Micro Turbines are Generating Power at the Plymouth Utilities 1.8 MGD Wastewater Treatment Plant

Mike Penkwitz, Wastewater Superintendent

March 22, 2016

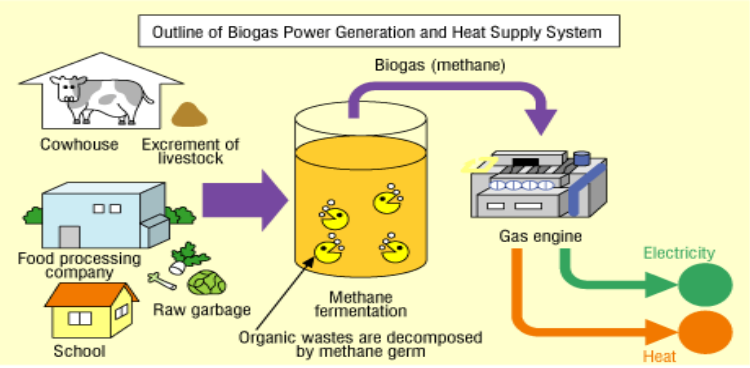
Spring Biosolids Symposium

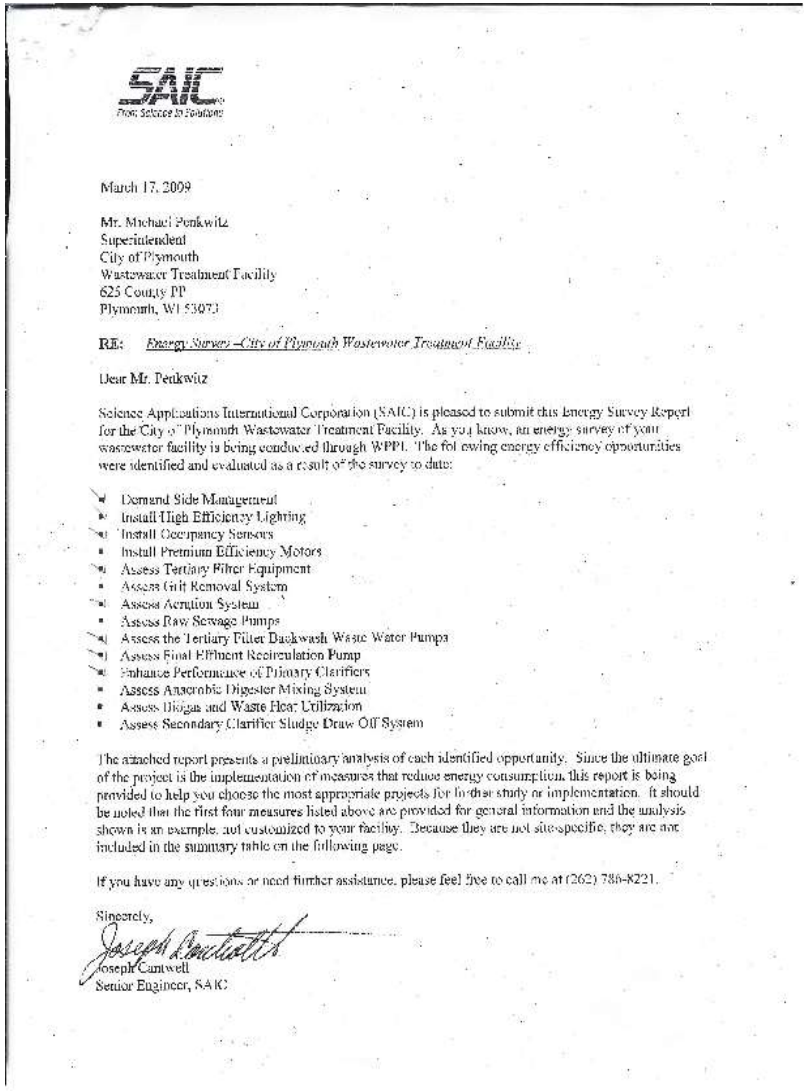
December 5, 2014

Two Capstone 65 Kw Micro Turbines Started Generating Power

What Prompted the Idea of Generating Power?

- Answer – ***A WPPI Energy Audit***
  - Lighting
    - LED's, occupancy sensors
  - Pumping Equipment
    - Final effluent pump
    - Filter backwash waste pumps
  - Aeration System - 2012
    - Added a VFD
    - Upgraded fine bubble system
  - Anaerobic Digestion System
    - **Added a linear mixer**
      - Methane gas production increased
  - Biogas Project
    - Generate power
    - Generate heat





SAIC
From Science to Solutions

March 17, 2009

Mr. Michael Penkwitz
Superintendent
City of Plymouth
Wastewater Treatment Facility
625 County PP
Plymouth, WI 53073

RE: *Energy Survey –City of Plymouth Wastewater Treatment Facility*

Dear Mr. Penkwitz

Science Applications International Corporation (SAIC) is pleased to submit this Energy Survey Report for the City of Plymouth Wastewater Treatment Facility. As you know, an energy survey of your wastewater facility is being conducted through WPPI. The following energy efficiency opportunities were identified and evaluated as a result of the survey to date:

- Demand Side Management
- Install High Efficiency Lighting
- Install Occupancy Sensors
- Install Premium Efficiency Motors
- Assess Tertiary Filter Equipment
- Assess Grit Removal System
- Assess Aeration System
- Assess Raw Sewage Pumps
- Assess the Tertiary Filter Backwash Waste Water Pumps
- Assess Final Effluent Recirculation Pump
- Enhance Performance of Primary Clarifiers
- Assess Anaerobic Digester Mixing System
- Assess Biogas and Waste Heat Utilization
- Assess Secondary Clarifier Sludge Draw Off System

The attached report presents a preliminary analysis of each identified opportunity. Since the ultimate goal of the project is the implementation of measures that reduce energy consumption, this report is being provided to help you choose the most appropriate projects for further study or implementation. It should be noted that the first four measures listed above are provided for general information and the analysis shown is an example, not customized to your facility. Because they are not site-specific, they are not included in the summary table on the following page.

If you have any questions or need further assistance, please feel free to call me at (262) 786-8221.

Sincerely,

Joseph Cantwell
Senior Engineer, SAIC

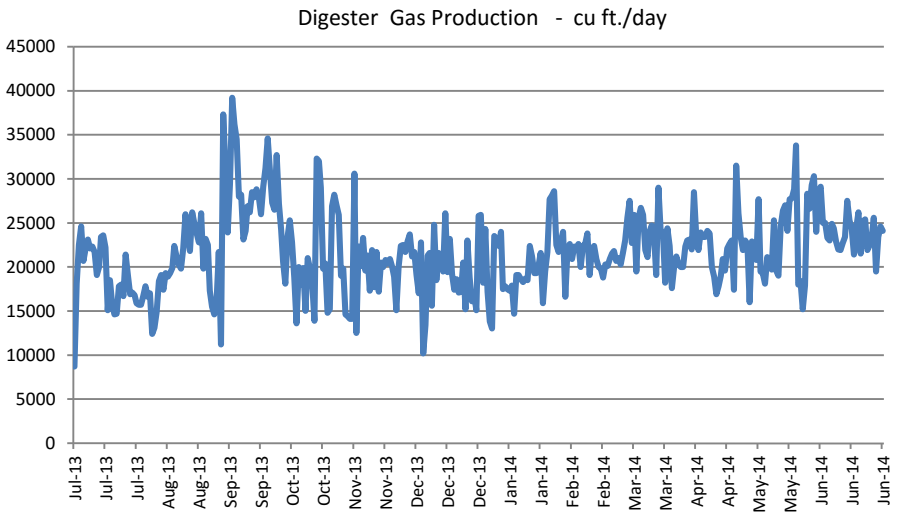
Focus On Energy Grant

- Biogas Grant Available Jan 2013
- Application Due Feb 2013
  - Three week window to apply
- Applied
  - $700,000 projected cost
    - Installation and equipment
- Application Accepted Apr 2013
  - $285,000 Focus on Energy Grant
  - $25,000 WPPI Grant
  - $310,000 Total Grant
- Council Approval Apr 2013

Without the Focus on Energy Grant we would not have gone forward with the project

The Planning Process

- September 2013
  - Trucked in HSW
  - Gas production doubled
    - Unmixed/unheated secondary digester
  - HSW needed and gas production potential
- Visited/contacted existing installations
- Had inlet gas analyzed
  - Used to design the system
    - H2S
      - Ferric chloride
    - Siloxanes
- Selected turbines over an engine
- Selected two turbines
  - The skid could run two
  - Faster payback
- Looked at our layout and put the system on paper
  - The manufacturer made several site visits
  - We were able to utilize existing rooms
    - No building expansion required
    - Turbines outside
    - Compression skid, oil cooler and chiller
- Consulted haulers
    - Access for trucks
    - Gate and driveway
    - Unloading
- No Storage Tank
  - Struggled with where to locate it
  - Address it at a later date
- Heat Recovery
  - Added a heat recovery loop to the existing heat exchanger
- Engineering firm
  - Hired a firm that had experience designing these systems
  - We felt we had to bid the project out



Increased gas production from HSW and linear mixer

Construction

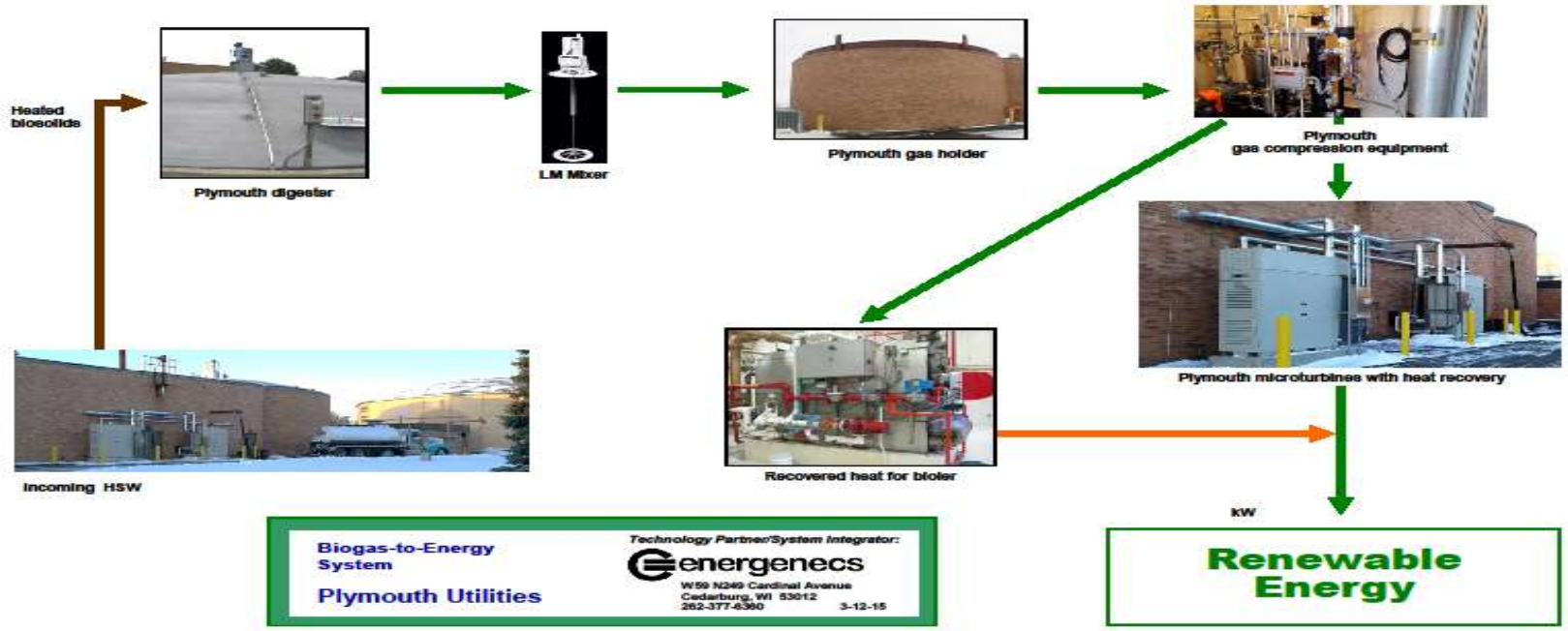
Accepted bids / selected a contractor

Construction September 2014

Equipment arrived August 2014

Startup December 2014

Few problems



The System Layout

- No Bricks and Mortar
  - Utilized existing space
    - Chiller – outside
    - Skid – in two rooms
      - Digester room
      - Compressor room
    - Oil cooler – outside
    - Turbines outside

Start Up

- Went well
- A few days of programming and testing

Equipment Reliability Thus Far

- Chiller
  - Control module for fan
- Skid
  - Condensate valves
  - Heat exchanger
  - Motor on oil cooler
- Turbines
  - Replaced a control board

- One year warranty, parts and labor
  - Covered the above
- Extended warranty
  - Did not purchase
  - Capstone 65 track record
  - Not available on the skid

$53,000 Titanium Engine - 40,000 hours

Initial Operations

- It would come down to me
- Find HSW
  - 7 year contract with a local business
  - Called or visited HSW sources in surrounding area
  - No shortage of HSW in our area
  - Availability
    - Tried 13 sources the first year
    - BOD range - 4000 mg/L to 138,000 mg/L
      - » Grease traps
      - » Cheese process waste
      - » Spoiled milk
      - » Current feed stock 50,000 to 60,000 mg/L

Initial Operations

- No storage tank
  - Used sludge pumps
  - 20 to 30 minutes

Initial Operations

- Added gas meter - $15,000
  - Aids in media changes

Initial Operations

- Added a self priming pump - $27,000
  - Dictated the location for a storage tank
  - Stainless steel
  - Clogging
    - Vac trucks
    - Changed impeller
  - Draw from the trucks
    - Up to 800 gpm
    - Empty in 5-10 minutes

Initial Operations

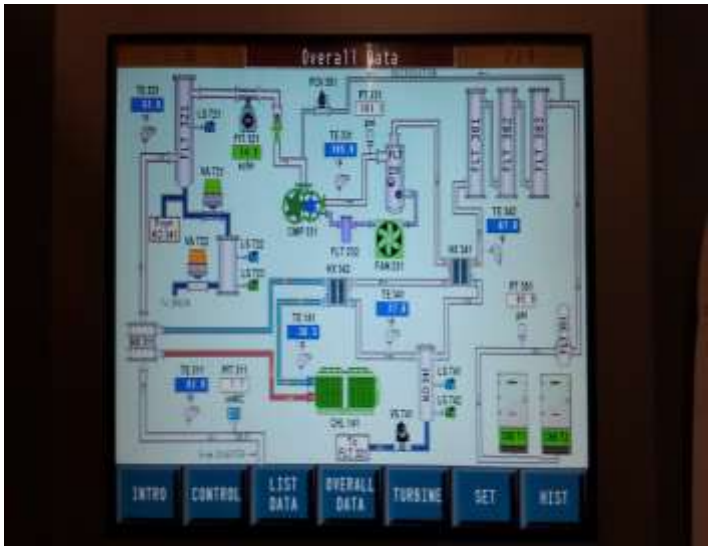
- Added a HSW feed line
  - Directly from truck to primary digester

Initial Operations

- Intake Area
  - On/Off Switch
    - Remote
    - Illuminated
  - Piping
    - Insulated
    - Heat tape
  - Exterior lighting
  - Truck log mail box
  - Fittings
    - 6 X 4
  - Hoses
    - Four inch
  - Waste container

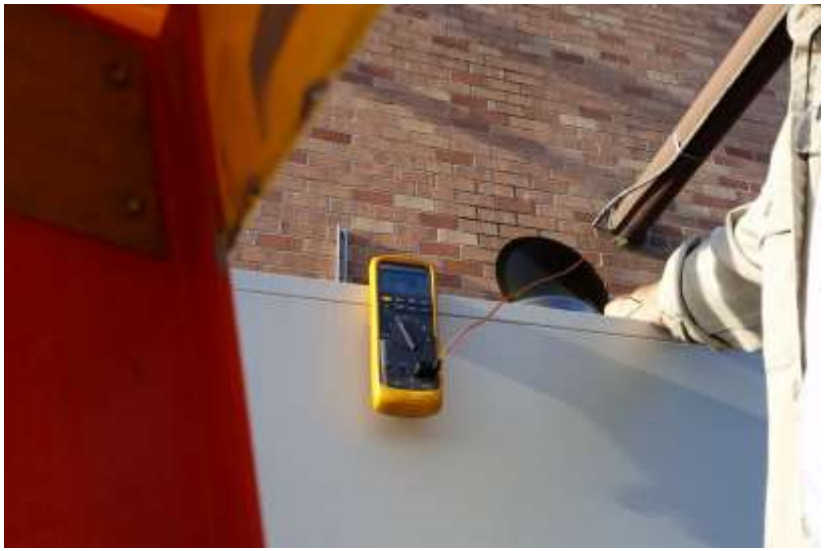
Initial Operations

- Added net metering
- VPN Line
  - Remote access to field techs
  - Been very useful



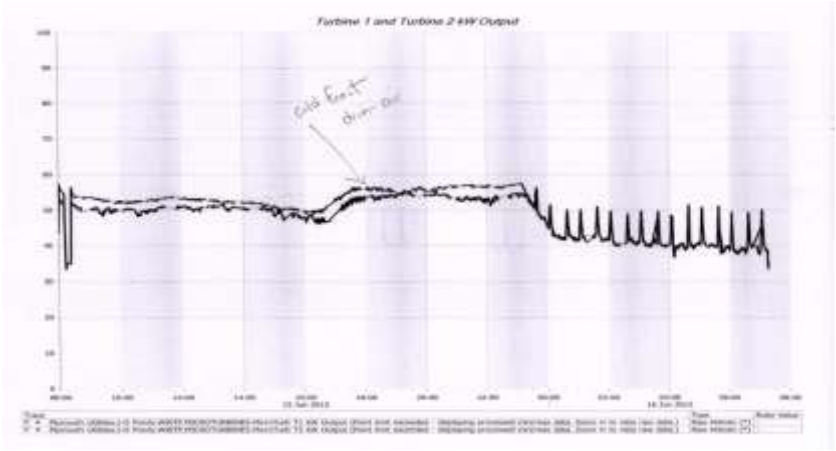
Theory of Operation

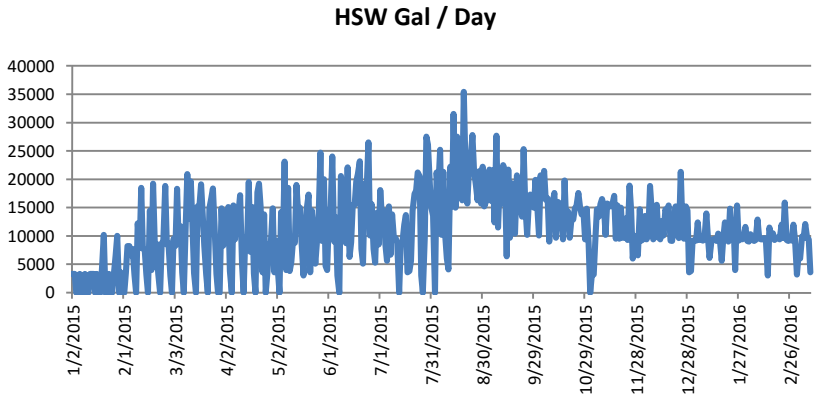
- Anaerobically digest the waste
  - Add HSW
  - Produces methane gas
- Start the power system
  - Chiller
    - Cools methane gas to 37F
  - Cleaning / compression skid
    - Takes the moisture out of the gas
    - Compresses the gas
    - Filters out H2S and siloxanes
      - Siloxanes harmful to turbines
    - Sends the gas to the turbines
    - Maintains an inlet pressure to turbines
  - Turbine
    - Comes up to speed (9600 rpm)
    - Tries to maintain 900 F
    - Lead/lag
    - Generate excess heat
      - Captured in water and looped through the heat exchanger
      - Heats the anaerobic digester
      - Exhaust 450 F
      - Water temperature up to 165 F



What We Have Learned

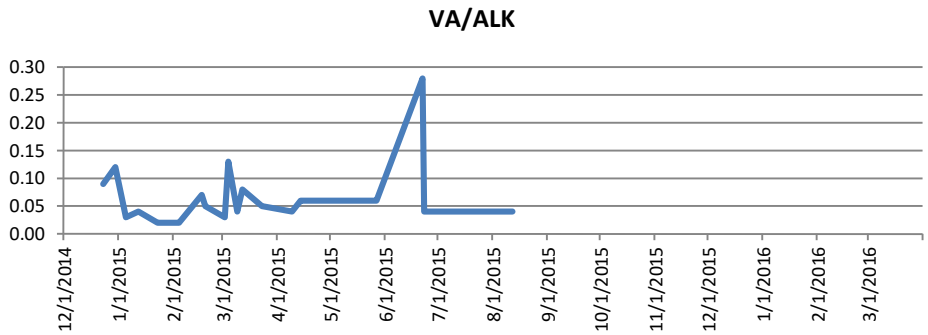
- The good and the bad –
  - depends on how you look at it
- Downtime
  - 35 days the first year
  - None Since Nov 3
- Service has been great
- Cooperation/communication with haulers good
- Ambient temperature
  - Turbines like cold temperatures
  - <70 F no matter what you feed them
  - Stops and starts reduce engine life
- Biogas make up
  - Pre Project Methane was 60%
  - Now Methane 29 – 53%
    - Slug loads HSW
      - Instant gas production
      - Composition of HSW
      - Less HSW has helped
  - Affects turbine output
    - Try to maintain the 900 F
    - Asking for more gas
    - inlet pressure drops
    - Flame out
    - Decreases output
    - Less HSW has helped
- HSW needed
  - 10,000 gpd
  - Was putting in 20,000+
  - Morning load/evening load





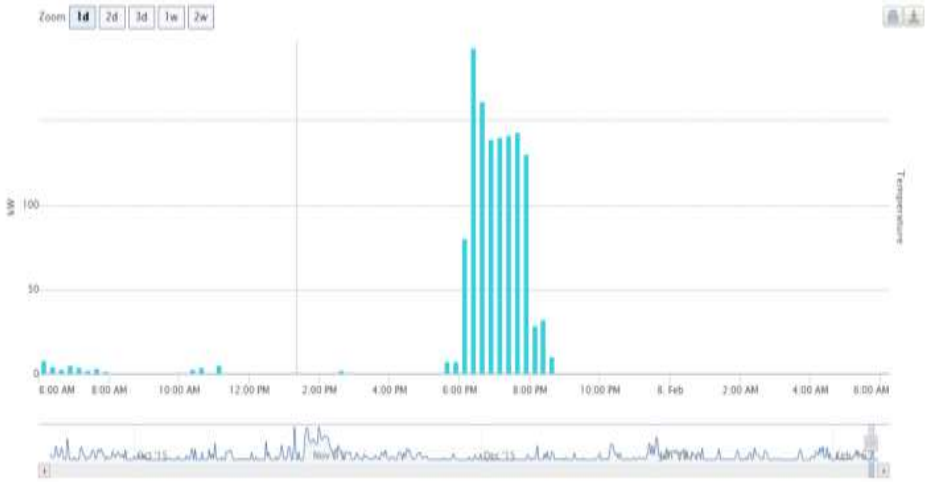
What We Have Learned

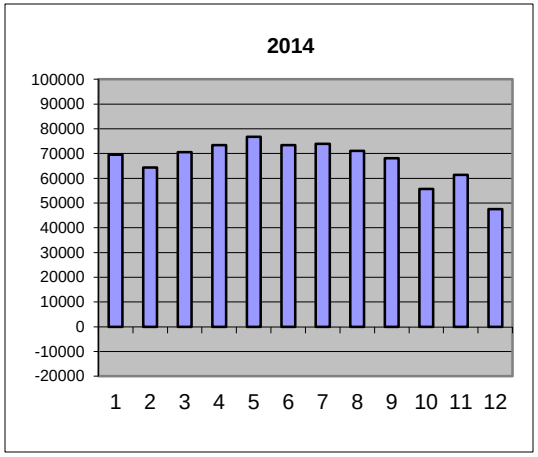
- VA/ALK
  - Has not changed
- pH
  - Has not changed
- Digester temperature
  - Has not changed
- Heat recovery
  - Heat exchanger does not run
- TS has increased in primary digester
  - 1.0 % to 2%
  - Sludge characteristics
- Sludge production becoming a problem
  - Volume increasing
  - Won't settle
  - Sludge hauling
  - Warmer temps/gas production

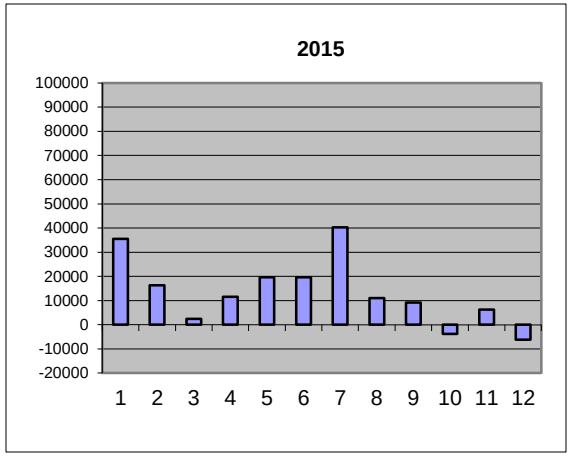


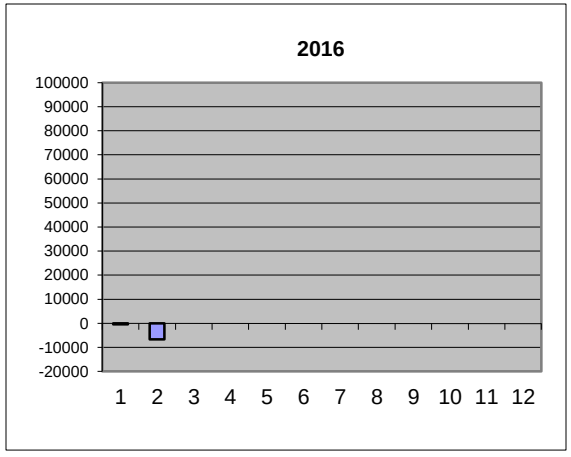
What We Have Learned

- Power Use
  - 2014 819,840 kW
  - 2015 233,280 kW
- Percent Decrease 72%
  - Still must manage the demand side
  - Turbines down=demand charges up
  - Still in learning curve
  - Eight days without the meter spinning



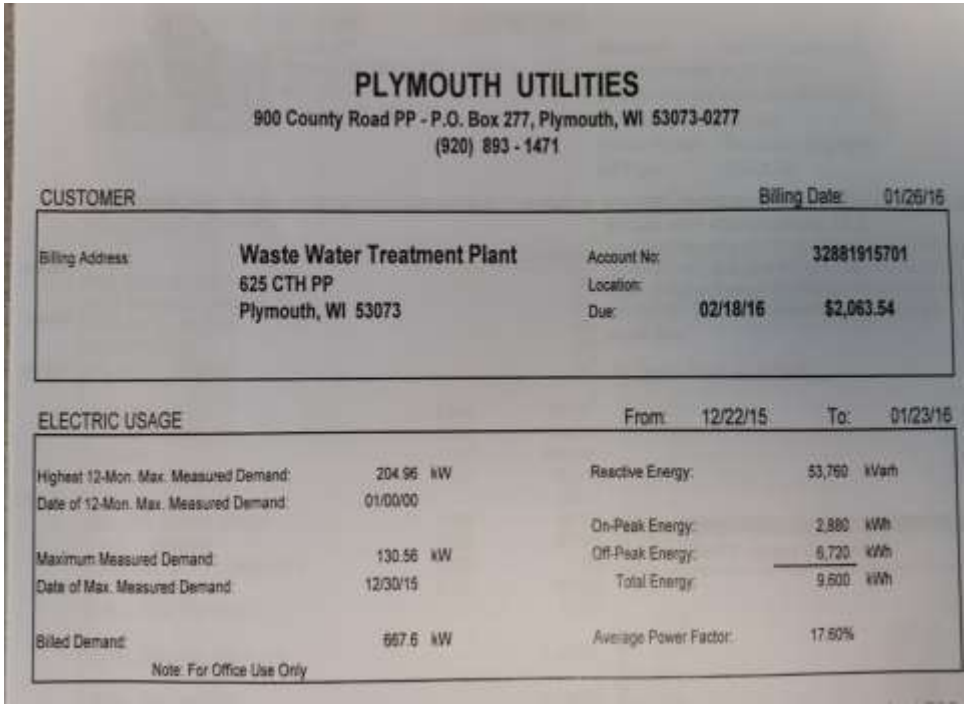






What We Have Learned

- Power Cost
  - 2014 $75,733
  - 2015 $32,445
- Percent Decrease 57%
  - 72% to 57%?
  - Charges
    - Yearly peak
    - Monthly peak
    - Customer charges
    - Energy charges
      - CP2 to CP1
      - Lower rates
    - Heat exchanger
      - Tubes
      - Cleaning
      - Pressure regulators



PLYMOUTH UTILITIES
900 County Road PP - P.O. Box 277, Plymouth, WI 53073-0277
(920) 893 - 1471

CUSTOMER Billing Date: 01/26/16

Billing Address: Waste Water Treatment Plant
625 CTH PP
Plymouth, WI 53073

Account No: 32881915701
Location:
Due: 02/18/16 $2,063.54

ELECTRIC USAGE From: 12/22/15 To: 01/23/16

Highest 12-Mon. Max. Measured Demand:	204.96 kW	Reactive Energy:	53,760	kVarh
Date of 12-Mon. Max. Measured Demand:	01/00/00			
		On-Peak Energy:	2,880	kWh
Maximum Measured Demand:	130.56 kW	Off-Peak Energy:	6,720	kWh
Date of Max. Measured Demand:	12/30/15	Total Energy:	9,600	kWh
Billed Demand:	667.6 kW	Average Power Factor:	17.60%	

Note: For Office Use Only

Our Maintenance Program

- Chiller
  - Added inlet filters - dandelions
  - Coils
- Skid
  - Oil cooler
    - Coils
  - Gas compressor
    - filter
      - 4 times per year - $5 each
  - Media
    - 3-4 times per year - $2100 each
    - Working out a formula
- Turbines
  - Air filters
    - electronics
    - engines
      - Dust
      - Sludge truck
      - Three times per year - $300 each

Total $10,000

- Annual
  - Recommended
  - Change oil
  - Check turbines
  - A Contract service for all above

Suggestions

- Know your local utility bill
- Planning
  - complete equipment & construction cost estimate
    - Turbine's life cycle
  - How much HSW is available
  - Enough digester volume
  - Inlet gas
    - multiple samples
  - Look at your layout
    - Utilize existing space
  - Truck access
    - Consult haulers
  - Storage tank
    - Grit removal / screen
  - Gas meter
  - VPN
  - Local service for chiller
  - Stainless steel piping
  - Visit other sites/operators
  - Heat recovery layout
  - Get support from elected officials
- Watch for Grants
- Construction
  - Label conduit and piping

Suggestions

- Start up
  - Understand the HMI
  - Understand isolating the system
  - Understand gas pressure
- Operations
  - Feed waste over a 24 hour period
- Maintenance
  - Create a maintenance schedule
- Sludge disposal
  - More land may be required
  - Storage

THANK YOU!!!