Optimizing the Value of Biogas at Municipal and Industrial Wastewater Facilities

PRINCETON ENERGY SYSTEMS

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August 8, 2007

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Useful Energy from Biogas

Common Excuses

- Not enough biogas
- Cost too much
- Already using boilers
- Too complicated

Presentation Overview

Site Specific Conditions

- Technology Options
- Case Study Project Factors
  - Biogas Production Rate
  - Plant Energy Profiles
  - Financial Incentives
  - Utility Rate Structures and Costs
- Gas Treatment Requirements

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Selected Case Studies

Biogas source	State	Average cf/day	Solution
Industrial Food Waste	CA	350,000	Fuel Cell
Municipal Sewage Waste	PA	1.4×10^6	Pipeline Gas
Industrial Food Waste	NH	60,000	Engine

What Can Your Plant Use?

Biogas Energy Products

- Electricity
- Hot Water or Steam
- Thermal Chilling
- Direct Mechanical Drive
- Methane
- Carbon Dioxide

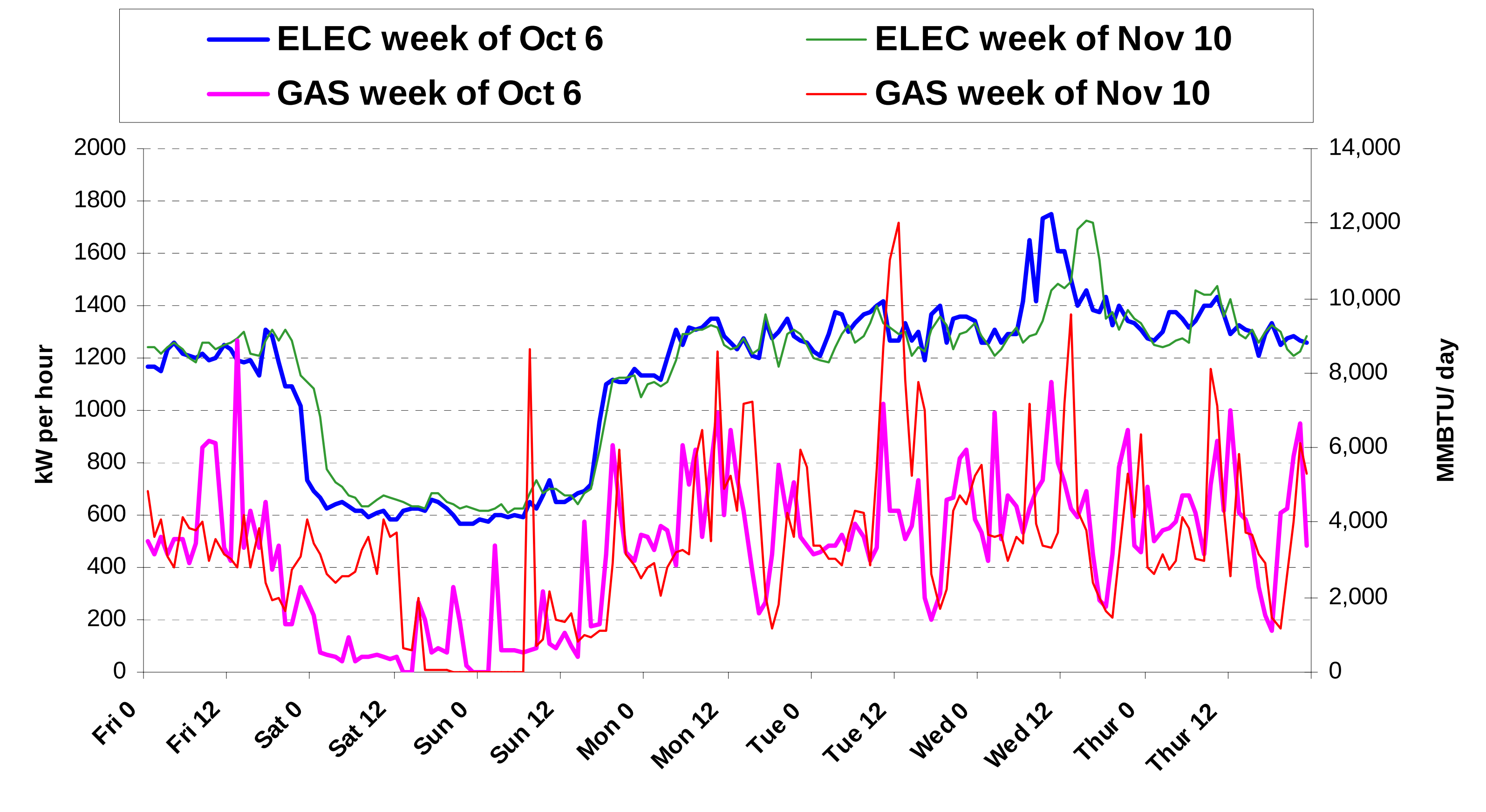
Which Technologies Fit Your Plant?

Technology	Smallest size (kW)	Minimum Biogas Required (cf/day)
Combined cycle turbines	1000	>500,000
Gas turbine	1000	500,000
MC Fuel Cell	300	95,000
PA Fuel Cell	200	81,000
Pressure Swing Absorption	n/a	72,000
Steam turbine	100	57,000
Gas Engines	87	40,000
Boiler	150 (0.5 MMBTU/hr)	26,000
Microturbine	30	16,000

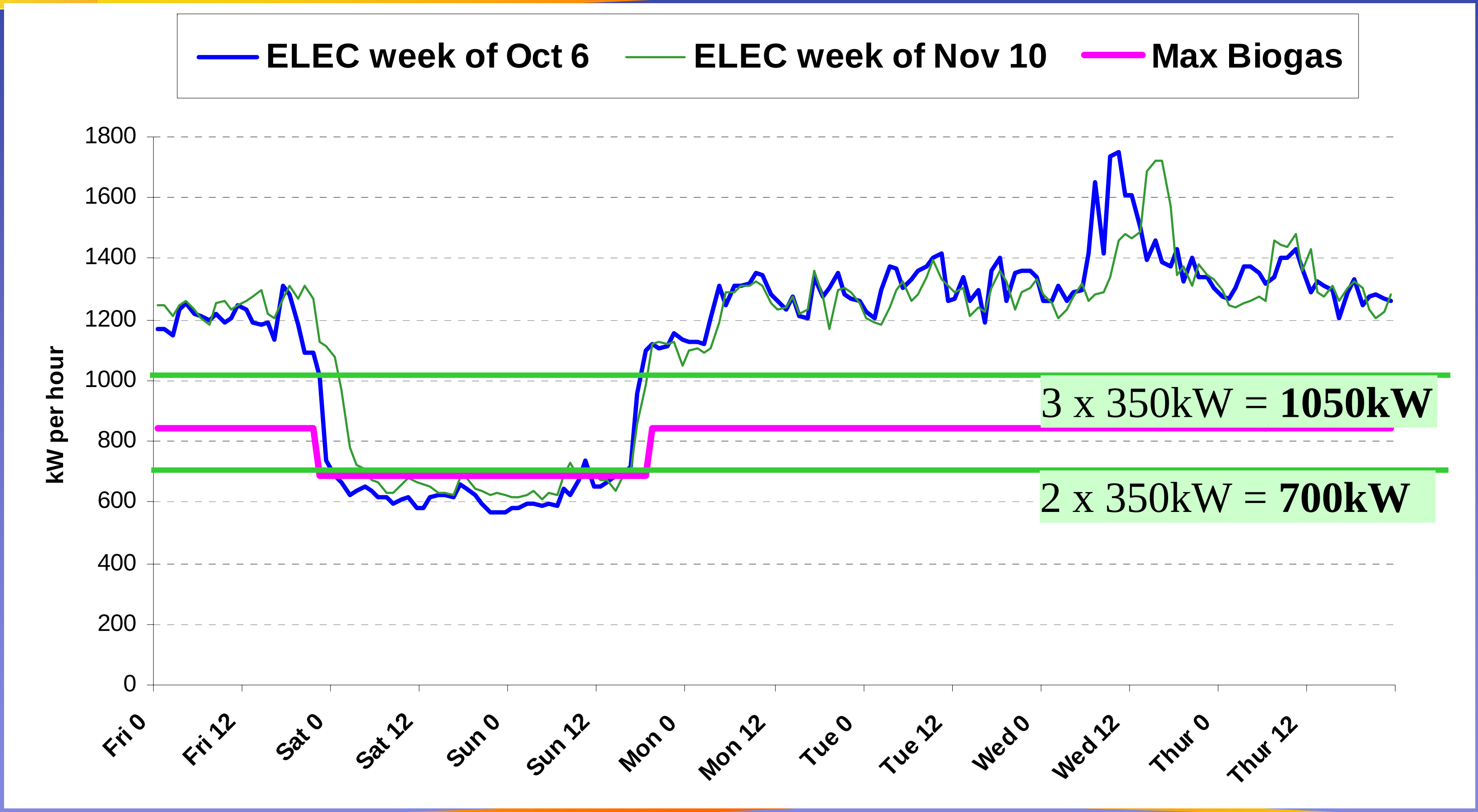
~ 50 mgd

1 - 2 mgd

Case 1: Food Plant (CA)
Sample Energy Profile



Case 1: Food Plant (CA)
Modular Design



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Case 1: Food Plant (CA)
Technology Summary

	Boilers	Fuel Cell	Engines	M-turbine
	Existing	1x 1.2 MW	2x 350kW	3x 250 kW

Case 1: Food Plant (CA)
Economic Summary

	Boilers	Fuel Cell	Engines	M-turbine
Net Capital Investment ($)	$75,000	$3.37 M	$2.35 M	$2.91 M
Net Annual Savings ($)	$0.97 M	$1.73 M	$1.40 M	$1.43 M
Payback Period (Years)	0.2	2.1	2.5	3.1

Case 1: Food Plant (CA)
Financial Incentives

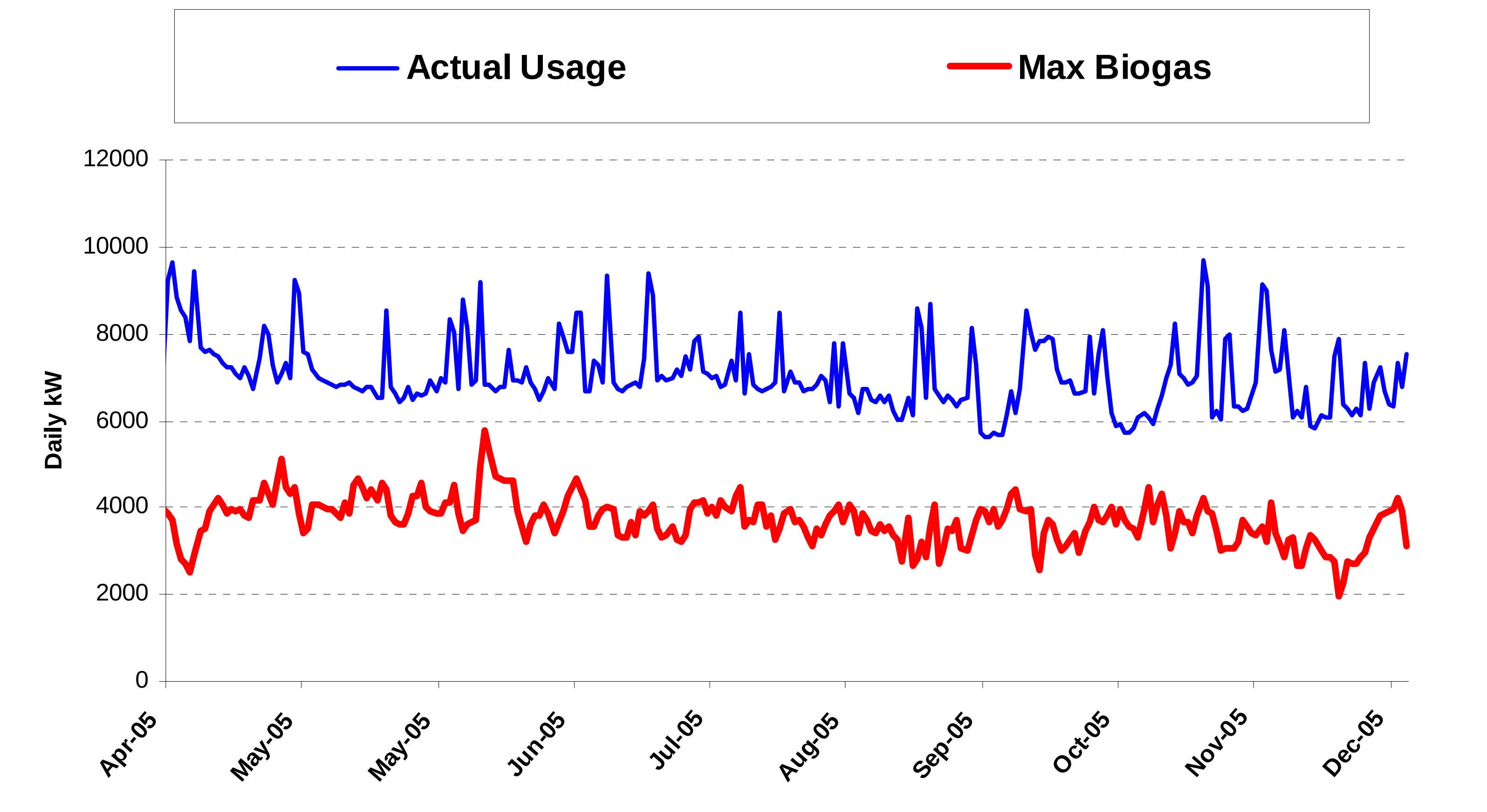
Eligible programs for 1.2 MW fuel cell

- State: Self Generation Incentive Program ($4.5M maximum)
- Federal: Business Energy Tax Credit Program ($1M maximum)
- Federal: Renewable Electricity Production Tax Credit ($0.01/kWh)
- Others: RECs, Net Metering

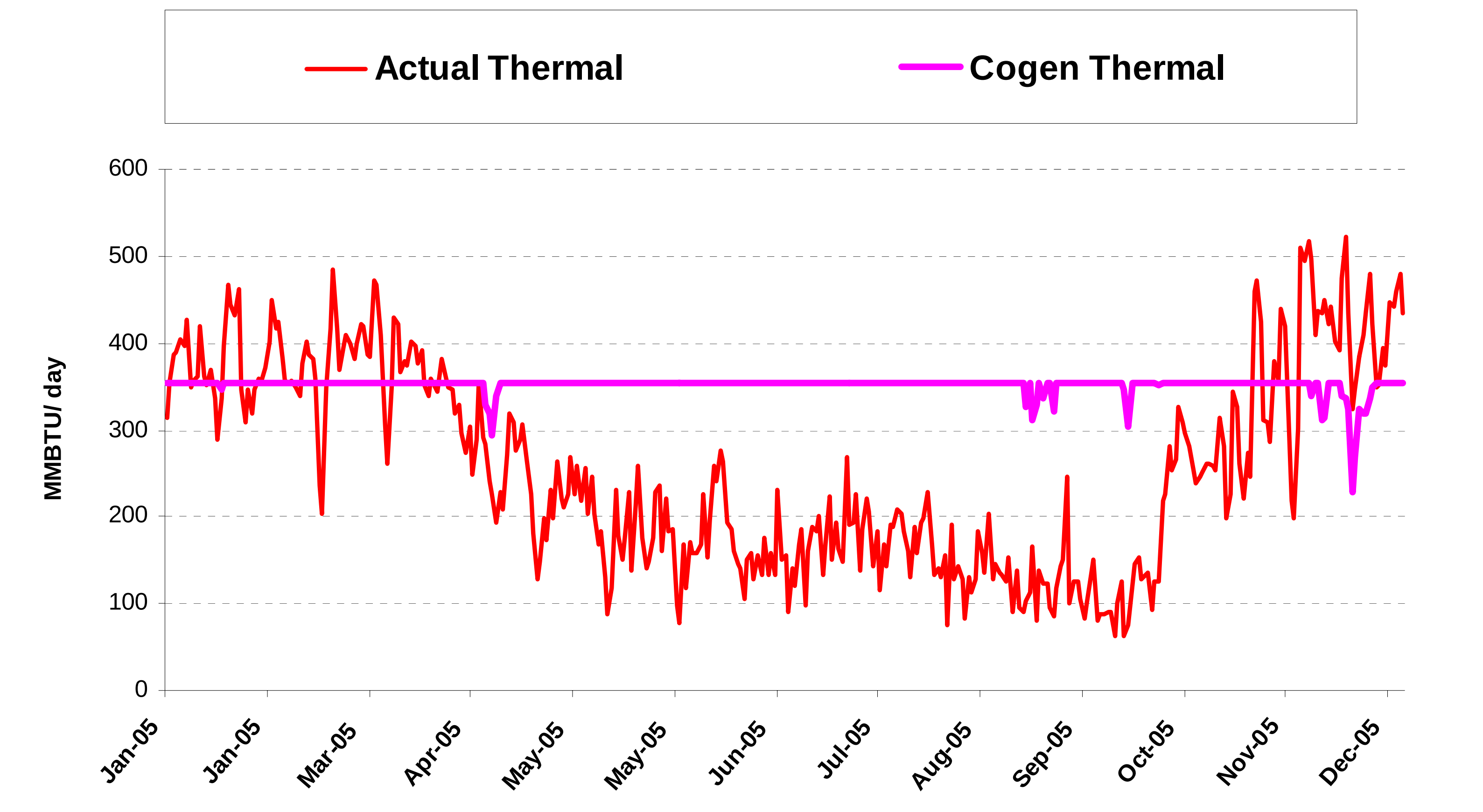
Project Driver: Financial Incentives

- Federal Programs
  - Renewable Energy Production Incentive
  - Renewable Electricity Production Tax Credit
  - Business Energy Tax Credit
  - USDA Renewable Energy Systems and Energy Efficiency Improvements Program
- State Programs
- Other: Local, Utilities

Case 2: Sewage Plant (PA)
Sample Electric Profile



Case 2: Sewage Plant (PA)
Sample Thermal Profile



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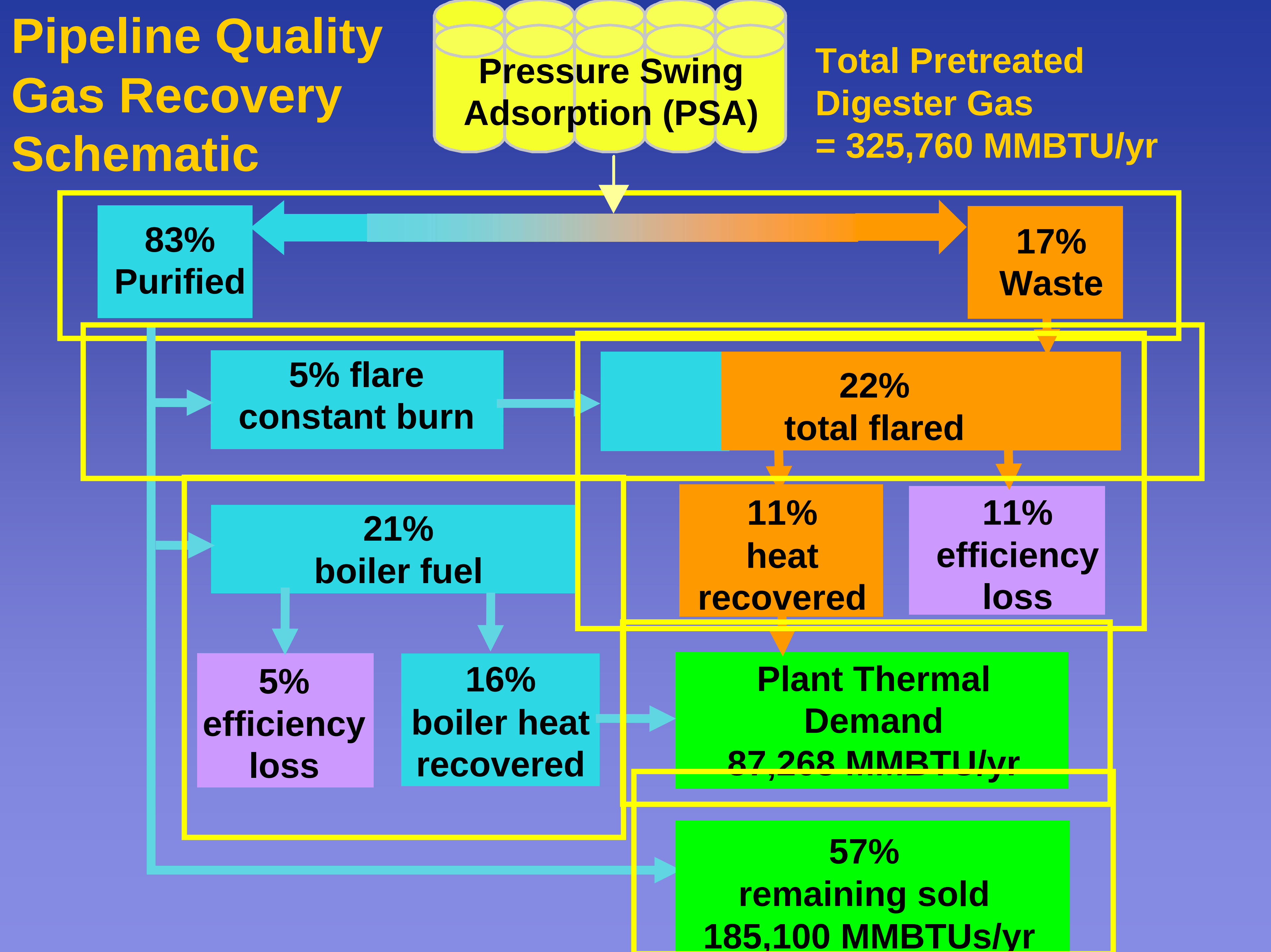
Case 2: Sewage Plant (PA)
Influence of Utility Rates

Average bill rate is $0.07/kWh, but Tariff rates:

Block of Electricity	Cost per kWh
1st Block	$0.08/kWh
2nd Block	$0.05/kWh
3rd Block	$0.03/kWh


Pipeline Quality Gas Recovery Schematic
Pressure Swing Adsorption (PSA)
Total Pretreated Digester Gas = 325,760 MMBTU/yr
83% Purified
17% Waste
5% flare constant burn
22% total flared
21% boiler fuel
11% heat recovered
11% efficiency loss
5% efficiency loss
16% boiler heat recovered
Plant Thermal Demand 87,268 MMBTU/yr
57% remaining sold 185,100 MMBTUs/yr

Case 2: Sewage Plant (PA)
Project Summary

- 1.4 million cf/day biogas, currently 57% flared
- Cogen potential of 4MW+
- Best option: scrub to pipeline quality gas
- In preconstruction/ design phase
- Total Capital Cost $2.7M
- Awarded $500,000 State grant
- Payback < 2 years

Project Driver:
Utilities and Tariffs

- Utility structure – more than average $/kWh
- Time of use – peak hours, summer
- Ratchet charge
- Multiple accounts/meters
- Tiered rates
- Power factor corrections
- Minimum/Maximum usage restrictions
- Limits on self-generated power

Case 3: Food Plant (NH)
Facility Challenges

- WW facility separate from food plant, with different utility meters and rates
- 60,000 cf/day biogas average
  - Excess flared in summer
  - Additional natural gas purchases in winter
- Biogas can produce 171kW, but WW facility only consumes 83 kW

Case 3: Food Plant (NH)
Gas Utilities Summary

	Food Plant		WWTF		Units
	August	October	August	October	
Average daily purchase	111	157	1	6	MMBTU
Tier 1	$ 10.7[illegible]	[illegible]	[illegible]	[illegible]	Per MMBTU
Tier 2	$ 10.74	[illegible]	[illegible]	[illegible]	Per MMBTU

Boiler Fuel	33 MMBTU	47 MMBTU
With I/E HEX	**8 MMBTU**	**19 MMBTU**

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Case 3: Food Plant (NH)
Electric Utilities Summary

Cogeneration Potential with Biogas	171 kW

	Food Plant		WWTF	Units
	meter 1	Meter 2		
Power	1776 - 1785	754 - 980	70 - 83	kW
Demand Charge	$ 6.90	$ 4.27	$ 4.82	per KW
On peak usage charge	$ 0.1028	$ 0.0958	$ 0.10938	per kWh
Off peak usage charge	$ 0.0944	$ 0.0958	$ 0.10938	per kWh

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Case 3: Food Plant (NH)
Solution Summary

- Influent/effluent HEX reduces WW facility thermal energy needs by 60-75%
  - Purchase natural gas for remainder
- Send all biogas to gas engine to produce power (171kW) and recovered heat for food plant site
- Estimated capital cost of $900,000 (before financial incentives) and payback within 5 years

Project Driver:
Combination of Solutions

- Improve process energy efficiency
- Redirecting biogas to maximize usability
- Balance utility purchases

Biogas Treatment

1. Entrained Water
2. H_2S
3. Water Vapor
4. Siloxanes and other VOCs
5. Halides and particulates
6. Carbon Dioxide

Biogas Treatment
Hydrogen Sulfide

- Forms sulfuric acid - Corrosive to prime movers, piping, compressors, etc.
- Combustion forms sulfur oxides
- Poisonous to catalysts and methane reformers
- Inhibits siloxane removal

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Biogas Treatment
Hydrogen Sulfide – Removal Methods

- Iron salts dosing/ digester operation
- Media based adsorption
- Liquid Absorption: water and caustic scrubbing/ catalytic oxidation
- Other: Biological scrubbers

Biogas Treatment
Siloxanes

- In consumer products, volatize in biogas
- Combustion product (silicon dioxide) is abrasive damaging to prime movers
- Harmful in ppbv, cumulative effect
- Removal: Deep chilling, carbon bed, proprietary carbon technology

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Biogas Treatment
Carbon Dioxide

- Generally not harmful for energy recovery
- Remove if high content (>40%), compressed, or required for special use eg. pipeline gas, food grade CO_2
- Removal Methods
  – Pressure Swing Adsorption (PSA)
  – Liquid Scrubbing
  – Membranes
  – Solvents

Economies of Scale

- Prime mover and Biogas Treatment Technologies don't scale down well
- Problematic when small systems and demanding gas cleanup requirements

Summary

- Biogas Energy Use - **Site Specific Conditions**
- Technology Choice, Size, Configuration
  - Biogas Production Rate
  - Plant Energy Profiles
- Qualifying Economics
  - Gas Treatment Requirements
  - Economies Scale
  - Utility Rate Structures and Costs
  - Financial Incentives

There are Alternatives

Thank You

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