Tailor-Made PlascoSyngas™ obtained from heterogenous flows of feedstock as a Precursor to H₂ and Other Fuels

Global Syngas Technologies Conference– October, 2019
Plasco is a Canadian company that has developed the GPRS™ technology to convert heterogeneous streams of waste into a stable, tailor-made clean syngas (PlascoSyngas™) and a vitrified valuable material (PlascoRock™).

This disruptive technology was successfully proven in a commercial sized plant treating 135 tpd of bulk waste diverted from the landfill of Trail Road, Ottawa.

PlascoSyngas™ can substitute economically for natural gas in many industrial uses as well as being a precursor to H₂ and other chemicals, contributing to global decarbonization. Fly ash can also economically be converted into useful PlascoRock™ enabling incinerators to enhance their circular economy practices.
Plasco GPRS™
(Gasification and Plasma Refining System)

PROVEN AT COMMERCIAL SCALE

Renewable resources

Complete Conversion of Waste to Value closing the loop of the CIRCULAR ECONOMY practices

PLASCO®Syngas™
PLASCO®Rock™

Process with NO EMISSIONS and NO RESIDUALS
Plasco Gasifier

Gasifier designed and patented by Plasco for random waste to pristine tailor-made PlascoSyngas™

Grate-based converter accepts random waste, removes water, gasifies volatiles with recycled heat.

The grate discharges char into the CRV, where Fixed Carbon is removed to generate CO, H₂ and CH₄ fuel, and inorganics are melted.

- Syngas conversion efficiency 74%-90%
- ~90% of this energy in syngas as chemical energy
- ~10% in sensible heat from excess air at 650°C to 800°C

Particulate is reintroduced into the gasifier; no fly ash or char for disposal.

Bottom ash of the CRV goes towards the SRM to be superheated, then quenched into vitrified PlascoRock™
Plasco GPRS™
(Gasification and Plasma Refining System)

Plasco Trail Road, Ottawa

More than a decade of making value from waste …
✓ Founded in the 1980s using NASA technology.
✓ Pilot plant in Spain 2005-2008 treating MSW.
✓ 135 tpd development and demonstration plant operated at Plasco Trail Road from 2007-2014
✓ $407M USD, 1.2M person-hours invested
✓ Operated on unsorted “black-bag” waste diverted from landfill with minimal preparation.
✓ PlascoSyngas™ powered Jenbacher IC engines for several thousand hours with no overhauls
✓ No poisoning of platinum/rhodium catalysts by syngas.
✓ Never failed a source test
✓ 200 GB of data
✓ Extensive due diligence led to technology performance insurance from New Energy Risk (AXA).
A tailor-made and clean Syngas
Adjustable PlascoSyngas™ Composition

Typical PlascoSyngas™ LHV vs. Mol%, with water and carbon dioxide removed

- Carbon Monoxide
- Methane
- Hydrogen
- Nitrogen
- NMHCs

LHV (MJ/Nm3) vs. Mol%
What does Clean Syngas mean?

- No Tar
- No Metals
- No Particles
- Low Sulfur content
- Low Nitrogen content
- Low Chlorine content
• Controlled LHV from 4.0 to 10.4 MJ/Nm$^3$
• Tars reduced by >99.95%
• Hazardous compounds broken down by plasma catalysis
• pH balanced
• Sulfur removed to low levels
• Particulate and aerosols removed to submicron levels
• Dioxins and furans below Level of Quantification
• Pressure regulated
• Temperature and relative humidity tightly controlled
1. Tars cracked using partial oxidation and plasma catalysis in patented configuration, followed by at least 5 seconds of residence time. Plasma also breaks down hazardous compounds. Plasma is not used to gasify, so parasitics are low.

2. Remaining tars are removed from syngas with quench, Venturi, spray tower, chilled scrubber, WESP and carbon bed.

3. Tars and particulate are recirculated in water distilled from the syngas and removed with filter presses.

4. Filter press cake is reintroduced into the process.

5. Result: 99.95% removal of tars from the syngas. Remaining tars in the syngas are mostly naphthalene (C_{10}H_{8}). With reheat from syngas blower, will not condense prior to use.
# Low Syngas Contaminant Levels

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>Basis of design for MSW, taken from data at Plasco Trail Road</th>
<th>Mitigation if too high for downstream processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total sulphur</td>
<td>40.8</td>
<td>Change parameters in SulfCat® removal system</td>
</tr>
<tr>
<td>COS</td>
<td>31.7</td>
<td>Add a COS removal step to the GQCS</td>
</tr>
<tr>
<td>(\text{H}_2\text{S})</td>
<td>0.014</td>
<td>Change parameters in SulfCat® removal system</td>
</tr>
<tr>
<td>(\text{HNO}_3)</td>
<td>35.9</td>
<td>Change parameters in GQCS</td>
</tr>
<tr>
<td>PAH main naphthalene (\text{C}_{10}\text{H}_8)</td>
<td>&lt;27&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Reduce the temperature at the exit of the HCl spray tower.</td>
</tr>
<tr>
<td>Particulate matter</td>
<td>&lt;10</td>
<td>PM removed to submicron level with WESP, can be further reduced with HEPA filtration for severe applications like low-level radioactive waste.</td>
</tr>
<tr>
<td>(\text{HCl})</td>
<td>0.24</td>
<td>Change parameters in GQCS</td>
</tr>
<tr>
<td>HF</td>
<td>ND</td>
<td>Not required</td>
</tr>
<tr>
<td>Halogenated Hydrocarbons</td>
<td>ND</td>
<td>Not required</td>
</tr>
</tbody>
</table>

<sup>1</sup> Expressed in mg/Rm<sup>3</sup>

<sup>2</sup> 99.95% reduction from levels in syngas prior to plasma refining
Dioxin and Furan Formation Avoided

- Oxygen starved process.
- Syngas heated to 1100°C for 5 seconds minimum.
- Quench in water from 550°C to 70°C in 0.19 seconds or less to prevent *de novo* formation. Particulate removal means fewer points for D&F formation to initiate.

**RESULTS**
- Dioxins and Furans consistently less than 1.0 pg/Rm³ I-TEQ.
- **No need to remove D&F.**
- GPRS can deal with difficult wastes with high plastics and other sources of halogens.
An Universe of Applications
1. Far less expensive than cost of producing hydrogen by electrolysis
   • 1/6 of electrical consumption of electrolysis per kg of H$_2$
   • "Green" H$_2$ can be made from biomass or biogenic waste
   • Gate fees for MSW, RDF, certain plastics markedly improve revenues
2. Omnivorous - uses minimally prepared MSW, Biomass, RDF
3. Very clean syngas, consistent, predictable
4. Ultra-low tars and contaminants – best in class
5. Complete diversion of waste from landfill
6. Proven at commercial scale
7. Oxygen and steam can be varied to tailor composition over a very wide range
8. High conversion efficiency, low parasitic power usage
9. Excess hot process air up to 800°C for downstream processes
10. Can operate at turndown
11. Small footprint
12. Modular and repeatable
Bécancour, Québec “Green” Hydrogen Project

• As announced on Radio Canada and in local news last month, H2V Énergies is planning a green hydrogen plant to be built in the industrial park in Bécancour, Quebec.

• The plant will convert 720,000 tpy of biomass to ultra-pure syngas using the Plasco GPRS™ technology. The syngas will then be converted to 50,000 tpy of hydrogen using water-shift and steam reforming.

• FEED will take place in Q4/2019, with construction and commissioning to follow, and production to commence in 2022.
### Typical Leachability

<table>
<thead>
<tr>
<th>Element</th>
<th>Slag Concentration</th>
<th>Slag Leachate</th>
<th>Ontario Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>2.2</td>
<td>ND</td>
<td>2.5</td>
</tr>
<tr>
<td>Barium</td>
<td>1,855</td>
<td>0.065</td>
<td>100</td>
</tr>
<tr>
<td>Boron</td>
<td>205</td>
<td>ND</td>
<td>500</td>
</tr>
<tr>
<td>Cadmium</td>
<td>1.3</td>
<td>ND</td>
<td>0.5</td>
</tr>
<tr>
<td>Chromium</td>
<td>290</td>
<td>ND</td>
<td>5</td>
</tr>
<tr>
<td>Copper</td>
<td>840</td>
<td>0.08</td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>54,670</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>Lead</td>
<td>118</td>
<td>0.015</td>
<td>5</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.29</td>
<td>ND</td>
<td>0.1</td>
</tr>
<tr>
<td>Nickel</td>
<td>44</td>
<td>0.075</td>
<td></td>
</tr>
<tr>
<td>Selenium</td>
<td>0.51</td>
<td>ND</td>
<td>1</td>
</tr>
<tr>
<td>Silver</td>
<td>0.35</td>
<td>ND</td>
<td>5</td>
</tr>
<tr>
<td>Zinc</td>
<td>370</td>
<td>0.035</td>
<td></td>
</tr>
</tbody>
</table>

**ASTM 1311**

*mg/litre – fully crushed sample, water granulated*

### Uses

- Abrasive blasting medium
- Cement industry
  - Cement substitute
  - Aggregate for concrete
- Addition to asphalt in pavement
- Precursor to rock wool
Particulate Removal to Submicron Level
NOTHING FOR DISPOSAL

All particulate is vitrified. GPRS is ideal for hazardous waste and low-level radioactive waste.
Thank you for your attention
Adjustable PlascoSyngas™ Composition

Typical PlascoSyngas™ LHV vs. Mol% 

Typical PlascoSyngas™ LHV vs. Mol%, with water and carbon dioxide removed
Results of ASPEN Simulation of Conversion of RDF Streams to PlascoSyngas™ using the Plasco GPRS
Comparative of Results (i)

Figure 1 - Inputs to Plasco GPRSTM for 10% Moisture RDF

Figure 2 – Inputs to Plasco GPRSTM for 30% Moisture RDF
Comparative of Results (ii)

Figure 5 - Mol% of Principal Gases in PlascoSyngas for 10% Moisture RDF

Figure 6 - Mol% of Principal Gases in PlascoSyngas for 30% Moisture RDF