PRESENTATION OF A SHREDDED BIOMASS GASIFIER WITH COMBINED HEAT AND POWER PRODUCTION

January 2015

Introduction

This document has the main intent to briefly present an innovative solution for electrical and thermal energy production using renewable sources coming as byproducts or waste materials of established agricultural and industrial processes.

This new solution is based on a gasification process designed, tested and manufactured by PiroFlameGas in cooperation with “DICMA” (Department of Chemical, Material, Environmental Engineering of the University of Rome “La Sapienza”, Italy) and Azzurra s.r.l. for process and environmental issues and development.

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About Us

PiroFlameGas is a NewCo established in 2014 with the following **purposes**:

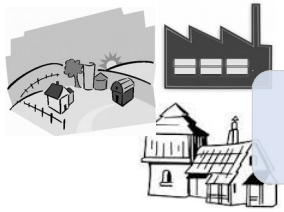
- **Transfer to industrial size the experience achieved** on a preindustrial gasification unit completely designed and manufactured with internal resources. The unit has a **capacity up to 500 $KW_{thermal}$** and has been running for more than one year for heating a ski resort.
- **Organize an industrial production** of units having electric capacity from **0,1 to 1 MW**. All units will be supplied as a **turnkey**, **fully automated**, with the possibility of **remote control**.
- **Continue the technological improvement program** in cooperation with the Team of Researchers and Process Experts already involved in the past years in the Business Start Up Process.

A first industrial unit, arranged as a Heat and Power System (electric net capacity of 100 KW, heat net capacity of 150 KW), **has already been realized. This unit will be commissioned on Final User site within the end of January 2015.**

Project Overview

The Project has many possible applications. Wherever there are established communities producing waste and agricultural-industrial byproducts, the **Gasifier allows a transformation of** these **raw materials into energy converting** related **costs** (waste and byproducts treatment and disposal) **into revenues** and **valuable resources** (electricity and heat sale and utilization).

ENERGY PRODUCTION AND SUPPLY



SOCIAL AND PRODUCTIVE ACTIVITIES

WASTE AND BYPRODUCTS TREATMENT AND LANDFILLING

Output*: 1 KWh electrical + 1,5 KWh thermal

NEW

GASIFIER

Input*: 1 Kg of feedstock

- ***Energy Production and Supply Cost***
- ***Waste and Byproducts management Cost***
- ***Environmental and Social impact coming from treatment and disposal***

Suitable feedstock categories*:

- Materials commonly classified as byproduct of agricultural or industrial activities
  - Byproducts resulting from the production of wheat, maize, and others commodities for food use
  - Wood residuals coming out from plants pruning or forestry activities.
  - Residuals from fruits and vegetables production and packaging (shucks, husks, skin, etc)
  - Residuals from food production (sugar, wine, milling activities, etc.)
- Waste from intensive farming activities, mainly manure from cattle, poultry, and similar.
- Residue from industrial waste sorting processes

BENEFITS

- ***COST REDUCTION** due to **waste** and **byproducts revaluation***
- ***COST REDUCTION** due to **reduction** of **energy need** provisioned with traditional technologies (big power plants and networks)*
- ***LESS ENVIRONMENTAL AND SOCIAL IMPACT** due to **reduction** of **waste** and **byproducts** managed in with established methods such as **landfilling** and **polluting treatments***

(*) Indicative data

Project Target and Opportunities

The **Gasifier** has been **defined looking at specific needs frequently occurring** in production activities and in specific areas. Often, **small and relatively isolated communities** may face **difficulties in dismissing byproducts** and **waste** coming from most common **agricultural and industrial processes**. Furthermore, **energy production** and **distribution** may have a **considerably high price** and **environmental impact**.

NEEDS	and	OPPORTUNITIES
How do I revaluate byproducts coming from my established activities?		Materials commonly classified as **byproducts** of agricultural or industrial activities, **having no economical value, often representing a cost for its correct disposal, can be used as feedstock of our gasifier**
How do I reduce social and environmental impact of waste coming from my activities?		**Waste can become a resource**: to feed our gasifier it is possible to use **waste from intensive farming activities**, mainly manure from cattle, poultry, and similar, and **residue from industrial waste sorting processes**
How do I develop sustainable energy production and distribution?		Many Governments are giving access to **Green Energy Incentives** recognized to **Combined Heat and Power Plants using green renewable feedstock**

ECONOMIC AND ENVIRONMENTAL BENEFITS

- ***Overcome*** *of* ***negative*** *environmental and social* ***impacts*** *coming from traditional practices of* ***byproduct*** *and* ***waste disposal****, like landfilling; in addition, the gasifier allows the* ***conversion*** *of these materials* ***into a valuable source*** *for energy production*
- ***Reduce of the combined cost of energy production and distribution*** *using small gasifier units locally producing and using renewable energy starting from feedstock coming from neighboring areas.* ***Even without incentives****, doing the overall cost-benefits calculation, it is possible to find many situations where* ***economic advantages are consistent***

Design Criteria and related Benefits

The **Gasifier** has been tailored to match requirements coming out from following **criteria**:

FEEDSTOCK FLEXIBILITY	**Possibility of using different type of feedstock without any change on the hardware**, but only adjusting the critic operating parameters on the control panel
PLANT SIZE FLEXIBILITY	**The plant size may be adjusted from 50 to 1000 Kw electric capacity passing through many intermediate sizes** (100, 200, 250, 500, 750 Kw)
PRODUCTION FLEXIBILITY	The combined heat and power production, and the use of internal combustion engine allow to follow the request both in electricity and in heat. **The gasifier can modulate its power, reduce or increase quickly according to the request**. It could be equipped with apparatus for matching sudden power peaks until the gasifier follows the request
EASY OPERATION AND REDUCED REQUEST OF MANPOWER	**Operation is fully automatic**, from the weekly feedstock storage to the connection to the users. Operators have only to supervise the plant, and provide periodic operations (i.e. feedstock supply, ashes removal, cooling water make up, ordinary maintenance and consumables refill). **The control system has a continuous operation control**, with an operator interface panel for alarm acquisition, instruction for trouble shouting, synoptic plant view. **A remote control is also provided** for remote assistance from PiroFlameGAS server
POSSIBILITY OF PRODUCING LARGE PART OF THE PLANT LOCALLY	**Large mechanical items, piping, electric boards, could be easily manufactured locally**, where the plant will be located**. Company is open to assign local Partners** in order to increase the provision through local resources and reduce investment costs

Process Basic Description

The **plant** is intended as a **turnkey supply preassembled on containers** (sizes up to 250 $Kw_{electrical}$), **or on skids** for bigger sizes.

EVENTUAL

BASIC SUPPLY SCOPE

FEEDSTOCK PRETREATMENT

- *Depending on the feedstock chemical-physical characteristics, a **pretreatment system** could be designed in order to prepare the input raw material (shredding, refining, dehumidifying, etc.)*
- *Shredded biomass is then handled to the storage phase*

FEEDSTOCK STORAGE

- *This area is equipped with **storage and handling systems** which convey the stored feedstock to the gasification phase entrance at a determined rate*
- *An **optional drying system** could be installed to get a reduction of feedstock humidity*

GASIFICATION

- *This is the **core area of the plant** provided with the **gasification chamber** and all related systems*
- ***Shredded biomass** is conveyed inside the **gasification chamber** where the **syngas production and treatment** take place*
- *Then, **syngas** is handled to the power generation phase to **feed the generator***

POWER GENERATION

- *This third area is made of a container that contains a **combined heat and power generation system**:*
  - *Electric generator*
  - *Heat exchanger for energy recover from exhaust gases. The heat may be recovered through hot thermal oil, hot water, or hot air. Hybrid systems may be provided*
- *Solutions with **gas turbine** could also be supplied*

SHREDDED AND DRYED BIOMASS

INDICATIVE PROCESS FLOW

BASIC CHARACTERISTICS

Max humidity **25 %**

Max particle diameter **3-5 cm**

INPUT

Per **1 kg** of feedstock in input

OUTPUT AS SYNGAS

Syngas **≈2,5 Nm^3**

OUTPUT AS ENERGY

Electrical power **≈1 KWh**

Thermal power **≈1,5 KWh**

In addition to its three main areas, the plant is provided with all ancillaries needed for the designed operation.
Civil works, site infrastructures, site sewer, area washing system, site internet connection and energy end user connections are excluded from the supply (out of scope).

Control System – Safety – Environment

Alarms and **emergency procedures** follow the most advanced **Good Engineering Practice**, and match **European Community requirements** for safety, and health control

CONTROL SYSTEM PHILOSOPHY	• The Plant has been designed for a **full automatic** operation. A **central PLC acquires parameters from field instrumentation**, and provides the process operation according to the set values. It also provides the **emergency and safety logic control**, stores data in a central database, and gives back to the operator curves with main parameters trends. • The **interface panel** gives to the operator the possibility of **checking trends, alarms, quantity of feedstock processed, energy produced, etc**. It is also provided the possibility of **remote assistance** through PiroFlameGAS central server to the operators in case of troubles.
SAFETY	• **Automatic shut down procedures** have been implemented in order to shut the plant before any parameter exceed the high level value. The shut down procedure includes that **critical parameters** continue to be **monitored** until all the system reaches a safe condition. • The **correct status of critical parameters** is **basic condition for PLC to maintain the plant in operation**.
ENVIRONMET	• The type of energy production machine (internal combustion engine) requires **syngas** to be produced with an high purity grade. The purity grade is then **comparable with natural gas**. • The syngas is produced trough a low temperature gasification (about 600°C), in a reducing ambient which **avoid any formation of noxious components** during the oxidation phase. • **TARs** and **CHARs** are processed and **transformed in lighter gases** (CO, H2, CH4); eventual residuals are re injected in the gasification chamber for re processing • The system is **totally closed**; in normal operation all the syngas produced is sent into an **internal combustion engine**. The **only continuous emission** to atmosphere is the one coming with the **exhaust gas from the engine**. Compliance with ambient regulations is guaranteed from the engine manufacturer • **Ashes** produced during the process are **collected**; when using biomass, or wood and paper non contaminated by any chemical compound, the ashes are mineral salts, **reusable** in agriculture

Plant Basic Supply

Present estimation is based on already tested scenarios (example: woodchip). **Many other feeding materials had already been tested, including cattle manure**.

Basic evaluation for a plant having a capacity of 250 $KW_{electric}$ and 300 $KW_{thermal}$

DESIGN DATA

- *Max feedstock processing capacity: 300 Kg/h of shredded biomass having a density between 0,4-0,7 Kg/l*
- *It is assumed a net caloric value for biomass equal to 6 Kwh/Kg, and an humidity content below 25%*
- *Expected syngas production: between 600 and 700 Nm^3/h having a net caloric value around 4,2 MJ/Nm3 (the caloric value depends on biomass quality and humidity content)*

FUNCTIONAL TEST

The plant will have a functional test consisting of:

- *Blank tests on single components and on single systems*
- *Control loop simulation*
- *Test of safety routines*
- *Five days production tests*

An acceptance test will follow at the end.

Functional test will be carried out at the workshop where the plant is produced. If requested by the Customer, a second test with plant on site could also be arranged (optional).

EXCLUSIONS

- *Delivery to site*
- *Civil works and infrastructures*
- *Construction and operation Permits on site*
- *Connection to thermal networks*
- *Connection to electric grid*

DELIVERY TIME

Six months from purchase order

Final Consideration

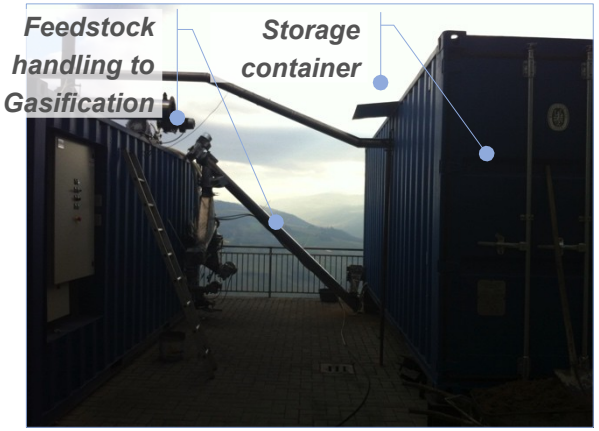
- **The Gasifier may have flexible application** according to possible raw materials in input. Therefore **it is possible to design and develop custom solutions** according to specific feedstock.
- **An overall cost-benefits evaluation depends on technical and economical parameters** (feedstock characteristics, manufacturing method, feedstock cost, electrical energy price, thermal energy price, specific needs, etc.).
- **Developers are looking for a future partnership** to realize industrial plants based on this technology wherever there are suitable opportunities both from commercial and manufacturing point of view.

Annex A – Plant Pictures

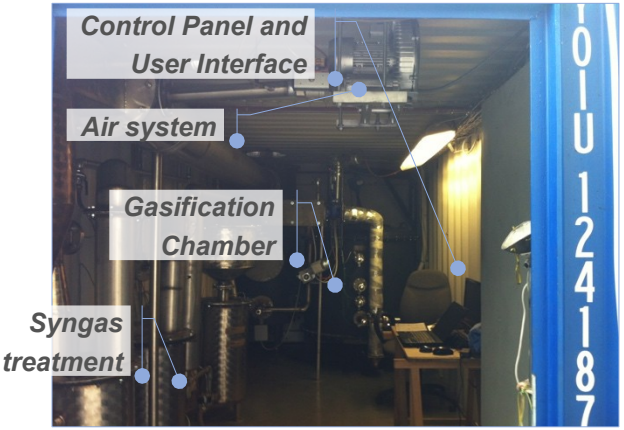
Pictures refer to an industrial application having a capacity of 100 $KWh_{electrical}$ commissioned in January 2015.

Plant Overview 1

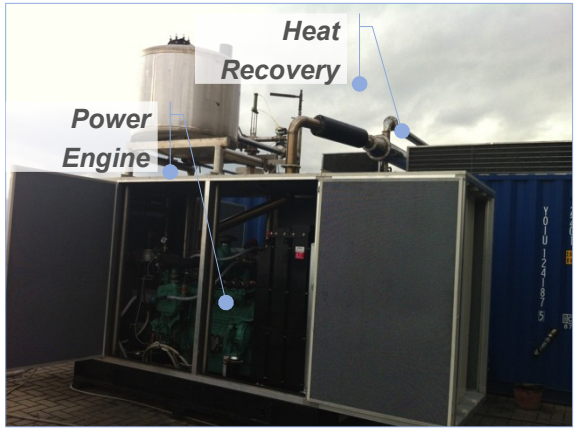
Plant Overview 2



Feedstock Storage



Gasification



Power Generation