Flare Reduction Field Trial
Cost Effective Flare Gas & VOC Reduction
May 9, 2017

Clean Waters Initiative
The 15,000 MW Opportunity
**ORC SYSTEM OVERVIEW**

**THE ORC CYCLE**

- **HEAT IN:** Heat enters ORC via hot water stream, transferred into system through evaporator where working fluid changed from liquid to vapor.
- **HEAT OUT:** Heat leaves ORC via cooling water stream, heat transferred through the cooling water stream changing vapor back to liquid.
- **WORK OUT:** Work is provided via shaft output from expander, and converted to electricity by a generator.
- **IMPORTANT:** 90% of the heat input into the ORC passes through the machine to the cooling side.
Flare to Power
Reduce Flaring, Generate Power

- Reduce or eliminate flare
- Much lower capital and maintenance than other power generation technologies
- Significantly reduced emissions

Waste Water Treatment

For WWTPs under pressure to reduce flaring and lower emissions, the pairs with boilers and anaerobic digesters for a cost-effective solution.

Oil & Gas Wells

In the fall of 2015, ElectraTherm demonstrated a paired with a boiler to reduce flaring on a Hess oil well in the Bakken.
Increased Efficiencies and Reduced Emissions
Flare and Emission Reduction Trial
Sponsored By:
Environmentally Friendly Drilling Systems Program
and
Houston Advanced Research Center, HARC
Field Test – Flaring Mitigation

Objectives
Identify & test simple/robust technologies to reduce flaring

Location
• Field trials ongoing in the Bakken

Status
• ORC equipment installed, commissioned, successfully operated. Data compiled and submitted.
Our Solution:
Provide Beneficial Use for Flare Gas

Gas to Boiler

Reduced Flaring

kW Output
Well Site
Pre-Commissioning
Day 1
Equipment Lands
Installation
Day 1-2
Day 2
Hot Water Boiler Commissioned

Hot Water Boiler – **NO** operator required
Day 2
Power+ Generator Commissioned
Day 3
System Successfully Commissioned
The real benefit is the power generated by raw gas or fuel gas which would otherwise be wasted by open flaring. Furthermore, this new technology would meet the goals of the US EPA and North Dakota Department of Health — Air Quality by reducing emissions and providing energy by reuse of the produced raw gas or fuel gas.”
Results

Total Run Time: 1857 HR
Total kWh Produced: 99,000

Emission Reduction

Study by Texas A&M/Institute of Renewable Natural Resources
October 2015

CO ↓ 89%
NOx ↓ 48%
VOC ↓ 93%
COA FM 812 Landfill Flare
## Austin Landfill

### Anticipated Emissions Reductions and Values

- **Values for TCEQ Credits for HGM Area**

### Calculated Reductions #/yr.

<table>
<thead>
<tr>
<th>lb/hr</th>
<th>Flare</th>
<th>Pwr+ Boiler</th>
<th>% Decrease</th>
<th>#/yr Reduction</th>
<th>Price/ton*</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC</td>
<td>14,541</td>
<td>438</td>
<td>97</td>
<td>14,103</td>
<td>$200,000/ton</td>
<td>$1,410,000</td>
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<tr>
<td>CO</td>
<td>38,368</td>
<td>11,388</td>
<td>70</td>
<td>26,980</td>
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<td></td>
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<tr>
<td>NOx</td>
<td>6,291</td>
<td>3,591</td>
<td>42</td>
<td>2,700</td>
<td>$5,200/ton</td>
<td>$14,040</td>
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</tbody>
</table>

*Note: Price/ton from TCEQ Emissions Banking Division 6/1/2016*

### CALCULATION METHODS

Landfill Emissions Calculation: Average Flow (SCFM or ft³/min) \( \times 60 \text{ min/hr} \times 476 \text{ Btu/ft}^3 \times \text{MMBtu/10}^6 \text{ Btu} \times \text{Emission Factor (lb pollutant/MMBtu)} \)
Existing Landfill Flare
City of Austin*

- VOC reduction: 7 tons/yr.
  (Equivalent of taking 512 cars off Austin streets)

- NOx reduction: 1.2 tons/yr.
  (Equivalent of taking 108 cars off Austin streets)

- CO reduction: 13 tons/yr.
  (Equivalent of taking 104 cars off Austin streets)

*Applies IRNR Hess/HARC Project research results
Power+ Generator vs. Engine
Economic Comparison

- 92% reduction in Costs – CapEx + Maintenance
- $2.8 Million savings over engine over 10 years
- Power+ provides a positive ROI + Dramatic Emissions Reductions

Notes:
*Installed cost for Genset is calculated including Gas Cleanup (4.4M) + Genset/Switchgear (1.5M)
**Genset Uptime and Maintenance based on Jenbacher 320 – Truckee Meadows WWT report
Value of Power Based on $.08/kWh
Hess Project – Fall 2015

In October 2015, ElectraTherm completed a flare reduction demonstration at a Hess oil well in the Bakken

Series 4000 -- 65 kW

- Total Run Time: 1,857 Hours
- Total kWh Produced: 99,000
- Positive Hess Feedback
- Iraq delegation/DOE visit to site
- “Beneficial Use” Approval from North Dakota
- Visibility to all producers in Bakken

Media Highlights:
Cover story in Oil, Gas & Petrochem Equipment
Bakken Magazine feature story
# Technology Comparison

## ORCs for raw flare gas

<table>
<thead>
<tr>
<th>Feature</th>
<th>Power+ and Boiler</th>
<th>Engine</th>
<th>Micro Turbine</th>
<th>Fuel Cell</th>
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</thead>
<tbody>
<tr>
<td>Lowest LCOE per kWh</td>
<td>✓</td>
<td></td>
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<tr>
<td>Lowest O&amp;M</td>
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<tr>
<td>No Costly Gas Conditioning</td>
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<tr>
<td>No Costly Gas Storage</td>
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<tr>
<td>Low Emissions</td>
<td>✓</td>
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<tr>
<td>Ease of Installation</td>
<td>✓</td>
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<tr>
<td>Accepts Varying Gas Flows</td>
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<tr>
<td>Smallest Footprint</td>
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<tr>
<td>MW Output for Grid Export</td>
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<td>✓</td>
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<tr>
<td>kW Output for Local Loads</td>
<td>✓</td>
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<td></td>
<td>✓</td>
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</table>
## Family of Products

<table>
<thead>
<tr>
<th>Model</th>
<th>Product</th>
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<tbody>
<tr>
<td><strong>POWER+ 6500</strong></td>
<td>![Image of 6500 product]</td>
</tr>
<tr>
<td><strong>POWER+ 4400</strong></td>
<td>![Image of 4400 product]</td>
</tr>
<tr>
<td><strong>POWER+ 4200</strong></td>
<td>![Image of 4200 product]</td>
</tr>
</tbody>
</table>

- High Power Output (kWh)
  - **POWER+ 6500** Up to 110kW
  - **POWER+ 4400** Up to 65kW
  - **POWER+ 4200** Up to 35kW

We offer 3 output levels packaged with cooling circuit or standalone.
Stationary Engines

Produce More Power & Reduce Cooling Fan Load

Waste heat from engine jacket water or combination exhaust & jacket water
Radiator Replacement for Stationary Engines

Avoid Radiator Expense on a Greenfield Project
Offset ORC Capex by 20-30%

Benefits:

- Complete Engine Radiator Replacement
- 10% - 12%+ Improved Fuel Efficiency
- Easily Transportable
- Limited Site Construction
- Payback 2-3 years (diesel)

Containerized 1.1MW Cummins Genset + ORC Packaged in two 40-foot containers

1.1 MW Cummins Genset and Exhaust Gas Heat Exchanger

“The Radiator with a Payback”
Video at https://youtu.be/fca0faX8R84
For More Information Contact:

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