DIGESTER GAS ENERGY RECOVERY ALTERNATIVES

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URS

Presentation Overview

- Digester Gas Production and Characterization
- Gas Production Rates at JPWWTP & SWWTP
- Project-Specific Goals at JPWWTP & SWWTP
- Digester Gas Cleaning & Energy Recovery Alternatives

Digester Gas Production

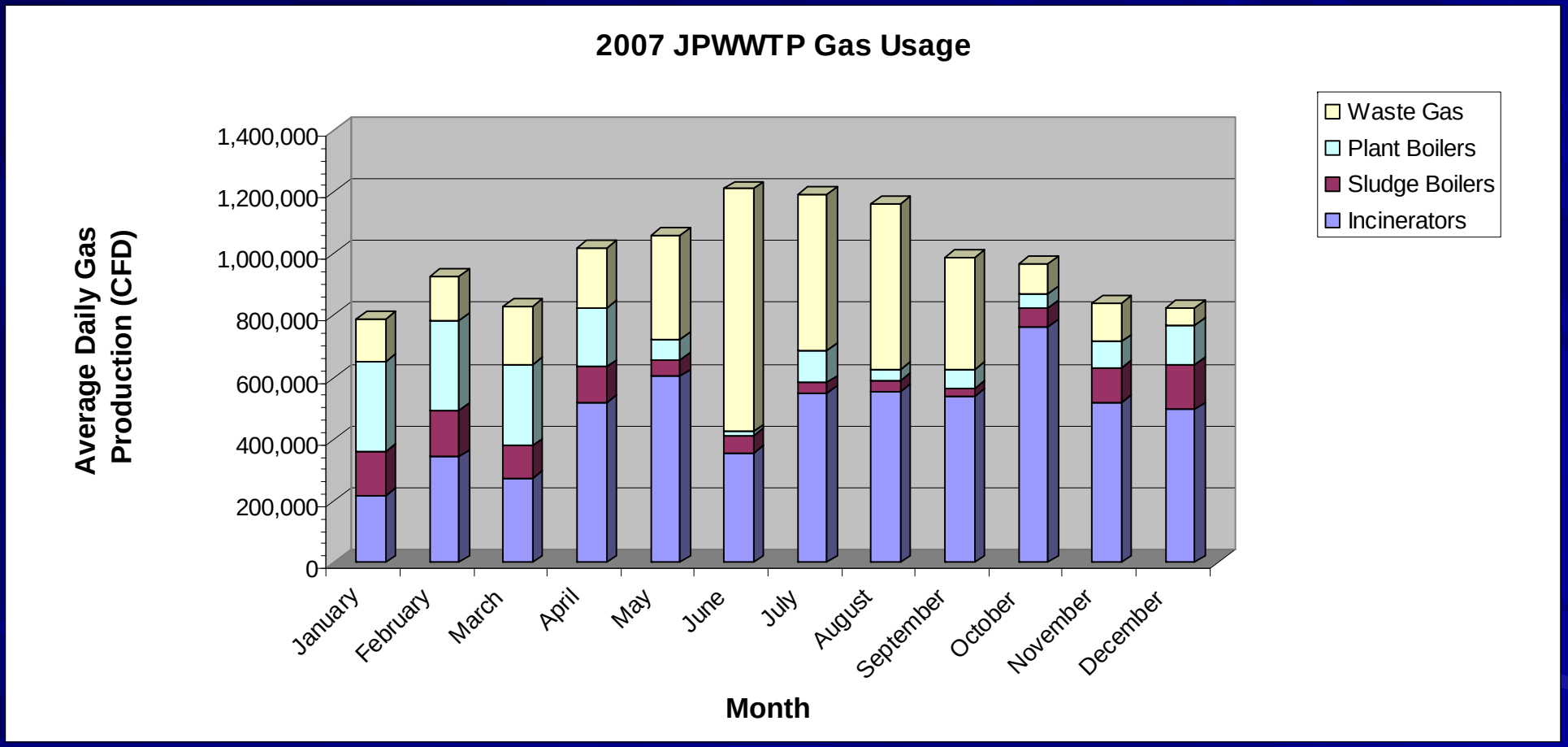
- Anaerobic digestion: 50 to 65% of VSS destroyed

SRT (days)	% Reduced
30	65.5
20	60
15	56
10	50

- 12 to 18 ft^3 digester gas produced per pound of VSS destroyed
- Rule of thumb: 9,000 to 12,000 ft^3 per day of digester gas per million gallons of plant capacity

JPWWTP Digester Gas Production

- Avg. Gas Production & Usage (Jan ‘07 – Dec ‘07)



Total Gas: Monthly average range of 800,000 to 1,200,000 CFD

“Waste Gas” Monthly average range of 57,000 to 790,000 CFD

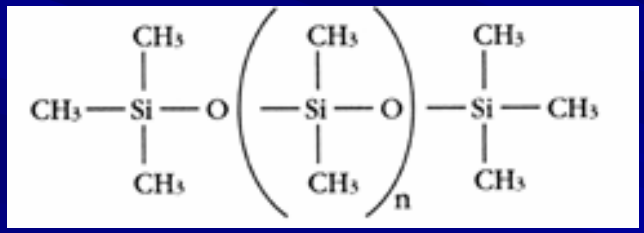
SWWTP Digester Gas Production

- At time of study, there was no anaerobic digestion at Southerly
  - S66 improvements incorporate two-stage acid-phase digestion
- Estimated average gas production & usage:

Gas Usage	Gas Flow Rate (CFD)	Gas Flow Rate (CFM)
Boilers	509,000	353
Incinerators	158,000	109
“Waste” Gas	380,000	264
Total	1,046,000	726

Digester Gas Composition

- Methane, CH_4 (55 to 70%)
- Carbon Dioxide, CO_2 (30 to 45%)
- Trace Amounts of the following:
  - Hydrogen Sulfide H_2S
  - Siloxanes,



- Heating value of 530 to 675 BTU / ft^3

Digester Gas Trace Constituents

- Hydrogen Sulfide
  - Up to 10,000 ppm H_2S (typically 40 to 1,000 ppm)
  - Combustion in presence of water vapor results in H_2SO_4
  - “Pipeline quality” requires < 4 ppm H_2S
- Siloxanes
  - By-product of cosmetics and toiletries
  - Typically 2 to 4 ppm siloxanes
  - Damage to equipment can occur at levels approaching 50 ppb

Digester Gas Cleaning Technologies

Hydrogen Sulfide Removal

- Sorption techniques
  - Activated Carbon, Iron Sponge
- Chemical addition
  - Iron Salts (Ferric chloride)
- Scrubbing with liquid media

  Packaged Systems

Sorption media columns

Liquid Scrubbers

Siloxane Removal

- Sorption Systems
  - Siloxane-specific media
- Liquid Scrubbing
- Condensation
- Packaged Systems

Carbon Dioxide Removal

- Generally not harmful for engine operation
- “Pipeline Gas” requires 2% maximum CO_2
- Removed with:
  - Liquid scrubbers
  - Membrane separation technologies
- Packaged Systems available

Cleaning System Costs

- Hydrogen Sulfide
  - Cleaning system: ~ $100,000 per 100 CFM
  - Operation ~ $7,000 per year per 100 CFM
- Siloxanes
  - Cleaning system ~ $190,000 per 100 CFM
  - Operation ~ $15,000 per year per 100 CFM
- Carbon Dioxide / Nitrogen Removal
  - Cleaning System: ~ $220,000 per 100 CFM
  - Operation: ~ $30,000 per 100 CFM

Levels of Treatment

Pipeline Quality Gas

Treatment A

Carbon dioxide (< 2%)

Water Vapor (< 7 lb/MMSCF)

Hydrogen Sulfide (< 4 ppm)

Siloxanes (< 30 ppb)

~ 98% Methane
Trace inert gases

On-Site Energy Generation

Treatment B

Hydrogen Sulfide (< 10 ppm)

Siloxanes (< 50 ppb)

~ 55 to 65% Methane
~ 35 to 45% Carbon Dioxide
Reduced Constituents Other
Inert Gases

Alternatives - Cogeneration

- Typical electrical efficiency: 28 to 33% efficient
- Per 1 MGD of plant capacity*:
  - 500 to 600 kWh per day generated
  - $15,000 + per year in electricity savings
- Typical thermal efficiency: 45 to 60% efficient
- Per 1 MGD of plant capacity*
  - 3 to 3.5 MMBTU per day in recoverable heat
  - $7,000 + per year in natural gas savings

* Assuming no other usage of digester gas

Possible Implementation of Electricity Generating Engine at JPWWTP & SWWTP

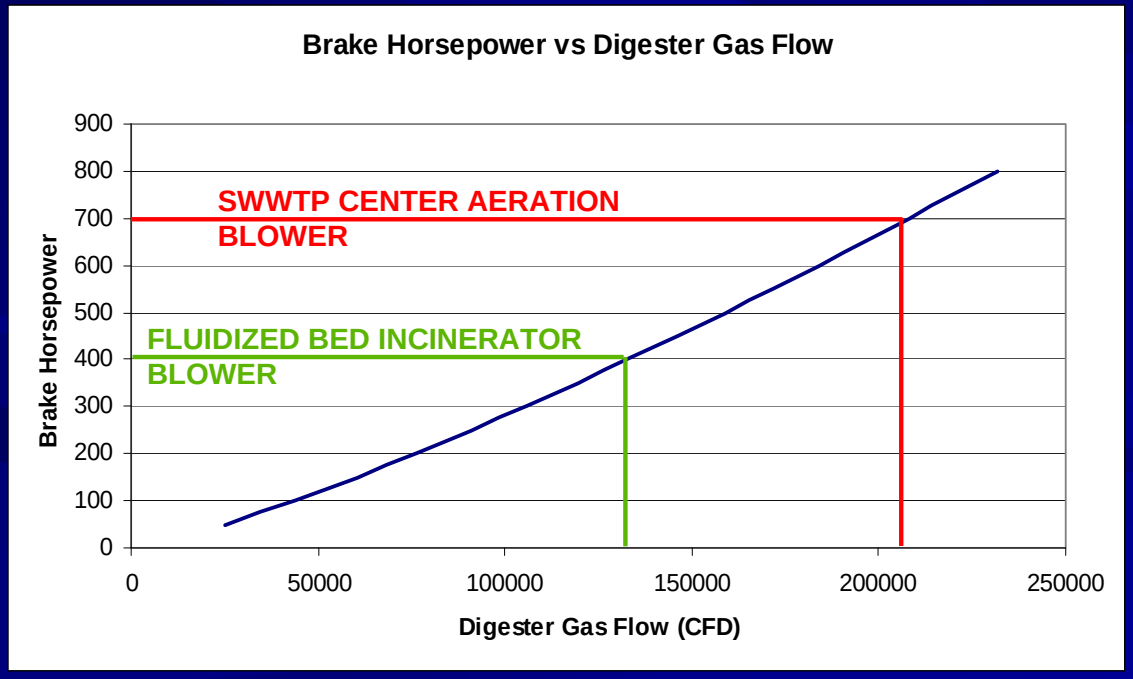
Plant	Average Gas Flow	Engine Size	kWh per Month Generated	Plant Monthly Power Usage	Percent of Plant Power Usage
Jackson Pike	240,000 CFD	570 kW	411,000 kWh	4.51 MM kWh	9%
Southerly	380,000 CFD	900 kW	651,000 kWh	5.03 MM kWh	13%

- JPWWTP: $390,000 per year in electrical savings
- SWWTP: $625,000 per year in electrical savings

- GE Jenbacher Engine
  - Approx $100,000 per 100 kW

Possible Implementation of Direct Drive Engine at JPWWTP & SWWTP

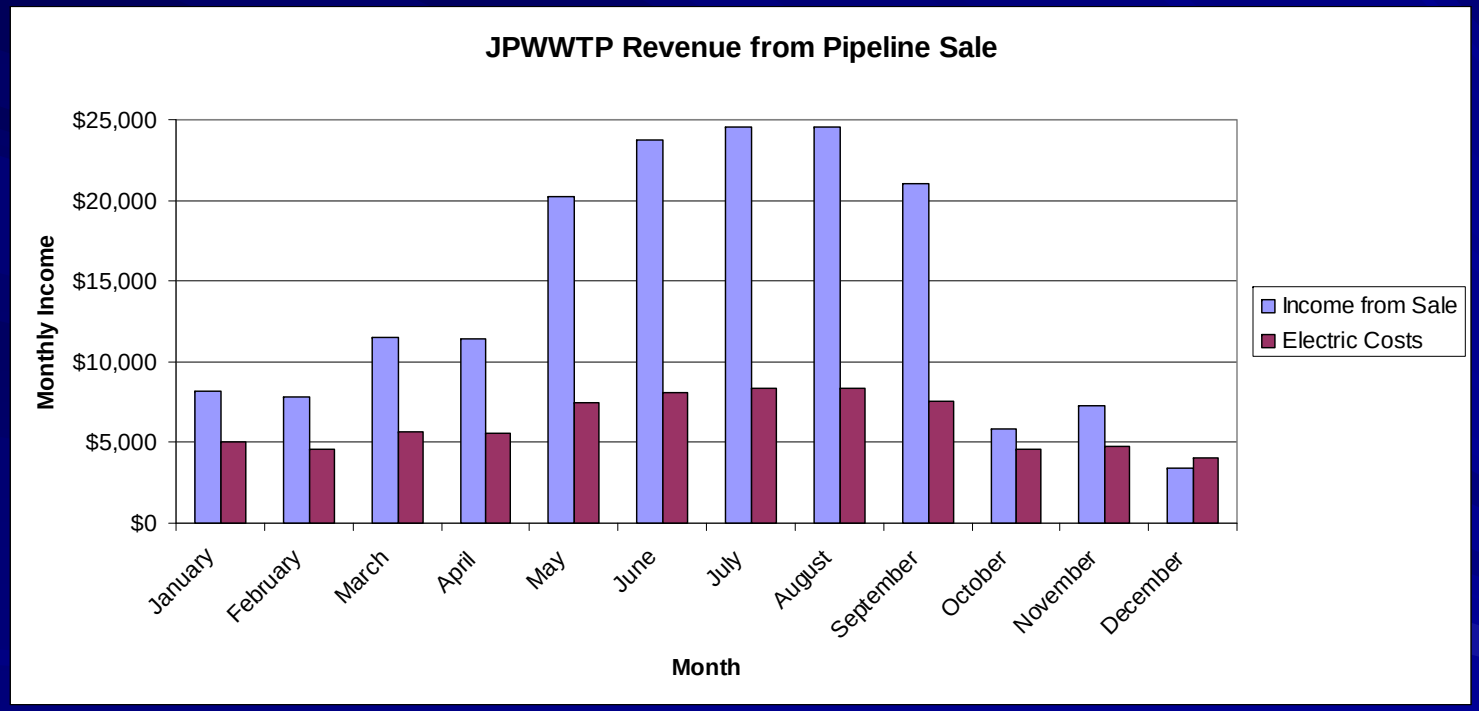
- JPWWTP: Operation of 400 HP fluidized bed incinerator blower
  - Electrical savings of ~ $210,000 / year
- SWWTP: Operation of 700 HP center aeration blower
  - Electrical savings of ~ $365,000 / year



- Cost of approximately $30,000 per 100 HP capacity

Alternatives – Clean Natural Gas Sale

- Option 1: Public / Private Partnership
  - Gas cleaning system ($1.5 million) provided by private company
  - City pays electrical costs
  - City and private company split revenue of gas sale



- JPWWTP (2007 data) net revenue of $95,000
  - $170,000 in gas sale (after 50 / 50 split)
  - $75,000 in annual electric cost

Alternatives – Clean Natural Gas Sale

- Option 2: Gas cleaning system owned by City
- JPWWTP (2007 data) net revenue of $125,000
  - $340,000 in gas sale
  - $75,000 in annual electric cost
  - $115,000 in amortized annual payment
  - $25,000 in miscellaneous operation and maintenance

Alternatives – CNG Vehicles

- Installation at SWACO (Green Energy Center)
  - Phase 1 ($4.5 Million) can process 430,000 CFD landfill gas
  - Cleaning system and microturbine in pre-engineered metal building
  - Compressor and storage (3,000 and 3,600 psi tanks) located outside
  - Filling stations

CNG storage tanks

CNG filling station

Compressor

Facility Building

Alternatives – CNG Vehicles

- Cost analysis for implementation at SWWTP, based on:
  - Sell gas not used for CNG to pipeline at $7.00 per MMBTU
  - Capital cost of $4,000,000 amortized at 4.5% interest
  - Electrical costs of 8 cents per kWh
  - Additional O&M expense of $25,000 per year
  - CNG demand of 100 GGE per day
- CNG cost of approximately $1.60 per GGE for “break even”

Summary and Conclusions

- Electrical and thermal energy savings
  - Electrical: $15,000 + per year per MGD of plant capacity
  - Heating: $7,000 + per year per MGD of plant capacity
- Electrical and thermal recovery system costs
  - Return on investments ~ 3 to 7 years
- Clean natural gas and CNG
  - Public / private partnerships or facility-owned
  - Not profitable for smaller plants
- Varying energy costs can have substantial impact on the return on investment

Questions