

**ISO 9001 and ISO 14001 certified:**

fine carbon production, carbon surface modification, carbon regeneration and pyrolysis technology design

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**EU FP5 NNE5/3636 TDT-3R MULTI FUEL FINAL REPORT (synthesis)**

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

**Project status: successfully closed.**

The 3R (Thermal Desorption Technology Recycle–Reduce–Reuse) Low Temperature Carbonization Process Clean Coal technology represents the advanced generation of solid feedstock-based energy production systems: by pre-treatment it breaks down any carbon-based feedstock into its basic constituents and remove contamination by preventive measure. This enables the preventive separation of HAP's to produce clean gas for efficient and improved electricity generation.

The 3R technology may be applied as vital component for an integrated strategy towards near zero emission targets to combine technologies for environmentally sustainable and economical solid fuel power generation, including but not limited to the decrease or even removal of output green house gases, such as CO<sub>2</sub>.

**PROJECT OBJECTIVES ACHIEVED:**

1. Model method and develop engineered design for preventive pre-treatment process by low temperature carbonization of low grade solid multi fuels (brown coal, lignite, high Sulfur coal, derived fuels and biomass) for efficient (e.g organic S and Cl removal at least 95%, and Hg removal at least 99%) and economical removal of HAPs from feed stream in downsized reductive environment prior main thermal process of energy conversion. By use of clean fuel provide economical add-on option to decrease GHG emission compared to best available technique.
2. Increase feed flexibility by turning the different types of high S content browncoal, lignite, derived fuel and renewable biomass into cleansed and chemically even and homogeneous coal.
3. Improve overall design energy efficiency >3% for boilers using 3R Clean Coal as compared with the unit as operated before retrofit.
4. Decrease total production cost below the cost versus technologies that are in operation, when all costs are included.
5. Recycle/reuse the removed S through scrubber water treatment.
6. Decrease boiler corrosion by use of cleansed and homogeneous fuels thus saving maintenance cost.

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7. Improve expanded use and European dimension acceptability of renewable biomass by preventive pretreatment carbonization decomposition to obtain homogenized clean fuel for environmentally safe and near zero emission clean energy production.
8. Provide solutions which: enhance the security and the diversity of the energy supplying sources, reduce emissions of the major HAPs, contribute to the objectives of the Renewables' White paper, contribute to the development of an effective internal market for energy and provides an efficient solution for add-on/link of the system to any existing or new solid fuel power generation systems.
9. Targeting markets of solid fuel power generation up to 300 MWe power capacity.
10. Develop, design and install a "product like" pilot plant and through performance tests demonstrate the viability of the innovative technology. The project provided feed material treatment study through the pilot test and end product evaluation, where the end product evaluation reflects realistic operating conditions.

### Conclusions

*The preventive pre-treatment of low grade solid fuels is safer, faster, better and less costly versus the "end-of-the-pipe" post treatment solutions. The "3R" Recycle-Reduce-Reuse integrated environment control technology provides preventive pre-treatment of low grade solid fuels, such as brown coal and contaminated solid fuels to achieve high grade fuels. The 3R technology may be applied as vital component for an integrated strategy towards near zero emission targets to combine technologies for environmentally sustainable and economical solid fuel power generation, including but not limited to the decrease or even removal of output green house gases, such as CO<sub>2</sub>.*

*Summary of achieved results:*

1. *Data received for Clean Coal material quality and characteristics for different feed material input and treatment conditions.*
2. *Engineering experience achieved:*
  - a. **PROCESS:** *very positive engineering experience achieved form the "product like" pilot plant overall process under different operational conditions, in terms of temperature ranges (350°C – 850°C), residence time (30 min to 90 min) and variating moisture content (as received). As high as 97% organic Sulfur removal achieved.*

#### **RECONGNIZED PROCESS LIMITATION FACTORS:**

- (1) *High input ash content: treatment of high - over 18 % w/w - input ash content coal is not economical for Multi Fuel methodic. Ashes with low softening points may cause slagging in the combustion chamber at CC utilization.*
- (2) *High input moisture content (over 18%), for which case pre dry is required.*
- (3) *Add-on technology needed for greenhouse gas - carbon dioxide recycling.*

- b. **EQUIPMENTS:** *successful functionality and stabile operational evaluation*

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*made:*

- a. *Rotary kiln, whereas 850°C mantel core temperature achieved, sealing and thermal expansion of the kin and other hot components tested,*
  - b. *Thermal insulation performance tested,*
  - c. *Air closed feed system redesigned, modified and rebuilt,*
  - d. *Post burner, whereas up to 1150°C <sup>+/- 2sec</sup> chamber temperature achieved,*
  - e. *Off-gas scrubber successfully tested,*
  - f. *Carbon cooler and airlock end unit tested,*
  - g. *Electric and electronic process control installation in manual and automatic operational mode tested.*
- c. **EQUIPMENT OPERATION:** *111,410 kg brown coal feed material treated under different conditions and 1779 work hours used for total operation (incl. adjustments, maintenance and modification of minor parts and components).*
2. *Comprehensive data collection and analyses made by the University of Rostock, Center of Solid Fuels and Aristotle University of Thessaloniki of Greece.*

*Based on the achieved results, the 3R technology may be applied as vital component for an integrated strategy towards near zero emission targets to combine technologies for environmentally sustainable and economical solid fuel power generation up to 300 MWe. The 3R technology is efficient for significant decrease or even removal of hazardous air pollutants from coal and organics feed stream by carbonization means, even in those case when the feed is of varying in flow, composition and concentration of toxic input elements. Important element of the feed selection strategy is the low ash and low moisture content.*

*The 3R Anthracite Clean Coal end product may advantageously be used in the oxyfuel and boiler technologies*

*The 3R technology may advantageously be integrated to the oxyfuel - oxy-firing, Foster Wheeler anthracite arch-fired utility type boiler and Heat Pipe Reformer technologies in combination with CO<sub>2</sub> capture and storage programs.*

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*For pre-treatment a specific purpose designed, developed and patented pyrolysis technology used, "3R", consisting of a horizontally arranged externally heated rotary kiln, post burned and off-gas treatment scrubber, where the contaminated feed material is carbonized and decomposed in true reductive environment under less than 850°C material temperature and vacuum. Low process gas volume generated.*

*The flexible operation provides wide range of 25 % to 125 % of nominal capacities. The volatile hazardous air pollutants are safely removed in the reduced volume of gas-vapour stream and burned out in the post burner at 850°C<sup>2sec±50°C</sup>, while the Clean Coal solid end product is utilized for clean energy production.*

*Concerning economy, the estimated price gap between low grade and high grade coal is > \$*

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*25-40 / tons in 2005, which price gap - due to the more strict global environmental normative - is expected to significantly rise to higher levels over time. The 3R pretreatment option technology in industrial scale is already economical from \$ 25 / throughput tons price gap.*

*“Product like” pilot plant with >100 kg/h throughput capacity has been built and successfully tested and demonstrated in Hungary in 2005.*

*The 3R advantages are the feedstock and technology flexibility, near zero pollutants for hazardous air pollutants, cost reduction and cost decrease of overall production costs when all real costs are calculated and improved safety.*

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