Ownership has a background in O&G production and processing equipment (Cimarron Energy 1977-2012)

Urged by customers in early 2000’s to provide evaporative solution for produced water in the Piceance Basin

Began utilizing submerged combustion technology in 2009

Founded Logic Energy Solutions in 2012 with a focus on oil and gas wastewater evaporation

Operated evaporators in the following producing areas:

- STACK (Oklahoma)
- Permian (Texas)
- Fayetteville (Arkansas)
- Bakken (N. Dakota)
- Marcellus (Pennsylvania)
- Utica (Ohio)
- Powder River (Wyoming)
STRATEGY

- Evaporate close to the source, and reduce truck traffic as a result
- Provide modular equipment that can be easily relocated
Well Site Flow Diagram

- Wellhead
- 3-Phase Separator
- Water
- Oil
- Nat Gas Pipeline
Well Site Flow Diagram

Wellhead → 3-Phase Separator → Water → Evaporator → Heavy Brine → CONCENTRATOR

Wellhead → 3-Phase Separator → Oil → CRYSTALLIZER

Nat Gas Pipeline
Volume Reduction via Concentration

<table>
<thead>
<tr>
<th>Influent TDS (mg/L)</th>
<th>325,000mg/L Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>30,000</td>
<td>91%</td>
</tr>
<tr>
<td>50,000</td>
<td>85%</td>
</tr>
<tr>
<td>100,000</td>
<td>69%</td>
</tr>
<tr>
<td>150,000</td>
<td>54%</td>
</tr>
<tr>
<td>200,000</td>
<td>38%</td>
</tr>
<tr>
<td>250,000</td>
<td>23%</td>
</tr>
</tbody>
</table>
Submerged Combustion is a thermal process which heats a liquid by forcing combustion exhaust gases through the solution.

Primary Benefits: Efficient, No heat transfer surfaces
PROCESS

- Burner Type: Forced Air
- Fuel Type: Natural Gas
- Fuel Consumption: 400,000-450,000 btu’s per evaporated barrel
- Inlet Fuel Pressure: 15 psi
- Blower Type: Positive Displacement
PROCESS

- Evaporate up to 1,000 bpd (1,750 gal/hr)
- 1 Day Mobilization
- 25’W x 25’L x 30’T
- Dry Weight of 45,000 lbs
- Operating Pressure: 10 Oz.
- Operating Temp: 180°F
- Materials of Construction:
  - Carbon Steel
  - 2205 Stainless Steel
  - Fiberglass
IMPACTS

- **NOISE:** <85 dBA
- **VISUAL:** White plume that varies in size depending on atmospheric conditions and evaporation rates; never had a complaint
- **SURFACE:** TDS of water vapor is less than 500 mg/L
- **ODOR:** Little to no smell, unless VOC’s are in the vapor plume
MANAGING EMISSIONS

- Particulate Matter (PM): Carryover of droplets containing solids
- Combustion Gases: Incomplete combustion causes the release of organic compounds to atmosphere
- Organic Compounds (Entrained in the Water): Organic compounds with a boiling point equal to, or less than the evaporator operating temperature (methanol is a challenge)
MANAGING EMISSIONS

- Pre-heat influent water to 150-160°F
- Sparge water with blower air
- Recover volatilized organic compounds and inject into burner

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WHERE IS THE CATALYST?

- Disposal wells are inexpensive and easy; the default for producers
- Forced evaporation is relatively new and unfamiliar to the O&G industry; still kicking the tires
- Penetrating a market requires:
  - Cheaper than injection (T&D) on a direct cost basis; forget the hidden / soft costs
  - Easy for the producer to implement
GETTING CREATIVE

- Price reduction for evaporation
  - Design
  - Scale
  - Volume through quantity
  - Product mix

- Investing in product mix
  - Bundle production and flowback services with evaporation yields cheap and easy
CONTACT INFORMATION

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