

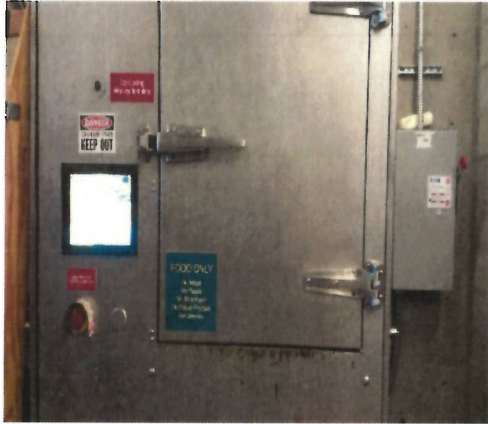
On-Site Foodwaste Processing Demonstration Projects with Businesses

Seattle Public Utilities conducted three on-site processing demonstration projects with businesses starting in 2015 through early 2017. The selected projects demonstrated two different technologies, the WISErg Food Harvester and the Impact Bioenergy Anaerobic Digestion HORSE Micro Digestion Unit, for processing discarded food. These technologies are feasible on-site at grocery stores and brewing companies. Monthly monitoring was conducted of the amount of food scraps diverted to the processing unit, the energy and water inputs required and the quantities and quality of the end products.

The three demonstration projects and individual project findings are described on the following pages.

- **Columbia City Puget Consumers Co-op, WISErg Harvester Pilot**
- **Pike Place Market, WISErg Harvester Pilot**
- **Fremont Brewing Company, Impact Bioenergy HORSE Anaerobic Digester Pilot**

Columbia City PCC WISErg Harvester Pilot (Fall 2015 – Fall 2016)



Harvester input unit and standard 5,000-gallon tank with proprietary mix of enzymes installed at PCC loading dock (84 square feet).

The input unit tracks all discarded food types by weight with each entry and by which store personnel

No paper or compostable cups or serviceware

Grinding of discarded food inputs followed by addition of water and a short residence time in the tank.



Pumpouts of effluent “broth” from Harvester tank and transportation to WISErg Redmond Plant for further processing to meet State 3-01-1 fertilizer standard.

End product is in liquid form for land application on organic farms and for public use on vegetable and flower gardens.

Little contamination reported

Project Summary:

- Discarded Food Diversion: 125 tons (250,000 lbs.) of non-edible dairy, meat, seafood, deli, fruits, vegetables
- Water Inputs: 3.1 gallons per lb.
- Energy Input: .072 kwh per lb.
- Pump Outs Needed for Transport of Liquid “Broth”: 90
- PCC Columbia City store continuing with use of WISErg Harvester

Final Study Monitoring and Lab Results:

- Puget Consumers Co-op, Report Form (next page)

Quarterly Report Form
 Puget Consumers Co-op, dba PCC Natural Markets

Submit this form to SPU's Project Manager for this contract.

Month	Food Waste Quantities (lb)	Food Waste Types**	Water Inputs to Unit (gallons)	Wastewater Quantity (gallons)	Wastewater Quality (List lab tests performed - attach lab results to report)	Energy Usage (kWh or therms)	Liquid Fertilizer Outputs (gallons)	Liquid Fertilizer Quality (List lab tests performed - attach lab results to report)	Maintenance Time (# of hours)	Contamination (quantities & types)	Pump Outs Needed	User or Staff (# of sessions and attendees)
1st Quarter												
Installment of unit in September 2015												
Oct-15	10,472	Preconsumer Deli, Floral, Meat, Seafood, Produce	5,029	0 N/A		117	6,338		2-2.5 hrs	Handful of wire ties/day	3	5 sessions, 20 employees, 1.5 hrs WISErg time
Nov-15	18,936	Preconsumer Deli, Floral, Meat, Seafood, Produce	10,126	0 N/A		706	2,575		5.75 hrs	6 wire ties	4	4 hour open house
12/31/2015	19,062	Preconsumer Deli, Floral, Meat, Seafood, Produce	6537	0	Attached for facility results	725	2,400	See attached	2 hrs	None reported		None
Report due January 15, 2016												
2nd Quarter												
Jan-16	18,312	Deli, Meat, Seafood, Floral, Produce	5754	0 N/A		903	3,000	see fourth tab	4 hours	Handfull of wire ties, rubber bands, small plastics	3	none
Feb-16	15,385	Deli, Meat, Seafood, Floral, Produce	4729	0 N/A		634.3	0	see fourth tab	4.5 hrs	Handfull of wire ties, rubber bands, small plastics	2	none
3/30/2016	19,013	Deli, Meat, Seafood, Floral, Produce	5721	0 N/A		751.6	18,000	see fourth tab	4 hrs	Handfull of wire ties, rubber bands, small plastics	3	none
Report due April 15, 2016												
3rd Quarter												
Apr-16	17,759	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	4685	0 N/A		996.9	8,600	See attached	10 hrs	Small handfuls from time to time of rubber bands, strings, and tags	9	none
May-16	23,608	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	5621	0 N/A		1190.7	17,100	See attached	10 hrs	Small handfuls from time to time of rubber bands, strings, and tags	13	none

Quarterly Report Form
 Puget Consumers Co-op, dba PCC Natural Markets

6/30/2016	26,088	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	6857	0 N/A	889.2	73,000	See attached	10 hrs	Small handfuls from time to time of rubber bands, strings, and tags	15	none
Report due July 15, 2016											
4th Quarter											
Jul-16	28,692	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	8388	0 N/A	720	26,844	See attached	4 hrs	Small handfuls from time to time of rubber bands, strings, and tags	14	none
Aug-16	27,660	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	8381	0 N/A	720	64,127	See attached	4 hrs	Small handfuls from time to time of rubber bands, strings, and tags	13	none
9/30/2016	24,650	Deli, Meat, Seafood, Floral, Produce, Bakery, Dairy	7515	0 N/A	695	27,257	See attached	4 hrs	Small handfuls from time to time of rubber bands, strings, and tags	13	none
Report due October 15, 2016											
Draft Final Report due November 20, 2016											
Final Report due December 15, 2016											
**Detailed Vendor Supplied Information Forms can substitute for this form											
Note any events such as unit cleanup or shut down for maintenance											
Provide copies of business vendor staff educational handouts for training sessions											

Pike Place Market WISerg Harvester Pilot (Spring – Summer 2016)



Small 2,250-gallon tank installed due to location in a high use pedestrian/vehicle area in front of the Market. A double walled design was also required since the tank was adjacent to a storm drain. This reduced the volume of the normal Harvester tank size by half.

Training provided for 20 market stall vendors with wide variety of organics from cut flowers to fish wastes but not compostable paper or service ware

Little contamination recorded

Project Summary:

- Discarded Food Diversion (only three months): 31.11 tons (62,220 lbs.) of organics
- Water Input: 2.2 gallons per lb.
- Energy Input: .045 kwh per lb.
- Pump Outs Needed: 39
- Project discontinued after one quarter since the small size of the tank was a problem particularly for processing the large amount of fish wastes. Odor issues developed and daily pump outs of the tank liquid effluent was required.

Final Study Monitoring and Lab Results:

- Pike Place Market, Report Form (next page)

Month	Food Waste Quantities (lbs.)**	Food Waste Types** (such as pre-consumer veg, post-consumer, floral, paper or industrial/organic residuals)	Water Inputs to Unit	Wastewater Quantity (gallons)	Wastewater Quality - at lab tests performed - at lab results to report	Energy Usage (kWh or)	Liquid Fertilizer Outputs (gallons)	Liquid Fertilizer Quality - at lab tests performed - at lab results to report	Maintenance Time	Contamination Monitoring (quantities & types)	Pumps/Outs Needed	User or Staff Training Sessions (# of sessions and attendees)
1st Quarter												
Installation of unit in April 16												
Apr-16	20,513	Pre-consumer Meat, Produce, Vegetables, Baked Goods, Dairy Items	11,893	NA	NA	980	0 *PPM pilot is unique in terms of the material mix (nearly triple the protein inputs of other Harvesters/procers) and the tank size is much smaller than utilized in other installation, which also impacts pump out frequency. Biology has been difficult to stabilize and therefore we have diverted the material to AD in the interim. The nutrient value of this broth is very rich and we are working aggressively to stabilize the tank and incorporate into our processing (which is the point of the pilot); progress looks extremely promising.	NA	15	Small handfuls from time to time of rubber bands, strings, and tags	11	1) Twenty 10 minute information sessions with individual vendors to explain why the Harvester was selected and timing of implementation (this may be considered planning instead of training; approx 3.5 hours) 2) 1 hour overview and background with PDA staff, 3) Twenty 10 minute information sessions with individual vendors to show how to operate the Harvester, functional use (approx 3.5 hours).
May-16	20,654	Pre-consumer Meat, Produce, Vegetables, Baked Goods, Dairy Items	8,112	NA	NA	885	0	NA	15	Small handfuls from time to time of rubber bands, strings, and tags	13	NA
6/1/2016	21,053	Pre-consumer Meat, Produce, Vegetables, Baked Goods, Dairy Items	7,749	NA	NA	912	0	NA	15	Small handfuls from time to time of rubber bands, strings, and tags	15	NA
2nd Quarter												
Report due July 15, 2016												
Jul-16												
Aug-16												
Sep-16												
3rd Quarter												
Report due October 15, 2016												
Oct-16												
Nov-16												
Dec-16												
4th Quarter												
Report due January 15, 2017												
Jan-17												
Feb-17												
Mar-17												
Report due April 15, 2017												
Draft Final Report due April 30, 2017												
Final Report due May 15, 2017												
**Detailed Vendor Supplied Information Forms can substitute for this form												
Note any events such as unit cleanup or shut down for maintenance												
Provide copies of business vendor staff educational handouts for training sessions												

Fremont Brewing Company – Impact Bioenergy HORSE Anaerobic Digester
Pilot (spring 2016 – spring 2017)



Micro sized Anerobic Digestion unit located in parking lot for the Fremont Brewing Company Ballard plant

Company interested in potential biogas generation from AD for energy/heat production with different types of brewery residuals

Another end product from AD is a liquid digestate for either composting or direct land application on farms



Digestate was land applied at Seattle Urban Farm as a commercial fertilizer for experimental use on fall and winter cover crops

Lab testing of the digestate produced from brewery residuals – met Class A pathogen requirements so not necessary to compost before being land applied on farmland

Crop Growth Trials using the digestate from this micro digester is currently being conducted

Project Summary:

- **Discarded Brewery Residuals: 3.76 tons or 7,517 lbs. of spent yeast, sugar, grains, hops with minor amounts of restaurant residuals and fats, oils and grease**
- **Liquid Input: 543 gallons of liquids such as used beverage water and recirculated digestate to ensure macerated residuals could be pumped**
- **Energy Output: 971 BTUs per lb.**
- **Digestate Output for Land Application: 5 tons (10,044 lbs.)**

Final Study Monitoring and Lab Results:

- **Impact Bioenergy Final Report, 2017 (next page)**

HORSE, AD25 Narrative for On-Site Foodwaste Processing Demonstration Project Agreement #15-105-Z – April 30, 2017 (June 6 supplement)

HORSE (High-solids Organic-waste Recycling System with Electrical output), AD25 microdigester operations at Fremont Brewing Co. continued throughout the winter and spring after Performance Report #3, delivered on December 15, 2016. The following is a courtesy narrative with graphical representations of real performance data. Our official deliverable is the 4th Quarterly Report Form where the reporting period is 149 days long (December 1, 2016–April 28, 2017). This extended period makes up for an abbreviated first quarter (April 25, 2016–May 31, 2016), therefore completing a year-long demonstration period.

In the prior period, pH monitoring alone proved to be an insufficient performance indicator of process biology since it did not indicate a problem until it was too late to remediate. It was determined through the month of January that too much fats, oil and grease (FOG) caused an overload of organic compounds, in turn disturbing the system beyond remediation. In sustainable anaerobic digestion (AD) systems, a reinforcing feedback loop needs to exist between saprophytic and methanogenic bacteria. The former break down (hydrolyze) and convert organic compounds into volatile fatty acids (VFAs), which the latter convert into methane and carbon dioxide. In a well-functioning AD system, the methanogens convert VFAs as fast as the saprophytes reproduce them. During methanogenesis, large amounts of bicarbonate (a buffering substance) are released which stabilize pH to optimal ranges between 6.5 and 8. However, when disturbances to the microbial ecology persist due to organics overloading, the stock of bicarbonate is exhausted and there is a rapid drop in pH.

During the final period, given the addition of 1,547 lbs. of biomass (food and beverage “waste” residuals) over a feeding period of 149 days, approximately 3,251,736 BTUs of renewable natural gas (5,420 cubic feet) were generated. On average, each pound of wet biomass generated approximately 2,102 BTUs or 3.5 cubic feet of gas (14,013 BTU/dry lb. at 15% solids). This average is higher than previous periods due to the co-digestion of high-strength solid residuals coupled with enhanced process controls. *Figure 1*, below, reflects the cumulative mass input and energy output.

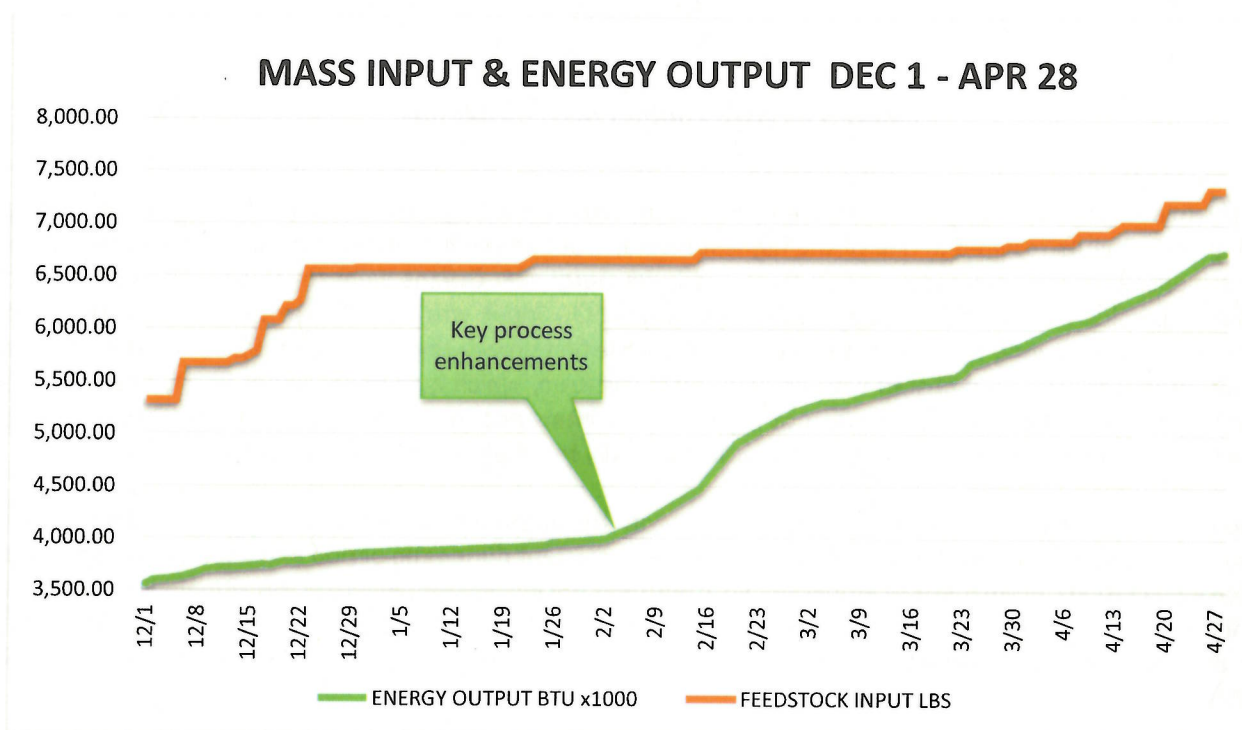


Figure 1 – Cumulative mass input and energy output.

Crucial lessons were assimilated in order to continually improve operational controls and digester performance. On February 7th, the HORSE bioreactor was reseeded with new biological material—fresh digestate from healthy digesters. The reseed process took less than one day. Then, in order to be proactive with process controls, instead of reactive, a state-of-the-art bicarbonate testing process was adopted to measure alkalinity. The acceleration of energy output during early February shown above in Figure 1, and below in Figure 2 – *Energy output in BTUs per day*, highlights the significance of alkalinity as a key performance indicator, measured in millimoles per liter (100 to 300 mmol/L is optimal) and milligram per liter as calcium carbonate (5,000 and 15,000 mg/L CaCO₃ is optimal). During sub-optimal conditions sodium bicarbonate was cycled through the bioreactor in order to increase its buffering capacity. Approximately 66 lbs. of sodium bicarbonate were consumed during the period.

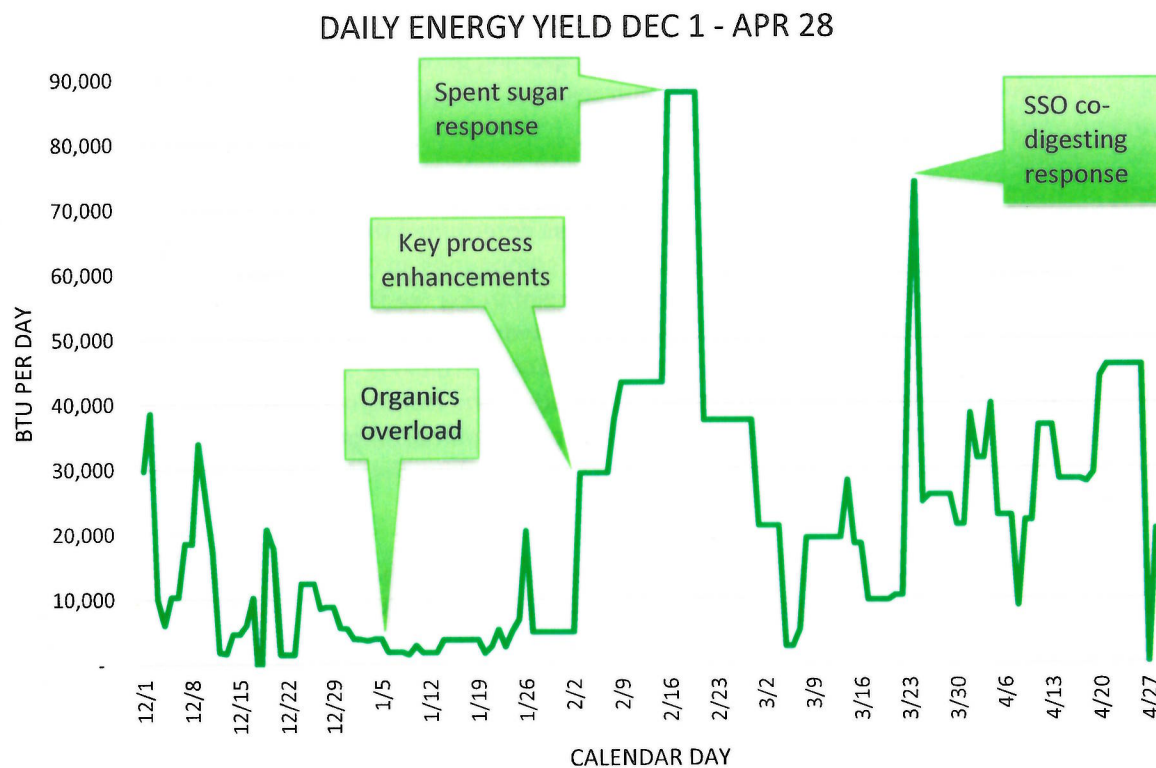


Figure 2 – Energy output in BTUs per day.

During the middle of February, given a renewed and healthy microbial ecosystem within the bioreactor, spent sugar from Mighty-O Donuts resulted in one of the highest intensity of energy output. During the middle of March, pre-consumer source separated organics (SSO) from Giddy-up Burgers & Greens were re-introduced. SSO primarily consisted of surplus fryer foods and vegetable trimmings—FOG input was limited due to lessons learned from organics overloading. During the end of March and April, for the first time during the project, SSO from the restaurant and donut producer were co-digested with brewery residuals (trub, which is primarily spent yeast, heavy fats and coagulated proteins). The diversified feedstock regime is advantageous since a balanced diet mitigates the risk of overloading on a single type of substrate, such as acidic brewery residuals or high strength FOG.

Once again, all liquid handling was completely enclosed with the exception of the few minutes of mass transfer and receiving tank input during each feeding. Fruit flies were non-existent during the period and odor control once again exceeded expectations. From mid-December to mid-April, heat tracing was employed on the effluent line feeding the external tote in order to prevent it from freezing. Approximately 226 gallons of digestate were discharged from the HORSE and stored in intermediate bulk containers for beneficial use during the growing season. No wastewater was generated.

The HORSE digestate was not pasteurized before being tested for fertility and for public health quality requirements per Title 40 CFR 503.13. *Table 1 – UNIBEST lab results on bioavailable primary macronutrients in digestate, and Table 2 – Unibest lab results on bioavailable secondary macronutrients and micronutrients in digestate.* As expected, on a wet basis the macronutrients were lower than the prior reporting period levels (52 – 166 ppm vs. 80 – 318 ppm) due to digester reseedling. Total Solids measured 2.15% therefore, on a dry basis, the macronutrients are estimated to be 0.3-0.0-0.5 as percentage N-P-K, down from 6.4-1.6-3.4 in prior periods. Lab results are in ppm, extracted with 50ml 2M HCl. Sodium content of 365 ppm is a result of additional sodium bicarbonate consumption for greater alkalinity.

Sample Location	#	Depth	Total N	NO3-N	NH4-N	P	K
Fremont Brewing	#5		71.74	0.00	71.74	3.66	98.06
as received							
as reported							
correction to dry basis			0.3%	0.0%	0.3%	0.0%	0.5%
total solids	0.0215						

Table 1 – Unibest lab results on bioavailable primary macronutrients in digestate.

Sample Location	Al	B	Ca	Cu	Fe	Mg	Mn	Na	S	Zn
Fremont Brewing	0.66	0.03	38.14	0.05	2.05	46.49	0.04	364.60	3.93	0.01
as received										
as reported										
correction to dry basis	0.0%	0.0%	0.2%	0.0%	0.0%	0.2%	0.0%	1.7%	0.0%	0.0%
total solids	0.0215									

Table 2 – Unibest lab results on bioavailable secondary macronutrients and micronutrients in digestate.

pH and conductivity were 7.88 and 15.1 mS/cm respectively. Per *Table 3 – AM Test & Fremont Analytical lab results on public health qualities* and *Figure 3 – Percentage metals allowable per Title 40 CFR 503.13*, total metals were between zero and 36% of limits set forth in Title 40 CFR 503.13. Salmonella tests were Negative per method TMECC 0702.

Salmonella	MPN/4 g	NEGATIVE
conductivity	mS/cm	15.1
pH		7.88
Hg	ug/l	0.00077
AS	mg/l	0.317
Cd	mg/l	0.00602
Cu	mg/l	1.66
Pb	mg/l	0.0991
Mo	mg/l	0.0467
Ni	mg/l	0.0952
Se	mg/l	0.0167
Zn	mg/l	3.58

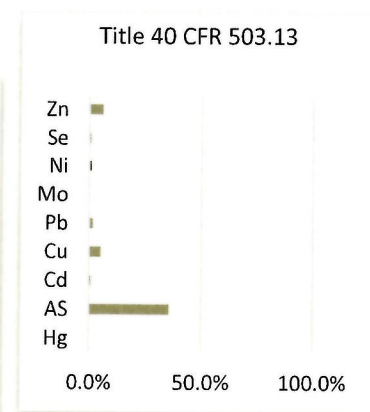


Table 3 – Am Test & Fremont Analytical lab results on public health qualities.

Figure 3 – Percentage metals allowable per Title 40 CFR 503.13

According to the revised National Organic Program (NOP) Standard, products of AD processes are considered as generic material that is allowed without restriction and are classified as Crop Fertilizers and Soil Amendments that are acceptable if made from allowed, non-manure feedstock materials. Randomized, replicated commercial growth trials continue at Seattle Tilth’s Red Barn Ranch and Seattle Urban Farm Company’s “urban fringe farm,” which has transitioned in ownership to Ecolibrium Farms. Retail channels for *Brew Dew: Probiotic Plant Food & Soil Booster* include Walt’s Organic Fertilizer Co. and direct trade. Milk run deliveries of *Brew Dew* to Seattle Urban Farm Co, Ballard, via carbon-negative cargo vehicle, have begun this growing season.