Innovative Energy Solution

OVERVIEW AND PLASMA GASIFICATION

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Senior Research Engineer
Background

Energy technology development founded in 2004.
- 7 Employees: 6 engineers and 1 technician.
- Growing and in the process of spinning off first technology.

Mission Statement:
Innovative Energy Solution is dedicated to developing innovative, robust, and cost efficient solutions for the global energy sector.

Goals:
Provide our customers with a single yet simple solution for solving multiple problems.
Position

Focused portfolio of unique thermal-based solutions in renewable and non-renewable hydrogen generation

- Superadiabatic autothermal reforming (SuperATR)
- Charge induced gasification (CIG)
SuperATR (Green Pasture Energy)

Spinning off GPE to help refineries and natural gas plants decrease utility costs and emission footprints with tri-generation:
- Hydrogen: refinery off-gases, residual fuels (very cheap), hydrogen sulfide (waste)
- Cogeneration: Electricity and steam
- Emissions: Carbon (reduce and/or capture), NO$_x$ and SO$_x$ reduction

Two pilot units at the primary laboratory in Highland (IN)
Conventional Partial Oxidation (fluidized bed, entrained flow)

- **High capital cost**: cryogenic oxygen generation, large reactors, gas clean-up.

Conventional Partial Oxidation (continued)

- **High operating costs**: large quantities of oxygen and fuel to generate high temperatures.

Operating Cost Breakdown

- ASU: 2%
- Coal Handling: 82%
- Gasification Block: 5%
- Gas Cleanup: 5%
- Balance of Plant: 2%
- Power Generation: 4%

Hybrid Plasma / Partial oxidation

- **Gliding arc plasma**: a crossbreed between thermal (equilibrium) and non-thermal (non-equilibrium) plasma.
- **Ultra-substoichiometric partial oxidation**: Less oxygen consumption. Operation (biomass) has less nitrogen in product.
- **High efficiency**: Reduces oxygen usage.
- **Catalytic effect**: Speed reactions (smaller reactor)

Gliding Arc Plasma Discharge (very different from normal plasma)

- **Part thermal**: for stability and high pressure operation.
- **Part non-Thermal**: Offers good catalytic potential for high selectivity.

Radical concept...but also challenging.
CIG Concept

Catalytic Effect for speeding reactions

- *ions*: for creating catalytic surfaces.
- *electrons*: for radical generations.

![Diagram showing the catalytic effect of CIG Concept](image-url)
Unique design being developed:

- Coal, biomass, refuse
CIG In Operation
**Power Input**

- Chemical Power: greater than 91%
- Electric Power: less than 9%
Hydrogen Production

Initial testing with methane
• Hydrogen production increased by almost 3x
• Ultra-substoichiometric operation

<table>
<thead>
<tr>
<th>Experimental Conditions</th>
<th>H₂ Production (% of Exhaust Flow)</th>
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</thead>
<tbody>
<tr>
<td>Flame only</td>
<td>C/S = 8.47</td>
</tr>
<tr>
<td>Flame with Steam</td>
<td>C/S = 10.33</td>
</tr>
<tr>
<td>Plasma with Steam</td>
<td>C/S = 12.95</td>
</tr>
<tr>
<td>Plasma</td>
<td>C/S = 1.25</td>
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</tbody>
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Plasma Benefit (higher overall efficiency)
• Decreased oxygen usage (C/O >> 1)
• Air operation much more viable
Commercial Outlooks

Mini gasifiers: < 100 kW
• Wastes from processing plants and farms

Small gasifiers for distributed generation: ~ 1 MW
• Refuse from large military installations
• Agricultural residue from small farm communities
• Dust from saw mills

Cogeneration (electricity and steam) units: ~ 10 MW
• Refuse from transfer stations
• Agricultural residue from very large farm communities
• Pulp and paper mills
• Waste coal and fines in upgrading operations

Large gasifiers: > 100 MW
• Refinery hydrogen from petroleum coke
• Power generation from integrated gasification combined cycle
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