Economic assessment of pyrolyzers for the utilization of agricoltural residues for biooil production

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1. INTRODUCTION

In the course of the years, Common Agricultural Policy (PAC) of the European Union has had various adaptations. Initially it was oriented to improve the agricultural productivity and to guarantee the security of supply to reasonable prices. Subsequently it has been oriented to eliminate the quantitative imbalances (surplus).
On 26 June 2003, European Council has launched the reform to meet the long term interests of the European farm managers, focusing on a reference picture in order to adapt the productions to the consumers and market requirements, along with the optimisation of the costs. With this new communitarian normative, in Italy starting from 2005, the modalities of support for the agricultural entrepreneurs are changed radically with the introduction of the *decoupling* and the *conditionality*[1] .
With the decoupling of the payments, the farmers have acquired a great freedom in the productive choices. If till now, in fact, the presence of specific subsidies guided the choices on cultivation, now the farmer has more options, comprised the production diversification. With the conditionality the farmers will share periodic relationships with the control organisms, in respect to the fundamental requirements of alimentary emergency, of well-being and health of the animals and of good agronomic conditions. Therefore the future of agriculture requires new professional figures: not more a utility man but a specialist technician in a position to orienting the enterprises on the single necessities; as an example, to choice the production in order to be on the market, to manage the set-aside, the conversions.
This plan is placed in such context, having tried to supply the necessary instruments for an exploitation also of the other resources that the agricultural production supplies and in particular the residual ones from grain cultivation. It has been therefore analyzed the possibility of conversion of the straw in an alternative energy resource.
Vegetation offers, by photosynthesis, a natural process for the storage of solar energy. The efficiency of the photosynthetic process for the conversion of the sun's rays into a usable fuel form is low (less than 2 percent is probably realistic).
The photosynthesis process is basic to all agricultural practice. The human animal has long known how to convert grain to alcohol. It can be said that as long as we can grow green stuff we should be able to harness some of the sun's energy [2].
The agricultural residues, and in particular the straw, can represent an important energy source in the world, but is today in great part unutilised. The utilization of straw for energy production is neutral for the carbon-dioxide formation and also it can gain more independence to the national economy from the oil importation.
Unfortunately the straw property is different from crude oil products. In fact it presents a

relativity low volumetric energy content, bad transportability and difficulty in use.

The principal barrier are the expenses associated with logistics (e.g. bailing, storage and transport). Also the uninterrupted supply of fuel is relevant to energy consumers and accordingly expensive transport makes straw less competitive with fossil fuels under free market conditions.

Due to the above factors a way to make competitive the straw derived energy would be the thermic conversion to an alternative attractive product in the energy field, e.g. bio-oil [3].

2. Plant

This study is based on the pyrolysis of straw, that produces a high quantity of bio-oil, char and a combustible gas [4].

Bio-oil has a lower heating value than light fuel oil and diesel, but can be easily transportable and simply in use. The char and the combustible gas can be of value for providing energy for all reaction.

Several research groups and companies have developed technologies for production of bio-oil from woody biomass and agricultural residual [5] .

In this plan the more suitable number of reactors to construct in a central Italy zone, the Val di Cecina-Tuscany, is determined.

In the "Val di Cecina" there is the agricultural and forest distribution as in Table 1.

The cereal cultivation covers 12.200 hectare (Table 2).

The straw production is about 3 tons/ha. Therefore the total production in Val di Cecina is the 36,600 tons.

This plan foresees the constitution of a cooperative that will deal with :

- Production of the straw;
- Storing of the straw;
- Transport to pyrolyzer;
- Storing of bio-oil;
- Transport bio-oil to power station.

In the first step the number of pyrolysis reactors to build has to be determined. This number depends both on the economic profile and the logistic one, related to the transport of the biomass. (Figure 2). From such diagram it has turned out that a good compromise is the choice of three reactors (Figure 3).

It has been therefore given one economic appraisal of the final price of the bio-oil. Such appraisal has been uniform in 2 periods of time:

- First 8 year: the cooperative re-enter to investment
- The other year

The result of such subdivision has been of two distinguished prices of the bio-oil (Table 3).

It has been then analyzed the prices composition of the bio-oil produced from reactors of 5,27 MWth in order to try to see which voice could be diminished (figure 4).

One of the voices that could be diminished is the operating cost and in particular way the cost of the job. In order to make that it must be realized an high level of automation.

A part of the plan has been therefore dedicated to analyze such situation, and to try to have an efficient automatic control of the transformation biomass – bio-oil process [6].

With an automated process the following hypotheses are considered:

Reduction of labour cost of 40%;

Reduction of biomass transport cost of 40%.

Therefore the costs that have been previously calculate for a 5,27 MWth system endure the variations as in Table 4.

A pushed automation has carried a reduction of the cost of the bio-oil from 4,5 c€/Mcal to 4,1 c€/Mcal in the first considered period, while in in the second period to from 2,9 c€/Mcal to 2,1 c€/Mcal.

In order to verify the economic feasibility of the row biomass-bio-oil-electrical energy, the the power station costs have been analysed.

In such analysis three different temporal intervals has been considered:

1) First 8 years;
2) Other 4 years;
3) After 12 years.

This distinction is necessary inasmuch as in the first 8 years of exercise the power station has an ulterior profit with "CERTIFICATI VERDI" (state incentive); after, for other 4 years such contribution comes down to 60% of the total produced energy; while after 12 years there aren't such state incentives and therefore the analysis of its economic account becomes much different.

3. CONCLUSION

We can make the following considerations:

- In the years of state incentive the station power profit is higher if bio-oil is used as combustible instead of the crude oil ;

- Instead the operating results diminish without the contribution of "CERTIFICATI VERDI", and substantially a budget in parity is obtained;

- The actual technological knowledge allows to produce the bio-oil at a price that is about the 2,9 c€/Mcal; it is a value higher 15% of fossil fuel cost in 2006, in fact, the price of fuel "STZ" (without taxes) has been of 2,5 c€/Mcal in Italy.
- A pushed automatic does diminished the bio-oil cost to 2,5c€/MCal and the power station profit increases about 450.000-500.000 €.

The illustrated situation shows already a competitiveness with actual energetic sources. Moreover in this analysis, more aspects have been underrate and/or does not consider:

- In the calculation of the necessary energy to the biomass preliminary operations before entering in the reactor, it has been considered also that necessary one to eliminate the eventual present humidity, but this plane considers the possibility to use the straw that in the storing period has just inferior humidity to 10% and that therefore it does not demand such preliminary operation. The energy effectively demanded could diminish about a 20-30% of that one considered in the study;

- The straw price is more high regarding the market price. In Italy, it in fact is sold to a price of the 30-35 € ton;

- The pyrolysis transformation efficiency could be higher. Modern organizations (BGT, ROI, ABRI…) have obtained energy efficiency of 85%! Therefore to parity of costs supported from the cooperative, the bio-oil production could increase of 15% approximately and consequently the specific cost to the MCal to diminish;

- It has been estimated that with the automation process realization we can obtain a reduction of 40% approximately of the cost of the job. A positive experimentation could reduce the employment of the labour of 60% approximately.

- In the made economic considerations the eventual surplus of char has not been considered. Esteem that the amount of char that it can be sold collection, is about of 5% of the total used biomass.
- Also the ash amount can be collected, sold and used like fertilizer.

- In the economic analysis the co-generation possibility has not been considered. That could increase the station power profit;

- After 12 years it is possible that there are other incentive for the renewable sources;

- It has not been considered the increase of the price of the energy. The selling price of fossil fuel is destined to increase, and therefore the energy cost will increase.

4.Acknowledgments.

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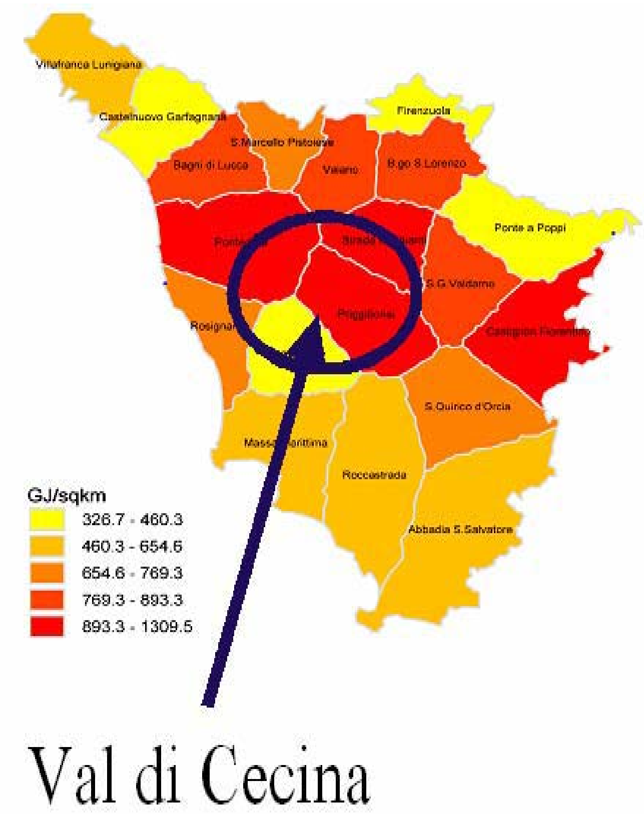

Fig. 1: Val di Cecina map

Table 1: Destination of total hectare

TOTAL HECTARE	FOREST HECTARE	SEEDED HECTARE
67.226,35	31.770,91	23.500

OTHER FOREST HECTARE	GRASSLAND HECTARE
2.356	9.599,44

Table 2: Destination of seeded hectares

SEEDED HECTARE	CEREAL CULTIVATION HECTARE
23.500	12.200

FORAGE HECTARE	OTHER HECTARE
4.000	7.300

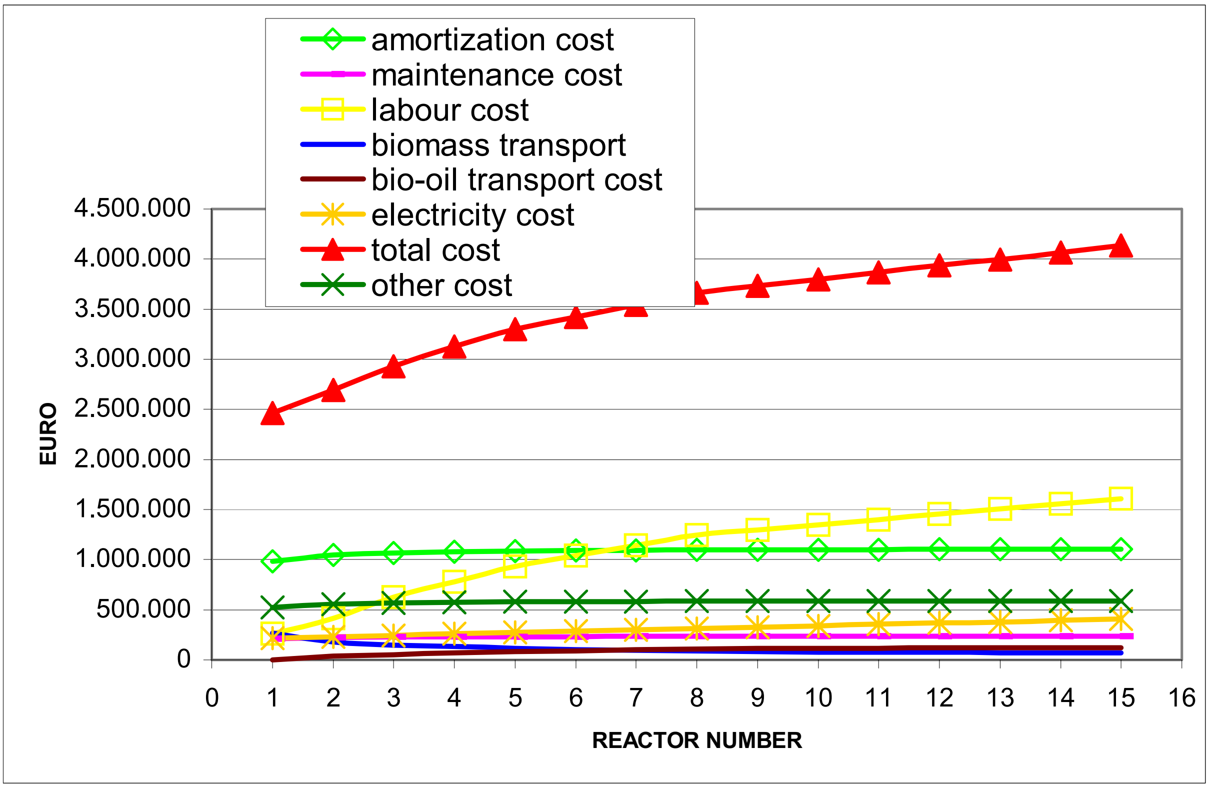

Fig. 2 Production cost.

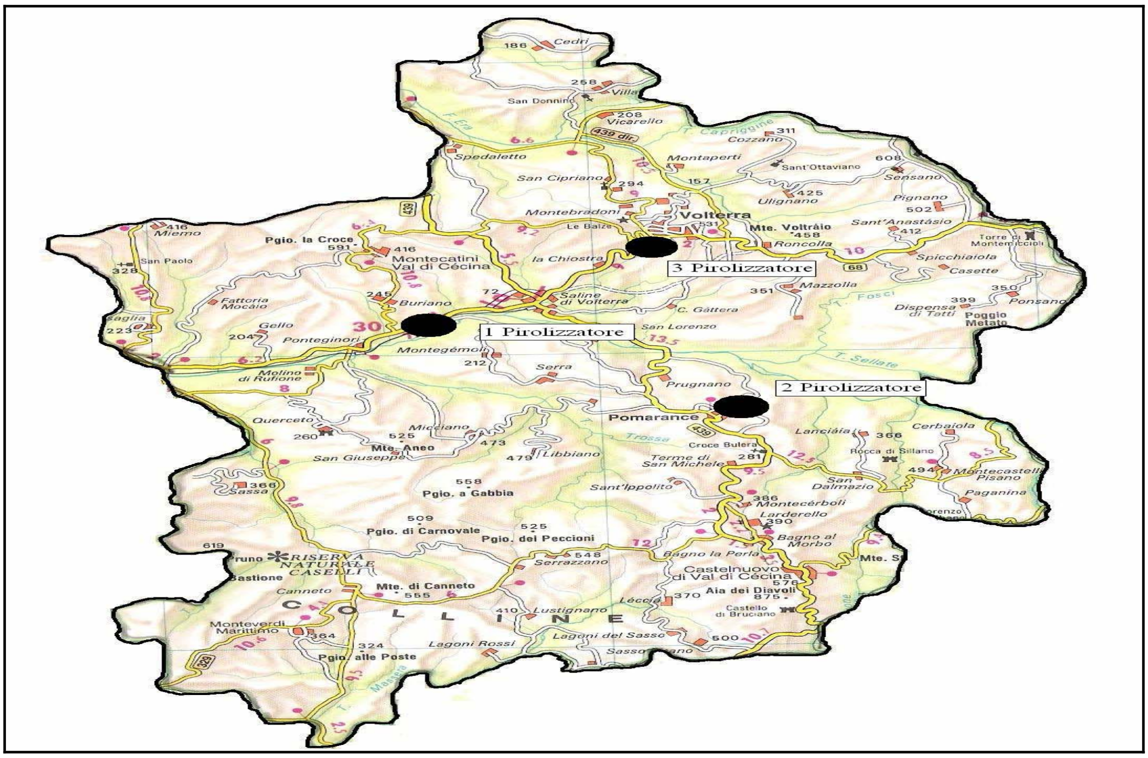

Fig. 3: Pyrolyzer positioning

Table 3

ECONOMIC EVALUATION		First PERIOD	Second PERIOD
Biomass Transport	EURO	148.000	148.000
Amortization	EURO	991.000	0
Other costs	EURO	570.000	0
Maintenance	EURO	228.000	228.000
Electrical energy	EURO	552.000	552.000
Labour	EURO	623.000	623.000
Bio.oil transport	EURO	51.000	51.000
Biomass buying	EURO	1.647.000	1.647.000
TOTAL	EURO	4.810.000	3.249.000
cost c€ / Mcal	C€/Mcal	4,5	2,9

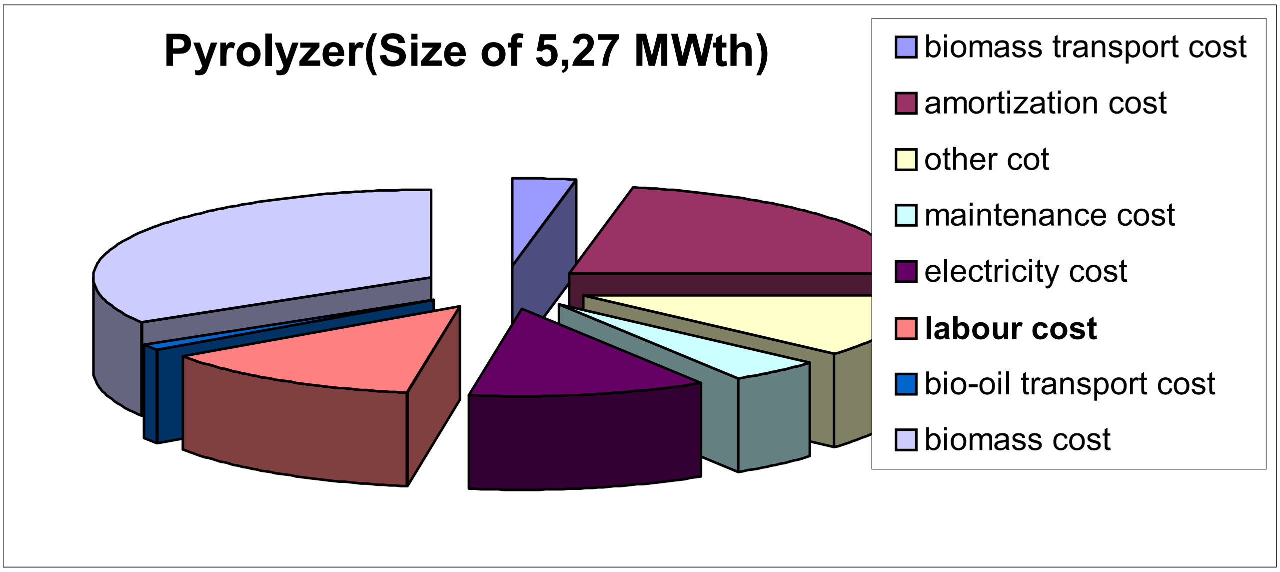

Fig. 4 . Bio-oil formation price (reactor size 5,27 MW_{th})

Table 4

ECONOMIC EVALUATION		***First PERIOD***	***Second PERIOD***
Biomass Transport	EURO	60.000	60.000
Amortization	EURO	991.000	0
Other costs	EURO	570.000	0
Maintenance	EURO	228.000	228.000
Electrical energy	EURO	552.000	552.000
Labour	EURO	250.000	250.000
Bio.oil transport	EURO	51.000	51.000
Biomass buying	EURO	1.647.000	1.647.000
TOTAL	EURO	4.349.000	2.788.000
cost c€ / Mcal	C€/Mcal	**4,1**	**2,5**