

VOCGEN CHP Level One Project Feasibility Financial Summary



Automobile Manufacturing Company State of Kentucky

Operational Costs	Air Pollution Control Equipment & Utility Supplied Energy	VOCGEN CHP Equipment
Natural Gas	(\$645,896)	(\$1,200,740)
Electricity	(\$292,309)	\$0
Maintenance	(\$25,000)	(\$47,250)
Plant Natural Gas	(\$934,736)	
Plant Electricity	(\$547,255)	
	(\$2,445,197)	(\$1,247,990)
Annual Savings		\$1,197,207
Capital Equipment		
Regenerative Thermal Oxidizer (RTO)	(\$4,420,000)	\$4,420,000
VOCGEN CHP System	\$0	(\$6,079,800)
	(\$4,420,000)	(\$1,659,800)
Simple Payback Period	None	1.39-year payback
Potential savings over 20-years		\$23,984,334
Internal Rate of Return		72%
Net Present Value (NPV)		\$8,298,668
Carbon Dioxide Emissions (MT)	12,530	9,113
Carbon Equivalent Emissions (MT)	3,417	2,485
Annual Carbon Reduction		72.73%



**Automobile Manufacturing Company Example Level One (1) Cost
Benefit Analysis**

VOC loading Rate	30 lb/hr
Plant location	Kentucky
Natural Gas Price	\$7.95 USD/MMBtu
Electricity Price	\$0.105 USD/kWh

US Energy Information Agency - Energy Prices June - 2013..... Primer Coat - VOC Heat Content 14,143 Btu/lb

**RTO - Regenerative Thermal Oxidizer Air Pollution Control Equipment &
Utility Supplied Energy - Option 1**

**VOCGEN CHP Equipment
Option 2**

Equipment Selection

VOCGEN Equipment Selection

Equipment Option 1

RTO - Regenerative Thermal Oxidizer (40) KCFM at 337°F	1	Unit(s)
Other Equipment	1	Unit(s)

VOCGEN Genset -*0.560 MW	2	Unit(s)
VOC Concentrator Refrigeration	1	Unit (s)
* Nominal rating 560 kW per gas turbine		

Operating Hours

VOCGEN Operating Hours

(RTO - Regenerative Thermal Oxidizer) Operating hours	6,240 hr/yr
(8hrs/shift, 3shifts/day, 260days/yr)	

Genset(s) Operating hours	8,712 hr/yr
(8hrs/shift, 3shifts/day, 363days/yr)	

Air Flow

VOCGEN Air Flow

System airflow (CFM)	40,000 CFM
Other	

VOCGEN Genset(s) - CFM ISO Cond.	6,200 CFM/genset
Elevation: 820 Feet	12,400 CFM

1. Fuel

1. VOCGEN Fuel

System operating hours (8hrs/shift, 3shifts/day, 260days/yr)	6,240 hrs/yr
Regenerative Thermal Oxidizer fuel requirement	1.28 MMBtu/hr
Other equipment fuel requirement	11.74 MMBtu/hr

VOC Energy Contribution

Operating hours (VOC production) (8hrs/shift, 2shifts/day, 260days/yr)	4,160 hrs/yr
VOC load	30 lb/hr
Heat content	14,143 Btu/lb
	1,765 MMBtu/yr

Natural gas pilot fuel use is regulated by an automated system compensating for VOC heat content contribution.

Estimated Fuel Required

Annual Carbon Reduction

Equipment Option 1

RTO - Regenerative Thermal Oxidizer (40) KCFM at 337°F	(\$63,498) USD
Other Equipment	(\$582,398) USD
Total Natural Gas usage by Option 1	(\$645,896) USD/yr

Natural Gas Fuel

VOCGEN Genset(s) 0.560 MW	
Heat rate	15,660 Btu/kWh
	8.77 MMBtu/hr/genset
	17.54 MMBtu/yr
	152,802 MMBtu/yr



<p>Estimated Fuel Required</p> <table border="1"> <tr> <td>Natural Gas</td> <td>81,245 MMBtu/yr</td> </tr> <tr> <td>Total fuel</td> <td>(\$645,896) USD/yr</td> </tr> </table>	Natural Gas	81,245 MMBtu/yr	Total fuel	(\$645,896) USD/yr	<p>Estimated Fuel Required</p> <table border="1"> <tr> <td>VOC</td> <td>1,765 MMBtu/yr</td> <td>\$14,032 USD/yr Savings</td> </tr> <tr> <td>Natural Gas</td> <td>151,036 MMBtu/yr</td> <td>(\$1,200,740) USD/yr</td> </tr> <tr> <td>Total fuel</td> <td>152,802 MMBtu/yr</td> <td>Cost (\$1,200,740) USD/yr</td> </tr> </table>	VOC	1,765 MMBtu/yr	\$14,032 USD/yr Savings	Natural Gas	151,036 MMBtu/yr	(\$1,200,740) USD/yr	Total fuel	152,802 MMBtu/yr	Cost (\$1,200,740) USD/yr
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<p>2. Regenerative Thermal Oxidizer Electrical Cost</p>	<p>2. VOCGEN Parasitic Loads</p>													
<p>Estimated RTO Electricity Cost <i>Using total motor Hp of 457.5 & power draw of 446.1kW</i></p> <table border="1"> <tr> <td>2,783,896 kWh/yr</td> </tr> <tr> <td>(\$292,309) USD/yr</td> </tr> </table>	2,783,896 kWh/yr	(\$292,309) USD/yr	<p>VOCGEN Genset(s) 0.560 MW</p> <table border="1"> <tr> <td>Chiller</td> <td>75 kW/unit</td> </tr> <tr> <td></td> <td>150 kW - parasitic load</td> </tr> <tr> <td>NG Booster Compressor</td> <td>50 kW/unit</td> </tr> <tr> <td></td> <td>100 kW - parasitic load</td> </tr> </table>	Chiller	75 kW/unit		150 kW - parasitic load	NG Booster Compressor	50 kW/unit		100 kW - parasitic load			
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<p>4. Avoided Electrical Requirements of Facility</p> <table border="1"> <tr> <td>870 kW</td> <td>VOCGEN Cost Avoidance</td> </tr> <tr> <td>5,211,954 kWh/yr</td> <td>(\$547,255) USD/yr</td> </tr> </table>	870 kW	VOCGEN Cost Avoidance	5,211,954 kWh/yr	(\$547,255) USD/yr	<p>4. VOCGEN Electrical Output Contribution (Less Parasitic Load)</p> <table border="1"> <tr> <td>(1120kW - 250kW)</td> <td>870 kW</td> </tr> <tr> <td></td> <td>5,211,954 kWh/yr</td> </tr> </table> <p><i>Altitude factor at 820ft is 0.975 of nominal output power VOCGEN parasitic load deducted from total electrical output</i></p>	(1120kW - 250kW)	870 kW		5,211,954 kWh/yr					
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<p>5. Avoided Natural Gas Requirements for Heating/Cooling</p> <table border="1"> <tr> <td>117,577 MMBtu/yr</td> <td>VOCGEN Cost Avoidance</td> </tr> <tr> <td></td> <td>(\$934,736) USD/yr</td> </tr> </table>	117,577 MMBtu/yr	VOCGEN Cost Avoidance		(\$934,736) USD/yr	<p>5. VOCGEN Heat Output Contribution</p> <table border="1"> <tr> <td>VOCGEN Genset(s) 0.560 MW</td> </tr> <tr> <td>17.54 MMBtu/hr Fuel</td> </tr> <tr> <td>3.68 MMBtu/hr Electrical power</td> </tr> <tr> <td>13.86 MMBtu/hr Heat</td> </tr> <tr> <td>13.50 MMBtu/hr Heat w/radiated heat loss</td> </tr> <tr> <td>117,577 MMBtu/yr nominal heat</td> </tr> </table>	VOCGEN Genset(s) 0.560 MW	17.54 MMBtu/hr Fuel	3.68 MMBtu/hr Electrical power	13.86 MMBtu/hr Heat	13.50 MMBtu/hr Heat w/radiated heat loss	117,577 MMBtu/yr nominal heat			
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<p>Regenerative Thermal Oxidizer annual operating cost</p> <p>(VOCGEN cost avoidance included in Regenerative Thermal Oxidizer annual operating cost below)</p>	<p>VOCGEN Carbon Emissions Reductions - Potential</p> <table border="1"> <tr> <td>Federal Proposed Value</td> <td>932 ton Carbon/year</td> <td>\$0 USD/yr</td> </tr> <tr> <td></td> <td>\$0.00 USD/ton</td> <td>Not included in total savings</td> </tr> </table>	Federal Proposed Value	932 ton Carbon/year	\$0 USD/yr		\$0.00 USD/ton	Not included in total savings							
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6. Capital Equipment Budget- First year	6. VOCGEN Capital Equipment Budget- First year
<p>Equipment Option 1</p> <p>RTO - Regenerative Thermal Oxidizer (40) KCFM : (\$1,500,000) USD Other Equipment (\$1,900,000) USD</p> <p>One Additional 'RTO' unit(s) will be purchased during the 20-year evaluation period with installation costs included (factor: 1.30): (\$4,420,000) USD</p>	<p>Equipment Option 2</p> <p>0.560MW VOCGEN Genset cost (\$1,723,000) USD</p> <p>Equipment Package Engineering and Designs w/Specifications and Operations Manual Skid-mounted equipment enclosure Natural Gas Booster Compressor and Receiver Tank (optional) D.I. Water Purification System (optional) Electric Chiller (300°F to 65°F) Honeywell Catox Air Purification Catalyst (optional)</p> <p><i>Functional Specification for 480 VAC 560 kW Gas Turbine Designed by EPSI and Gas Technology Institute 1700 South Mount Prospect Road Des Plaines, IL 60018-1804</i></p>
<p>Estimated Equipment Costs</p> <p style="text-align: right;">(\$3,400,000) USD/yr</p>	<p>Estimated Equipment Cost</p> <p style="text-align: right;">(\$3,446,000) USD</p>
<p>Installation (est. 30% of equipment)</p> <p style="text-align: right;">(\$1,020,000) USD</p>	<p>Estimated Project Costs</p> <p>Installation (est. 30% of equipment) (\$1,033,800) USD Const. Mgmt., Subcontractors and Suppliers Engineering, Civil, Mechanical, and Electrical Heat utilization VOC Concentrator HRSG (\$1,600,000) USD</p>
<p>Estimated Capital Equipment Costs</p> <p style="text-align: right;">(\$4,420,000) USD</p>	<p>Estimated Capital Equipment Costs (Rebate of \$ subtracted from the cost)</p> <p style="text-align: right;">(\$6,079,800) USD</p>
<p>Year Zero Avoided Costs</p> <p style="text-align: right;">\$4,420,000 USD</p>	<p>Adjusted First Year Costs</p> <p style="text-align: right;">(\$1,659,800) USD</p>



7. Cash Flow

	Equipment Option 1	VOCGEN Equip. Option 2	
	Each year	Each year	Difference
Year 0	(\$4,420,000)	(\$6,079,800)	(\$1,659,800)
Year 1	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 2	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 3	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 4	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 5	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 6	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 7	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 8	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 9	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 10	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 11	(\$6,345,197)	(\$3,447,990)	\$2,897,207
Year 12	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 13	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 14	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 15	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 16	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 17	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 18	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 19	(\$2,445,197)	(\$1,247,990)	\$1,197,207
Year 20	(\$2,445,197)	(\$1,247,990)	\$1,197,207

Simple Payback 1.39 years

Potential savings over 20-years
\$ 23,984,334

IRR 72%

Example
Discount Rate 10%
Net Present Value \$8,298,668 USD



Carbon Emissions Impact

Emissions from Natural Gas		VOCGEN Natural Gas Emissions	
Equipment Option 1			
RTO - Regenerative Thermal Oxidizer (40) KCFM :	1,040 MT CO ₂ / year	Total usage	44,264,439 kWh/year
Other Equipment	MT CO ₂ / year	Carbon emissions from natural gas	0.185 kg CO ₂ /kW
CO ₂ emissions	1,040 MT CO ₂ / year	CO ₂ emissions	8,188,921 kg CO ₂ /year
	945,791 kg CO ₂ / year	Carbon equivalent	2,233,342 kg Carbon/year
Carbon equivalent	284 MT Carbon/year		
	257,943 kg Carbon/year		
Emissions Avoided by On-Site Energy Generation		VOCGEN VOC Emissions	
Grid supplied electricity avoided	870 kW	Total usage	517,284 kWh/year
	7,579,440 kWh/year	Carbon emissions from natural gas	0.185 kg CO ₂ /kW
	7,579 MWh/year	CO ₂ emissions	95,698 kg CO ₂ /year
Carbon emissions from grid electricity	0.537 kg CO ₂ / kW	Carbon equivalent	26,099 kg Carbon/year
CO ₂ emissions	4,070,159 kg CO ₂ / year		
Carbon equivalent	1,110,043 kg Carbon/year		
Emissions Avoided by On-Site Heat Generation		VOCGEN Electricity Generated	
Natural gas usage avoided	34,458,397 kWh/year	Total electricity generated	870 kW
Carbon emissions from natural gas	0.185 kg CO ₂ / kW	Parasitic load	250 kW
CO ₂ emissions	6,374,803 kg CO ₂ / year	Theoretical - total electricity available	620 kW
Carbon equivalent	1,738,583 kg Carbon/year	Actual - total electrical available	598 kW
			5,211,954 kWh/year
			5,212 MWh/year
			No carbon emissions (see natural gas above)
Emissions Avoided by On-Site Heat Generation		VOCGEN Heat Generated	
Natural gas usage avoided	34,458,397 kWh/year		34,458,397 kWh/year
Carbon emissions from natural gas	0.185 kg CO ₂ / kW		No carbon emissions (see natural gas above)
CO ₂ emissions	6,374,803 kg CO ₂ / year		
Carbon equivalent	1,738,583 kg Carbon/year		
Estimated CO₂ emissions (Metric Tons - MT)	11,390,754 kg CO₂ / year	Estimated CO₂ emissions (Metric Tons - MT)	8,284,619 kg CO₂ / year
	12,530 MT CO₂ / year		9,113 MT CO₂ / year
Estimated Carbon equivalent	3,106,569 kg Carbon/year	Estimated Carbon equivalent	2,259,442 kg Carbon/year
	3,417 MT Carbon/year		2,485 MT Carbon/year
		Net Estimated Annual Savings	3,417 MT CO₂ / year
			932 MT Carbon/year

VOCGEN CHP Project Feasibility Maintenance Schedule



Automobile Manufacturing Company

Prices:	US Energy Information Agency - Energy Prices for June, 2013	
	Quarterly Service	\$6,000.00
	Minor ASE8 engine rebuild	\$70,000.00
	Major ASE8 engine rebuild	\$85,000.00

		Total
Year 1	Quarterly Service	(\$24,000.00)
Year 2	Quarterly Service	(\$24,000.00)
Year 3	Quarterly Service and minor rebuild	(\$94,000.00)
Year 4	Quarterly Service	(\$24,000.00)
Year 5	Quarterly Service	(\$24,000.00)
Year 6	Quarterly Service and major rebuild	(\$109,000.00)
Year 7	Quarterly Service	(\$24,000.00)
Year 8	Quarterly Service	(\$24,000.00)
Year 9	Quarterly Service and minor rebuild	(\$94,000.00)
Year 10	Quarterly Service	(\$24,000.00)
Year 11	Quarterly Service	(\$24,000.00)
Year 12	Quarterly Service and major rebuild	(\$109,000.00)
Year 13	Quarterly Service	(\$24,000.00)
Year 14	Quarterly Service	(\$24,000.00)
Year 15	Quarterly Service and minor rebuild	(\$94,000.00)
Year 16	Quarterly Service	(\$24,000.00)
Year 17	Quarterly Service	(\$24,000.00)
Year 18	Quarterly Service and major rebuild	(\$109,000.00)
Year 19	Quarterly Service	(\$24,000.00)
Year 20	Quarterly Service	(\$24,000.00)
	Total over 20-years	(\$945,000.00)
	Yearly cost	(\$47,250.00)
	Monthly cost	(\$3,937.50)

GEN



Assumptions and Notes

	Energy			Maintenance (k\$)	Annual O&M (\$k)	Capital (k\$)	Annual CO2 Emissions (MT)	Annual Carbon Emissions (MT)
	Gas (k\$)	Electric (k\$)	Credit (k\$)					
Thermal Oxidizer (<i>TO</i>)	(\$646)	(\$292)	\$19	(\$25)	(\$1,256)	(\$4,420)	12,530	3,417
TO Heat Recovery (<i>HR</i>)								
VOCGEN Gas Turbine Oxidizer (<i>GTO</i>)	(\$1,201)	\$0	\$1,482	(\$47)	\$234	(\$6,080)	9,113	2,485
GTO Heat Recovery (<i>HR</i>)								

Volatile Organic Compounds/HAP

Total	413,602 VOC lbs/year	39,921 CFM Airflow Total
Topcoat Oven A	10-100 lbs/hr	12,000 CFM Oven Air
Destruct Removal Efficiency (DRE) Requirement		4,400 CFM Combustion Air BACT
VOCGEN Gas Turbine Oxidizer (GTO)	ASE 8 Gas Turbine VOC	6,000 cfm inlet air at 60°F
GTO Recoverable Heat	60°F inlet air Temp	Exhaust Gas Heat Content ≈6.22 MMBtu/Hr high-grade (<1000°F) waste heat
Natural Gas Fuel	20,100 Btu/lb Lower Heating Value	
Radiated heat:	"radiated, conducted and convected" from the engine at continuous duty - 100,000 Btu/hr	
The amount of natural gas required to run the gas turbine is dependent on two process variables: 1) the load placed on the gas engine (kW demand), and 2) the energy content supplied by the VOC laden air stream.		
The system's main function is to convert the energy provided primarily from a natural gas supply (and to a lesser extent, the energy provided by a volatile organic compound laden air stream) to produce 525 kW of electrical power at 480 VAC, three-phase, 60 Hz, destroy VOC waste streams, as well as produce approximately 6 MMBTU" recoverable heat. Inlet air combined with a concentration of a volatile organic compound (at a level below 50 % LEL), will be drawn in, compressed and heated in a secondary combustion chamber, then introduced into a primary combustion chamber with natural gas to fuel a combustion process which operates the gas turbine at a speed of 41,730 rpm. The mechanical rotation of the gas turbine drives an AC generator at a rate of 1,800 rpm via a gearbox.		
Maintenance Schedule: Service checkup including replacing belts, filters and other consumables is required quarterly. Minor rebuild of the ASE8 engine every 2.5 years and major rebuild of the engine every 3 years.		

State	Natural Gas	Electricity
	(\$ / MMBtu)	(\$ / kWh)
	Jun-13	Jun-13
Alabama	5.94	0.0604
Alaska	3.98	0.1208
Arizona	7.81	0.0613
Arkansas	7.49	0.0569
California	7.95	0.1046
Colorado	6.09	0.0631
Connecticut	10.40	0.1681
Delaware	15.70	0.0927
District of Columbia	--	0.0837
Florida	9.72	0.0937
Georgia	7.06	0.059
Hawaii	14.83	0.1585
Idaho	6.53	0.0515
Illinois	6.65	0.0745
Indiana	6.49	0.0584
Iowa	5.39	0.0497
Kansas	5.07	0.0642
Kentucky	7.95	0.105
Louisiana	5.24	0.0478
Maine	15.24	0.0966
Maryland	8.83	0.1035
Massachusetts	17.23	0.1006
Michigan	9.47	0.0717
Minnesota	4.99	0.0616
Mississippi	7.14	0.0659
Missouri	9.74	0.0498
Montana	9.25	0.0515
Nebraska	6.36	0.056
Nevada	11.34	0.072
New Hampshire	15.87	0.1477
New Jersey	7.77	0.109
New Mexico	4.68	0.0572
New York	8.00	0.065
North Carolina	8.31	0.0584
North Dakota	5.55	0.0561
Ohio	9.00	0.0685
Oklahoma	10.77	0.0499
Oregon	10.44	0.0465
Pennsylvania	9.32	0.0759
Rhode Island	11.64	0.1269
South Carolina	8.11	0.0574
South Dakota	5.63	0.0562
Tennessee	7.23	0.0674
Texas	6.04	0.0699
Utah	5.89	0.0476
Vermont	8.16	0.0925
Virginia	7.24	0.0687
Washington	12.64	0.051
West Virginia	5.19	0.054
Wisconsin	6.62	0.066
Wyoming	4.59	0.0463
Other (Site specific)	0.00	0