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

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Spring Biosolids Symposium
Two Capstone 65 Kw Micro Turbines Started Generating Power

December 5, 2014
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
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

[Graph of Digester Gas Production - cu ft./day]

[Image of 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
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

Total $10,000
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!!!