Potentials of Hydrothermal Carbonisation Technology
Ingelia’s Profile

Ingelia was established in Spain in 2005. It started to develop HTC technology in 2007.

The first industrial plant working in continuous process with HTC technology has been commissioned in Valencia in 2010.

Patents on the process have been granted to Ingelia in Spain, USA, Mexico and Russia and they are ongoing at last stage in Canada, European Union and other territories.

Ingelia has been awarded with several recognitions to innovation and sustainability, among others:

- Ulyses Prize from UNWTO in 2011 to innovation on tourism sector
- Perseo Prize (Iberdrola group) in 2011 to Innovation on biomass sector
- Finalist Clean Tech Open in Spain in 2012
- El Mundo Prize (Il Corriere della Sera group) in 2013 to innovation
- EUBIA Award in 2015 for the advancement of biomass industry

European Comission Support:

- FP7 Newapp Project: Financing to research of new applications of HTC technology and products in 2013
- H2020 SME Instrument: Financing of Business Plan to deploy the technology in 2014
The Hydrothermal carbonization has several advantages as a way to carbonize biomass

- The great advantage of this process is that it takes place in a water solution, so **humidity of biomass is not a problem**
- **No toxic waste product**, excess of process water contains soluble components which have fertilizer effect on plant growing, like N, K, and Fe,
- **Exothermic reaction**, thermal energy consumption very low, mainly for start up
- HTC Biocoal **concentrates almost all carbon molecules** present in original biomass
- HTC Biocoal is very **low in hydro-soluble chemicals** (which are washed away with the water) such as sulfur, chlorite and potassium

Source: Global Sustainability, a Nobel Cause, 2010. Cambridge University, Ingelia research
Ingelia has been involved with current leading researchers in the topic

- The process was first described by Friedrich Bergius in 1913


- Since 2009, Ingelia pursue its research agenda on the subject with the support of the Instituto de Tecnología Química integrado (ITQ) of the Polytechnic University of Valencia and the CSIC, under the direction of Prof. Avelino Corma
Process characteristics

Waste

- Wet biomass
  - 30%-80% moisture

- Avoiding CO₂ emissions
- Waste management reduction cost

180°C-200°C
18 bar
Without emissions

Process HTC (6-8 hours)

Products

- HTC carbón with <5% water
- Process liquids

Sustainable:
- Waste valorization without emissions

Innovative:
- Patented technology

Scalable:
- Treatment capacity is increased by increasing the number of reactors
  (Scalability risk is strongly reduced)

Comfortable:
- Fast and continuous operation
- Odor free and silent operation
- Controlled by a Scada program

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Ingelia has ground experience carbonizing several biomasses:

- Orange Peel
- Corn straw
- Rice Straw
- Sugar Cane Bagasse
- Onion Peel
- Pruning
- Sewage Sludge
- OFMSW

HTC allows to transform organic residues into a solid biofuel with high calorific value.

- Residues valorization
- Management cost

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Improvement of waste management

1. Solving odor problems
2. Hygenized products
3. Confined space
4. Waste transport reduction
5. Avoiding CO₂ emissions
6. Product for an available market
7. Cost of waste management is reduced
8. Attractive investment for privat investors reduces the public debt
9. Coherent with European Commission objectives

Following the directives of the European Union

Waste  Products
Ingelia’s biocoal from our Plant in Valencia – Spain

High density energy carrier: Concentrates energy from biomass, HCV > 24 MJ/kg* LCV > 23 MJ/Kg*

Presentation form for Coal: pellets, briquettes or powder

Low Sulphur < 0.3%*
Low Chlorine < 0.3%*

Nitrogen: 0.6% - 1.4% *
Hydrogen: c.a. 5.8%-6.2%*

Carbon Content: >60% *

1Tm bio-coal avoids about 2.2 Tm of CO₂ emissions to the atmosphere

Produced from from garden pruning with 50% humidity

Ashes variable depending on client needs down to less than 4% with a fusion point above 1250ºC

* On dry basis net of ashes

* Ingelia’s Copyright @2015
Liquid fertilizer

<table>
<thead>
<tr>
<th>Parámetros</th>
<th>promedio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Materia seca (%)</td>
<td>2,48</td>
</tr>
<tr>
<td>2. Sedimentos (%)</td>
<td>0,66</td>
</tr>
<tr>
<td>3. Mat.org.total (%)</td>
<td>1,66</td>
</tr>
<tr>
<td>4. Mat. Org.oxidable (%)</td>
<td>1,58</td>
</tr>
<tr>
<td>5. Carbono org.oxidable (%)</td>
<td>0,91</td>
</tr>
<tr>
<td>6. Extracto húmico total (%)</td>
<td>1,53</td>
</tr>
<tr>
<td>7. pH</td>
<td>6,09</td>
</tr>
<tr>
<td>8. Nitrógeno total (mg/kg)</td>
<td>490</td>
</tr>
<tr>
<td>9. N amoniaco (N-NH₄⁺) (mg/kg)</td>
<td>60</td>
</tr>
<tr>
<td>10. N nítrico (N-NO₃⁻) (mg/kg)</td>
<td>2,95</td>
</tr>
<tr>
<td>11. Relación C/N</td>
<td>19,75</td>
</tr>
<tr>
<td>12. Fósforo (P₂O₅) (mg/kg)</td>
<td>17,69</td>
</tr>
<tr>
<td>13. Potasio (K₂O) (mg/kg)</td>
<td>1306</td>
</tr>
<tr>
<td>14. Calcio (CaO) (mg/kg)</td>
<td>2326</td>
</tr>
<tr>
<td>15. Magnesio (MgO) (mg/kg)</td>
<td>511</td>
</tr>
<tr>
<td>16. Sodio (Na₂O) (mg/kg)</td>
<td>571</td>
</tr>
<tr>
<td>17. Boro (B)</td>
<td>2,86</td>
</tr>
<tr>
<td>18. Hierro (Fe) (mg/kg)</td>
<td>18,77</td>
</tr>
<tr>
<td>19. Cobre (Cu) (mg/kg)</td>
<td>0,14</td>
</tr>
<tr>
<td>20. Manganeso (Mn) (mg/kg)</td>
<td>2,62</td>
</tr>
<tr>
<td>21. Zinc (Zn) (mg/kg)</td>
<td>1,00</td>
</tr>
<tr>
<td>22. Níquel (ni) (mg/kg)</td>
<td>0,12</td>
</tr>
<tr>
<td>23. Plomo (Pb)(mg/kg)</td>
<td>0,04</td>
</tr>
<tr>
<td>24. Cadmio (Cd) (mg/kg)</td>
<td>0,00</td>
</tr>
<tr>
<td>25. Cromo (Cr) (mg/kg)</td>
<td>0,06</td>
</tr>
<tr>
<td>26. Conduc..electrica (dS/m)</td>
<td>11,38</td>
</tr>
</tbody>
</table>

Water with nutrients

N and K contents cover the fertilization needs

Valid for irrigation

Investigated by IVIA

We apply the liquid fertilizer for irrigation of orange trees since 2010

Research made by IVIA (Valencian Ministry of Environment)
HTC biocoal can compete in terms of LCV and density with some type of coals

<table>
<thead>
<tr>
<th>Typical properties of solid fuels, as supplied</th>
<th>Anthracite</th>
<th>Bituminous Coal</th>
<th>Lignite Briquettes</th>
<th>Peat Briquettes</th>
<th>Dry Wood Logs</th>
<th>Wood Pellets</th>
<th>BioCoal</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Moisture %</strong></td>
<td>4.5</td>
<td>7.5</td>
<td>18.5</td>
<td>11.5</td>
<td>18.5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td><strong>Ash %</strong></td>
<td>8.5</td>
<td>5</td>
<td>7.5</td>
<td>5</td>
<td>&lt;1</td>
<td>0.15</td>
<td>10</td>
</tr>
<tr>
<td><strong>Volatile %</strong></td>
<td>8.5</td>
<td>32.5</td>
<td>56.5</td>
<td>68</td>
<td>84</td>
<td>80</td>
<td>70</td>
</tr>
<tr>
<td><strong>Heat content</strong> kJ/kg</td>
<td>31.1</td>
<td>26.8</td>
<td>19.5</td>
<td>18</td>
<td>18.5</td>
<td>18.6</td>
<td>20</td>
</tr>
<tr>
<td><strong>Bulk kg/m³</strong></td>
<td>879</td>
<td>800</td>
<td>720</td>
<td>750</td>
<td>370</td>
<td>650</td>
<td>700</td>
</tr>
</tbody>
</table>

Source: CPL Industries
Carbon Taxes in Europe

**Ireland - Solid Fuel Carbon Tax**

- Leading the way in introduction of carbon tax.
- Introduced in the finance bill 2010.
- Partial exemption for biomass content announced in 2013 finance bill.
- c600k tonnes of coal burnt in domestic market.
- Carbon tax/gate fee environment market HTC products particularly competitive in the peat market.

<table>
<thead>
<tr>
<th>Ireland Solid Fuel Carbon Tax</th>
<th>Rate of Tax plus Vat per tonne from May 1st 2013</th>
<th>Rate of Tax plus Vat per tonne from May 1st 2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>26.33</td>
<td>52.67</td>
</tr>
<tr>
<td>Peat briquettes</td>
<td>18.33</td>
<td>36.67</td>
</tr>
</tbody>
</table>

**France - Carbon Tax**

- Initially implemented in 2014
- Principally a Lignite market
- CPL currently sell c25kt into this market
- Sharp increase planned through to 2016

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Lignite/Briquettes</td>
<td>20.38</td>
<td>42.28</td>
<td>64.17</td>
</tr>
<tr>
<td>Anthracite</td>
<td>21.28</td>
<td>44.18</td>
<td>67.05</td>
</tr>
</tbody>
</table>

Source: CPL Industries
The Project sustainability
Ingelia Biorefinery concept

- Organic Waste valorization
  Reduction of waste management costs

- HTC Plant
  Green Investments

- Waste
  Location is important to reduce logistic costs

- Biocoal
  Renewable markets

- Industry/Energy
  Avoiding CO₂ emissions
  (2.2 tons CO₂ / ton biocoal)

Local Circular Economy

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Ingelia HTCC deployment strategy

Project deployment in:
- Spain
- Italy
- UK
- Poland

With different raw materials:
- Belgium
- France
- Spain

Biocoal commercialization
In the UK

First HTC Plant for organic waste treatment

Public Administration Role

Involvement in the project in order to follow the state of progress

New Standards and norms definition: Need to know well new products and processes

Plans elaboration for projects contributing to circular economy

Technology evaluation

Definition of financial instruments

Facilitate resources for project development
Next ongoing steps

**Technical**
Applications of technology and products to other sectors like Agroindustrial sector
New proposals for European projects for different uses of the biocoal
Other applications for the biocoal for industrial uses and soil ammelioration

**Commercial**
Strategic agreements with
   - Equipment Manufacturers
   - Waste managers
   - Product offtakers (coal, water fertilizer, etc...)

**Legal**
Direct participation with the technical committees to develope the new standards for HTC products and technology

**Financial**
Negotiations to finance the deployment of the technology in Europe
The biocoal is the main product generated from organic wastes. There are many forms to valorize the coal for energy, through combustion or gasification. Besides the properties as energy carrier, the biocoal is raw material for the following processes:

- Filter (of activated carbon)
- Dyestuffs
- Electrodes for Batteries
- Fuel cell
- Fotocatalizators

The biocoal or hydrochar, has good properties also for soil amelioration, due to its porous structure and its capacity to retain water and nutrients, in form of filter cake.

Source: Ingelia Italia
Conclusions

HTC process has three key advantages:

1. It can tap into a wide range of wet biomasses and generate value in the waste management sector
2. The process is very stable as it works at autogenous pressure
3. The hydrochar is quite homogeneous regardless of the type of input biomass, has good logistic properties and is easily recoverable

These characteristics make HTC technology a qualified way to take value from organic wastes
Thanks for your kind attention
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http://www.cplindustries.co.uk/content/cpl-ingelia

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