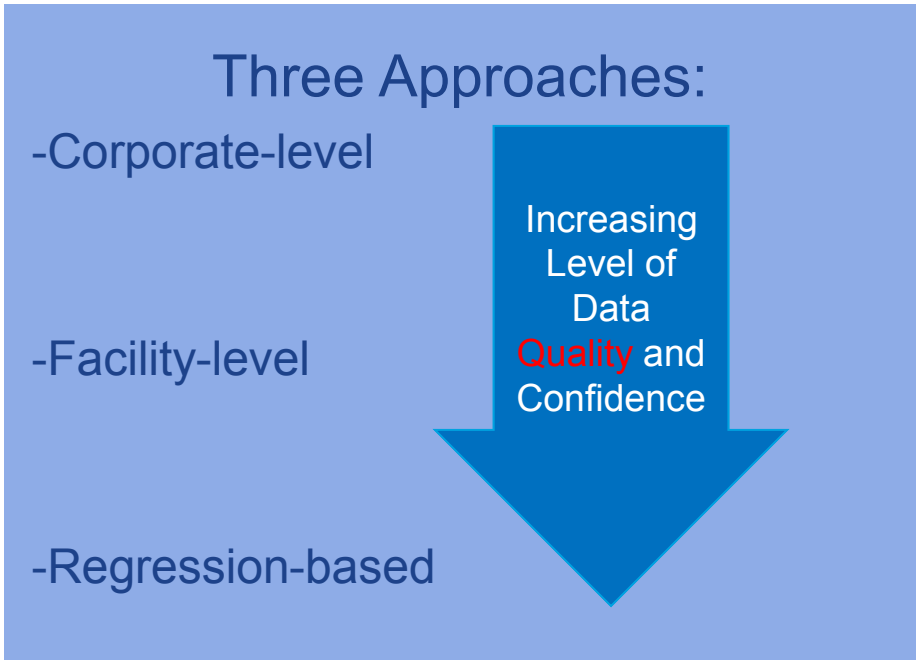
- Webinar to explore appropriate indicators for energy intensity in the wastewater treatment sector
- Presents preliminary findings of review of energy and operating data submitted by Better Plants partners in the wastewater sector
- Provides initial guidance on determining program metric, and reviews timelines
- The related water treatment sector is not currently addressed in this webinar, as data collection is still underway

Background of Better Plants Engaging Water/Wastewater Sector

- During late 2014, the DOE Better Plants staff began working with water and wastewater organizations
- Collaborative efforts with the Water Environment Research Foundation (WERF) and Water Environment Federation (WEF)
  - Sharing of knowledge and potential partner contacts
  - In addition, WERF and WEF shared information on their work in engaging agencies in managing energy intensity
  - DOE reached out to several water/wastewater organizations about joining Better Plants
- Currently, there are fifteen Better Plants partners in the water/wastewater treatment sector
  - Five partners have wastewater plant data reviewed in this webinar, including one that operates both water and wastewater facilities
  - Ten other partners are in various stages of collecting and evaluating data, and could be included in subsequent updates on this topic

Better Plants Program: Developing a Baseline and Tracking Energy Performanc

- Draw boundary to include all appropriate operations
  - Treatment plant
  - Lift or pumping stations
  - Admin buildings
  - If under 5% can be deemed insignificant, and left out
- Choose baseline year
  - Usually year of joining or year prior
  - Can be up to three years prior to joining
- Include all relevant energy sources
  - Electricity
  - Natural Gas
  - Biogas (optional)
- Time period for data
  - Annual reports, based on monthly data
  - Other options, such as weekly or daily data
- Work with TAM to find best approach for tracking and reporting, regression approach is recommended

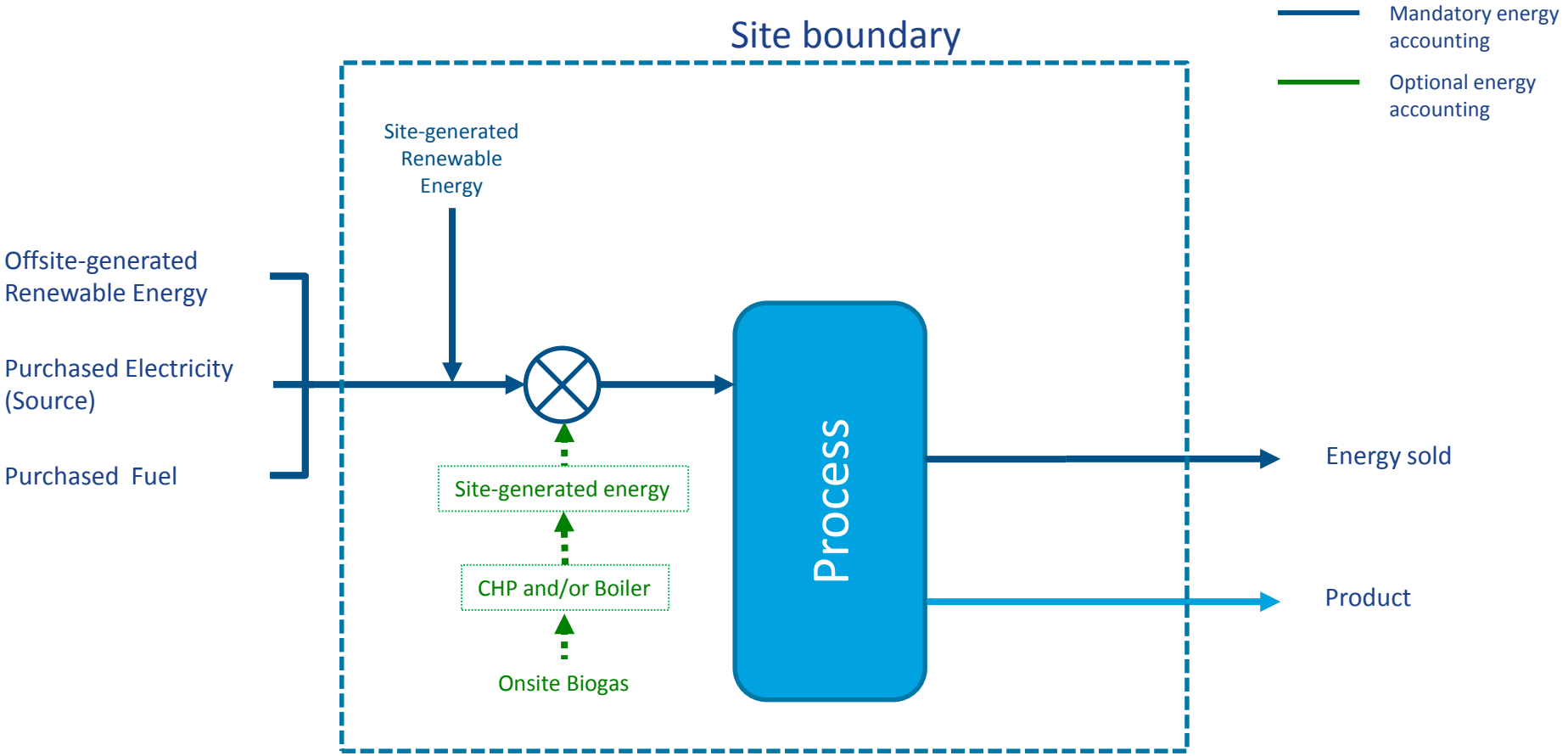


Comparison of Better Plants Approach

	Regression-based Approach	Facility-level Approach
1	Define the boundary	Define the boundary
2	Choose a baseline year	Choose a baseline year
3	Determine relevant variables affecting energy consumption at each facility	Decide on the energy intensity denominator for each facility, usually units of output
4	Gather data on energy consumption and relevant variables for each facility	Gather data on energy consumption and units of output for each facility
5	Use regression analysis to normalize each facility's data	Calculate energy intensity for the baseline year and the current year for each facility
6	Calculate the change in energy intensity from the baseline year for each facility	Calculate the change in energy intensity from the baseline year for each facility
7	Aggregate the data on energy intensity change from each facility to the corporate level	Aggregate the data on energy intensity change from each facility to the corporate level
8	Calculate total and new energy savings	Calculate total and new energy savings

Source: U. S. Department of Energy, Energy Intensity Baselining and Tracking Guidance, January 2015.

Better Plants Boundary Definition Considerations



Superior Energy Performance (SEP) and Better Plants are Complementary Program

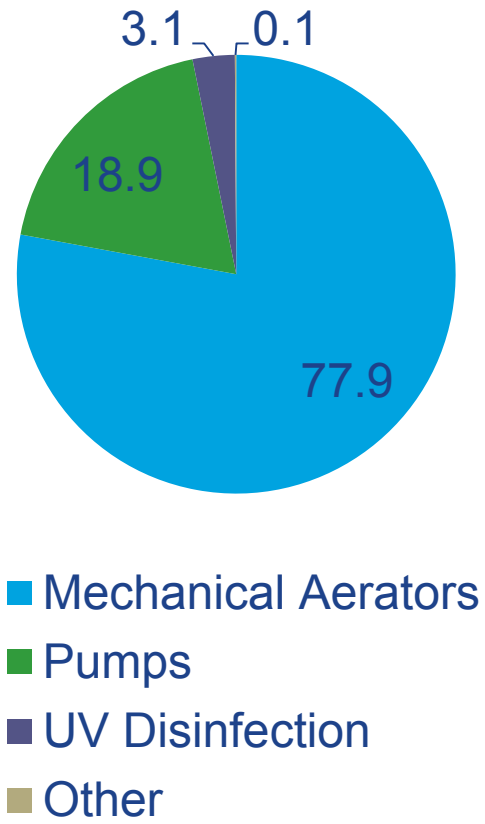
- Several water/wastewater partners also pursuing SEP, a plant-level certification program that requires conformance with ISO 50001 and third-party verified energy savings
- SEP Pilot underway
  - Started Fall 2015
  - 7 wastewater utilities and one water utility are participating (4 are Better Plants partners)
  - Target mid 2017 for certification and performance verification
- Complementary aspects of the programs
  - Energy-savings achieved through SEP will help agencies meet their Better Plants targets
  - Metrics tracked in the two programs will be generally consistent, but Better Plants provides more flexibility
  - Regression analysis is ***required*** for SEP, but ***recommended*** for Better Plants
  - TAMs will work with partners to develop regression models, leveraging findings from the SEP process

Energy Intensity at Wastewater Treatment Plants

- WERF efforts suggests that globally two primary metrics are in use for energy intensity
  - In Europe, facilities use metric based on biological oxygen demand (BOD) whereas in U. S. more facilities use flow-based metric
  - Advantage of flow-based metric is being more accepted in the U.S.
  - If trend is toward reduced flow, flow based intensity could be disadvantageous as energy intensity tends to improve at higher volumes
- NYSERDA provided guidance on developing energy intensity metric
  - Agrees with the use of energy use per volume of flow and per unit of BOD removed for benchmarking purposes
  - More emphasis placed on understanding energy use with given volume of flow
- EPA developed tool for energy intensity benchmarking
  - ENERGY STAR tool expresses source energy intensity in terms of BTU per unit flow
  - Tool provides ENERGY STAR score which considers both BOD and flow

Typical WWTP Energy Using Processe

- Data suggests that flow and BOD removal are reasonable energy intensity variables
- Primary uses of energy are for pumping and aeration
- Aeration used to mix air (oxygen) with wastewater to remove BOD, and this portion of energy consumption is tied to BOD removal
- Pumps are used to move wastewater through treatment plant, and thus tie the consumption of energy to flow



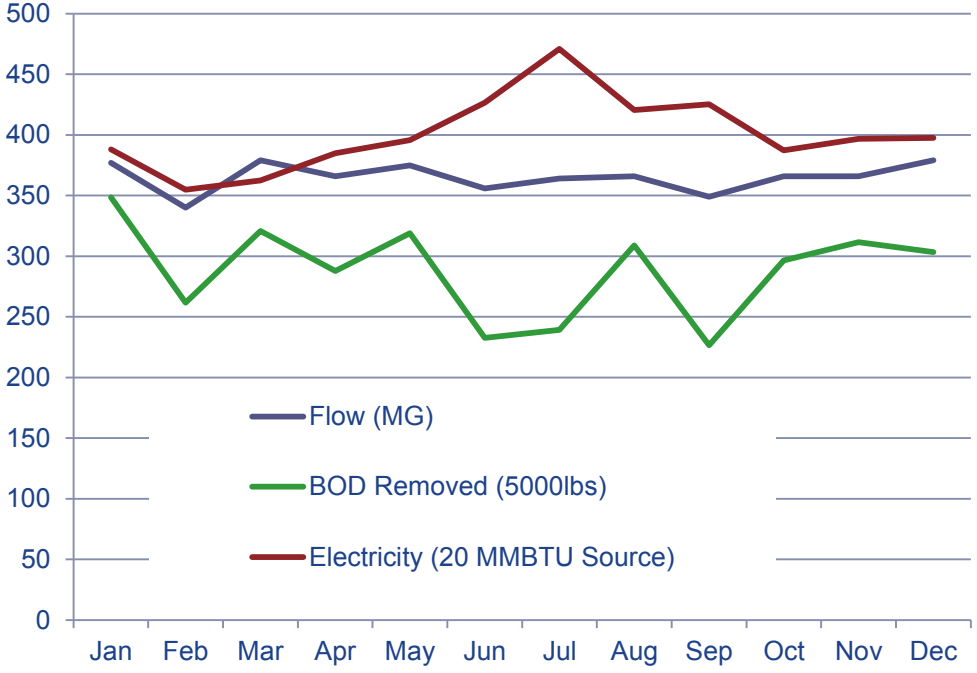
Source: Malcolm Pirnie, the Water Division of ARCADIS

Treatment Plants with Data Reviewed

Partner	Plant	Flow (MGD)	
		Design	2014 Avg
City of Los Angeles Bureau of Sanitation	Hyperion	450	269
Delta Diablo	Main Treatment Plant	17	13
Narragansett Bay Commission	Bucklin Point	46	20
Saint Petersburg Water Resources Department	SW Water Reclamation Facility	NA	11
Victor Valley Wastewater Reclamation Authority	Main Treatment Plant	14	12

Review of Victor Valley Wastewater Treatment Plant Data

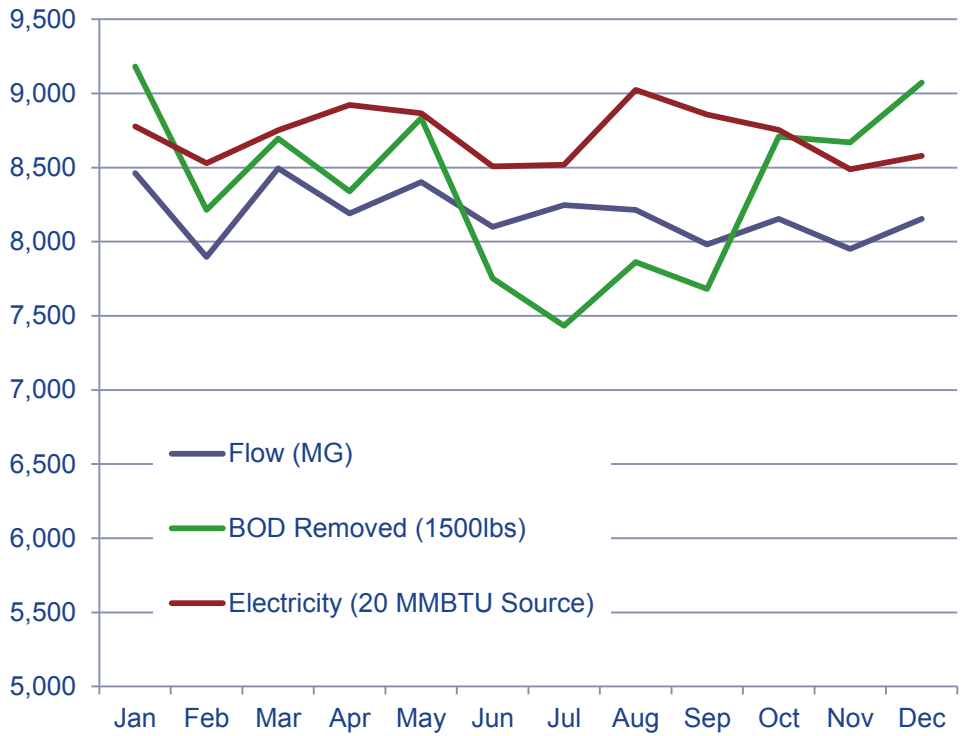
- Dependency of source electricity use on flow and BOD removed appears very unclear, based on a review of 2014 data
- Chart shows values moving together for Jan-Mar, then starting to diverge in Apr, Jun and other months
- Neither variable was seen as a strong indicator for changes in electricity use



Similar inconsistencies were observed with the 2012-2013 data

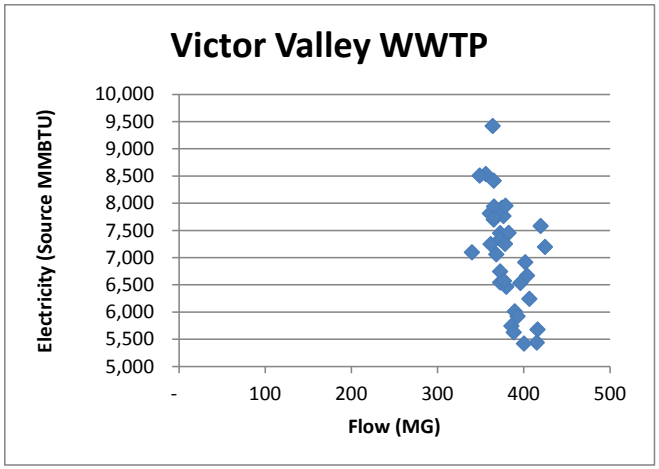
Review of LA Sanitation Wastewater Treatment Plant Data

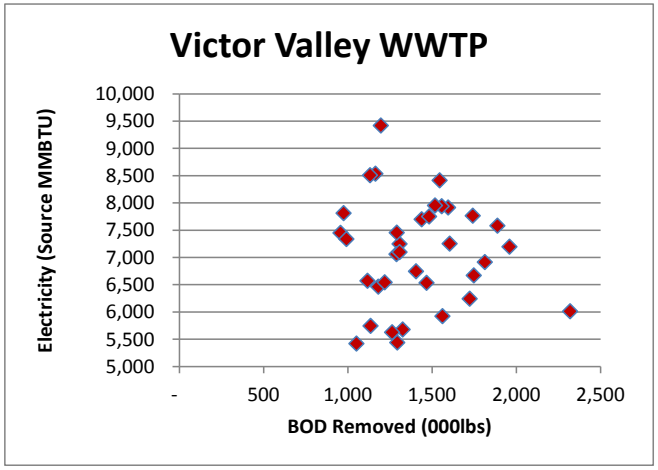
- Similarly, at LASAN's Hyperion Plant, the dependency of energy use on flow and BOD is not pronounced
- Chart shows values moving together for Jan-Mar, then starting to diverge in Apr, May and other months

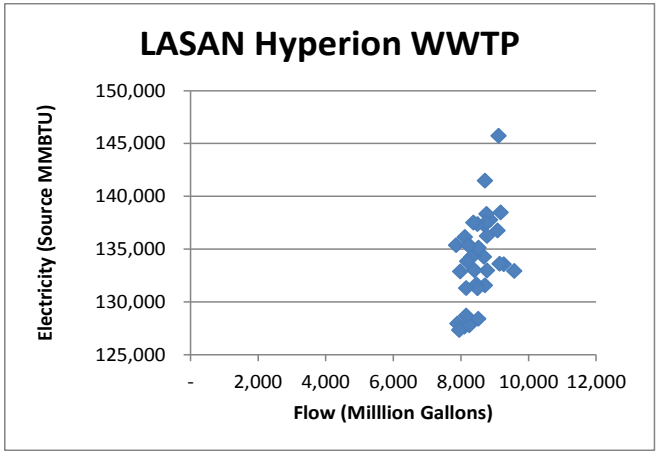


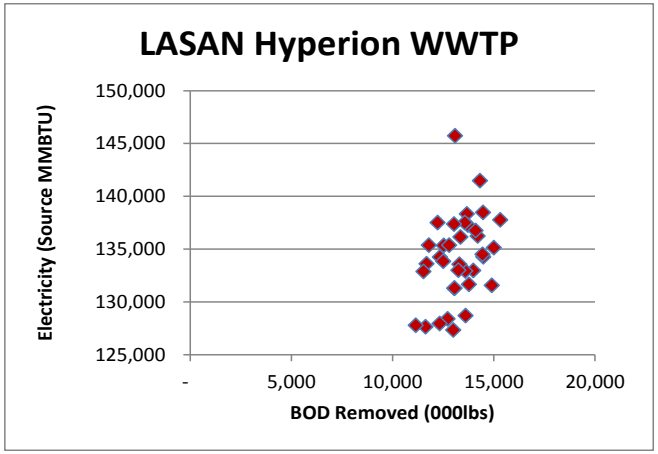
Similar inconsistencies were observed with the 2012-2013 data

Treatment Plant Electricity Consumptio vs Flow and BOD









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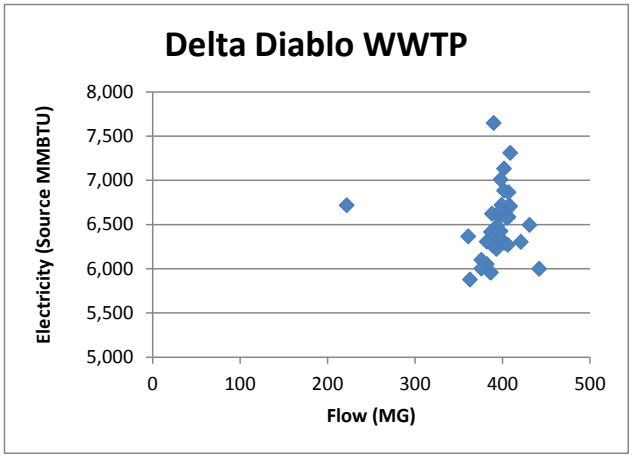

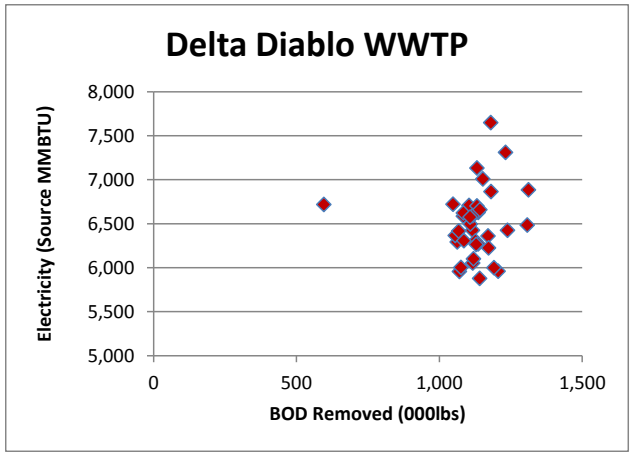

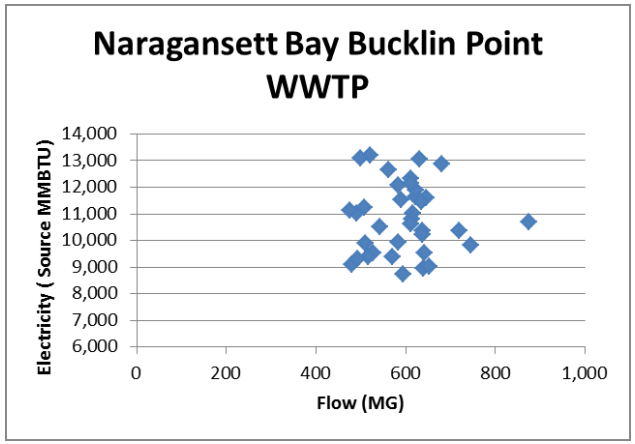

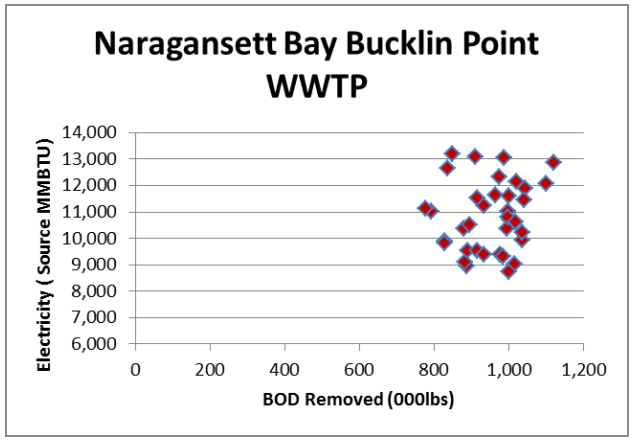

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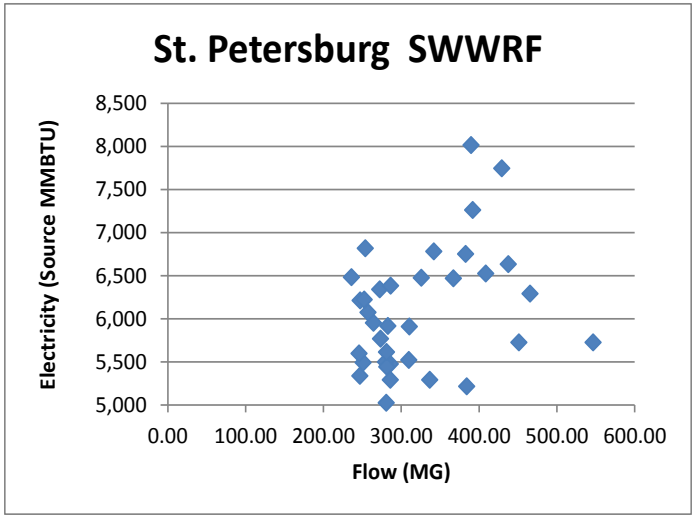

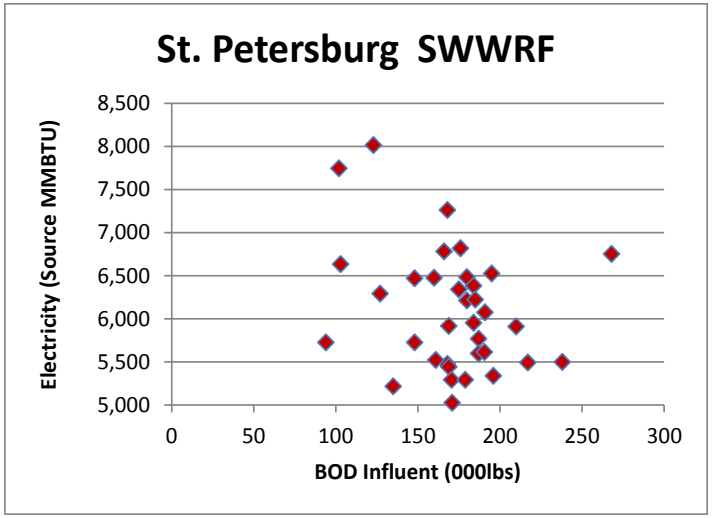

Use of Regression Analysis

- Linear regression analysis of energy consumption is a recommended practice for Better Plants partners
- The primary benefit of the regression approach is that it facilitates comparisons of performance under periods with differences in key variables
- Regression analysis allows a facility to estimate what energy consumption would have been for the same level of flow as a comparison year (a.k.a. model year), so that any improvement in energy performance can be more accurately determined
- For example, if current year energy consumption were much lower than the baseline year energy consumption, but flow was also much lower, it would be difficult to determine if the facility has improved its energy performance

EnPI Tool

- DOE Energy Performance Indicator (EnPI) Tool is used by program partners to perform regression analysis on their energy performance data
- EnPI tool was applied to each of the five partner treatment plants, with the intent of eventually reporting regression-based metrics
- An additional use of the tool is to evaluate the strength of relationship of certain independent variables to energy consumption

Victor Valley WWTP Preliminary EnPI Results

- The 2014 model was analyzed to compare with 2012 data, to determine whether the 2014 model is statistically valid
- Results did show valid statistical fit with just weather as variables, using heating degree days (HDD) and cooling degree days (CDD)
- Alternative model based on flow, BOD and CDD also fit well statistically, but with the model now showing a dependency on flow and BOD removal
- This model recommended for use based on better fit with the understanding of what variables drive energy use

Model is Appropriate for SEP	Variable	Variable p-Values	R2	Adjusted R2	Model p-Value	Formula
TRUE	HDD	0.0404	0.8458	0.8115	0.0002	2.1 * HDD + 2.8 * CDD + 7080
	CDD	0.0002				
TRUE	Flow MG	0.0878	0.8287	0.7644	0.0020	24 * Flow - 1.3 * BOD + 1.7 * CDD + 679
	BOD 000Lbs	0.1885				
	CDD	0.0054				
TRUE	CDD	0.0003	0.7476	0.7224	0.0003	2 * CDD + 7510
TRUE	Flow MG	0.0614	0.5224	0.4163	0.0360	39.4 * Flow - 3.5 * BOD -1330
	BOD 000Lbs	0.0123				

Analysis of EnPI Results: Victor Valley WWTP

- Flow is assigned a coefficient of 24 whereas BOD removed is assigned a negative 1.3
- Negative value for BOD coefficient is a concern and should be further evaluated
- Model shows a higher impact on energy use from flow than for BOD, as evidenced by the percent of impact relative to the impact of flow
- In addition, the P value is lower for flow than for BOD (.09 vs .19), also indicating a stronger fit with that variable in the regression

Equation: 24 * Flow - 1.3 * BOD + 1.7 * CDD + 679

Month		Flow (MG)	BOD (1000 lbs)	CDD	Intercept	Total Electricity Consumption (Source MMBTU) Modeled	Actual	% Difference
Jan-14	Variable Value	377	1,727	-		7,477	7,762	-4%
	Coefficient	24	(1.3)	1.7	679			
	Coefficient x Variable	9,042	(2,245)	-	679			
	Percent of Flow Impact	100%	-25%	0%	8%			
Mar-14	Variable Value	379	1,595	16		7,719	7,250	6%
	Coefficient	24	(1.3)	1.7	679			
	Coefficient x Variable	9,086	(2,074)	27	679			
	Percent of Flow Impact	100%	-23%	0%	7%			

LA Sanitation Hyperion WWTP Preliminary EnPI Results

- EnPI tool was applied to 2014 energy and operating data but the results did not reveal a statistical fit for flow, BOD or weather
- To help determine independent variable impact on electricity use, 2012 data was analyzed to compare with 2014 data to see how the modelled values compare with actual
- 2012 results did show valid statistical fit with flow and BOD
- While the 2012 model could not be used for future analysis and reporting as that year is outside of the reporting period, it does support the understanding of what variables drive energy use

Model is Appropriate for SEP	Variables	Variable p-Values	R2	Adjusted R2	Model p-Value	Formula
TRUE	Flow (Million Gallons)	0.0174	0.5636	0.4666	0.0240	7.3 * Flow-2.6 * BOD Removed + 109518
	BOD Removed (000lbs)	0.0400				

Analysis of EnPI Results: LA Sanitation Hyperion Plant

- Flow is assigned a coefficient of 7.3 whereas BOD removed is assigned a negative 2.6
- Negative value for BOD coefficient is a concern and should be further evaluated
- Model shows a higher impact on energy use from flow than for BOD, as evidenced by the percent of impact relative to the impact of flow
- In addition, the P value is lower for flow than for BOD (.017 vs .04), also indicating a stronger fit with that variable in the regression

Equation: 7.3 * Flow - 2.6 * BOD Removed + 109518

Month		Flow (MG)	BOD (1000 lbs)	Intercept	Total Electricity Consumption (Source MMBTU) Modeled	Actual	% Difference
Jan-14	Variable Value	8,463	13,772		135,490	131,674	3%
	Coefficient	7.3	(2.6)	109,518			
	Coefficient x Variable	61,780	(35,808)	109,518			
	Percent of Flow Impact	100%	-58%	177%			
Mar-14	Variable Value	8,494	13,043		137,612	131,276	5%
	Coefficient	7.3	(2.6)	109,518			
	Coefficient x Variable	62,006	(33,912)	109,518			
	Percent of Flow Impact	100%	-55%	177%			

Use of Regression Approach Alleviates Need to Choose Between Flow and BOD

- Improvement in energy intensity based on actual and modelled energy use
- EnPI tool handles calculations

Equation 2: Forecasting to determine Total Improvement in Energy Intensity

Forecasting (baseline year is selected as the model year)

$$\textit{Total Improvement in Energy Intensity}_{CY} = \left(1 - \frac{EC_{CY}}{\widehat{EC}_{CY}}\right) \times 100\%$$

Program Guidance and Next Steps

- Program Guidance
  - Need to choose initial metric for reporting purposes
  - Work with TAM to evaluate options and choose metric
  - Regression approach is recommended, but may take time to gather data, understand variable relationships, and develop acceptable model
  - Partner may change metric in future
- Timeline on Annual Reporting
  - Annual reports generally due 3 months after conclusion of reporting year
  - March 31 for most, using calendar year
- Better Plants program provides flexibility to consider future changes
  - Participation in SEP could influence choice of metric
  - EnPI analysis can be ongoing, and could identify other variables as being important. Also, co-relations between variables such as BOD and rainfall could be examined.
  - Other factors could emerge, such as separate metrics based on primary, secondary and tertiary treatment

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Questions?

References

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