



Chapter 5.8 – Biogas Utilization

Vic Smith

2014 Biogas Production

(@ 550 BTU per cubic foot)

479 MCF per year

263 kMBTU per year

2,633 kTherms per year

30,070 kBTU per hour

Raw Natural Gas Value

(@ \$1.00 per therm)

\$2,633,000 per year

103

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Some Other Assumptions and Clarifications

- Boiler efficiency 75%
- Electricity cost \$0.09/kWH
- Over time, natural gas and electricity will escalate at approximately the same rate per energy value
- 1 kW □ 3,414 BTU per hour
- M □ 1,000,000
- k = 1,000
- BTUH = BTU per hour
- 1 Therm □ 100,000 BTU

104

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Biogas Options

- On-site electricity and heat generation (combined heat and power, CHP 1 and 2)
- On-site heat and cooling generation only (heating and cooling use, HCU1)
- Third party use and agreements (TPU 1 and 2)

165

Combined Heat and Power System Alternatives

- Turbines
- Microturbines
- Fuel cells
- Sterling (external combustion) engines
- IC (internal combustion) engine-generators*

166

Primary CHP Selection Criteria

- Mechanical and electrical efficiencies
- Tolerance to biogas impurities
- Fit with and adaptability to existing power plant systems
- Proven technology
- Cost per kW
- Emissions

167

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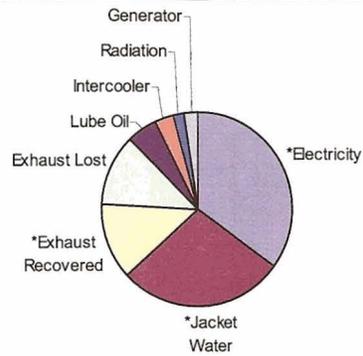
IC (Internal Combustion) Engine Generators – Energy Balance by System and Percentage

System	% Energy in	Useful Energy
*Electricity	35%	35%
*Jacket Water	28%	28%
*Exhaust Recovered	13%	13%
Exhaust Lost	12%	
Lube Oil	5%	
Intercooler	3%	
Radiation	2%	
Generator	2%	
	100%	76%

168

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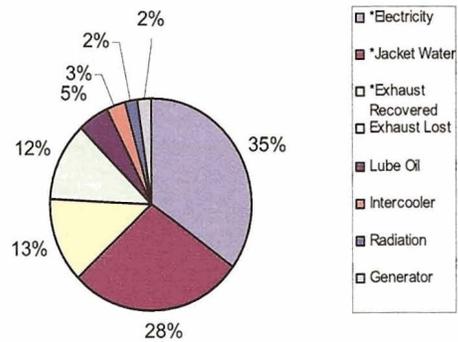
IC Engine Energy Balance – By System



169

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IC Engine Energy Balance – By Percentage



170

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Existing Power Plant IC Engine Capacities

Maximum Electric	4,550 kW
Maximum Thermal	22,400 kBTUH

Assuming One Standby and 80% of Max Output

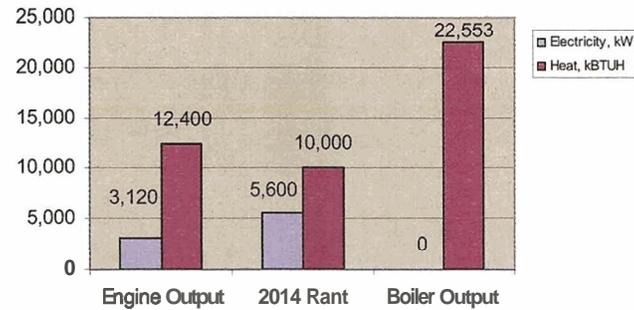
Nominal Electric	3,120 kW
Nominal Thermal	12,400 kBTUH

Coincidental, but a surprisingly good match for projected biogas production.

171

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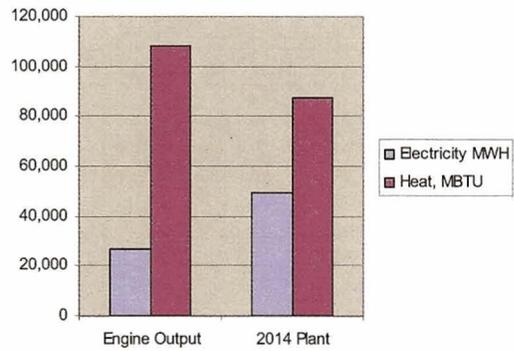
IC Generator and Boiler Outputs Compared to Projected Plant Demands



72

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IC Engine Annual Energy Output Compared to Projected Plant Usages



173

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Annual IC Engine Savings



174

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Incremental Savings

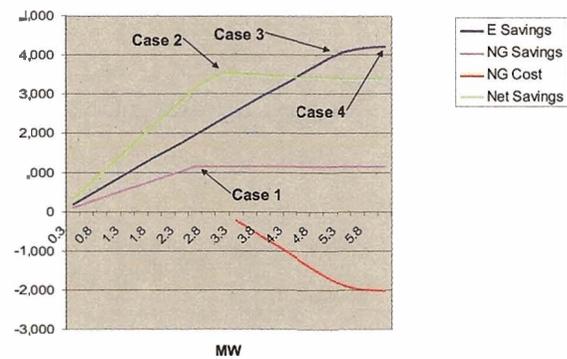
As the size of the energy recovery facility increases:

- Case 1: All biogas produced electricity and heat are consumed
- Case 2: All biogas produced electricity and part of the heat are consumed
- Case 3: NG is used to produce electricity up to the average demand
- Case 4: NG is used to produce electricity up to the peak demand

175

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Incremental Savings (\$ × 1,000)



176

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Savings by Case, \$kWH

Case 1:	All biogas produced electricity and heat are consumed	\$0.13
Case 2:	All biogas produced electricity and part of the heat are consumed	\$0.09
Case 3:	NG is used to produce electricity up to the average demand	(\$0.05)
Case 4:	NG is used to produce electricity up to the peak demand	(\$0.05)

Cases 1 and 2 are representative of Option CHP1
Cases 3 and 4 are representative of Option CHP2

177

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Biogas Options and Alternatives

- Combined heat and power
 - CHP1: Biogas consumption only
 - CHP2: Biogas consumption and natural gas consumption to supply remaining electrical usage
- Heating and cooling use
 - HCU1: Biogas consumption for heating and cooling only
- Third party use and agreements
 - TPU1: Off-Site energy developer use
 - TPU2: On-Site energy developer (or operator) use

178

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CHP 1 and 2 Economics

(\$ x 1,000)

Option and Alternative	Capital Cost	Energy Savings	Operating Costs	Annual Savings
CHP1: BG only	5,500 to 12,000	3,595	1,475	2,125
CHP2: BG + Nat Gas	25,000 to 30,000	3,375	1,975	1,400

79

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CHP1 Cost Considerations

■ Capital costs

Value of existing power plant

- Central cooling
- Cooling distribution
- Central process and space heating
- Heating distribution
- Engine heat rejection systems
- General infrastructure

Changes needed

- New generators and synchronization
- New electrical addition and remodeling
- Gas conditioning
- Closely matches projected 2014 biogas output

180

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CHPI Cost Considerations

(continued)

■ Operating costs

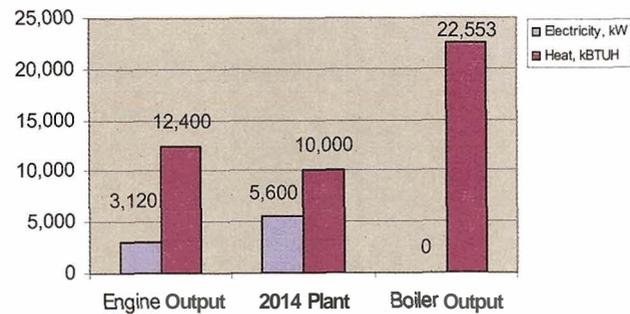
- Gas conditioning
 - Hydrogen sulfide
 - Siloxanes
- Consumables
- Major overhauls (and other contract work)
- Personnel

181

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HCU1 Economics

Heating and cooling uses less than 45% of the biogas



182

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TPU1: Off-Site 3rd Party Use Economics

- The energy developer accrues capital and operating costs similar to those of PCWMD in option **CHP1**
- The energy developer faces additional capital and operating costs for gas transport
- At this point in time, there are no significant capital incentives, operating rebates or tax deductions for TPUI (or **TPU2**)

183



TPU2: On-Site 3rd Party Use Economics

- The energy developer does not have a significant labor advantage; other costs like consumables, overhauls, etc., are similar
- This alternative may be cumbersome from a labor relations perspective
- Proposed green and renewable initiatives are available to both PCWMD and the energy developer

184



Green and Renewable Energy Incentives – REST

- Arizona Corporation Commission- Environmental Portfolio Standard (EPS): Rulemaking to encourage an increasing percentage of renewable **generation**-biogas is one of the renewable categories
- The program name is being changed to Renewable Energy Standard Tariff (REST) from EPS
- REST is currently out for review by manufacturers, interest groups, utilities and others
- Upon review completion and comments incorporation, the program still needs funding approval

185

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REST Incentives

- Proposed Incentives for biogas are:
 - \$0.054 per kWh, electricity generation only, or
 - \$0.031 per kWh-elec and \$0.016 per kWh-thermal for CHP
- There is no **'Upfront Incentive'**
- The incentives, as proposed, are transferable
- Baseline for incentive calculation is 1996 biogas consumption for electricity or CHP generation

186

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REST Example

- Assume the biogas flared at Roger Road could be burned in the engines at Ina Road
- Since the baseline year approximately **140MCF** are flared annually
- If this gas were consumed at Ina, the annual energy savings are \$845,600 assuming only half the thermal output is used, **\$.08/kWH** and **\$.80/Therm**
- The REST incentive, based upon its Uniform Credit Purchase Plan table, is \$355,460

187

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Non-Metro Treatment Facilities WW Process

Gordon Culp