Pre-feasibility study of a waste wood district cogeneration in Sambuca industrial park as an area resources recovery project in the middle of Chianti hills

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Summary

The aim of this study is to identify an optimal and profitable solution that could take advantage of waste wood resources in Sambuca industrial park. The study has suggested different possibilities of biomass energetic use but the analysis key elements have shown that a small-scale gasifier installation and production of electric and thermal energy with a CHP internal combustion engine is the most profitable solution. Many environmental benefits could arise (1320 tCO_2/y avoided and 554 TOE/y avoided) and the initiative, being one of the few Italian examples of local recovery of wood wastes for small cogeneration, could represent a valuable starting point. There is also the opportunity of combine CHP plant with wastewater treatment facilities, which allowed interesting technical developments and efficiency improvements.

Keywords: feasibility study, recovery of residues, combined heat and power generation (CHP)

End-user area		**Target Audience**		**Technical**	
	New buildings		Citizens		Energy efficiency
	Refurbishment of buildings		Households		Heating
	Transport and mobility		Property owners		Cooling
	Financial instruments		Schools and universities		Appliances
■	Industry		Decision makers		Lighting
	Legal initiatives (municipal regulations, directives, etc)		Local and regional authorities	■	CHP
	Planning issues		Transport companies		District Heating
	Sustainable communities		Utilities		Solar energy
	User behaviour		ESCOs	■	Biomass
	Education		Architects and engineers		Wind
	Other		Financial institutions		Geothermal
			Other		Hydro power
					Other

Context

The Sambuca industrial park is a local system of SMEs located in a rather flat and narrow Chianti valley along the course of the Pesa river, nearby the Florence-Siena highway, in Tavarnelle Val di Pesa municipality. The land surface is 600.000 m^2, of which 250.000 m^2 covered with more than 200 companies of 29 different commodities and employing more than 2500 people.

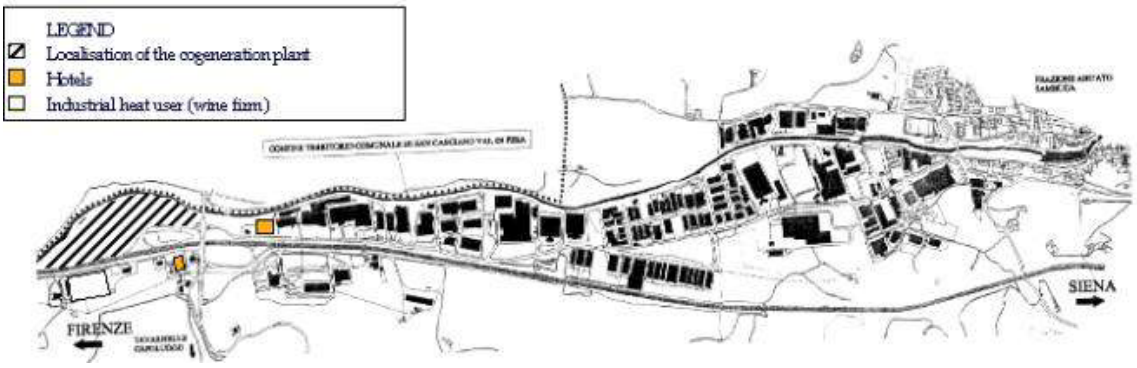

Figure 1: Sambuca industrial park map and location of plant and heat users

The Sambuca development Project 2000-2010 was launched in the year 2000 upon a participation process called European Awareness Scenario Workshop (EASW) titled "Nuts (in Italian "Viti" which also means Wineyards) and Bolts 2010: a model of industrial park in Chianti", aimed to promote and setup structural improvement actions for the benefit of industry, local authority, workers and citizen.
The present study on wood-energy recovery has been accepted by the project management as a sort of "tool" to give an additional competitive advantage to the SMEs and to the image of the park although no energy issue came up from the EASW process.

Objectives

The aim of this study is to identify an optimal and profitable solution that could take advantage of waste wood resources in Sambuca industrial park. The study has suggested different possibilities of biomass energetic use but the analysis key elements has shown that a small-scale gasifier installation and production of electric and thermal energy with a CHP internal combustion engine is the most profitable solution.
The most profitable local wood sources, either for the logistic costs and wood quality (mainly clean wood waste) are:

- Wood waste from selective collection in 8 Chianti's municipalities 1400 t/y;
- Clean wood from Sambuca local firms 800 t/y.

Further local wood biomass resources, wood harvest from local forests (located within a distance up to 5-10 km) and wood waste from local vineyards and olive trees pruning, have been carefully estimated; however, they will be initially considered as fuel reserves.
Even the not pure industrial wood waste (800 t/y) has not been considered in this phase, due to the possible plant operating problems and emission controls.

Process

The location of the plant has been selected taking into account of two important elements: areas owned by Tavarnelle's municipality and sites in the near of potential heat users.
Figure 2 shows the Sambuca industrial park map and the possible location of the powerplant: this area was originally due to host a new water treatment facility for civil and industrial sewage but it is wide enough to contain the CHP plant too.
The possible heat users are the following:

- an existing hotel (winter heating);

- a new hotel under construction (winter heating and possible summer cooling);
- an industrial heat user (washing bottles of a wine farm);
- the new wastewater treatment facilities.

The combination CHP plant / wastewater treatment facilities allows to achieve interesting technical developments of the plant: the possibility of having available thermal energy is very important because allowing features not commonly available to small size depurators.

For the heat demand, two cases with different heat users have been analyzed (figure2):

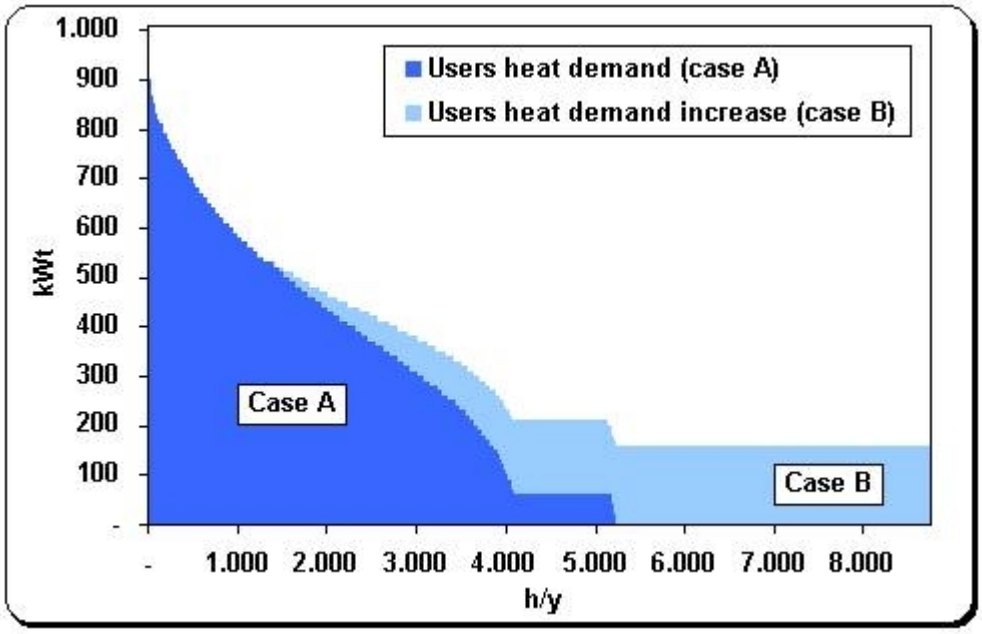

Figure 2: Heat load curves; CASE A : 2 hotels + Wine Firm; CASE B : 1 hotel + Wine Firm + depurator.

The case of heat use for sludge treatment facility has still to be improved, because at present time not enough data are available and any specific project of the wastewater treatment facilities has not been proposed yet (figure 3).

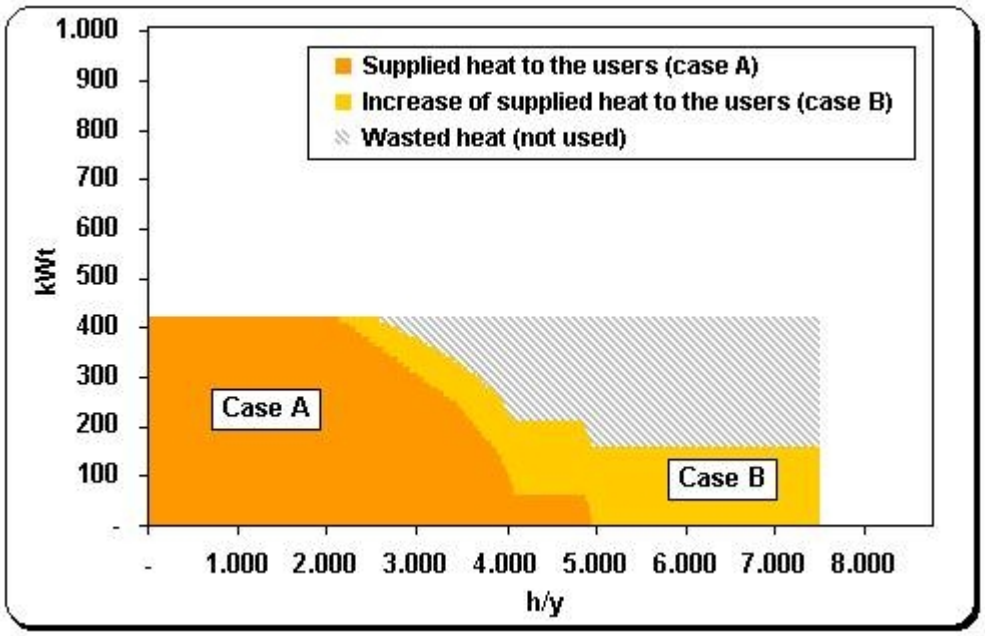

Figure 3: Heat supplied curves

The study has suggested three different possibilities of wood waste resources energy use in Sambuca:
1) wood chips boiler and district heating for industrial and civil users;
2) use of wood chips and briquettes in different heating systems (hotels and public buildings located in the surroundings);
3) gasification and production of electric and thermal energy (CHP) with internal combustion engine.

The economic analysis showed that the possibility of district heating was the worst one, due to the high investment cost. Moreover, the heat demand does not match the production, then it is not possible to have a satisfactory recovery of the available thermal energy.
At this stage the second scenario is still available, particularly having a briquette-equipment investment already made by the major wood-frames manufacturer with no potential returns so far, but a focus was given to power production and thus to the third opportunity.
The main objective of this study is the economic and technical analysis of a small-scale cogeneration system with biomass gasifier for production of electric and thermal energy with an internal combustion engine.
At present time, some experiences in the field of microcogeneration (30 to 500 kW) using fuels from biomass are available. Generally, they are pilot plants installed and used by power companies in cooperation with research boards, aimed to assess performance and troubleshoot along a fixed test campaign period. Most of times, the biomass micro cogenerator consists of an atmospheric air gasifier working with batch feedstock and coupled to an internal combustion engine, reliable when very low calorific value fuels of 4 to 6 MJ/scm (like in cases of air gasification) are used.
Other conversion systems like micro gas turbines are not yet able to operate with such low heating value fuels without a deep redesign of the combustion chamber.
Some manufacturers are testing micro turbines with landfill gas (50% of methane calorific value) and planning to reach the market level.
The flexibility of the gasification system may be regarded as an interesting opportunity to replace the eventual lacks in wood chips supply for the Sambuca area.

Financial resources and partners

The results of the preliminary economic analysis of the Sambuca waste wood CHP system are:

Investment initial cost	720.400 €
Annual O&M cost	93.500 €/y
Project life	15 years

The high investment cost is the major problem to the financial feasibility of a small-scale powerplants using biomass gasification, if compared to the traditionally fuelled systems (diesel engines).

Results

The size and the technical characteristics of this plant have been identified through the evaluation of data on the amount of wood resource continuously available during the year.

Technical characteristics of the plant:

Operating hours	7.500 h/y
Electric Power	233 kWe
Gasifier Thermal Power	1.165 kWth
Electrical Energy Efficiency	20%
Thermal Energy Efficiency	36%
Heat of cogeneration	419 kWth
Electricity production	1.747.000 kWhe/y
Maximum heat amount	3.144.500 kWhth/y
Biomass Low Heating Value (LHV)	14.114 kJ/kg
Biomass mass flow rate	300 kg/h

The proposed powerplant consists of a fuel feeding section, gasifier, dry gas cleaning system syngas cooler and, finally, the gas engine (figure 1).

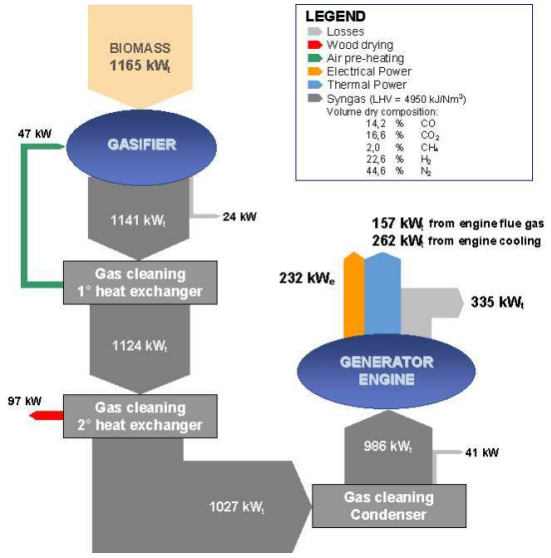

Figure 4: Schematic of powerplant energy diagram

Investment initial cost	720.400 €
Annual O&M cost	93.500 €/y
Annual benefit (case A)	208.400 €/y
Annual benefits (case B)	242.005 €/y

Income tax rate	40%
Project life	15 years
Discounted rate	12,0%
Inflation	2,5%
Average wood biomass cost (transport)	10 € /t
Avoided cost of users thermal energy	0,052 € /kWh

For the plant there are very profitable scenarios:

	Case A	Case A	Case B	Case B
Self financed Investment %	100%	75%	100%	75%
Tuscany State incentive %	-	25%	-	25%
NPV	€211.210	€391.300	€371.120	€551.200
IRR	17,87%	25,88%	21,77%	30,57%
Profitability Index - PI	1,29	1,72	1,52	2,02
Simple Payback Time	3,5 years	2,6 years	3,0 years	2,2 years
Discounted Payback Time	7-8 years	4-5 years	6-7 years	4-5 years

Lessons learned and repeatability

During this analysis, many positive results have been shown. However, it is important to remark that several more issues are already in process.
The first is a legislative one, linked to energy use of wood-waste coming from selective collection: this amount is not computable as a target percentage of the local waste-manager, which is supposed to be investor in the engineering, construction and O&M of the biomass microcogeneration system (EU policies do not give specific directives on this matter).
Then, the small size of the plant and its sensitivity to the sole wood-supplies in the industrial park represent crucial problems that could be overcame in a second phase of the project by the integration of a natural gas fired CHP (around 1,5-2 MWe). It would supply both thermal and electrical energy to the industrial district of Sambuca with possible co-investment of the local gas utility.
About the biomass, an action is in place now by the local authority to have an estimate and get commitments from local farms to collect wine and olive waste as additional base material for the gasifier. This could lead to further increase in the scale of the plant.
This initiative could be used by other countries where large biomass waste are available and the flexibility of the gasification system may be regarded as an interesting opportunity to replace the eventual lacks in wood chips supply.

Contact for more information:

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