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Project:	Pilot plant
Attention to:	Mr. David Jeong Executive Director **Changjo E&E Co., Ltd** KOREA

BUDGET QUOTATION

Biogreen© pilot plant for converting flammable waste

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ETIA

Biogreen®
Continuous pyrolysis since 2003

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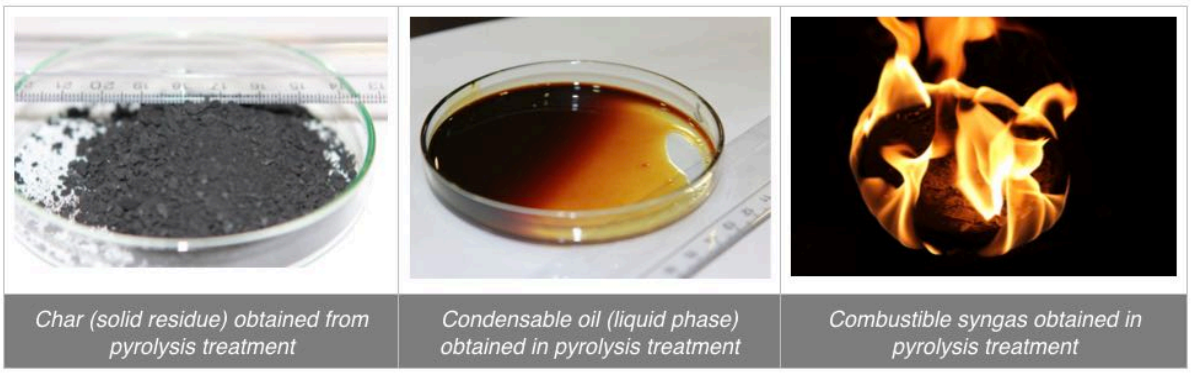
I. General process description

1. Biogreen® technology description

Biogreen® is an innovative, patented by ETIA process for continuous thermochemical conversion of biomass and waste residue that allows torrefaction, pyrolysis and high temperature pyrolysis treatment of various bulk materials.

Technology is based on electrically heated screw conveyor (Spirajoule®) designed for advanced thermal treatment in pyrolysis conditions. Screw conveyor heats the product inside the reactor as a result of the Joule effect. The product temperature is precisely controlled basing on the temperature settings. The dwell time of material inside Biogreen® reactor is regulated by screw rotation speed. Thermal conversion is performed in oxygen-free atmosphere in unique construction of pyrolysis chamber which guarantees constant quality of product obtained from the treatment.

The products generated in the conversion process are: solid residue (char) and syngas that carries condensable (liquid, oil) and non-condensable phases.



Char (solid residue) obtained from pyrolysis treatment	*Condensable oil (liquid phase) obtained in pyrolysis treatment*	*Combustible syngas obtained in pyrolysis treatment*

Example of products obtained in high temperature pyrolysis; non-contractual photos

Obtained **solid residue (char)**, depending on its characteristics, can be used as a fuel, intermediary of manufacturing second-generation biofuels, fertiliser, soil amendment (biochar) or economical substitute of industrial carbon-based products.

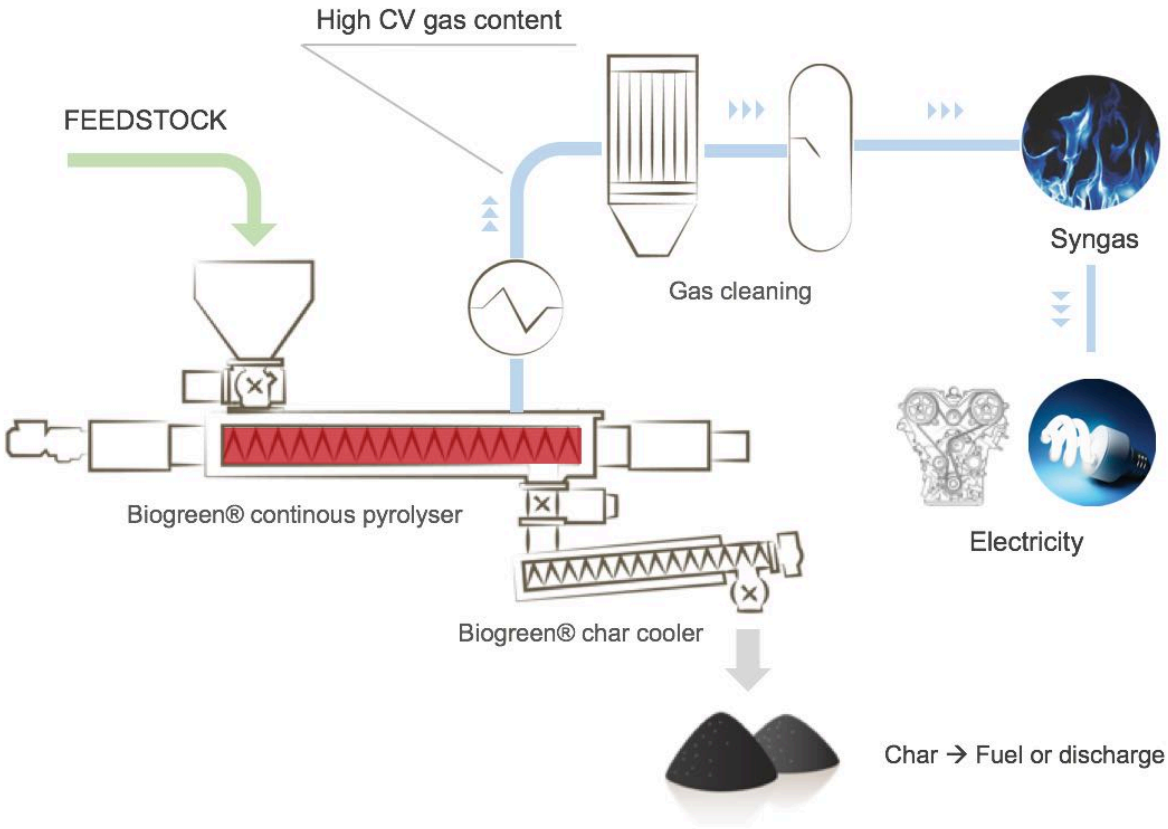
Pyrolysis oil is a condensate extracted when cooling down the gas produced in Biogreen® system. It often represents a concentrate of energy that may be considered to use as fuel or as raw material for the extraction of bio-based molecules for the platforms that can be used further in synthesis as a biochemicals.

Produced **gas** consists energy rich-mixture and can be beneficial in several ways, from heat production, through steam production, green gases generation, CH4 separation, as well as purification and electricity generation.

Efficient and precisely controlled conversion of variety of organic materials makes Biogreen® a perfect solution for **turning waste into products**. Since more than 12 years, system supports the industry in sustainable management of waste and biomass, including:

- biomass solid fuels production (torrefaction process)
- municipal waste, industrial waste (RDF / SRF) conversion into electricity
- biochar (soil nutrient) production
- conversion of sludge and industrial sludge into heat and electricity

Biogreen® range of operation concerns torrefaction, pyrolysis and high temperature pyrolysis modes and covers wide spectrum (250 – 800 deg C) of treatment temperatures applied. **High temperature pyrolysis mode, which will be used in your project, is presented below.**



Example of turnkey process involving Biogreen; non-contractual scheme

2. How Biogreen® works?

1. Waste product is dried, shredded and densified before the process in order to reach the demanded moisture and apparent density. ETIA can also supply continuous dryer equipment prior to Biogreen® process unit in order to prepare the feedstock for the Biogreen® process.
2. Material is introduced to a Biogreen® hopper with regular and controlled flow. Particle size and moisture will affect the yield of solid, oil and gas.
3. A high temperature rotary valve or dosing screw introduces the material into the pyrolysis chamber. This chamber is based on Spirajoule® technology, an exclusive and patented electrical heating screw conveyor designed by ETIA. Process allows perfect monitoring and control of product dwell time and temperature during the treatment. Temperature of conversion can be adjusted precisely up to 800°C, depending on specifications required. Dwell time of the product in the pyrolysis chamber can be adjusted from 5 to 30 min. Choice of operating conditions defines the ratio of syngas, oil and solid product generated with the process.
4. Syngas generated in the process exits the top of the Spirajoule® pyrolyzing chamber and arrives to the system of hot temperature ceramic filters dedicated for complete particle matter removal. After separating the particle matter, gas is directed to dedicated cooling system that

separates the non-condensable (NCG) and condensable fraction of syngas. Cooling system consists primary and secondary equipment for reducing the syngas temperature and extracting its condensable part. Tars, oil and water are the liquid phase are being condensed during the process of gas cooling down. The yield of liquid phases obtained in the treatment depends on waste composition and Biogreen® operating conditions.

5. Solid phase coming out from Spirajoule® pyrolyzing chamber is quickly cooled down in a flash cooler (UPZ®) based on a double jacketed auger cooling screw mounted with water spraying device. Solids are cooled down to a temperature not exceeding 60°C. The ratio of waste converted into solid products depends on feedstock composition and operating conditions.
6. The non-condensable gas (NCG) coming out from the cooling system features high energy value. After the contamination removal (adsorbtion towers) it is used as fuel to internal combustion engine for producing electricity.

The same principle is applicable for wide range of feedstock including agglomerate secondary fuel, tires, sludge, polymers etc.

3. Example views of industrial Biogreen Plant

Industrial Biogreen® equipment

Proven technology: oldest Biogreen® was installed in 2003 and continues operation

Biogreen in waste to energy applications

Biogreen in solid fuel production applications

Containerised Biogreen Module (BGR CM series) – 40' Container

4. Why we find Biogreen suitable for your project

✓	system allowing easy change of operating conditions - equipment suitable for pilot tests, research, development, testing and designing of new solutions
✓	the operator can easily regulate the process by changing the temperatures and residence time of material in pyrolysis chamber
✓	the system is compact and can be delivered in a container to work as a standalone unit
✓	equipment proven in operation since 2003 and available worldwide with CE standard

II. Technical proposition

1. Proposed solution & unit configuration

The proposed equipment configuration includes pilot reactor based on SPJ130 model designed for pyrolysis of flammable waste, which is followed by cooling system for solid residue produced in the process. The volumetric capacity of equipment is up to 60 l/hr. Presented proposal do not include the gas management system which is necessary for proper operation of the plant.

Product specifications at the inlet to Biogreen©		
Product	Flammable waste (SRF, RDF, Waste plastics (PE, PP, PS etc)	
Particle size at the inlet to pyrolyser	< 10 mm	
Inlet moisture	< 10%	
Product inlet temperature	20 °C	
Average apparent density	> 400 kg/m3	
Required dwell time	20 minutes	
Mass product flow	**10 kg/hr**	
Operation	Pyrolysis HT	
Treatment temperature	750°C	
Range of process temperatures	600 < T°C < 800	
LHV of product (MJ/Kg) a.r.	18 MJ/kg	
Power on feedstock (kw)	50 kW	
Product specifications at the output of Biogreen©		
Output product	**A. Solid (Char)**	**B. Hot syngas***
Yield	20%	80%
Mass flow	2 kg/hr	8 kg/hr
Temperature	Less than 60°C	700°C
Moisture	10-15%	n/a
Density	0.15-0.25 Kg/l	n/a
Low calorific value (d.b)	13 MJ/kg	19 MJ/kg
Power	7 kW	43 kW
*** Hot syngas decomposition (after cooling - not included)**		
Output product	B.1. Condensable	B.2. Permanent
Yield (by weight of feedstock)	15%	65%
Mass / volume flow	2 kg/hr	5 Nm3/hr
Low calorific value	38 MJ/kg	18 MJ/Nm3
Thermal power	16 kW	27 kW
Example composition	Mixture of oils and heavy tars from pyrolysis	CH4: 10-30%; CnHm: 1-9%; CO: 10-30%; CO2: 5-20%; H2: 10-30%; N2: 5-20%

Warning. Presented performance of Biogreen© is based on ETIA's current experience with similar feedstock and should be confirmed on the basis of pilot tests performed on product and in conditions relevant to the expected by Customer.

The actual capacity of Biogreen machine is linked to residence time and density of feedstock. Depending on this factors, the capacity may vary between 2 to 30 kg/hr.

System for hot syngas extraction and handling as well as electricity generation is configured and engineered individually, according to your product characteristics, project conditions, individual requirements and best available technologies suitable to your project demand. Data presented in this budgetary proposal are standardised and do not take into account your project conditions. Please consult ETIA for more details.

ETIA maintains the possibility of adjustments in its technological solutions that are a consequence of a engineering phase carried out after acknowledging more complex information about the local site conditions, feedstock and other relevant factors.

2. Standard operating conditions and additional information

Voltage	400V, 3 phases+ Neutral (T-N), 50 Hz
Negative pressure inside the Spirajoule required	- 20 Pa
Ambient temp. min/max	0 /+ 35 °C
Ambient humidity max.	80% HR max
Dusty atmosphere	Not allowed
ATEX area of installation	Not allowed
Equipment standard	CE
Indoor/Outdoor implantation	Indoor

Warning. In case of expected power shortages, uninterruptible power supply (UPS) should be available on site to ensure emergency power for maintaining minimum functions of control cabinet, engines and extraction fan and guarantee the security of process.

3. Configuration of our solution

3.1. Biogreen process

A.	BGR130	
A.	**Biogreen pyrolysis unit**	
A.1	**Hopper 60L with bolted cover** Design: Square design Hopper capacity: 60 l Includes 1 level sensor Construction: mild steel	✓
A.2	**Inlet rotary valve to Spirajoule®** Square construction 150x150mm Rotor made in high temperature stainless steel Body made in painted steel Motor driven by frequency drive High temperature material	✓

A.3	**Spirajoule® 130L1.6 (up to 800 oC)** Pyrolyser will include: - Electrical heating screw pyrolysis chamber – Spirajoule® technology - Casing in refractory material + insulation material - External casing SS304 - Screw Ø130/L1600 mm - Inert gas injection - Product temperature sensors x1 - Pyrolyser temperature sensor x2 - Screw temperature sensors x2 - Concrete temperature sensor x2 - Differential pressure transmitter inside the Spirajoule® - Outlet connected to cooling section - Pyrolysis gas exhaust connection - All parameters (temperature, dwell time, sensors and security) driven and conducted by the electrical panel (see after) - 1 fans with filter per cooling section	✓
A.4	**Gas extraction pipe** Heated connection for extraction of syngas from Spirajule©. Length 300 mm. Heating elements regulated by temperature sensor to keep the syngas hot Thermal insulation around the gas extraction	✓
A.5	**Outlet rotary valve** 150 x 150 mm square construction Rotor and body made in high temperature stainless steel Body made in painted steel Motor driven by frequency drive	✓
A.6	**Cooling screw UPZ / RS125L1.2** Designed for extraction and cooling the solid product from the system Made in stainless steel 304/304L Designed with bolted cover Tubular design with water double jacket for connection of cold water SEW motor with variable frequency drive Water spraying system (2 spray nozzles) - to moisturise char up to 20% Pulverization kit included (flow meter, electrovalve, stop valve, manual regulation valve, pressure reducer, manometer and filter) Product temperature sensor Inspection window	✓
A.7	**Electrical transformer** Tri Phase – Mono Phase Power: 20 kW Primary 400V +/- 15V Protection Index IP54, Class H Ambient temperature min/max: 0/+40°C	✓

A.8	**Control cabinet for control and power** Command panel + power panel Construction of control cabinet: mild steel Protection Index IP55 Siemens controller (Program in English) Includes all functions and security needed for the whole process Control panel features: - Main switch - Emergency stop button - Stop and start procedures - Dwell time regulation - Screw temperature regulation - System temperatures display - Product temperatures display - Pyrolyser temperatures display - Alarm monitoring and recording Access controlled by admin/user password Voltage 400V, 3 phases, 50 Hz Ambient temperature min/max: 0/+40°C	✓
A.9	**Piping/connection preparation kit** One control panel with connection and piping instrumentation. Construction of the panel on stainless steel Composed with of elements for cold water connection (distribution to UPZ cooler); set of elements for industrial water connection (distribution to UPZ); set of elements for nitrogen connection (distribution to Spirajoule and UPZ). Preparation of piping/cabling between control panel and Biogreen process.	✓
A.10	**Electrical connections preparation kit** Set of prewiring elements for electrical connections (motors and instrumentation) - 1x prewiring box for Spirajoule - 1x prewiring box for UPZ Cable tracing and installation box: - set of elements for control cabinet and prewiring box of the Spirajoule and UPZ (x2) - set of elements for control cabinet and electrical transformer (x1) - set of elements for electrical transformer and Spirajoule (x1), power cable. Emergency stop buttons included. Cable kit for power and control between all equipments provided (max. 10 m length delivered)	✓
A.11	**Skid for Biogreen BGR130L1,6** Complete support and frame for Biogreen process Structure made with painted steel Preparatory works for electrical connection (equipment already cabled). Preparatory works for fluid connections (piping and instrumentations installed), Fluid connections ready to connect on a panel (nitrogen, industrial water, cold water, compressed air, ...)	✓
A.12	**Implantation drawings**	✓
A.13	**Pre-reception of Biogreen in factory (FAT)** Mechanical validation of equipment (dimensions, functions, instrumentation), verification of assembly, motor rotation tests, preheating of the Spirajoule.	✓

A.14	**Assistance for installation (2 weeks – 2 technicians)** Remote assistance for mounting and installation On site assistance for finalisation of mounting and installation On site assistance for first start up of equipment On site assistance for integration and PLC communication Training for production and maintenance (5 persons max) Commissioning and SAT (according to SAT conditions described in final offer)	✓
A.15	**Warranty 1 year** Does not cover spare parts, thermal insulation part, gaskets of equipment covers, and all the filters damaged during maintenance performed by third parties.	✓
A.16	**Documentation in English**	✓
	Total net price EXW factory	**295 000 €**

3.2. Options

B	**Auxiliary equipment - options**	
B.1	**Water chiller SFT101** Temperature of cold water: 7/12°C Cold power generated: 23 Kw Water flow: 4 m3/h Pump pressure: 3,3 bars With rapid connection kit 1"1/4 galvanized steel (Y filter and stop valve) Absorbed power: 8,6 Kw	7 050 €
	Total net price FCA factory	**7 050 €**

3.3. Summary of investment

	SUMMARY OF INVESTMENT	
A.	Biogreen pilot bench	295 000 €
B.	Options	7 050 €
	Total with options	**302 050 €**

4. Items not included in the quotation

- Civil works and engineering required for site preparation
- Raw material shredding, drying and densification
- Uninterruptible power supply for emergency reasons
- Lifting and handling equipment required during the machines assembly and maintenance
- Cable tracing and grounding between the units
- Supply of hydraulic clams for cabling (required for installation during approx. 2 days)
- Piping and connection from factory to our equipment
- Fluids and managements distribution
- Electrical connection from Client's facility to delivered equipment
- Process or security flare

- Syngas cooling cleaning, when required due to pollutants
- Syngas extraction fan to keep negative pressure in Spirajoule: -50 Pa
- Syngas analyser
- Engine exhaust gases treatment when required
- Piping between chilling systems and gas cooling
- Automatic feeding system to the hopper of Biogreen
- Container for recuperation and storage of solid fraction
- Nitrogen bottles, tank or generator
- All other energies and fluids
- Delivery of feedstock required during commissioning
- Spare parts and consumables
- All items not specifically written in present offer

5. Fluids and electrical requirements

Provided estimations are based on ETIA experience on similar feedstock and may not reflect the conditions required by Customer.

5.1. Fluid requirements

Type of fluids	Maximum consumption	Consumption mode
Industrial water Stabilising the solid product 2 bars, 20°C	2 - 5 l/hr	Continuous
Nitrogen Ensuring inert atmosphere in Biogreen system N2 purity 99% at 6 bars, 20 deg C.	1 Nm3/h	Security and start/stop phases only.
Cooling water for char cooler Closed loop with water chiller (included) Deaerated water 2,5 bars (23 kw cooling power)	4 m3/hr (closed loop)	Continuous

5.2. Electrical requirements

Equipment	Nominal power	Max. consumption
Biogreen control cabinet	12 kW	6 kW
Electrical transformer	20 kW	6 kW
Water chiller for char cooling (option B1)	10 kW	8 kW
TOTAL	**42 kW**	**20 kW**

III. Terms and conditions of the offer

1. Availability of the offer

This is a budgetary offer presenting performance data based on ETIA's current experience with similar feedstock. For establishing performance individual for your project, outcome process specification should be validated by trials in ETIA facility. Please consult ETIA representative for the tests on your individual feedstock.

2. Conformity note

ETIA's products are provided with CE mark and comply with the provisions of applicable European Union harmonized legislation. Compliance with national, local or federal codes, standards and safety regulations specific to the country of operation must be assured by the customer/end user.

Product described in this quotation is intended to be incorporated with other equipment to create a complete system designed to perform the requested application in effective and safe manner.

End user shall be responsible for providing the associated equipment for managing the products of thermal treatment process, as well as carrying out a risk analysis with consideration to the national, local or federal codes, standards and safety regulations which are specific to the country of operation.

3. Payment terms

The price described in this offer will be paid by bank transfer on the basis of invoice issued by ETIA to the Customer in the following manner:

40%	Down payment upon order and signature of offer.
50%	After successful FAT, before the release of goods to the transport
10%	After successful SAT, commissioning and training (before industrial production starting)

All the bank payments and taxes generated and applied in the country of purchaser are valid and paid by the purchaser only.

4. Delivery time FCA

Engineering : 1 months from received downpayment. Within this time ETIA will issue the detailed PID and layout of equipment and provide it for the formal acceptance of the Purchaser.

Manufacturing, FAT : 5 months counted from receiving by ETIA the written or email acceptance of the issued documentation described in point above, up to the the acceptance test in factory.

The price is given FCA-Factory (according to Incoterm 2010) and includes goods ready to takeoff, and loading of the truck. It does not include the shipping, taxes, clearances, customs, transport assurance and unloading on site of destination.

5. Conditions of sales

According to ORGALIME S 2012 and detailed sales conditions presented in the final quotation.

IV. Visualisations