THE 3R PYROLYSIS TECHNOLOGY:
Economical conversion of brown coal to anthracite type clean coal by low temperature carbonization pre-treatment process

EUROPEAN UNION DG Energy and Transport
project results and achievements

Web: http://www.terrenum.net/cleancoal
TERRA HUMANA Clean Technology Engineering Ltd.
By Edward Someus
3R LOW TEMPERATURE CARBONIZATION

Key component: indirectly heated horizontally arranged rotary kiln. Characteristic: downsized reductive environment

- Material is separated in absence of air (in vacuum)
- Decomposition into gas vapours and a solid carbon char phase
- Hazardous air pollutants, such as S, Cl, Hg, are removed in the gas vapour phase and separately treated.

Fuel streams

Derived fuels  Coal  Biomass  Lignite  Organic Waste

3R value added process

Carbonization

Products

Recycled Energy  Clean Multi Fuel  Recycled byproducts

Input
40k tpa to 560k tpa

Technology
I. Grind and dry
II. Carbonize
III. Remove pollutants
IV. Reuse all streams

Output
1. Clean Multi Fuel
2. Recycled energy
3. Recycled byproducts

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The 3R PROCESS CONCEPTS

- Thermal Desorption Chamber: INDIRECT FIRED heat source used for primary desorption chamber, relatively low operating temperature.
- DOWNSIZED REDUCTIVE ENVIRONMENT.
- NON-DESTRUCTIVE AIR POLLUTION CONTROL DEVICES used.
- WASTE RESIDUAL MANAGEMENT: treatment of residuals is separate from the desorber. All outputs recycled and treated.
- DIRECT BURN OFF THE PYROLYSIS GAS-VAPORS – NO PYROLYSIS OILS.
- SELF SUSTAINING THERMAL PROCESS by recycling of the post burner’s hot flue gas energy.
THE 3R ANTHRACITE

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THE 3R TECHNOLOGY PERFORMANCE

✓ HORIZONTALLY ARRANGED INDIRECT FIRED ROTARY KILN provides a highly efficient and flexible thermal separation process into solid and gas phase.

✓ PROCESS PERFORMANCE WITH FLEXIBLE FEED CHOICE (with variations in flow, composition and concentration of toxic volatile input compounds).

✓ MODULAR SYSTEM DESIGN up to 70 t/h.

✓ LINK OR BOLT-ON to operating power plant as per local demand.

✓ CONTINUOUS OPERATION 7200 h/year.

✓ FULL AUTOMATIZATION.

✓ CONTAINING NO EXOTIC TECHNICAL SOLUTIONS and materials.

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THE „PRODUCT LIKE”
3R PILOT PLANT PERFORMANCE

✓ THROUGHPUT CAPACITY FROM 100 kg/h (depending on the feed characteristics).
✓ „PRODUCT LIKE” performance, suitable for industrial demonstration.
✓ COMPREHENSIVE SOLUTION, incl. feed system, indirectly heated pyrolysis reactor, post burner, heat exchangers, off-gas scrubber, process control and instrumentation.
✓ AUTOMATED OPERATION and pyrolysis process control software developed.
✓ Designed for CONTINUOUS OPERATION 6000 h/year.
PRE CONCEPT 3R RESEARCH PLANT
from the early development phase (1991)

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NEW GENERATION 3R PILOT PLANT
(Rotary kiln under manufacturing final phase)
3R POST BURNER (manufacturing phase)
INSTALLED 3R PYROLYSIS PILOT PLANT (2005)
POST BURNER 290 kW
POST BURNER INNER CHAMBER INSPECTION WINDOW AT OPERATIONAL TEMPERATURE 850 °C (2005)
MULTI VENTURI SCRUBBER

OFF-GAS TREATMENT
EMISSION CONTROL
BY THE UNIVERSITY OF ROSTOCK

Pressure difference
EMISSION CONTROL
BY THE CENTER FOR RESEARCH & TECHNOLOGY
AND THE ARISTOTLE UNIVERSITY OF THESSALONICA

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## COMPOSITION OF BROWN COAL AND CORRESPONDING 3R ANTHRACITE CLEAN COAL

<table>
<thead>
<tr>
<th></th>
<th>BROWN COAL</th>
<th>3R ANTHRACITE CLEAN COAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>&lt;20 %</td>
<td>&lt;1 %</td>
</tr>
<tr>
<td>Volatile Matter</td>
<td>30-35 %</td>
<td>&lt;5 %</td>
</tr>
<tr>
<td>Carbon</td>
<td>35 %</td>
<td>70-85 %</td>
</tr>
<tr>
<td>Ash</td>
<td>approx. 10-15 %</td>
<td>approx. 20-30 %</td>
</tr>
<tr>
<td>Sulphur</td>
<td>&gt;1 %</td>
<td>&lt;0.5 %</td>
</tr>
<tr>
<td>Energy content</td>
<td># 10 – 14 MJ/kg</td>
<td>&gt;27 MJ/kg</td>
</tr>
</tbody>
</table>

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PROCESS LIMITATIONS

✓ HIGH INPUT ASH content (over 18%).

✓ LOW SILICON CONTENT in feed. Low Si results in reduced ash softening point and causes slagging in the combustion chamber and fouling of the heat exchangers.

✓ HIGH INPUT MOISTURE content (over 18%), for which case pre dry is required.

✓ ADD-ON TECHNOLOGY NEEDED FOR GHG - CARBON DIOXIDE RECYCLING.
THE ADVANTAGES OF THE 3R PROCESS

✓ Reductive thermal pre-treatment in **DOWNSIZED ENVIRONMENTS**.
✓ **SAFE TREATMENT** of volatile toxic components with variations in flow, composition and concentration.
✓ **PROVIDING NEAR ZERO EMISSION SOLUTION**: comprehensive recycling and reuse of all material streams.
✓ **MODULAR CONSTRUCTION**.
✓ **FLEXIBLE OPERATION** and maintenance.
✓ **IMPROVING OVERALL COST EFFICIENCY** as per „open energy market” demand conditions and when all costs calculated.
3R PROCESS AND PROJECT STATUS

2003
Pilot plant development

2004
Business Plan and Technology Implementation Plan TIP

2005
PILOT DEMONSTRATION

United European know how and experience

Development 2002-2005 EU FP5 NNE5/363/2001

PILOT TESTS

3R TECHNOLOGY INTEGRATION PLANS:

✓ Oxyfuel.
✓ Foster Wheeler anthracite arc boiler.
✓ Heat Pipe Reformer.
✓ Different types of CO₂ recycling technologies.

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3R Pilot Project Results & Achievements

1) Comprehensive 100 kg/h throughput capacity pilot plant (hardware + software) developed, engineered, detailed designed, erected and successfully tested.

2) Scale-ups to 5 t/h pre designed + modular installations.

3) Comprehensive – EU compatible - industrial permitting viability successfully demonstrated.

4) Successful process data measurements completed.

5) High destruction & removal efficiency of the 3R pyrolysis process is achieved for all volatile components, where output off-gas HAP’s are near zero emission. Interlink to CO₂ recycling technology is required.

6) Feed selection strategy developed: high ash content feed is limiting factor.

7) Potential technology integrations: FW arc boiler, oxyfuel, Heat Pipe Reformer and CO₂ recycling technologies.
SUMMARY

✓ Safe solution by preventive measures.
✓ Removing environmental impacts prior burning.
✓ Environmental compliance towards near zero emission. Integration with CO$_2$ recycling required.
✓ Flexible feed stream choice by CMF.
✓ Prices to reflect the real costs. Cost reduction.
✓ Improved thermal process efficiency.
✓ Less corrosion in the boilers.
✓ Improved Community standards.