Leveraging the Energy of the Group to Manage the Energy of the Utility: The NWWBI Adopts Industry Tools to Improve Energy Performance

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ABSTRACT

Benchmarking wastewater treatment energy consumption is increasingly valuable in this time of change; the drive to reduce GHG emissions, changes in energy rates and rate structures, and the validation of new technologies are all having an impact on energy consumption trends. Single parameter energy metric benchmarking has been part of the National Water and Wastewater Benchmarking Initiative (NWWBI) since the program's inception in 1997. As an alternative to the conventional single parameter metrics, the WRF Energy Index was piloted for the Canadian municipalities during the 2012 NWWBI iteration. The results of the Energy Index pilot are presented in this paper.

KEYWORDS: Energy Management, *Benchmarking*, Wastewater Treatment, Process, Performance Improvement

INTRODUCTION

Since 1997, the National Water and Wastewater Benchmarking Initiative (NWWBI) has been benchmarking the energy performance of Canadian WWTPs. The primary metric is ***Energy Consumed per ML Treated***, an internationally used and accepted performance measure. However, there are limitations to the comparability of the results, due to local factors like influent strength and effluent requirements.

To address the limitations of the single parameter metric, a multi-parameter Energy Index model was published by AwwaRF in 2007. The associated report is titled "Energy Index Development for Benchmarking Water and Wastewater Utilities". The project was completed to enable benchmarking of water utilities energy performance in the United States, including water distribution systems, water supply systems and wastewater treatment. For the wastewater treatment Energy Index, the model takes into account local factors including the type of treatment, influent/effluent quality, type of energy used and the size of the treatment plant.

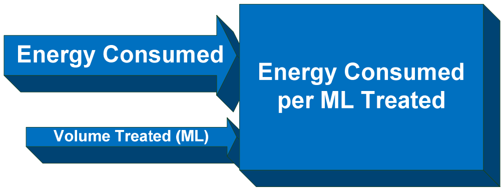

Figure 1a. Single Parameter Metric

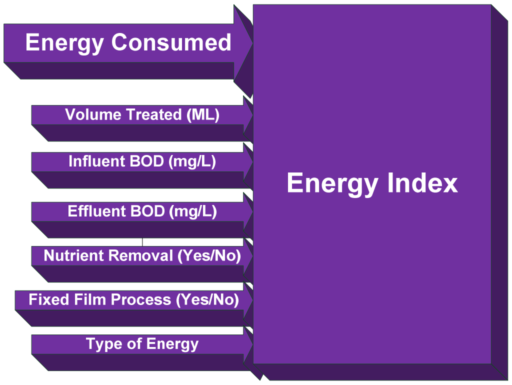

Figure 1b. Multi Parameter Metric

The primary objective of this paper is to evaluate the validity of the Energy Index noted above for the Canadian wastewater treatment plants participating in the NWWBI. The Energy Index was calculated for each WWTP using the mathematical model that is integral to the Energy Index spreadsheet provided for public use. The next step of our evaluation was the completion of a sensitivity analysis to see how the model responds to changes in the input parameters. The intent of the sensitivity analysis was not to provide mathematical proof of the model, rather a cross check of the results for Canadian WWTPs. The results and observations of the model analysis are discussed below.

THE NATIONAL WATER AND WASTEWATER BENCHMARKING INITIATIVE (NWWBI)

The Energy Index analysis is being completed as a subtask of the National Water and Wastewater Benchmarking Initiative (NWWBI). The NWWBI project is a partnership of 45 water and wastewater utilities and is facilitated by AECOM. The project is executed on an annual cycle, and each iteration supplemental activities such as this analysis are completed to support the core benchmarking exercise.

The NWWBI was established in 1997 in response to a need for Canadian municipal water and wastewater utilities to measure, track and report on their utility performance. While fundamentally a high level metric benchmarking process, it has developed into a network and information base for Canada's most progressive municipal utilities.

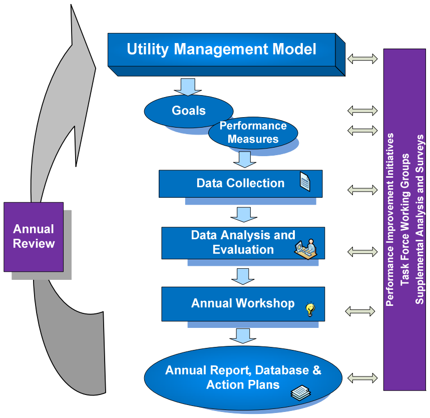

Figure 2. Utility Management Model

The core NWWBI program includes approximately 75 different Performance measures to measure attainment of the seven objectives. The objectives, or goals, were set in the early years of the project to reflect the overall mandate of the participating utilities. The seven core utility objectives are presented below:

NWWBI Seven Core Objectives

1. Provide Service Reliability
2. Provide Sufficient Service Capacity
3. Meet Service Requirements with Economic Efficiency
4. Protect Public Health and Safety
5. Provide a Safe and Productive Workplace
6. Have Satisfied and Informed Customers
7. Protect the Environment (Water, Land and Air)

Figure 3. 7 Core Objectives

Improvement in wastewater treatment plant energy performance will result in improvements in at least two of the core objective for the Utility;

- Objective 3. Meet Service Requirements with Economic Efficiency
- Objective 7. Protect the Environment

THE ENERGY INDEX

In 2007, the multi-parameter *Energy Index* model was introduced by AWWA/WRF. The following input data is used to calculate the Energy Index Score of a WWTP:

- Energy Used: Electricity, Natural Gas, Fuel Oil, Propane
- Utility Characteristics: Design Daily Flow (MGD), Current Daily Flow (MGD), Average Influent and Effluent BOD, Fixed Film process (Yes/No), Treatment Nutrient Removal (Yes/No)

The dataset used for the development of the mathematical model consists of 266 wastewater treatment plants in the United States. The original intent was to create a multi-parameter benchmark score method similar to the EPA's Energy Star rating system. The model normalizes external factors that impact energy use, theoretically leaving variability in performance due to choices made by designers and operators of the utility. The mathematical model was developed using a linear regression methodology and each WWTP receives a score based on it's placement on the curve (**Figure 4**). A complete discussion on the development of the model can be found on-line in the report titled "Energy Index Development for Benchmarking Water and Wastewater Utilities".

http://www.waterrf.org/ProjectsReports/PublicReportLibrary/91201.pdf

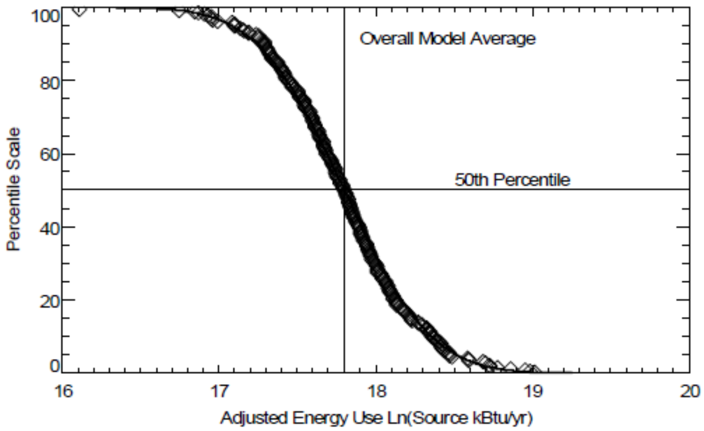

Figure 4. Energy Index Linear Regression (WRF 2007)

NWWBI WWTPS ENERGY INDEX SCORE

Thirty five (35) NWWBI secondary and tertiary wastewater treatment plants provided sufficient data in 2010 to be included in the Energy Index Score analysis. The input data and calculated Energy Index Score are presented in **Table 1**, and the scores range from 4 to 99.

Table 1. NWWBI Energy Index Input Data

WWTP	Energy Score	Design Daily Total Flow	Average Daily Total Flow	Average / Design Daily Flow Ratio	Average Influent BOD	Average Effluent BOD	Fixed Film - Trickle Filtration Process ?	Treatment Includes Nutrient Removal ?	Electricity	Fuel Oil	Natural Gas	Propane
	X out of 100	MLD	MLD	%	mg/l	mg/l	yes (1) or no (0)	yes (1) or no (0)	kWh	L	GJ	kg
WWTP-A	**2**	0.24	0.07	29%	383	1.9	no	yes	168,234	541	0	0
WWTP-B	**1**	2.04	0.87	42%	85	1.1	no	yes	935,168	0	0	0
WWTP-C	**2**	4.55	1.66	37%	35	0.6	no	yes	806,067	2,906	4,064	0
WWTP-D	**23**	5.22	2.68	51%	130	1.4	no	yes	1,332,199	5,201	821	0
WWTP-E	**8**	4.09	2.80	68%	128	2.9	no	no	872,906	1,643	3,737	0
WWTP-F	**100**	17.3	8.8	51%	169	2.0	no	yes	218,332	0	0	0
WWTP-G	**7**	12.0	10.3	85%	152	8.6	yes	no	2,405,825	0	0	0
WWTP-H	**11**	17.0	12.0	71%	297	10.0	yes	no	3,561,944	0	0	0
WWTP-I	**56**	13.6	12.5	92%	142	9.8	no	yes	1,585,129	2,005	7,271	0
WWTP-J	**66**	68.1	22.3	33%	247	4.3	no	yes	7,455,404	13,357	2,646	0
WWTP-K	**25**	32.5	30.7	94%	160	4.2	no	yes	5,619,353	0	36,522	0
WWTP-L	**70**	35.0	29.3	84%	251	5.8	no	yes	5,916,433	0	986	0
WWTP-M	**26**	72.7	32.0	44%	275	14.4	no	yes	10,512,129	33,994	21,983	0
WWTP-N	**30**	39.5	34.5	87%	369	4.4	no	yes	12,528,000	5,085	14,245	0
WWTP-O	**83**	81.8	37.0	45%	230	6.0	no	yes	6,973,432	0	6,299	0
WWTP-P	**62**	47.5	39.0	82%	256	4.0	no	yes	7,111,177	0	25,204	0
WWTP-Q	**14**	56.8	34.1	60%	257	13.1	no	yes	9,136,461	0	57,150	0
WWTP-R	**75**	68.2	41.4	61%	146	1.4	no	yes	8,339,602	15,896	7,033	0
WWTP-S	**98**	72.7	42.0	58%	277	3.5	no	yes	5,580,348	0	0	0
WWTP-T	**76**	64.0	43.7	68%	233	5.9	no	yes	7,803,150	15,471	4,764	0
WWTP-U	**57**	100.0	66.7	67%	405	4.0	no	yes	15,541,352	55,380	64,758	0
WWTP-V	**70**	81.7	61.3	75%	276	6.0	yes	no	7,425,600	16,627	1,170	0
WWTP-W	**95**	123	64.3	52%	363	8.6	no	yes	6,377,279	0	37,499	0
WWTP-X	**34**	84.5	61.9	73%	133	4.3	no	yes	12,778,704	0	26,629	0
WWTP-Y	**49**	90.0	74.1	82%	451	12.0	no	yes	17,641,372	119,846	24,723	0
WWTP-Z	**18**	69.0	74.0	107%	231	11.0	yes	no	11,934,040	0	994	0
WWTP-AA	**96**	88	74.0	85%	349	3.1	no	yes	9,793,776	2,395	2,673	0
WWTP-AB	**65**	152.2	117.7	77%	220	1.5	no	yes	23,112,854	0	55,027	0
WWTP-AC	**70**	200.0	142.9	71%	193	8.0	no	yes	20,924,370	1,320	10,590	0
WWTP-AD	**7**	330	224	68%	153	29.9	no	no	47,327,606	0	45,250	0
WWTP-AE	**34**	420	326	78%	198	6.4	no	yes	61,164,708	1,456,591	85,880	0
WWTP-AF	**80**	500	346	69%	243	6.6	no	yes	36,034,476	299,013	124,194	0
WWTP-AG	**52**	518	401	77%	240	6.0	no	yes	70,523,957	325,454	74,966	0
WWTP-AH	**95**	545	413	76%	241	16.5	no	yes	28,682,000	0	25,117	0
WWTP-AI	**84**	580	482	83%	176	7.0	yes	no	28,818,940	0	623	0
Range												
10th Percentile	**7**	5	3	43%	131	1.4	-	-	897,811	-	-	-
Median	**56**	69.00	41	71%	233	5.9	-	-	7,803,150	541	7,033	-
90th Percentile	**95**	468	338	87%	367	12.6	-	-	33,148,262	94,060	61,715	-

SENSITIVITY ANALYSIS

To assess the validity of the model for the NWWBI WWTPs a sensitivity analysis was completed. A sensitivity analysis is by definition the study of how different variations (changes) in the input of a statistical model can be attributed to different variations of the output. To complete a sensitivity analysis on the Energy Index model, each input variable is varied individually. The input variables are as follows:

- Design Daily Influent Flow
- Average Daily Influent Flow
- Average Influent BOD
- Average Effluent BOD
- Fixed Film – Trickling Filtration Process (Yes or No)
- Treatment Includes Nutrient Removal (Yes or No)
- Electricity Used
- Natural Gas Used
- Fuel oil #2
- Propane

For each numeric parameter the score was calculated under 5 conditions, Actual Value, and Variation 1 through 4; -20%, -50%, +20% and +50%, respectively. Five (5) WWTPs with varying base scores and varying local factors were selected for the sensitivity analysis. The results of the sensitivity to each parameter are provided below.

Input Parameter 1 - Design Daily Influent Flow

Table 2 presents the input Design Daily Influent Flow for five plants and the relevant scores. The effect on the energy scores varies depending on the value of the actual design daily influent scores. The smallest plant score decreases by 6 points with the -50% variation and increases by 6 points with the +50% variation. The median size plant score decreases from by 24 points with the -50% variation and increases by 14 points with the +50% variation. The largest plant score decreased by 19 points with the -50% variation and increased by 7 points with the +50% variation. The observed changes in energy scores show that varying the design daily influent flow has a significant impact on the score. The WWTPs with scores closest to the median value are affected more than high or low scores. This is expected with normal distribution of the linear regression model as show in **Figure 5**.

Table 2. Design Daily Influent Flow Sensitivity

WWTP	**Actual**		**Variation 1 (- 20%)**		**Variation 2 (- 50%)**		**Variation 3 (+ 20%)**		**Variation 4 (+ 50%)**	
	Design Daily Influent Flow (ML/D)	Score	Design Daily Influent	Score	Design Daily Influent	Score	Design Daily Influent	Score	Design Daily Influent	Score
WWTP-G	12	7	9.6	4	6	1	14	9	18	14
WWTP-P	47.5	62	38	54	24	36	57	68	71	75
WWTP-Y	90	49	72	41	45	25	108	55	135	63
WWTP-AC	200	70	160	63	100	46	240	75	300	81
WWTP-AI	580	84	464	79	290	65	696	87	870	91

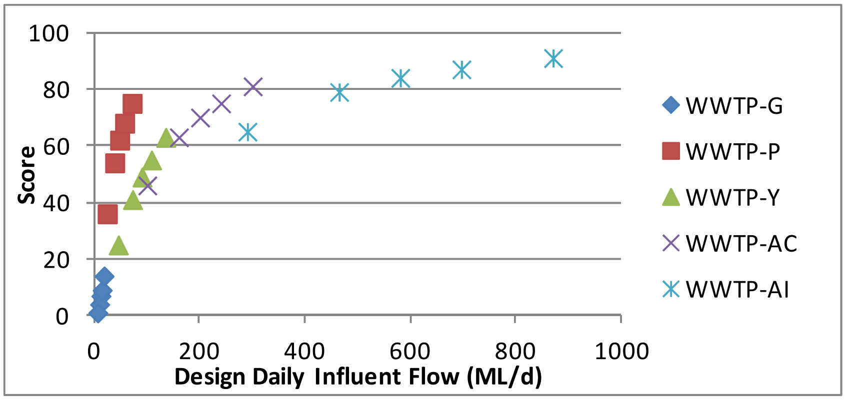

Figure 5. Design Daily Influent Flow Sensitivity

Input Parameter 2- Average Daily Influent Flow

Table 3 presents the input Average Daily Influent Flow for five plants and the relevant scores. The effect on the energy scores varies depending on the value of the actual average daily influent and the base score. The smallest plant score decreases by 6 points with the -50% variation and increases by 8 points with the +50% variation. The median size plant score decreases from by 26 points with the -50% variation and increases by 15 points with the +50% variation. The observed changes in energy scores show that varying the actual daily influent flow has a significant impact on the score. The WWTPs with scores closest to the median value are affected more than high or low scores. This is expected with normal distribution of the linear regression model as show in **Figure 6**.

Table 3. Average Daily Influent Flow Sensitivity

WWTP	**Actual**		**Variation 1 (- 20%)**		**Variation 2 (- 50%)**		**Variation 3 (+ 20%)**		**Variation 4 (+ 50%)**	
	Average Daily Flow (ML/D)	Score	Average Daily Flow (ML/D)	Score	Average Daily Flow (ML/D)	Score	Average Daily Flow (ML/D)	Score	Average Daily Flow (ML/D)	Score
WWTP-G	10.25	7	8	4	5	1	12	10	15	15
WWTP-P	39	62	31	53	20	34	47	69	59	62
WWTP-Y	74	49	59	40	37	23	88	56	111	64
WWTP-AC	143	70	114	62	70	44	172	76	215	82
WWTP-AI	482	84	386	78	241	63	578	88	723	92

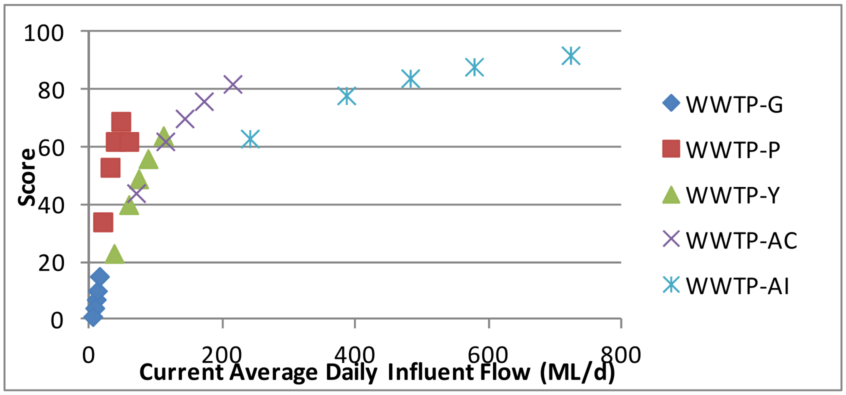

Figure 6. Average Influent Flow Sensitivity

Input Parameter 3 - Average Influent BOD

Table 4 presents the Average Influent BOD$_5$ under the five different scenarios for the five test plants and the associated scores. The effect on the energy scores varies depending on the value of the actual influent BOD and base scores. The smallest plant score decreases by 6 points with the -50% variation and increases by 8 points with the +50% variation. The median size plant score decreases from by 25 points with the -50% variation and increases by 15 points with the +50% variation. The largest plant score decreased by 19 points with the -50% variation and increased by 7 points with the +50% variation.

Table 4. Average Influent BOD Sensitivity

WWTP	**Actual**		**Variation 1 (- 20%)**		**Variation 2 (- 50%)**		**Variation 3 (+ 20%)**		**Variation 4 (+ 50%)**	
	Influent BOD$_5$ (mg/L)	Score	Influent BOD$_5$ (mg/L)	Score	Influent BOD$_5$ (mg/L)	Score	Influent BOD$_5$ (mg/L)	Score	Influent BOD$_5$ (mg/L)	Score
WWTP-G	152	7	122	4	76	1	182	10	228	15
WWTP-P	256	62	205	53	128	35	307	69	384	76
WWTP-Y	451	49	361	40	226	24	541	56	677	64
WWTP-AC	193	70	154	62	97	45	232	76	290	82
WWTP-AI	176	84	141	78	88	63	211	88	264	91

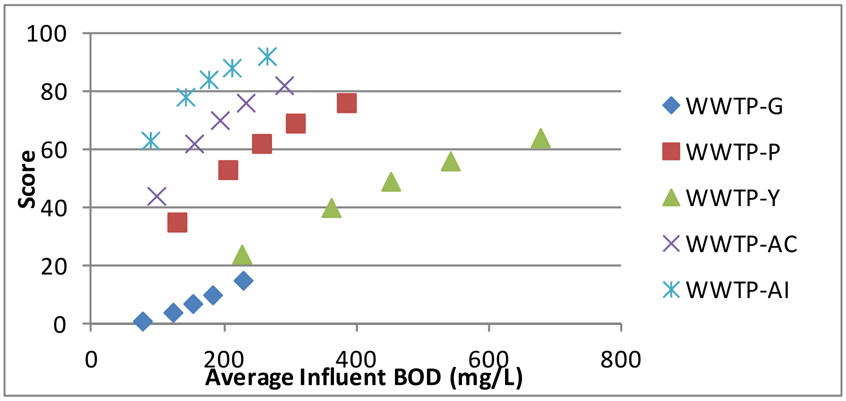

Figure 7. Average Influent BOD Sensitivity

Input Parameter 4 - Average Effluent BOD

Table 5 presents the average influent BODs under the five different scenarios for the five test plants and the associated scores. The effect on the energy scores varies depending on the value of the actual influent BOD and base scores. The smallest plant score decreases by 3 points with the +50% variation and increases by 5 points with the -50% variation. The median size plant score decreases from by 7 points with the +50% variation and increases by 11 points with the -50% variation. The largest plant score decreased by 4 points with the +50% variation and increased by 6 points with the -50% variation.

Table 5. Average Effluent BOD Sensitivity

WWTP	Actual		Variation 1 (- 20%)		Variation 2 (- 50%)		Variation 3 (+ 20%)		Variation 4 (+ 50%)	
	Effluent BOD (mg/L)	Score	Effluent BOD (mg/L)	Score	Effluent BOD (mg/L)	Score	Effluent BOD (mg/L)	Score	Effluent BOD (mg/L)	Score
WWTP-G	8.6	7	6.9	8	4.3	12	10	6	13	4
WWTP-P	4.0	62	3.1	66	2.0	73	4.8	59	6.0	55
WWTP-Y	12.0	49	9.6	52	6.0	60	14	46	18	42
WWTP-AC	8.0	70	6.4	73	4.0	79	10	67	12	64
WWTP-AI	7.0	84	5.6	86	3.5	90	8.4	82	11	80

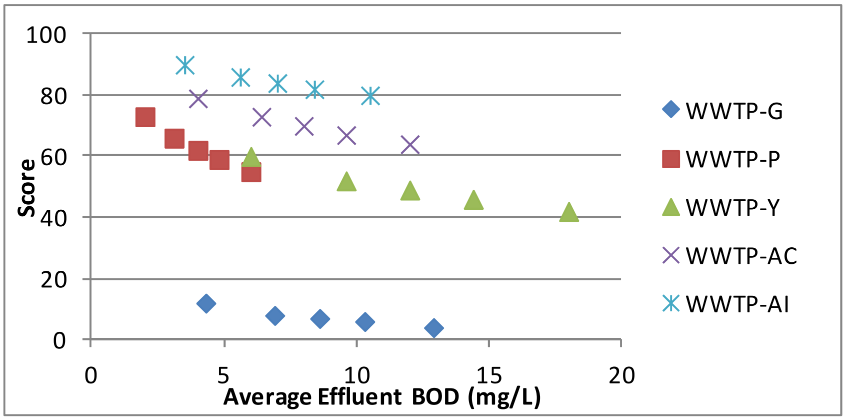

Figure 8. Average Effluent BOD Sensitivity

Input Parameter 5 - Fixed Film Process (Yes / No)

Fixed film processes include trickling filters, biological aerated filters and rotating biological filters, while suspended growth processes include activated sludge, membrane biological reactors and extended aeration processes. **Table 6** presents the score for each of the five test plants under actual conditions for whether or not the WWTP utilizes a fixed film process, as well as the score if the WWTP provided the opposite response.

The fixed film input parameter into the model has a very large impact on the output score. The smallest plant of the five test plants changed from a score of 7 (base case – fixed film process), to 24 if it were an activated sludge process. The median size plant's score dropped by 24 points if it were to be modelled as a fixed film plant. The high sensitivity to the fixed film process response indicates that the fixed film plants in the group of American plant used to generate the model must have been significantly lower energy consumers and therefore the adjustment to make a trickling filter plant and an activated sludge plant comparable.

Table 6. Fixed Film Sensitivity

WWTP	**Actual**		**Variation 1**	
	Fixed Film Yes/No	Score	Fixed Film Yes/No	Score
WWTP-G	Yes	7	No	24
WWTP-P	No	62	Yes	34
WWTP-Y	No	49	Yes	23
WWTP-AC	No	70	Yes	44
WWTP-AI	Yes	84	No	95

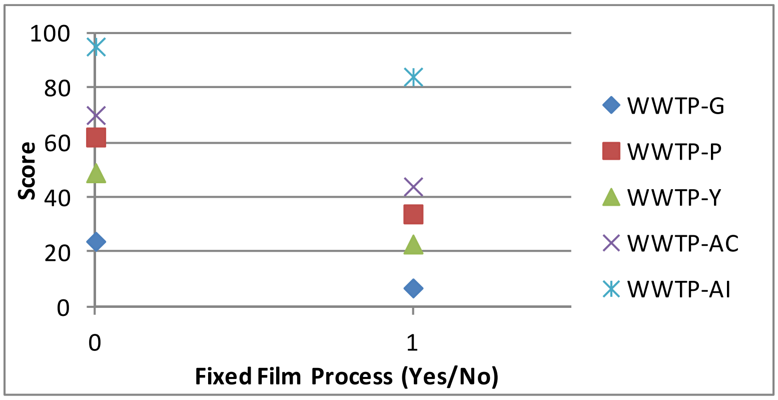

Figure 9. Fixed Film Process Sensitivity

Input Parameter 6 - Nutrient Removal (Yes / No)

Nutrient removal is the second Yes or No input parameter. If a plant is providing nutrient removal then a higher level of treatment is being completed. **Table 7** presents the score for each of the five test plants under actual conditions for whether or not the WWTP provides nutrient removal, as well as the score if the WWTP provided the opposite response.

The nutrient removal input parameter into the model has a very large impact on the output score. The smallest plant of the five test plants changed from a score of 7 (base case – no nutrient removal), to 14 if it were to provide nutrient removal. The median size plant's score dropped by 15 points if it were to be modelled as a non nutrient removal.

One issue with this parameter is that "Nutrient Removal" is a very broad topic. One plant may have very stringent nutrient limits, while another plant may have a limit that is much higher.

Table 7. Nutrient Removal Sensitivity

WWTP	**Actual**		**Variation 1**	
	Nutrient Removal Yes/No	Score	Nutrient Removal Yes/No	Score
WWTP-G	No	7	Yes	14
WWTP-P	Yes	62	No	47
WWTP-Y	Yes	49	No	34
WWTP-AC	Yes	70	No	56
WWTP-AI	No	84	Yes	91

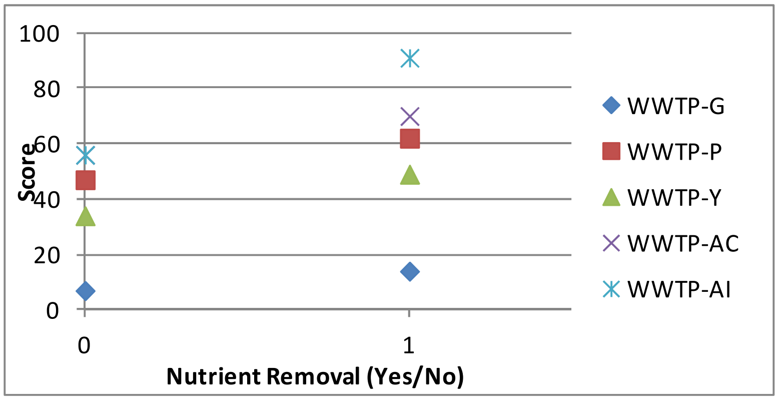

Figure 10. Nutrient Removal Sensitivity

Input Parameter 7 - Electricity Purchased

Table 8 presents the quantity of electricity purchased under the five different scenarios for the five test plants and the associated scores. The effect on the energy scores varies depending on the quantity of electricity used and the base scores, however as could be expected electricity purchased has the greatest impact on the score of all the input parameters. The smallest plant score decreases by 6 points with the +50% variation and increases by 50 points with the -50% variation. The median size plant score decreases from by 28 points with the +50% variation and increases by 40 points with the -50% variation. The largest plant score decreased by 28 points with the +50% variation and increased by 16 points to a score of 100 with the -50% variation.

Table 8. Electricity Purchased Sensitivity

WWTP	Actual		Variation 1 (- 20%)		Variation 2 (- 50%)		Variation 3 (+ 20%)		Variation 4 (+ 50%)	
	Electricity (kWh/yr)	Score	Electricity (kWh/yr)	Score	Electricity (kWh/yr)	Score	Electricity (kWh/yr)	Score	Electricity (kWh/yr)	Score
WWTP-G	2,405,825	7	1,925,000	16	1,203,000	57	2,887,000	3	3,609,000	1
WWTP-P	7,111,177	62	5,689,000	75	3,556,000	92	8,533,000	50	10,667,000	34
WWTP-Y	17,641,372	49	14,113,000	65	8,821,000	89	21,170,000	35	26,462,000	21
WWTP-AC	20,924,370	70	16,739,000	84	10,462,000	97	25,109,000	56	31,387,000	38
WWTP-AI	28,818,940	84	23,055,000	93	14,409,000	100	34,583,000	73	43,228,000	56

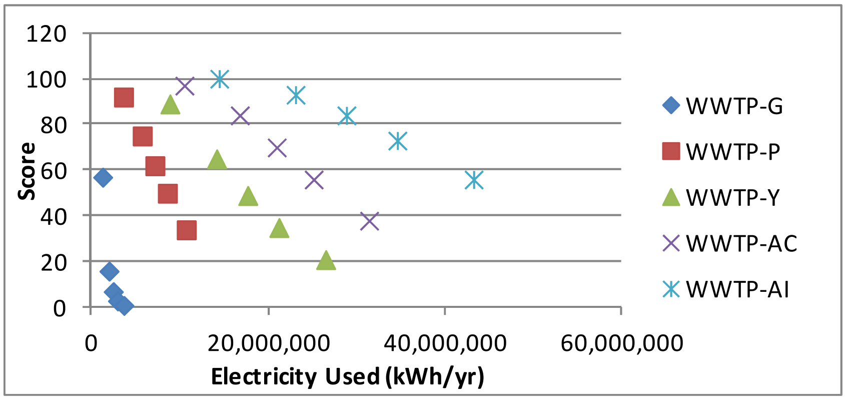

Figure 11. Electricity Purchased Sensitivity

Input Parameter 8 - Natural Gas Used

Table 9 presents the quantity of natural gas purchased under the five different scenarios for the five test plants and the associated scores. The effect on the energy scores varies depending on the quantity of natural gas used and the base scores. Four of the five test plants purchase natural gas for use at the facility. The median size plant score increases by 4 points with the -50% variation and decreases by 5 point with the +50% variation. The largest plant score did not change at all with the +50% variation and the -50% variation as only a relatively small amount of natural gas is consumed at this facility.

Table 9. Natural Gas Sensitivity

WWTP	**Actual**		**Variation 1 (- 20%)**		**Variation 2 (- 50%)**		**Variation 3 (+ 20%)**		**Variation 4 (+ 50%)**	
	Natural Gas (GJ/yr)	Score	Natural Gas (GJ/yr)	Score	Natural Gas (GJ/yr)	Score	Natural Gas (GJ/yr)	Score	Natural Gas (GJ/yr)	Score
WWTP-G	0	7	0	7	0	7	0	7	0	7
WWTP-P	25,204	62	20,163	66	12,602	72	30,245	58	37,806	52
WWTP-Y	24,723	49	19,778	50	12,362	53	29,668	47	37,085	44
WWTP-AC	10,590	70	8,472	71	5,295	72	12,708	69	15,885	68
WWTP-AI	623	84	498	84	312	84	748	84	935	84

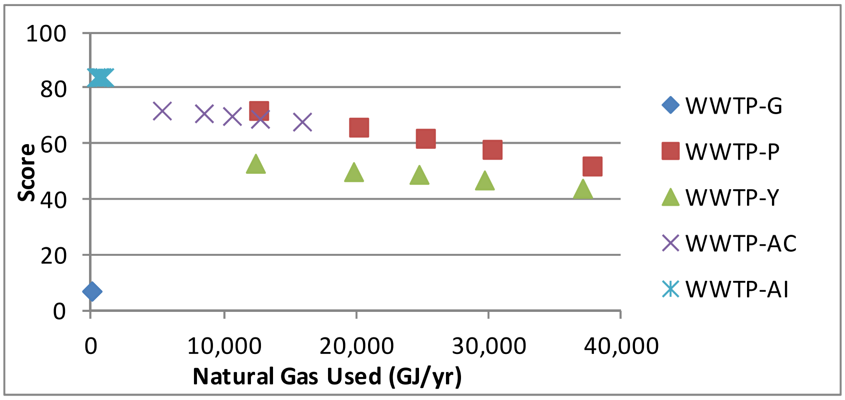

Figure 12. Natural Gas Sensitivity

Input Parameter 9- Fuel Oil #2

Table 10 presents the quantity of fuel oil purchased under the five different scenarios for the five test plants and the associated scores. The effect on the energy scores varies depending on the quantity of fuel oil used and the base scores. Only two of the test plants purchase fuel oil. The quantity of fuel oil consumed is relatively small compared to the other types of energy consumed, mainly natural gas and electricity, and therefore varying the quantity of fuel oil used by 50% did have any impact on the scores.

Table 10. Fuel Oil Sensitivity

WWTP	**Actual**		**Variation 1 (- 20%)**		**Variation 2 (- 50%)**		**Variation 3 (+ 20%)**		**Variation 4 (+ 50%)**	
	Fuel Oil (L/yr)	Score	Fuel Oil (L/yr)	Score	Fuel Oil (L/yr)	Score	Fuel Oil (L/yr)	Score	Fuel Oil (L/yr)	Score
WWTP-G	0	7	0	7	0	7	0	7	0	7
WWTP-P	0	62	0	62	0	62	0	62	0	61
WWTP-Y	119,846	49	95,877	49	59,923	49	143,815	49	179,769	48
WWTP-AC	1,320	70	1,056	70	660	70	1,584	70	1,980	70
WWTP-AI	0	84	0	84	0	84	0	84	0	84

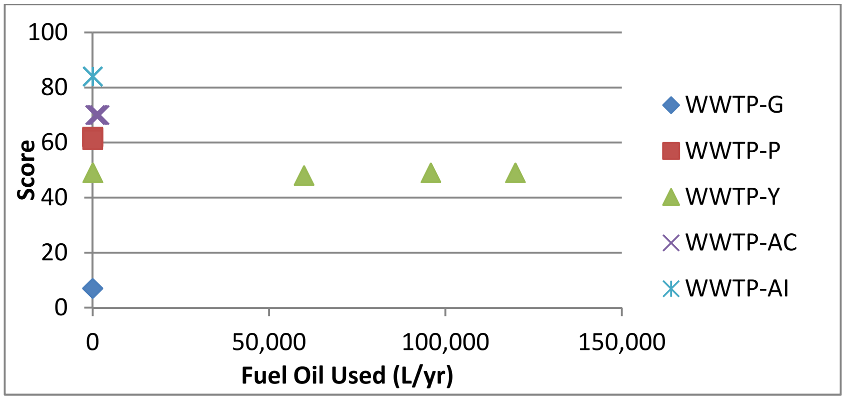

Figure 13. Fuel Oil Sensitivity

Validity and Limitations of the Energy Index for Canadian WWTPs

The review of the Energy Index using NWWBI data shows model validity and comparability using the multi-parameter *Energy Index* for plants with different local factors including plant size, operating capacity, influent load, and effluent quality with some limitations. The following section discusses the observations and limitations of the sensitivity analysis.

OBSERVATIONS

As concluded in the AWWA/WRF report, the Energy Index score only roughly correlates to traditional single parameter energy use metrics such as kWh/ML. A plant with a low kWh/ML can still achieve a low index score due to the adjustment for other local factors. **Figure 14** illustrates the Energy Score and the conventional single parameter energy consumed metric, and how they can deviate from one another in numerous cases. This variance indicates that input factors other than energy and flow can have a significant impact on the energy score.

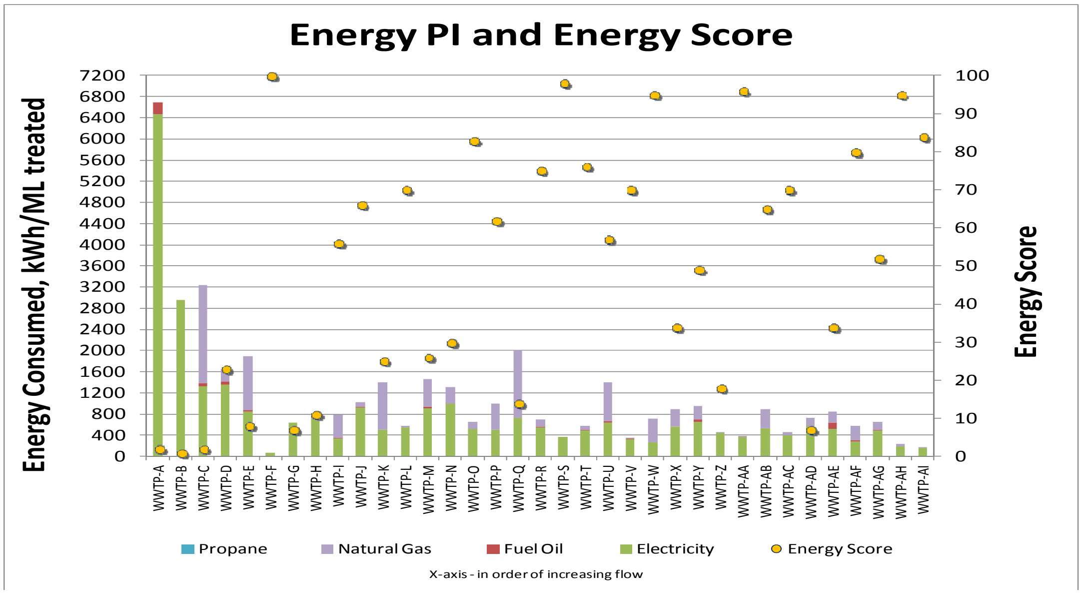

Figure 14. Energy Index Score and Energy Consumed per ML Treated

As expected influent and effluent quality have an impact on the score. **Figure 15** illustrates the energy score for each facility with the change in BOD concentration form the influent to the effluent of the plant. An interesting note is that all of the plants with scores below 25 have either high or low effluent BOD relative to the peer group. This relationship may be related to current technologies being optimized for the “typical” discharge, average BOD_5 between 5-10mg/L.

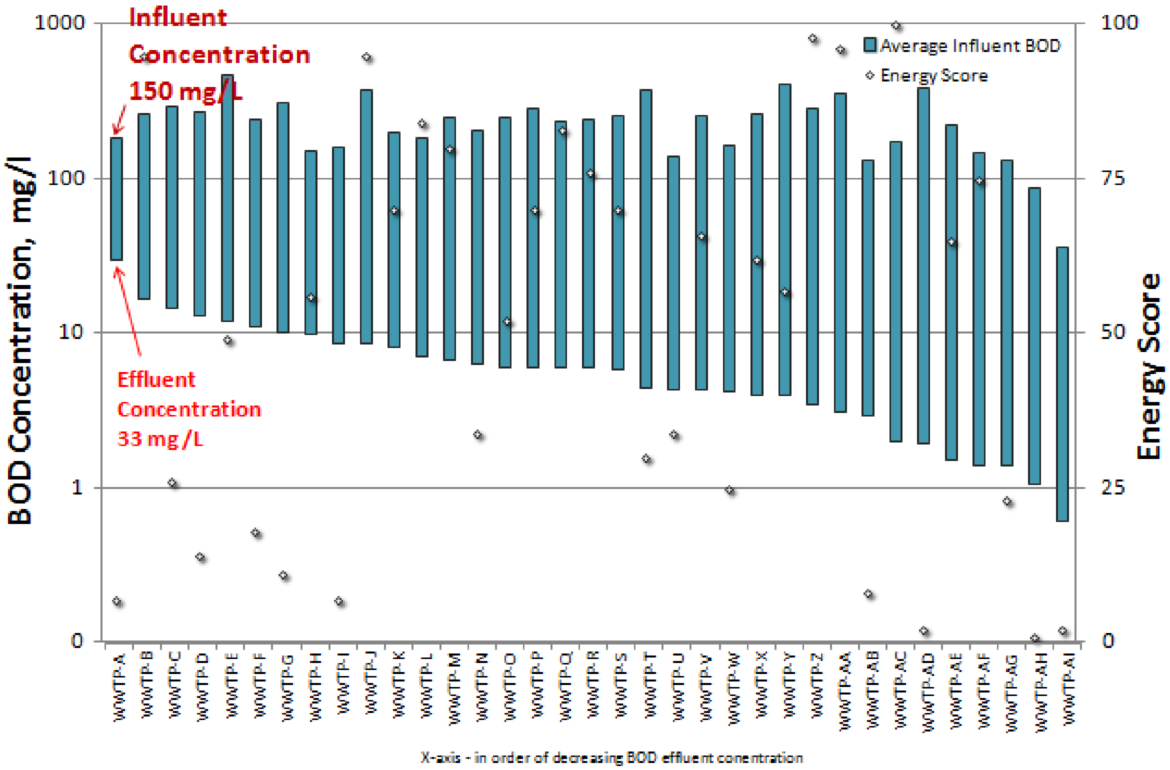

Figure 15. Influent/Effluent Quality and the Energy Score

Another parameter related to the regulatory requirements is the Nutrient Removal parameter. It is a Yes/No scoring, however, nutrient limits vary significantly across our group, from a fairly high ammonia limit that is reached through the design treatment of BOD/TSS, or very stringent N and P limits that require significantly more treatment. The model does not distinguish between these two extremes (or nutrient removal in the mid range). **Figure 16** illustrates the effluent phosphorous concentration with the range of energy scores. The fact that the plants with higher phosphorous concentrations are at the low scoring (and mid range) end of the spectrum, indicates that phosphorous removal is not driving energy performance down. In fact many of the high scoring plants have low phosphorous concentrations. This may be due to a number of reasons, chemical P removal may be use for nutrient removal which is not a significant energy consumer, and plants with stringent nutrient limits are more likely to utilize a tertiary filtration process which would lower the effluent BOD and increase the Energy Index Score.

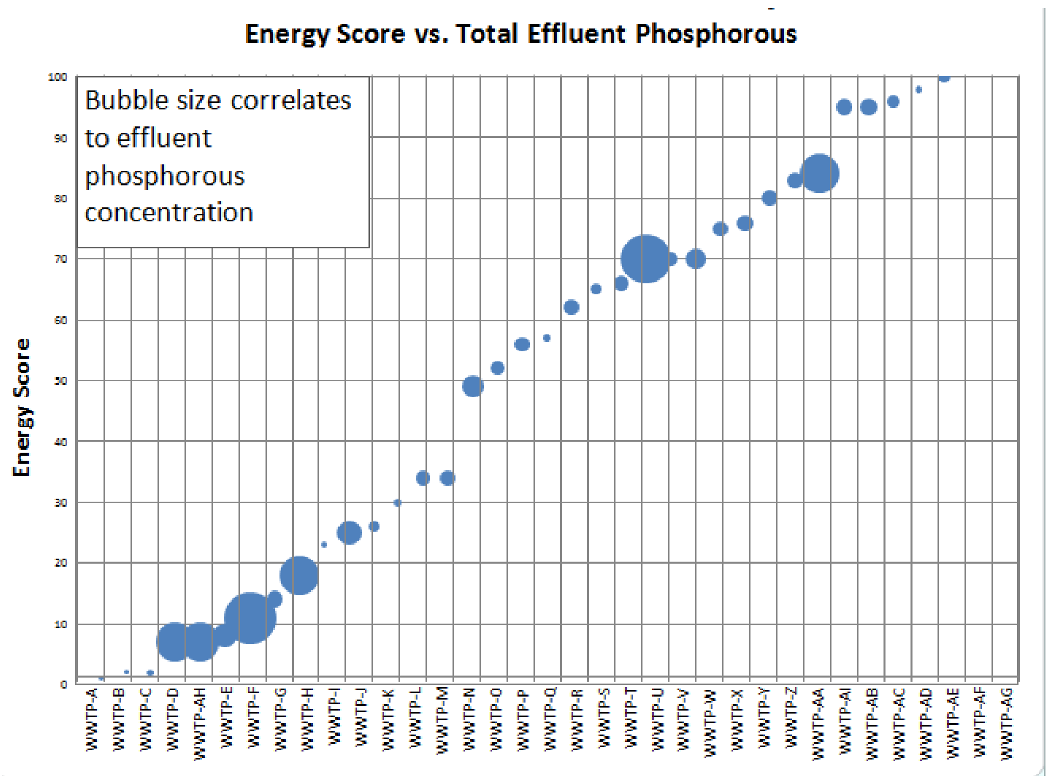

Figure 16. Nutrient Removal and the Energy Score

The trickling filter plants in the NWWBI group will score lower than activated sludge plants as they are fixed film processes. For example WWTP-AI scores 94 if the fixed film process is not accounted for, instead of the actual score of 82. This parameter was included in the model as it was shown to have a quantifiable affect on wastewater quality. However, this is the only local factor input parameter that is intrinsic to the plant and not a measure of what comes into the plant and what goes out of the plant. Therefore, this is the one parameter which I believe should not be included in the model. As well, many of the NWWBI "fixed film" processes are actually combined systems that consist of a trickling filter and solids contact tank, ie. fixed film and suspended growth systems.

The following limitations were observed for the Energy Index.

- The index is not valid for Primary treatment plants, the effluent load sensitivity is not high enough to provide even comparison for primary treatment plants.

- The hydraulic grade of the treatment plant is not included in the input parameters. According to the reference document pumping energy was considered in the model, however variations in pumping energy did not show a statistical significance in the Energy Score. This is an unexpected result.

- The model utilizes a conversion for site energy to sources energy. This conversion factor is specific to the type of power production and the integrity of the transmission system. The US average sources to site energy conversion factor is 3.3, while the Canadian average (NRC in draft) is 2.2. However, we do not want to use the Canadian average as it would not compare the actual efficiency of the plant. If the goal is to compare efficiency, an alternative comparator would be to use site energy only.

However, all comparison tools will have some limitations, and in benchmarking it is important to acknowledge when enough detail is sufficient to do the job of benchmarking. The limitations listed above will impact the score, however the results still provide an interesting tool for comparing different WWTP operations beyond the conventional single parameter metric.

DISCUSSION

Regardless of whether a single or multi parameter metric is being used it is important to remember that benchmarking is not a measure of good or bad, but rather an indicator of how an operation compares to a peer group, and it's own trend over time. The Energy Index comparison can be used to gauge whether there are opportunities for improved performance at a WWTP, or whether key WWTPs that can share their "secrets to success". The NWWBI's focuses on this information exchange. **Figure 17** illustrates the linkage between performance measures and key activities to improve energy performance. At the annual NWWBI conference participating utilities are ask to bring a topic of discussion such as the individual topics listed in **Figures 17** for discussion in a breakout session. The topic can be presented as a challenge the utility is having with the intent that the group share their experiences, solutions and expertise, or it can be a success story to share with the group.

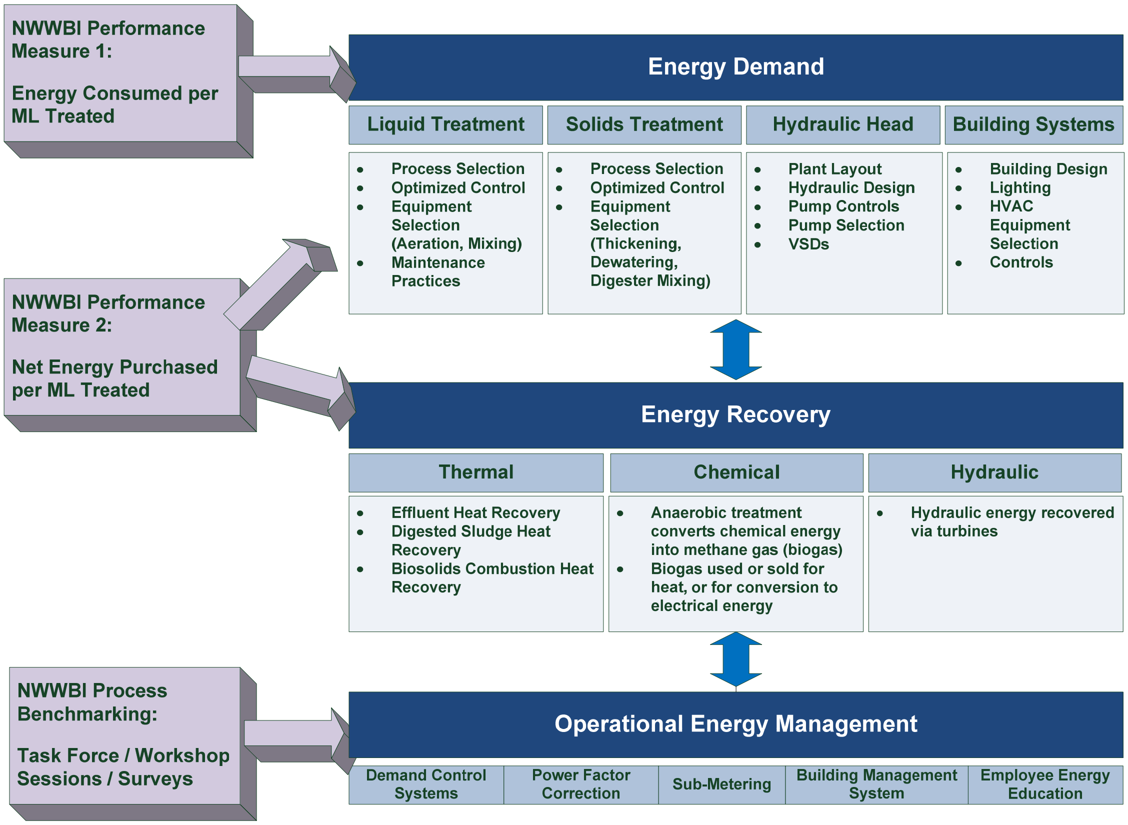

Figure 17. Energy Performance Improvement Map

CONCULSION

In conclusion, the Energy Index tool is a valid high level comparison for Canadian WWTPs to benchmark energy usage. As with any comparator there are some limitations in the apples-to-apples comparability of the Energy Index. Specifically, the source-to-site conversion factor used in the model is specific to the US and deviates from the Canadian value by approximately 30%, the model is not valid for primary WWTPs, the inclusion of the Fixed Film Process parameter is intrinsic to the treatment plant and topography (hydraulic grade line) is not considered. These limitations do not nullify the results all together, but should be acknowledged in the analysis of a WWTP's score.

Tools like the WRF Energy Index are developed to help utilities measure and assess their current energy performance. However, benchmarking alone will not improve a utility's energy performance, it will simply provide a picture of where the utility is currently at, and what order of magnitude is available for improvement. After benchmarking an entire facility as a whole, the next steps should be to benchmark the individual unit processes. The NWWBI is planning to complete this task in the 2012/2013 iteration of the project. Once a focus area is identified for an individual plant, specific energy improvement opportunities can be evaluated. After implementation of energy improvement projects benchmarking should be reiterated to quantify the impact of the improvements, and results should be communicated with stakeholders (operators, management, Council and the public).

There is a drive for utilities to become energy producing facilities and we have seen a number of facilities reach this goal in recent years. Partnerships like the NWWBI provide an opportunity for WWTP owners and operators to work together leveraging work that has been done to date at other facilities to improve energy management practices in the most efficient manner.

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