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2019

Proceedings of EFC2019
European Fuel Cell Technology & Applications Conference - Piero Lunghi Conference
December 9-11, 2019, Naples, Italy

EFC19207

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Energy Transition by means of "bottom-up" approach: PyrosludG_EN for Sustainability and Local Development

Abstract

The energy transition is a process of interaction between transnational and macroeconomic policies, which can be enriched by a small and "bottom-up" intervention; this document highlights the main objectives of the PyrosludG_EN project, a model of fully sustainable and "zero kilometer" local development, which can be easily replicated anywhere. It starts from the creation of a territorial HUB, based on the construction of a pyrolysis plant treatment of "local" organic waste components to produce energy, in particular using sludge from civil wastewater treatment.
It transforms the ecological, and economic, problem of waste treatment into heat, electricity and water production, with particular attention to emissions and environmental impact, following the most restrictive standards.
Further winning factors are represented by the research to use the syngas produced in the process in fuel cells and the recovery of the organic residues transformed in fertilizer to rebalance the soil, as well as the creation of a local energy community.

Keywords: Sustainable Development, Energy Transition, Pyrolysis Plant, Energy from Waste,

I. WASTE TO ENERGY AS PARADIGM OF CIRCULAR ECONOMY

Sustainability has become a central focus in our economy. Energy from renewables, cogeneration from biomass, energy saving, extension the lifespan of the landfills, reuse, recycle, integrated management of the waste, emission reduction, smart grid, energy communities…..are only some of the new paradigm who preside over the energy transition from fossil sources as traditional way of production and consumption of energy to innovative models compatible with environmental sustainability, without penalizing the competitiveness of the systems and the economic and social development of the communities. We need to focus on the development of prototypes and innovative business models, exchange and sharing at local level and integrated resource management, not least waste. In light of the technology evolution become very relevant for the environment the reuse, as feedstock for cogeneration of power, of biomass with short renewal cycle like for instance sludge from biological civil wastewater treatment plants.

G_EN Energineering brings its contribution, entrepreneurial, scientific, technological and social in this scenario, proposing and creating a model that, in the most traditional sense of creativity, combines elements known in different ways:

- uses "ancient" and safe technologies to produce energy (pyrolysis),
- valorize feedstock waste with a very high rate of renewability (sludge, agro-food by-products, green waste, plastics ...),
- reduce the disposal in the landfill and disposing inert material,

Sludge from water treatment plants are composed mainly by water and organic matter.

Today they end up in collection and storage plants and then to treatment, which separates the component that can be again assimilated to surface water from the biological residue, which is sent to the landfill after an inertization process using chemicals.

At the time of the disposal, the biological residue or sludge still contains a water rate of approximately 75%.

PyrosludG_EN is an industrial project focused in cogeneration in which the plant is fed by biological sludge coming from civil wastewater treatment plants, as well as biomass and agro-food by-product and micro-nano-plastics, treating the material using the process of pyrolysis a termochemical treatment in principle in absence of oxygen without any combustion.

Besides the PyrosludG_EN is able to recover material for recycling use, to produce an organic fertilizer useful for agriculture and as final result the volume reduction of the waste reducing up to 10 times the landfill use due to evaporation of the moisture.

The main values of the project are:

- Valorization of biological waste as a resource; the use of local biological matrix for the co-generation of electrical and thermal energy through pyrolysis plants for energy production and the simultaneous realization of an Energy Community
- Environmental sustainability in the overall balance sheet which allows to obtain a model with approximately zero emissions;
- Repeatability on a local scale and in a widespread manner on a territorial scale also based on the availability and type of matrix can be used in the process.

II. A PROCESS "ENVORONMENTAL FRIENDLY"

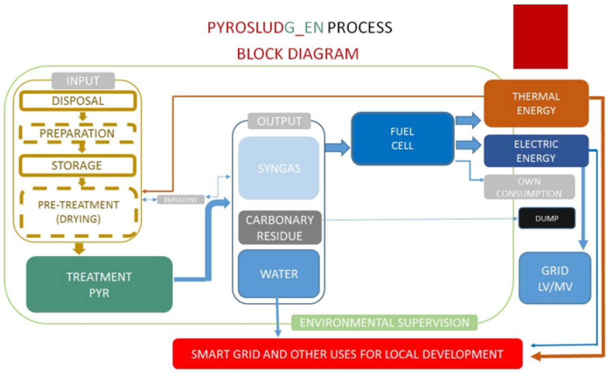
The aim of PyrosludG_EN is to provide a technologically advanced solution which solves two critical elements of current industrial development namely: the management and disposal of organic waste, and the high demand for energy. Its innovative value is configured as the real new frontier of the circular economy.

If until now the concept of "recycling" has been highlighted in the opportunity to obtain energy from sewage, here is another fundamental concept of a zero kilometer model, namely being the advanced point of a "circular economic model applied to the 'water".

Today, in Italy, waste water is considered as an element of possible health and environmental contamination, treated and, after separation, given to the landfill the organic solid component, with very high costs (it is paid to confer a matrix that weighs very much, due to the presence of water in the form of moisture and which has enormous volumes, again due to water, with over all very low times of saturation of the landfills and risks of contamination of groundwater).

The PYROSLUDG_EN process develop an extraordinary perspective: waste water as a source of energy co-generation and not as a cost to be paid.

Fig. 1 PyroGEN Process: Block Diagram



With the process of molecular breakdown at low temperature, the organic substances contained in the waste water are used for the production of a gas (syngas) similar to methane, which feeds the co-generation units, facilitating the transformation from plants at high energy consumption (negative With the process of molecular thermo-disintegration at low temperature, the organic substances contained in the waste water are used for the production of a gas (syngas) similar to methane, which feeds the co-generation units, facilitating the transformation from plants at high energy consumption (negative balance) to plants producing energy with positive energy balance.

As regards the modeling of the chemical part, the chemical reaction constants they are modeled according to Arrhenius and the accruals are calculated as shown in Tables 1 and Table 2. Table 2 also includes the values assumed for in the calculation of the constants of Arrhenius [1].

Reazione	R_j	E_i [J/K mol]	A_i [s^{-1}]
Biomassa → Gas	$R_1 = k_1 C_{bio}$	88600	14400
Biomassa → Tar	$R_2 = k_2 C_{bio}$	112700	4130000
Biomassa → CHAR	$R_3 = k_3 C_{bio}$	106500	738000
TAR → Gas	$R_4 = k_4 C_{tar}$	107500	100000
TAR → CHAR	$R_5 = k_5 C_{tar}$	107500	4280000

Tab. 1 Pyrolysis Process: Cynetic's Reaction

Reazione	R_j	E_i [kJ/mol]	A_i [s^{-1}]
$C + O_2 \rightarrow CO + CO_2$	$R_1 = \varepsilon \frac{C_{O_2}}{\frac{1}{T_s k_1} + \frac{1}{k_m}}$	160	5.67×10^9
$C + CO_2 \rightarrow 2CO$	$R_2 = \varepsilon \frac{C_{CO_2}}{\frac{1}{T_s k_2} + \frac{1}{k_m}}$	218	7.92×10^4
$C + 2H_2 \rightarrow CH_4$	$R_3 = \varepsilon \frac{C_{H_2}}{\frac{1}{T_s k_3} + \frac{1}{k_m}}$	218	79.2
$C + H_2O \rightarrow CO + H_2$	$R_4 = \varepsilon \frac{C_{CO}}{\frac{1}{T_s k_4} + \frac{1}{k_m}}$	218	7.92×10^4
	$R_5 = k_5 T_g (C_{CH_4})^{0.5} C_{O_2}$	80	9.2×10^6
$2CO + O_2 \rightarrow 2CO_2$	$R_6 = k_6 C_{CO} (C_{O_2})^{0.5} (C_{H_2O})^{0.5}$	166	$10^{17.6}$
$2H_2 + O_2 \rightarrow 2H_2O$	$R_7 = k_7 C_{H_2} C_{O_2}$	42	1×10^{11}
$TAR + O_2 \rightarrow CO + H_2O$	$R_8 = k_8 T_g C_{TAR} C_{O_2}$	80	9.2×10^6
$CO + H_2O \rightarrow CO_2 + H_2$	$R_{wgs} = k_4 \left(C_{co} C_{H_2O} - \frac{C_{CO_2} C_{H_2}}{K_E} \right)$	12.6	2.78

Tab. 2 Pyrolysis Process: CONSTANTS USED FOR THE CALCULATION OF REACTION RATINGS [2]

The following Figure 2 shows the profiles of the concentrations of the components of the syngas along the reactor

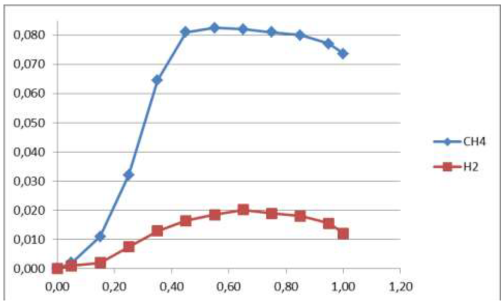


Fig.2 Pyrolysis Process: CONCENTRATION PROFILES OF CNG AND HYDROGEN [kg / Nm3]

III. INNOVATION AND RESEARCH FOR SUSTAINABLE DEVELOPMENT

The decisive element in the proposed model is research, a central and transversal asset to all phases, especially about the development of new solutions for the storage and use of energy and syngas produced in the process as a "poor" fuel for cells, the reuse of the carbon solid residual in agriculture as fertilizer, until the management of local communities of supplying energy for an "on-site" consumption.

One of the developments with the greatest potential in fact is the "fuel cells".Today the research is oriented to the use of hydrogen or bio-fuel, components that require large amounts of energy to be produced and/or managed.

In the PyrosludG_EN, the produced syngas will be used in a Fuel Cell battery for the production of electricity to be used for supplying the induction system and supporting the process.

IV. VIRTUOUS CYCLE AND BUSINESS MODEL

The proposed model combines sustainability, social responsibility and industrial profitability.

It is a process that starts from biomass and organic components, apparently at the end of the cycle, to generate energy, recover water, reuse solid carbon based by-product as fertilizer, feed cold storage for the preservation of agricultural products, develop new "poor" fuel cells, use energy in smart grids, develop energy communities.

The limited investment, about 1 million euros for a small-sized plant, and the very short payback time, in the order of three/four years, with excellent annual yields resulting from the value of the gate fee, make it scalable at a territorial and attractive level both for private and public investors.

V. CONCLUSION

The case presented, in the prototyping phase in a province of region Piemonte (Italy), by a B_corp oriented company, represents an interesting development in terms of "social design", of the creation of a green and circular economy model for local development that can be replicated in the territory with the objective of producing sustainable employment and territorial development, with particular emphasis on environmental and social impact.

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