"TDT-3R MULTI FUEL"
Contract No. NNE5/2001/363

THE NEW
CLEAN SOLID MULTI FUEL – CLEAN ENERGY TECHNOLOGY
OPENS NEW TECHNICAL - ENVIRONMENTAL - COST REDUCTION BENEFITS AND SUSTAINABLE
OPPORTUNITIES TO TARGET KYOTO PROTOCOL FOR NEAR ZERO EMISSION

The innovative Multi Fuel process provides preventive pre-treatment of low rank carboniferous materials (such as lignite, brown coal, derived fuels and combine such fuel utilizations with renewable biomass) to remove hazardous air pollutants in downsized environment and decrease moisture content prior to separate energy utilization of the cleansed and homogenized fuel in boiler.

The process is using low temperature carbonization process and highly innovative horizontally arranged indirectly heated rotary kiln apparatus to produce clean fuel. The ultimate application goal is to remove barriers and provide new alternative for continued, long term and sustainable use of solid fuels for traditional and new construction solid fuel electricity power plants and combined heat and power production, performed environmental friendly and cost efficiently as well. The process targets to improve boiler efficiency and overall environmental performance towards near zero emission of outputs with potential linked application to solid fuel power generation plants for power capacities up to 150 MW, possibly up to 300 MW.

In order to develop the European Union to the most progressive and competitive economical area in the world by 2010, affordable and competitive electric energy availability needed. The Multi Fuel process promotes the development of sustainable supply of the ever increasing energy as per "deregulated energy market" demand, where oil/gas based energy production is preferably substituted to the greatest possible extent with long term available cleansed solid fuels and renewable biomass energy sources as well.

The three years project with eight partners form The Netherlands, Germany, Greece, Hungary, Latvia and the U.K. has been started up on August 1, 2002 and DURING THE FIRST YEAR the following works have been successfully performed:

1. Multiple fuel characterization: selection of two representative feedstock streams made (I: low rank coal and lignite, II: agricultural residues), and provide characterization – with special concern to the targeted hazardous air pollutants, such as Sulfur, Chlorine and Mercury. Coal fuel characterization, proximate, ultimate and ash analysis from Greece, Hungary and Ukraine made.
2. Laboratory and bench scale pyrolysis test: test pyrolysis and characterization of different types of biomass from Netherlands and Germany made, by application of lab/bench-scale pyrolysis equipment "Pyromaat", with input capacity of approx. 1-10 kg/h, pyrolysis gas—vapor burning at temperatures 850° C and 1,250° C respectively and min 2 sec. residence time and scrubbing, off-gas analysis, (CO, CO2, NOx, SOx, Cl etc), particulate and toxic emissions measurements.
3. Modeling of TDT-3R Process: process modeling and evaluation of apparatus application alternatives for pilot equipment, field demonstration and full scale made, including modeling of energy efficiency of low temperature carbonization process and near Zero Emissions (no wastes), sustainable residual management and reuse technical opportunities as well.

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4. Development and design of "product like" pilot test equipment: process and engineering design of the TDT-3R Multi Fuel pilot test rotary kiln equipment for material treatment study and production of clean coal samples made. Installation permit for pilot plant has been applied and granted in West Hungary , in the city of Polgardi. Study for scale up, technical and economical modeling of TDT-3R Multi Fuel carbonization rotary kiln for future field demonstration and full-scale plants made as well.

DURING THE **SECOND YEAR** THE FOLLOWING WORKS HAVE BEEN SUCCESSFULLY ADD-ON PERFORMED:

1. Preparation of offer and tender specification for construction and erection of pilot test equipment. By the late phase of year 1 offer proposal have been made, in order to select the best offer of suppliers to manufacture equipment as per WP 5, manage delivery and erection. During selection of suppliers, the reliability, technical ability, business stability and offered guarantee performance have been valued.
2. KEY ACTIVITY: MANUFACTURING AND ERECTION OF THE "PRODUCT LIKE" PILOT PLANT: After careful considerations subcontracting general contractor suppliers have been selected. The most important advanced, innovative and very high tech part the innovative ROTARY KILN body has been separated from all the other components for manufacturing. The 3R pilot plant industrial manufacturing demonstrated, that the 3R Multi Fuel pyrolysis power plant is less complicated and less costly to manufacture and install than any other known thermal treatment system competitors, which removes barriers towards industrial application of the 3R Multi Fuel technology. Even if only one single small unit is manufactured (which is always significantly more costly than manufacturing of scale up large units or serial production), the cost and time for manufacturing and installation of the complete equipment has been well estimated in our work programme. The comprehensive installation including pyrolysis rotary kiln with closed feed input and output systems, high temperature post burner, carbon cooler, multi venturi offgas treatment system, heat exchangers and electric and electronic process control systems with field instrumentation. The pilot plant construction is containing confidential technical information.

   As per original work plan the test schedule is decided later on when more data is available. Based on the achieved highly successfully results, the following test schedule is planned for operation and tests with approx. 150 m3 multi fuels during 1500 hours of continuous operation:

   0: Operational permitting: August 2004 – January 2005
   I. Basic evaluation period : February 2005
   II. Hard test period for continuous run: March 2005
   III. Control test period: April 2005 – June 2005
3. Market study of renewable biomass in European dimension: Comprehensive market survey of biomass generation and supply executed in the Netherlands and Germany, and general overview of the other European countries as well. Market survey of forest industrial wood by-product generation in the European countries made. Selection of three different types of biomass for the performance test in the Pyromaat production potential made, furthermore characterization of different types, alternatives qualities, barriers of use, evaluation of handling and transport costs in the Netherlands and Germany, overview of available utilization technologies, predicted production and utilization potential up until 2010.
4. TGA tests: tests performed in a thermogravimetric analyzer (TGA) to obtain the fingerprint of the fuel and fuel blends and to estimate kinetic parameters at different operating conditions. Thus, the behavior of coals, biomass, wastes and their blends will be studied. In order to identify the behaviour of the selected fuels, thermogravimetric tests were performed under

nitrogen flow, at ambient pressure for particle sizes 150 – 250 mm, and heating rate 20°C/min. Tests were performed in a non-isothermal thermogravimetry (TA Q 600) coupled with gas chromatography and infra-red analyser (TGA – GC – NDIR). Volatile evolution and combustion yields were systematically examined in the temperature region between 150 – 1000°C. To account for the kinetics of the pyrolysis the independent parallel reactions model was elaborated.

5. Lab/bench-scale tests: analysis of selected fuels. Proximate, ultimate and ash analysis performed. The results put into the ECN database Phyllis and compared with in Phyllis available information on the composition of comparable biomass. Pre-treatment of selected biomass: the necessary particle size for feeding into the Pyromaat and LSIWC rotary drum type pilot-scale laboratory pyrolyser is approx. 1 cm max. The biomass feedstock will be shredded to meet this requirement. Pyromaat tests: the Pyromaat consist of a feeding system, pyrolysis reactor, gasifier/combustor, scrubber and post combuster. The solid pyrolysis product (char/secondary fuel) is collected in closed containers. The Pyromaat tests will give information on the composition of the pyrolysis gas, the char, flue gas, including impurities, such as chlorine, NH_3, H_2S, tar and dust. The LSIWC pilot scale apparatus modeling a rotary-drum-type continuous flow thermoreactors will give information on the process time, yield of pyrolysis products and their quality.
6. Market evaluation of pyrolysis oil production in Europe: a brief market evaluation of pyrolysis oil production and utilisation was performed. The potential utilisation of pyrolysis oil regarding (a) direct combustion, (b) impregnation in coals and (c) production of chemicals was investigated.
7. Technical cost evaluation of biomass-wood chips handling and logistics procedures for coal-biomass co-firing system supply and development of the road map from the source of origin to the feed point.
8. Simulation of CC process by using CFD code: the objective of this task is to identify the operational problems that associated with the production of CC products and to propose and evaluate methods for their solution. Investigation made using a CFD tool for predicting three-dimensional flows. A parametric study aiming at the investigation of the gas emissions, slagging and fouling problems as well.
9. Study of solid fuel power generation design: Study of solid fuel power generation design and constructions for comprehensive evaluation of thermal processing effects of the application of CC. ASPEN Plus used to evaluate the effect of the CC on the performance of an existing conventional coal-fired power plant concerning energy efficiency and environmental performance. Justification of CC end product quality that it will best meet the thermal engineering and the boiler design requirements.
10. Pre design concept for future full scale equipment design: engineering and design concept pre proposal has been made for future field demonstration and full-scale plant equipment construction suitable for power generation capacity up to 300 MW.

The achievements reached during the second year are lab and bench scale pyrolysis tests of biomass, analysis of by-products, market study of biomass in European dimension, preparation technology scale up and industrial manufacturing - erection of the “product like” pilot plant in West Hungary (located 80 km West of Budapest in the town of Polgardi). The pilot plant is sufficient large scale dimensioned in performance to provide credible evidence towards 3R technology pyrolysis scale up design. The 3R pyrolysis power plant has been ISO 9001 and ISO 14001 certified for »*research, development and implementation of pyrolysis technologies; application of pyrolysis technologies for production, surface modification and regeneration of carbon products*» activities. Web page information: http://www.terrenum.net/cleancoal.