MICROPOWER TC
Waste-to-Carbon (W2C) & Waste-to-Energy (W2E) Power Plants
Enormous Waste + Energy Problems Create Opportunity for Innovative Integrated Solutions

**Enormous “Waste and Environmental” Challenges**

- Enormous biomass/waste problems
- Increasing population
- Increasing urbanization
- Improving “standards of living”
- Landfill Issues
- Landfill closure issues
- Green house gas emissions
- Significant health and human problems

**Enormous “Energy” Challenges**

- Dependence on fossil fuels
- Increasing dependence on foreign oil imports
- Insatiable need for ever increasing electricity and power
- Improving energy security
- Global climate change mitigation
- Aging central power plants
- Untapped renewable energy resources

Opportunity for Next Generation State-of-the-art Waste Transformation Solutions
Biomass Waste to Carbon (W2C) and Waste to Energy (W2E) Platforms

- Municipal Waste
- Tires Waste
- Sewage Sludge
- Construction & Demolition Waste
- Plastics
- Medical Waste
- Animal Waste
- Industrial Waste
- Agricultural Waste
- Wood Waste
- Paper Waste
- Yard Waste
- Food Processing Waste
- Forestry Waste

- 1 Ton of MSW = ~ 480 kWh to 550 kWh
- 1 Ton of MSW avoids importing 0.75 to 1 Barrel (30 to 42 gallons) of oil
- 1 Ton of MSW avoids mining 1/3rd to 1/4th ton of coal
- 1 Ton of MSW avoids 1.3 Tons of CO2
Next Generation Waste to Carbon (W2C) and Waste to Energy (W2E) Power Plants

**W2C System**
- Biomass Waste
  - Agricultural Waste
  - Forestry Waste
  - Wood Waste
  - Yard Waste
  - Food and Food Processing Waste

**Primary**
- Biocarbon
- Biocoke
- Biochar or Biocoal
- Carbon Black

**Secondary**
- Bioenergy (Power)
- Sterile Ash

**Carbon**

**W2E System**
- Solid Waste
  - Municipal Solid Waste
  - Tires
  - Sewage Waste
  - Liquid Waste
  - Medical Waste
  - Plastics

**Primary**
- Bioenergy (Power)
- Sterile Ash

**Secondary**
- Biocarbon
- Biocoke
- Biochar or Biocoal
- Carbon Black

**Energy**
The Next Generation Waste Transformation Technologies
Biomass Waste to Carbon (W2C) Platform &
Waste to Energy (W2E) System

Guiding Principles &
Waste Management Hierarchy

Core Guiding Principles

- Reposition
  - Change the perspective for the way “we look at wastes”
  - Treat them as Assets rather than liabilities

- Transform
  - Transforms the “wastes” into value added products

- Recover
  - Recover the “values” and generate clean renewable energy
  - Focus on recovering Carbon & Energy

- Restore
  - Restore our environment – land, sea and air

Waste Management Hierarchy

Reduce
Reuse
Recycle
Reposition, Transform, Recover, Restore
Landfill
Over $9 billion was invested in new build waste to power facilities in 2010, largely in Brazil, Europe, and Asia. China is currently the largest investor in the sector with over 70% of new commitments in H2 2010.

According to the latest IEA assessment, global biomass and waste to power generation capacity is expected to grow 6% annually thru 2035 with 30GW of new generation capacity forecast for the US alone.

Biomass and Waste to Energy New Build Investment
(source Bloomberg New Energy Finance)

Global Biomass and Waste to Power Generation Capacity
(source IEA's WEO2010 Forecasts)
Strict emission standards, high tipping fees, tax credits driving opportunities in the US

- The number of waste to power facilities in the US has fallen from over 180 in the 1980s to around 90 today due to a heavy historical reliance on dirty, inefficient incinerators that can no longer meet emission standards.

- Tipping fees for municipal solid waste (MSW) are continuing to rise in line with EPA forecasts for waste generation, creating an opportunity to lock in long-term inflation adjusted contracts for MSW feed stocks.
Global Solid Waste-to-Energy Market & Opportunity for Innovative W2E Plants

- **Landfill**: 1.2 B Tons
- **Recycle/Compost**: 0.7 B Tons
- **WTE**: 0.2 B Tons

Global Waste-to-Energy Industry projected to be $28.8 Billion by 2015!

- **US**: ~ 87 W2E plants
- **Western Europe**: ~ 400 W2E Plants
- **Asia**: ~ 300 W2E Plants
Currently 87 W2E plants in US in 31 states
- Mostly combustion plants with 20-25+ year-old technology
- Process only 12-13% of solid wastes in US and generate 2,700 MW of electricity
- Lagging behind Japan and Europe

- Expensive - Higher $/MW
- Not modular or scalable
- Not decentralized
- Not distributed
- Not adaptive
- Not sustainable
- Perceived to be not environment-friendly

Opportunity for next generation, state of the art Waste Transformation Platforms
## Technology Comparison

<table>
<thead>
<tr>
<th>Process Description</th>
<th>Incineration</th>
<th>Anaerobic Digestion</th>
<th>Arc Plasma Gasification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MICROPOWER TC Gasification</strong></td>
<td>Waste fuel is directly combusted to produce heat</td>
<td>Biodegradable waste is broken down by micro-organisms to produce a methane rich biogas</td>
<td>Waste feedstock is converted at very high temperatures with controlled amount of oxygen to produce syngas</td>
</tr>
<tr>
<td>Waste feedstock is converted at moderate temperatures with controlled amount of oxygen to produce syngas</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale</td>
<td>Decentralized, 300tpd, scalable modular 10-12 MW units, small footprint, $37- $41 MM/facility</td>
<td>Decentralized, &lt;100tpd, difficult to scale under 50MW, large footprint, requires large amounts of waste, $250-500MM/facility</td>
<td>Centralized, &gt;1000tpd, difficult to scale under 50MW, large footprint, $400-500MM/facility</td>
</tr>
<tr>
<td>Conversion Efficiency</td>
<td>Less than 60% of energy content of waste is used to make electricity</td>
<td>Less than 35% of energy content of waste is used to make electricity</td>
<td>Less than 50% of energy content of waste is used to make electricity</td>
</tr>
<tr>
<td><strong>Conversion Efficiency</strong></td>
<td>90% of energy content of waste is used to make electricity</td>
<td>90% of energy content of waste is used to make electricity</td>
<td>90% of energy content of waste is used to make electricity</td>
</tr>
<tr>
<td>External Fuel Source</td>
<td>Powered by self-generated clean energy</td>
<td>Low operational power costs</td>
<td>Typically uses high voltage electrical power from the grid reducing net energy output</td>
</tr>
<tr>
<td><strong>External Fuel Source</strong></td>
<td>Typically powered by fossil fuels reducing net energy output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emissions</td>
<td>Pollution-laden process requiring large investment in pollution control</td>
<td>Odor issues a persistent problem for local communities</td>
<td>Cumulative emissions tend to be high due to the size of the facilities</td>
</tr>
<tr>
<td><strong>Emissions</strong></td>
<td>Surpasses all US and European Air Quality Standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process By-product</td>
<td>Waste is reduced 98% with sterile bottom ash being the only by-product</td>
<td>Waste largely remains in landfill</td>
<td>Waste is reduced by 90% with a dense, solid slag material remaining</td>
</tr>
<tr>
<td><strong>Process By-product</strong></td>
<td>Waste is reduced 70% with toxic ash and slag still requiring disposal</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
W2C/W2E Competitive Advantages Over Combustion/Incineration Technologies

• State-of-the-Art technology
• Moderate Temperature Advanced Pyrolytic Gasification Process
• Oxygen-Starved
• Runs Clean
• 98% volume reduction (for W2E systems)
• 2% Sterile Ash without any dross, clinkers or slag
  • Can be used as valuable byproduct
• Resource Recovery
  • All ferrous and glass materials recycled after processing
• Manages contaminants before they become emissions

Not Combustion or Incineration
Step 1 - MSW is loaded at a waste-to-energy plant into 25 ton (50 tons/day) advanced, specially designed waste transformation modules;

Step 2 - The waste is then heated and then gasified (cooked slowly) in an oxygen starved, pressure and temperature controlled, fully automated environment to chemically transform the waste to energy-rich syngas and sterile ash (2% to 10% of original volume);

Step 3 - Syngas is then cleaned and ignited into a conventional water tube boiler to generate steam;

Step 4 - Steam then turns a turbine and generates clean green energy
MICROPOWER TC Process Flow

**Feedstock**
- **Carbon Focus**
  - Agricultural
  - Forestry
  - Wood Chips
  - Paper waste
  - Food waste
  - Yard waste

- **Energy Focus**
  - MSW
  - Tires
  - Sewage Sludge
  - Liquid waste
  - Industrial
  - Plastic

**Waste Transformation Module**
- Slow, Moderate Temperature
- Two Stage, Pyrolytic/Gasification Technology
- 400 °C – 500 °C, 1000 °C – 1200 °C

**Fly Ash Removal**

**Steam Production & Heat Recovery**

**Power Generation & Steam Condensing**

**Flue Gas Conditioning & Emission Control**

**Energy Output**
- Carbon Products
- Sterile Ash

**Flue Stack**
- Energy
- Heat Exchanger

**Energy Focus**
- Agricultural
- Forestry
- Wood Chips
- Paper waste
- Food waste
- Yard waste

**Carbon Products**
MICROPOWER TC Technology

- The waste transformation process starts with untreated municipal, industrial, forestry, agricultural or medical waste being bulk-loaded into the **waste processing modules**.

- Once loading is complete, the gasification process occurs in the absence of oxygen at the relatively moderate temperatures of 600-800°C. The modules **automated control system** uses over 600 sensors to monitor temperature, emissions, airflow, and pressure during the conversion process.

- The waste is reduced by 98 percent, leaving only a residue of sanitized, **non-toxic sterile fly ash** that can then be sold as an additive for concrete or as an amendment for asphalt.

<table>
<thead>
<tr>
<th>Waste Processing Modules</th>
<th>Automated Control System</th>
<th>Non-toxic Sterile Fly Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.jpg" alt="Image of waste processing modules" /></td>
<td><img src="image2.jpg" alt="Image of automated control system" /></td>
<td><img src="image3.jpg" alt="Image of non-toxic sterile fly ash" /></td>
</tr>
</tbody>
</table>
Although the waste is processed in an undisturbed state, small particles of fly ash and other impurities may exist within the syngas and need to be removed.

The MICROPOWER TC technology uses a Venturi Cyclone to condition the syngas, which relies on particle density and velocity to separate out the fly ash and other impurities.

Filters may also be used to capture the smallest of particles in order to enhance the quality and combustibility of the syngas.
During the steam production phase, the syngas is ignited and the heat is transferred through the walls of sealed water tubes to produce steam.

The boiler also recovers heat from other areas within the system to preheat the water source, increasing system output.

The steam produced by the **watertube boiler** is then pressurized and superheated to turn the steam turbine and produce electricity.
The Packed Bed Scrubber, or **Thermal Oxidizer**, is designed to remove gaseous or vaporous pollutants from an air stream.

The process is accomplished by contacting the contaminated air stream with a scrubbing liquor that absorbs or chemically reacts with the pollutants.

The cleaned air is then discharged to the atmosphere and the contaminated scrubbing liquor is either disposed of in an approved manner or recycled.
During the energy output phase the **steam turbine generator set** produces electricity that is then exported to local distribution networks.

- The output can also be exported as heat to local industrial users.
- The system's heat exchanger also works to capture any residual heat from the waste stream so that it can be looped back into the system.
Advanced gasification system delivers clean energy that meets or surpasses all US EPA standards.

### Emission Profile

<table>
<thead>
<tr>
<th></th>
<th>US EPA Requirements</th>
<th>MICROPOWER TC System Rating *</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dust</td>
<td>0.03</td>
<td>0.013</td>
<td>gridsci</td>
</tr>
<tr>
<td>Hydrogen Chloride</td>
<td>25</td>
<td>7.12</td>
<td>ppm</td>
</tr>
<tr>
<td>Hydrogen Fluoride</td>
<td>no standard</td>
<td>none detected</td>
<td></td>
</tr>
<tr>
<td>Sox</td>
<td>50</td>
<td>5.44</td>
<td>ppm</td>
</tr>
<tr>
<td>Nox</td>
<td>150</td>
<td>30.74</td>
<td>ppm</td>
</tr>
<tr>
<td>CO</td>
<td>150</td>
<td>3.73</td>
<td>ppm</td>
</tr>
<tr>
<td>CO2</td>
<td>359</td>
<td>54</td>
<td>ppm</td>
</tr>
<tr>
<td>VOCx</td>
<td>150</td>
<td>21</td>
<td>ppm</td>
</tr>
<tr>
<td>Dioxin and Furans</td>
<td>125</td>
<td>2.71</td>
<td>mg/cft</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.08</td>
<td>0.05</td>
<td>mg/m³</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt; 0.2</td>
<td>0.07</td>
<td>mg/m³</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.02</td>
<td>0.01</td>
<td>mg/m³</td>
</tr>
</tbody>
</table>

In 2003, EPA named WTE one of the cleanest sources of energy.
(US Environmental protection Agency 2003, [www.wte.org/docs/epaletter.pdf](http://www.wte.org/docs/epaletter.pdf))
W2C Platforms/W2E Systems – Proven Technology!

- Reposition
- Transform
- Recover
- Restore

**Feedstock Processing**
- Modular
- Scalable
- Adaptive
- Base Module 50 TPD
- W2C – Standard System 150-200 TPD
- W2E – Standard System 200-300 TPD

**W2C/W2E Platform**
- Small Footprint
  - 10,000 sq ft/module
- Decentralized
- Distributed
- Optimized for Low Cost & Efficiency
- Long Life
- Automated
- Controlled
- Monitored
- Sustainable
- Environment-Friendly

**Valuable BioProducts**
- Per Module
  - 25-30 TPD Biochar
  - 25-30 TPD Biocarbon
  - 25-30 TPD Biocoke
  - 20-25 TPD Carbon Black
- Per System
  - 75-120 TPD Biochar/Biocoke/Biocarbon
  - 60 – 100 TPD Carbon Black
- W2C - 2 MW
- W2E – 10 MW!
  - 98% Conversion
  - 2% Sterile Ash

**FOCUS**
- Carbon / Energy

Reposition
Transform
Recover
Restore
## W2C/W2E Platforms

### Five Valuable Bioproducts – Broad Applications and Their Value Ranges

<table>
<thead>
<tr>
<th>Bioproduct</th>
<th>Applications</th>
<th>Value Range</th>
</tr>
</thead>
</table>
| **Biochar/ Biocoal** | - Soil Amendment  
                  - Cooking  
                  - Sequestering Carbon  
                  - Co-firing | $100-$200/Ton  
(for soil amendment)  
$200-$300/Ton  
(for biocoke & cooking) |
| **Biocoke** | - Replace up to 20% of Bituminous Coke for GHG Reduction  
                  - Fuel for Sintering & Pelletizing  
                  - Reductant | $200-$300/Ton (ready to be activated) |
| **Biocarbon** | - Mercury scrubbing from coal fired power plants  
                  - Gas and Chemical Refinement  
                  - Metal extraction | $250-$500/Ton (Activated Carbon) |
| **Carbon Black** | - Tires in Rubber and Auto industries  
                  - Toners, Ink & Paints  
                  - Plastic industry | $400-$800/Ton |
| **Bioenergy/ Power** | - On-Grid Power Generation  
                      - Feed-in Tariff  
                      - Net Metering | $60 - $120/MWh (Varies from state to state) |

**Agriculture, Cooking**  
**Metallurgy**  
**Gas, Air & Water Filtration**  
**Industrial**  
**Power Utilities**
W2C Platform/W2E System
Revenue Generation Model

Tipping Fees *

- MSW $25 - $30/Ton
- Tires ~ $70 - $80/Ton
- Wood Chips ~ $25-30/Ton
- Sludge Cake ~ $50/Ton
- Others Vary

Valuable Byproducts

- Biocarbon (Ready to be Activated)
- Biocoke
- Biochar
- Carbon Black
- Power
- Sterile Ash ~ $10 - $20/Ton
- Ferrous Metals - Varies

Investment Credits

- Investment Tax Credit (if applicable)
- Carbon Credit
- Renewable Energy Certificates (REC)
- Others

• Attractive Financial Model (2 key components)
  • Tipping Fees cover debt financing payments

* Tipping fees model for US
## W2C/W2E System Cost - Financial

<table>
<thead>
<tr>
<th>Components</th>
<th>W2C System</th>
<th>W2E System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base System</td>
<td>200 TPD/2MW</td>
<td>300 TPD/10 MW</td>
</tr>
<tr>
<td>Basic System Cost ($mm)</td>
<td>10</td>
<td>29</td>
</tr>
<tr>
<td>Site Development Cost + Installation Cost ($mm)</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>6-Months Working Capital ($mm)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total Cost ($mm)</td>
<td>15</td>
<td>37</td>
</tr>
<tr>
<td>Debt Interest Payment *</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Break Even Period</td>
<td>3-5 Years</td>
<td>3-5 Years</td>
</tr>
</tbody>
</table>

- Requires $350K of readiness assessment fee up front that can be credited towards the final purchase
- Crucial to do feedstock, site assessment & determine the optimum system configuration & final cost

* Financing terms and duration depends on each specific situation
Differentiated Value Propositions of W2C Platforms & W2E Systems

- **Economic**
  - Low Cost

- **Flexible Waste Processing**
  - Various Feedstock types

- **Flexible Bioproducts**
  - Biochar, Biocarbon, Biocoke, Carbon Black & Bioenergy

- **Scalable**
  - Modular, Adaptive and Customizable per Site

- **Decentralized**
  - Small Footprint

- **Distributed**
  - Located Close to the Source

- **Environment-Friendly**
  - Meets or Beats all EPA Emission Standards

- **Proven Technology**
  - Operation for 10 Years

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**Next Generation**

Waste Transformation Platforms
Precedent-Setting Environmentally
“In our opinion, the capability to provide heated air to the units should allow a shorter residence time to process a batch than a system using ambient temperature air...Further, the gas cleanup technology appears to be robust and could set a needed precedent in the industry by providing significant cleanup before combustion.”

Best Practices
“In our opinion, this technology, especially for treatment of municipal solid waste, could be considered “best practices” gasification around the world as it gains additional commercial operating experience across the overall market.”

High-Level Assessment
“The Technology Developer has incorporated certain innovative designs that have the potential to optimize the production of syngas from MSW and has demonstrated a good understanding of the gasification field as a whole. At a high level, nothing came to our attention to indicate a fatal flaw with the Technology Developer’s approach. The Technology Developer’s next step is pilot-scale testing, followed by more detailed due diligence review of technical design details

... SAIC Energy, Environment & Infrastructure, LLC
E. Larry Beaumont, P.E. Senior Project Manager

* December 5, 2011, High-Level Review of Cocurrent Gasification Technology, SAIC
MICROPOWER TC Build Out Methodology

**Plan**

**Readiness Assessment**
- Questionnaire
- Preliminary feedstock testing
- Preliminary system configuration
- Final review of financial model and pro-forma
- Statement of work issued

**Discovery and Design**
- Full-scale feedstock testing
- Site review and analysis
- Engineering and construction requirements
- System Configuration and customizations
- Project plan

**Pre-configuration and Staging**
- Planning and scheduling
- Facility construction and procurement
- Fabrication
- Pre-testing and quality review
- Factory acceptance testing
- Breakdown and packaging
- Shipping and logistics

**Installation and Training**
- Site assembly
- Feedstock production testing
- Performance testing
- System certification
- System and operations training
- System maintenance training

**System Acceptance and Go-Live**
- Final quality review
- System sign-off
- System go-live
- Production

**Deliver**

**Support**

**System Care**
- Technical Support
- Service and Maintenance
- Upgrades and additions
W2C/W2E Summary

- Next Generation, State-of-the-Art, Disruptive and Innovative Waste Transformation Technology
- Superior, Cost effective and Environment-Friendly
- Designed to Address Enormous Problem of Increasing Waste & Energy
- Reduce Green House Gas emissions, Protect the Environment
- Generate Valuable Clean Energy, Provide Energy Security
- Small Footprint - Ideal Decentralized, Distributed Operation
- Create Financial Revenues
  - Help Local Economies – Create Jobs
- Help achieve Self-Sustainable Goals
- Attractive Business Model - Quick Return on Investment
  - Break-Even Period 3 to 5 years