Benchmarking the Environmental Footprint of Water Utility Operations

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About Me

I am a third year student at Michigan State University studying chemical engineering with a concentration in environmental engineering. This is my first research experience. I plan to do work relating to sustainability throughout my academic and professional careers.

The Water Utility Energy Challenge

The Water Utility Energy Challenge aims to reduce the emissions that result from generating the electricity used by water utilities. Six water utilities selected from a pool of applicants in the Great Lakes area were provided with tools for timing their electric loads for low emission rate times. The following focuses on the project's methods for benchmarking the competitors' performance before and after implementing the Locational Emissions Estimation Methodology (LEEM) tool.

Electric Load Optimization

- Spatially optimizing electric loads has shown emission reductions of 3-6%[1].
- Optimized timing of household appliances has shown emission reductions of 21-35%[2].
- Water utilities make up 2% of the USA's annual electricity usage[3].

Approach

The Great Lakes Water Association and Ann Arbor water utilities' backwash schedules were used to determine the effect of optimizing the timing of massive pumps used to wash filters that clean the water they distribute. This was accomplished through a process I developed:

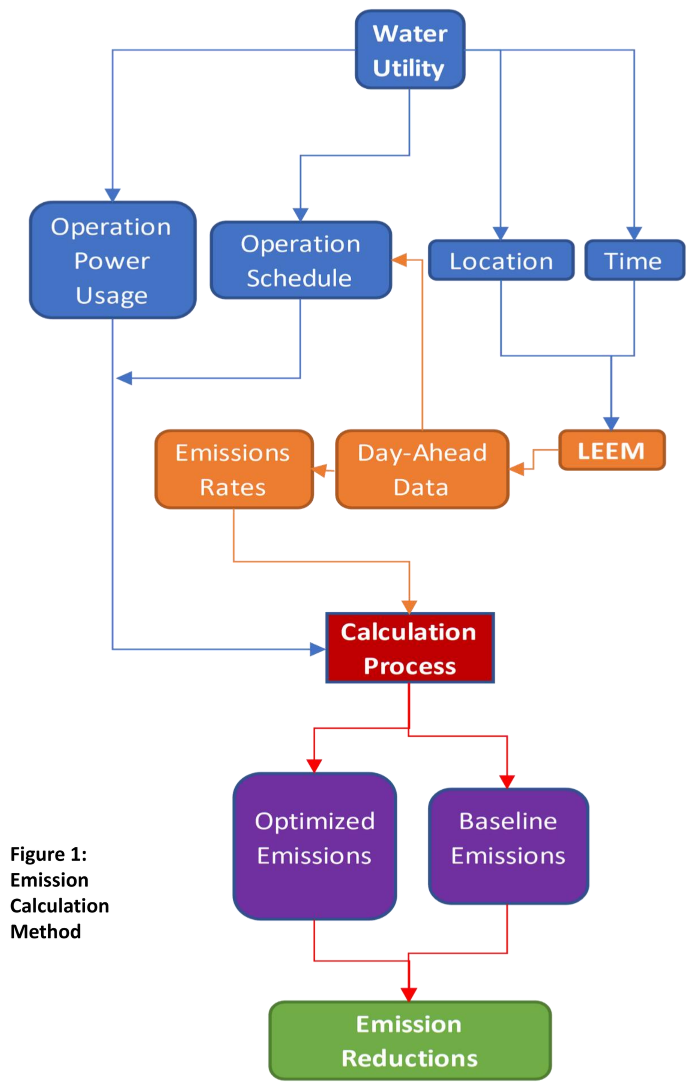

Figure 1: Emission Calculation Method

1. Gather water utility operation data.
2. Gather LEEM data for operation time period and location.
3. Combine operation times with corresponding emission rates (lbs/MWh).
4. Develop benchmark from previous performance.
5. Determine effect of LEEM.

References

1. Wang, Y., C. Wang, C.j. Miller, S.p. Mcelmurry, S.s. Miller, and M.m. Rogers. "Locational Marginal Emissions: Analysis of Pollutant Emission Reduction through Spatial Management of Load Distribution." *Applied Energy* 119 (2014): 141-50. Web.
2. Harris, A.r., Michelle Marinich Rogers, Carol J. Miller, Shawn P. Mcelmurry, and Caisheng Wang. "Residential Emissions Reductions through Variable Timing of Electricity Consumption." *Applied Energy* 158 (2015): 484-89. Web.
3. Pabi, S., A. Amarnath, R. Goldstein, and L. Reekie. *Electricity Use and Management in the Municipal Water Supply and Wastewater Industries*. Rep. ELECTRIC POWER RESEARCH INSTITUTE, Nov. 2013. Web. 20 Jan. 2017.

Results

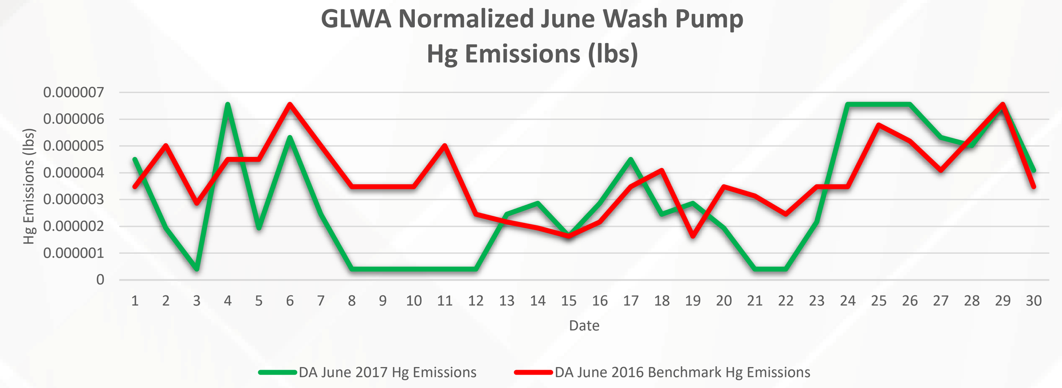

Figure 2: GLWA's comparison of lbs. of Mercury Emissions per Backwash before and after applying LEEM in June of 2017.

Table 1: Comparison of GLWA's lbs. of Emissions per Backwash Cycle before and after applying LEEM.

GLWA Normalized June Emissions		
2017 lbs CO2/Cycle	Benchmark lbs CO2 /Cycle	% Reduction
222.4844595	239.4144156	**7.1%**
2017 lbs NOx /Cycle	Benchmark lbs NOx /Cycle	
0.200678189	0.220386468	**8.9%**
2017 lbs SO2 /Cycle	Benchmark lbs SO2 /Cycle	
0.372263295	0.498049237	**25.3%**
2017 lbs Hg /Cycle	Benchmark lbs Hg /Cycle	
2.8946E-06	3.75605E-06	**22.9%**
2017 lbs Pb /Cycle	Benchmark lbs Pb /Cycle	
1.38658E-05	1.83896E-05	**24.6%**
Average Reduction		17.8%

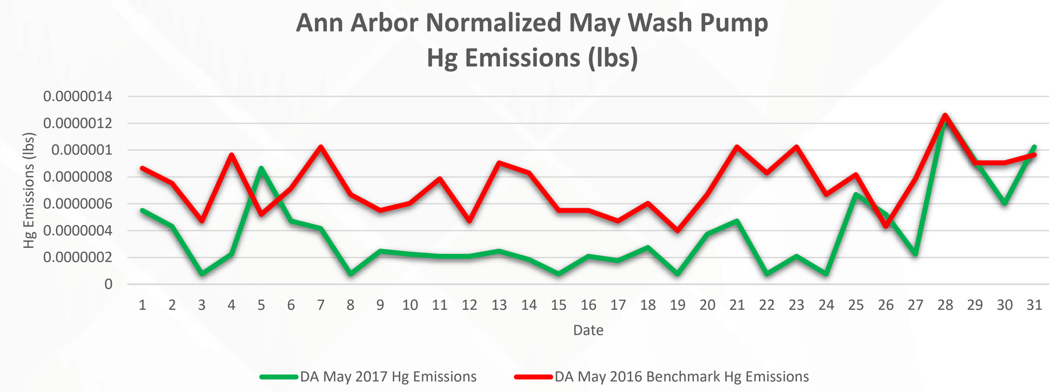

Figure 3: Ann Arbor's comparison of lbs. of Mercury Emissions per Backwash before and after applying LEEM in May of 2017.

Table 2: Comparison of Ann Arbor's lbs. of Emissions per Backwash Cycle before and after applying LEEM.

Ann Arbor Normalized May Emissions		
2017 lbs CO2/Cycle	Benchmark lbs CO2 /Cycle	% Reduction
34.75688976	44.42896552	**21.8%**
2017 lbs NOx /Cycle	Benchmark lbs NOx /Cycle	
0.022293898	0.037766897	**41.0%**
2017 lbs SO2 /Cycle	Benchmark lbs SO2 /Cycle	
0.043329783	0.097188403	**55.4%**
2017 lbs Hg /Cycle	Benchmark lbs Hg /Cycle	
3.47211E-07	7.2539E-07	**52.1%**
2017 lbs Pb /Cycle	Benchmark lbs Pb /Cycle	
1.56664E-06	3.55347E-06	**55.9%**
Average Reduction		45.2%

- Significant and consistent reductions in all five pollutant emissions
- Benchmark applied 2016's backwash schedule to 2017's LEEM data
  - Simulates not optimizing their pump schedules.
- Emissions are normalized for number of backwash cycles
  - Day's lbs. of emissions / day's number of backwash cycles

Conclusions

The method developed produced results showing emission reductions from optimized operation timing, accomplished without compromising service quality or customer satisfaction. Baseline construction being a confounding aspect of determining competition winners, it is essential to next design a way of accounting for size, resources, and available generator types.

Acknowledgments

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