Renewable energy from the production residues of vineyards and wine: evaluation of a business case[1]

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Jel classification: Q20, Q250, C60, C610

Abstract

The recovery of agricultural biomass, such as vine trimming wastes, for energy purposes represents one of the most significant innovations in the agricultural sector: apart from relieving producers of disposal costs, the process also has an economic return resulting from the conversion of biomass into energy and the related commercialization on the national market.

In Sicily, the significant economic potential related to the conversion and energy exploitation of residual biomass from the wine sector could play a strategic role for the immediate future of the island and for the numerous wineries and wine bottling companies operating within the territory.

This research project has the objective of analyzing the case of the largest Sicilian winery, Settesoli, which has recently launched a project to implement a 1-MW electric generator that uses the vine canes – from pruning – in conjunction with pomaces, and wastes from winemaking process.

Key words: agricultural biomass, renewable energy, pruning residues

Résumé

La valorisation énergétique de la biomasse végétale comme, par exemple, les résidus de la taille de la vigne, est à n'en pas douter l'une des innovations les plus importantes en agriculture: ce processus permet non seulement d'alléger les coûts pesant sur les producteurs pour l'enlèvement des déchets agricoles, mais aussi d'assurer un bénéfice économique grâce à la conversion de la biomasse en énergie et sa commercialisation sur le marché national.

En Sicile, le potentiel économique significatif de la conversion et de l'utilisation énergétique des résidus de la biomasse provenant du secteur de la vinification pourrait jouer un rôle de toute première importance pour le futur de l'île et pour les nombreuses caves et usines d'embouteillage des vins de la région.

Le but de ce travail est de présenter un cas d'étude, à savoir la plus grande cave sicilienne, Settesoli, qui a récemment lancé un projet pour la réalisation d'un générateur électrique de 1 MW utilisant les sarments de vigne avec des marcs de raisin et des déchets de fermentation vinicole.

Mots-clé: *Biomasse agricole, énergie renouvelable, résidus de la taille.*

Foreword

The recovery of agricultural biomasses for recyclable energy has become a significant eye opener for the agricultural world. As such, it allows in some cases to lower the cost of agricultural products as well as to gain from the recyclable energy produced and released.

In Sicily the economic potential connected to the biomass surplus, salvaged and converted into bio-energy could assume a major importance in the near future and in particular in the vine-growing sector.

In the context of the aforementioned theme, this paper is designed to analyse an experimental project initiated by one of the major Sicilian vine-growing holdings, "Cantine Settesoli s.c.a.", which decided to construct its Biomass Plant Energy of 1 MW that will use recyclable residues of the vineyard or of wine making.

Currently, Settesoli has a potential production of about 8.000 tons of grape marcs and about 12.000 tons of vine pruning residues each year, available for feeding the co-generator of electricity that allows to satisfy about 5.800.000 Kw[2] *annually.*

The case of "Settesoli" is an example of how the production of energy from renewable sources raises much attention among entrepreneurs interested in exploiting the new opportunities offered by the economic policies for green energy.

1. Legal framework

In the last ten years, the liberalization of the electrical energy market and the national and international legislation have encouraged the development of renewable energy and/or generators, in particular small generators.

Such a growth has been favoured in Europe by the directives 2001/77/EC and 2003/30/EC and, later, by the new directive 2009/28/EC; in Italy, an incentive for the production of alternative energy was promoted by a political initiatives.

As to recyclable Biomass Energy from agricultural wastes, laws were issued in Italy (decree n. 387 of 29th December 2003) based on the aforementioned directives.

This Decree and the new law n. 205 of 30th December 2008 clearly report the general notion of renewable energy, recyclable biomass, that include now *grape marcs, pips, stalks and all that comes from distillation or wine making.*

Since 2007, in Italy political initiatives have been providing financial incentives for the production of alternative energy. More in detail, for the production of electrical energy generated by plants not above 1 MW, the price is all inclusive *for each kWh (feed-in tariff), for a period of fifteen years.*

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[1] *Project Research MIUR PRIN 2007:Economical analysis and structural organization of the "Agricultural energy branches"*

The work is the result of the full cooperation of the authors. However, the paragraphs "Foreword", "Legal framework", "Materials and methods" and "Conclusions" are the work of G. Nicoletti. G. Corona is the author of "Quantity calculation of biomass necessary for the running of the plant", "Expenses foreseen for the provisions of salvaged vineyard pruning residues" and "The plant that transforms biomasses into electricity".

[2] *Source: Settesoli Wineries.*

The Ministry of Economic Development has confirmed the incentive also in the new National energy program.

About the biomass sector, the Ministry has reduced the all-inclusive prices for Power Plants under 1 MW, from €0,30 to € 0,22 per kWh; therefore, following the "Law 2009 on Competitiveness", the all-inclusive price has passed to € 0,28 per kWh released into the network.

However, despite the regulations on the subject, the policy of the Italian government appears extremely unstable and uncertain. Even if the policy was promoted nationwide and although the company which supplies electrical energy (from now on GSE) has started to pay the rate for such type of power plant, there is still much uncertainty about the quantity of such a rate during a long period of time especially for the power plants that started before December 30, 2010[3].

The decision about the precise amount of the all-inclusive rate from the 1st January 2011 shifted from a minimum of €0,18 to a maximum of € 0,30.

In this context, in 2009 the Sicilian Region prepared its own Regional Energy Plan (P.E.A.R.S.), in which a lot of attention was paid to the development of recyclable energy in general and in particular to the Biomass sector: *"Developing the energy exploitation of the Biomasses"* – declares the document – "*can specifically provide a strong support to the agricultural economy especially in the areas of agricultural decline"*. It can also help reducing unemployment; it has been calculated from the various energy plans that a Biomass Recycle Power Plant of average dimension would create 5 to 10 full-time jobs and about 5 part time jobs.

As to the vineyard/wine making, 'the residues of major interest from the energy point of view are the grape marcs from the winery, the vine canes from pruning and, in the transitory phase, the wine surplus that does not find any other use in the market (for the production of bio-ethanol).

In Sicily with a production of wine grapes of about one million tons (Istat), in the 2009 grape harvest, we can therefore estimate the possible production of biomass from vine pruning of about 207.005 tons[4] and grape marcs of about 102 thousand kilograms (Data from Fraud Repression). In particular, in 2009, the county of Agrigento – where Settesoli is based–on a surface of 21.440 hectares, 155.700 tons of grapes were produced, with residues of 178.696 hundred kilograms and a production of biomasses from pruned canes of about 68.198,40, the equivalent of 2,69 tons per hectare.

Taking into consideration the importance for the island of Sicily of such an energy chain, the Rural development programme 2007-2013, and the Sicilian ERDF O.P. 2007-2013, envisaged a series of public financial aids for the building of Recycling Power Plants.

Specifically the RDP for Sicily 2007- 2013 has foreseen a series of operations to favour the modernization not only with the intention of creating greater energy efficiency for the Sicilian farming companies but to implement the generation of renewable energy for their own use and even to be supplied to third parties.

These actions are transversal because of their natural development throughout rural Sicily – In terms of competitive growth of the agricultural sector and of the rural areas and in the life conditions or the diversity of the rural economy.

For instance, referring to Axis 1, Measure 1.2.1., the primary objective proposed is "Modernising and developing a competitive company system", through a reorganisation and modernisation of the agricultural production and of the agro-industrial one; promoting higher yield and repositioning these companies on the markets. This will be achieved through funds granted to single farmers or associations (co-operatives, companies or capital stocks), also to consortia[5] to help increasing energy saving and producing renewable energy (power plants under 1 MW) measured in proportion to the supplies and companies' energy needs. *(VII)*

Measure 1.2.3 foresees the reorganisation and modernisation of the agro-industrial production system with the objective of improving the economic gain of each company and promoting these companies to find a better place on the markets. This through funds granted to very small, small and medium companies to help incrementing energy saving and for the production of renewable energy to be used within the companies production cycle.

As to Axis 3, Measure 3.1.1 foresees funds to power plants which produce, use and sell energy generated from Biomass agro-forestry: these power plants use electrical energy generated from renewable sources, with a limited power of 30 kW. The financial aid will be distributed under the form of grants into Capital accounts and/or in Loan interest accounts or in a combined form, with a potential equal to 45% of the expense allowed; help may also be given through the "De minimis[6]" rule (a prefixed limited amount of money granted within 3 years).

Measure 3.1.2 supports economy in the rural areas creating and developing economic activities and services for the businesses and for the population, including the creation of food chains for the production and sale of the energy produced from renewable sources. Micro-companies are envisaged in individual form or as companies[7].

[3] *Standards, v.si AA.VV., "The renewables need certainty from the government", in the Agricultural Informer supplement,11/2010, p. 7 ss.*

[4] *The appraisal of the residue is based on a study from ENEA where the vine pruning is tied to the production with the following formula: Quantity of vine pruning (ton per acre) = 0,113 * grape yield + 2,000*

[5] *The funds foreseen for such measures will be distributed under the form of grants into Capital accounts and/or in Loan interest accounts or in a combined form, with a potential which varies from 40% to 50% of the amount of the allowed investment. However, the financial aid granted can not be higher than €1.500.000 for the productive phase and not more than €2.500.000 for investments.*

[6] *According to the European Market regulation n. 1998 of the 15th December 2006, as modified in the year 2009/2010 by the European commission "Temporary Community Procedural Reference for State procedures in granting financial aid during the actual economic crisis" step. GUCE n°. 16 of 2009.*

[7] *The amount available considered in step 3.1.2 is of €16,595,929, of which €12,445,929 covered by Public expenses with the aid of the "de minimis" procedure.*

Measure 4.1.3 contributes, with a financial aid, to achieving the objectives specified in Axis 3 which contains the development of renewable energy included in area plans of logical management well integrated into the region[8].

Even the Sicilian Regional Objective Plan ERFD 2007 – 2013, Axis 2, envisions a development strategy to achieve the objective of "guaranteeing an adequate level of service in the Natural resources through an efficient vision of sustainability and towards safety procedures and hazard preventions". The main objective of this Axis has been divided into four specific parts for explicit areas of intervention of which the first is to facilitate renewable sources.

In particular, in the Measure 2.1.1, the prefixed actions intend to "Facilitate the production of renewable energy creating energy production chains of technical, agricultural and bio-fuel sources" within the Region under the renewable sources sector. Such operations will be financed. Furthermore, through modern experimental projects in the Biomass sector and actions that will support the generation of energy from recyclable sources, the local authorities and other public sectors will act where necessary in compliance with the objectives of "PSR Sicily".

2. Materials and methods

Aim of this research is to estimate the cost of converting biomass into electrical energy in the vine sector, in order to assess the economic benefit that "Settesoli" could have if , in collaboration with ABE Ltd., it sets up a plant for converting biomass into energy supply (using the residues of the pruning of vines and grape marcs). The biomass is made of the grape marc residues from the winery and the vine canes from pruning. The grape marcs are to be considered as waste; therefore, their cost is only of gathering, transporting and stocking in a certain company area and consequently the transport to the power plant during its working period. With this in mind, the use for producing electrical energy is an alternative to being obliged to deliver the wastes to the distillery which creates another cost. Vineyard pruning residues etc. must be gathered in the vineyards by a specialized workforce and then transferred to the winery.

Currently, the vineyard pruning residues of the co-operative partners are finely cut and then buried. Each partner eliminates its own or they are eliminated by third parties that deal with such services, with a cost of about €60 to €80 per hectare. In the cases where the residues are delivered to the winery to produce bio-energy, the work of gathering and transporting is assigned to third parties hired by the winery (at a prefixed price per ton of biomass delivered).

Therefore, we have initially appraised the expense of gathering and transporting the pruning residues to the winery and then we have calculated the cost of running the transforming plant (boiler and generator), to get the cost of transforming the biomasses into electrical energy. In order to determine such costs, we assessed the value of the machinery of the power plant, the engineering expenses, the building, the connection with the electricity board, the cost of installation, the reinstatement expenses, the interest rates on the invested capital and the advance capital, the insurance for the machinery and shelters, the cost of the shelters and also the cost of maintenance, repairs, fuels and greases and any other material needed for this process.

To quantify the expenses we distinguished the fixed costs from the variables and we used specific calculation methods referring to the criterion proposed by MIPA[9].

- Particularly, for the fixed costs:
- annual reinstatement quota = (A – R)/n;
- interest on capital = (A + R)/2)*r;
- interest on advanced capital = (4/12 operational advanced capital[10])*r *(XV)*
- insurance R.C. = insurance premium (about €120,00 per year);
- fire safety insurance = 0,25% of the insurance estimate;
- shelters = encumbrance area (increased by 10 to 15% manoeuvring space) multiplied by 3% of the value of each square foot unit of the factory (calculated in €160,00 per sq. metre.);

where *A* is the value of new machinery or of the plant net eventual discounts; *R* is their retrievable value after (n.) years of useful life of the machinery and the plant; *r* is a sample of adopted interests (3%);

For the variable costs:

- cost of maintenance = [(u*CdM)*cost of workforce]/u;
- cost of repairs = [A/(U*n)]*C;
- fuel consumption = Pm*Cm*Cs*P;
- grease consumption = Pm*Cm*Csl*Pl;

where *u* is the annual functioning of the machinery or of the plant (expressed in hours); *CdM* is the coefficient of maintenance (hours/working hours); *C* is the coefficient of repairs (%); *Pm* is the motor power in (Kw); *Cm* is the motor charge (%); *Cs* is the specific fuel consumption; *P* is the price of fuel (for agricultural use); *Csl* is the specific grease consumption and *Pl* is the price of grease.

3. Quantity calculation of biomass necessary for the running of the plant

We presume that a plant will have a maximum power of 950 KW (as obliged to be under 1 MW of electrical power) and that it will work twenty-four hours a day for at least 315 days a year (7.560 hours). With such information, it is possible to calculate the initial combustion in KJ[11] thereby knowing the "lower calorific value" of the biomasses in question to calculate the necessary quantity.

The amount of the necessary combustion depends on the type of transformer used. In the case taken into considera-

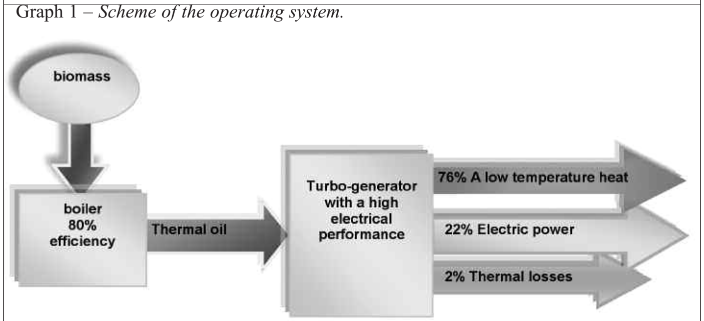
[8] *The entity of the grant is equivalent to that foreseen in Procedure n. 3. whilst the other forms of contribution are given through the "de minimis" rule which allows up to 80% of the allowable expenses for Public beneficiary and up to 75% for Private beneficiaries.*

[9] *MIPA technical economic parameters controlled by C.R.P.A. Central research of animal products Reggio Emilia 1998.*

tion in our study, the use of transformers with a boiler (with an automatic feeding system) for the combustion of the biomasses has been envisaged.

After a research on the subject and information given by the industries that produce this type of boiler, we discovered that the general equivalent of thermal yield is 80%[12]. The heat produced will therefore transform (due to the thermal oil) with the turbo-generator which has a coefficient of yield into electrical energy of about 22% (graph 1).

Graph 1 – *Scheme of the operating system.*



Hence, if we invert the procedure and start from the end to make an electrical power plant of 950 Kw work we need a quantity of biomass that generates a combustion energy of about 147 million MJ.

Taking into consideration that the lower calorific value (PCI[13]) of the grape marcs is of about 9.740 KJ/Kg, this is the type of biomass that will foremostly be used by the companies.

They will need about 69 million MJ of energy which they could obtain from the vineyard pruning residues and in that way a total energy production equal to 147 million MJ is reached; consequently, the amount needed for the plant is of about 5.240 tons of residues which corresponds to a vineyard area of about 2.350 hectares[14].

4. Expenses foreseen for the supply of salvaged vineyard pruning residues

As far as the supplies from the pruning residues are concerned, it is necessary to have a particular work site, connected to the vineyard.

Taking into consideration that one hectare contains about 4000 plants, every plant produces from 0,5 to 0,6 hectograms of biomass (from vineyard pruning residues).

To collect the pruning residues you need for the work site a towable working machinery like a round baler (C.A.E.B quick power 930[15]), a tractor to pull the machinery, another tractor with tyres and a trailer to transport the biomasses to the winery, a skilled worker for the round baler, two unskilled workers to load and unload and transport the trailer. The collection of the residues must be done within three months not to hinder the implementation of the necessary cultivation actions for the next vineyard harvest. With this in mind we have considered a working period of sixty days.

To facilitate the gathering of the pruning residues, it is necessary that they are deposited centrally between two rows, so that the tractor pulling the round baler is able to efficiently collect the residues.

Each bale weighs about 28 to 30 kilos and is loaded onto the proper container (baler pile upper); it piles up to seven or eight bales. This capacity usually allows the machines to finish the whole row and unload at its end.

The time needed to gather and produce bales depends on the quantity of residues between the vine rows and by the ability of each operator of the round baler.

Based on data supplied by ABE srl[16] on tests done in a vineyard, it is possible to estimate the normal quantity of biomass; the time it takes to gather and make it into bales is about 90 seconds per bale (table 1). Taking into consideration that recently established vineyards contain about 4000 plants/hectare, every plant produces from 0,5 to 0,6 hectograms of biomass (from vineyard pruning residues) which means that each hectare of the vineyard will produce at least 2.200 Kg of biomasses which correspond to about 80 bales per hectare.

To gather the necessary quantity of biomass to make the plant work transforming it into electricity you need about 5.240 tons of pruning residues, at least 12 work-sites of residue collection; as aforementioned the biomasses must be

Table 1 – *Collection test of bales of pruning residues.*

Items	**1 hectar**
Number of plants/ha	4000-4500
Average weight of bale (Kg)	28
Bales collected/hour	40
Collecting time (minutes)	120
Minutes to collect one bale	1,5
Collected/hour (KG)	1.120
Collected/ha (KG)	2.240
Collected per vine (KG)	0,5 – 0,6
Bales collected **in 6,5** hours	260
Surface collected in 6,5 hours: ha	3
Bales collected in 60 days (6,5 hours per day)	15.600
Surface collected in 60 days (6,5 hours per day): ha	195
Annual quantity needed of pruned canes(tons)	5.240
Number of bales needed	187.143
Surface needed : ha	2.345
No. teams for collection (6,5 hours per day)	12

Source: elaboration on data from ABE Ltd

[10] *Advanced capital is the amount of the annual variable expenses and the insurances.*
[11] *Kilojoule: unit of energy measure, work and heat.*
[12] *The efficiency of the biomass boiler is about 80% in case of boiler without the "split", and 88% in case of machine with "split".*
[13] *For traditional boilers you consider the* lower calorific value *which refers to the material used, when normally used as combustion. To obtain the sum of the value we have taken into consideration the percentage of humidity of both types of biomass used. Particularly the grape skins were calculated as PCIss = 17,86 MJ/Kgss (source UNI CEN/TS) and a humidity value of 40%; the pruned vine stalks were calculated as PCIss = 19,11 MJ/ Kg and a humidity value of about 30%.*
[14] We have considered the plant with 4,000 plants per hectare.
[15] *CAEB* International is a company that produces small round balers.
[16] *The company ABE Srl* has performed a test on the residue gatherings on behalf of the winery "Settesoli"

Table 2 – *Composition of yard work and related costs of machinery.*

Items	Tractor with tyres	Round baler	Trailer	Other tractor with tyres
Pm = Engine power (KW)	40	15	-	40
List price (€)	20.000,00	15.000,00	6.000,00	20.000,00
State contributions [1] (50%) (€)	10.000,00	7.500,00	3.000,00	10.000,00
Value added tax (IVA) 20% (€)	4.000,00	3.000,00	1.200,00	4.000,00
A= purchase price (€)	14.000,00	10.500,00	4.200,00	14.000,00
U = annual use (hour)	600	390	480	600
N = machine life (years)	15	15	20	15
Total work hours (machine life)	9.000	5.850	9.600	9.000
C_r = coefficient residual value (%)	24%	10%	20%	24%
Residual value = A*C_r(€)	3.360,00	1.050,00	840,00	3.360,00

[1] PSR Sicily 2007-2013, Measure 123 and 312.

collected within three months, (at least 60 working days). The work will have to be done in a vineyard area of about 2.350 hectares (table1).

To determine the cost of collecting the bales, we proceeded with the analysis of the fixed prices and relative variables like the machinery used for collecting, the salary of the work force. We also considered the working area previously described, adaptable for storing, packing, loading and transport towards the winery (table 2).

More precisely, we calculated the hourly costs, fixed and variable. The time taken into consideration was 600 hours yearly for each tractor and 390 hours for the round balers (in the hypothesis that they will be used only for the action of gathering the vineyard pruning residues) and 150 hours for the trailer (tab. 3).

Once the total hours are calculated, we could calculate the annual cost of the machinery used for the vineyard pruning gatherings, this time just considering the period deveoted to this particular activity (table 4).

Tab. 3 – *Fixed and variable hourly costs relating to machinery.*

Items	Tractor with tyres	Round baler	Trailer	Other tractor with tyres
Annual usage (ore)	600	390	150	600
Fixed cost				
Annual reinstatement quota (€)	709,33	630,00	168,00	709,33
Interest on invested capital (€)	260,40	173,25	75,60	260,40
Interest on advanced capital (€)	95,90	18,07	2,90	34,60
Insurance machine (€)	175,00	26,25	10,50	175,00
Shelters (€)	48,00	48,00	72,00	48,00
Insurance shelters (€)	40,00	40,00	60,00	40,00
Total fixed cost /hour (€)	***2,21***	***2,40***	***2,59***	***2,11***
Variable cost				
Cost of repairs (€)	0,70	0,72	0,09	0,70
Cost of maintenance (€)	0,63	0,63	0,63	0,63
Fuel consumption (€)	6,07	0,00	0,00	6,48
Grease consumption (€)	0,35	0,13	0,00	0,35
Total variable cost /hour (€)	***7,75***	***1,48***	***0,72***	***8,15***

Table 4 – *Total costs of collection of pruning residues (only machines).*

Items	Tractor with tyres	Round baler	Trailer	Other tractor with tyres
Working hours (year)	390	390	120	120
Fixed cost /hour (€)	2,21	2,40	2,59	2,11
Variable cost /hour (€)	7,75	1,48	0,72	8,15
Total variable cost	**9,96**	**3,88**	**3,31**	**10,26**
Fixed annual cost (€)	863,61	935,57	311,20	253,47
Variable annual cost (€)	3.021,58	576,14	86,07	978,29
Total annual cost (€)	**3.885,19**	**1.511,71**	**397,27**	**1.231,76**

Table 5 – *Calculation of salaries of the workforce.*

Workday (6,5 hours)	Salary (€)	Compulsory/mandatory contribution [1]	Total (€)
Skilled worker (€)	63,54	18,15%	**75,07**
Unskilled workers (€)	50,71	18,15%	**59,91**

Type of worker	Unskilled worker	Skilled worker
number	2	1
total wages (€)	119,83	75,07
Total salary per day	**194,90**	

[1] National Social Security Institute

To this price we added the salaries of the workforce calculated on the current amounts given in 2009 in the province of Agrigento (table 5); we also took into consideration the cost of string to tie the packaging of the pruning residues.

Finally we obtained the amount of all the expenses and could therefore calculate the daily costs and those for a period of 60 days (table 6).

Tab. 6 - *Total costs of collecting of the pruning residues.*

Items	Cost (60gg)	Daily cost
Tractor with tyres (€)	3.885,19	64,75
Round baler (€)	1.511,71	25,20
Trailer (€)	397,27	6,62
Other tractor with tyres (€)	1.231,76	20,53
Cost workers (€)	11.694,01	194,90
Wrapping cost (€)	982,80	16,38
total cost = (€)	**19.702,74**	**328,38**

Unit cost per bale: Cu_b = (daily cost) / (n° bales collected) = 328,38/260 = €1,26

The value obtained allows us to estimate the cost of the biomass needed (other than the grape marcs) to bring the functionality of the transforming biomasses into electricity. As we said before the biomass needed is about 187 thousand bales (5.240 tons) of vineyard pruning residues, which is equal to an economic value of about € 236 thousand.

[17] PSR Sicily 2007-2013, Measure 123 and 312.
[18] National Social Security Institute

Tab. 7 – *Total processing costs (€).*

Items	Annual cost (period)	Daily cost (24 hours)	Daily cost (6, 5 hours)
Boiler	318.578,53	1011,36	
Generator OCR	197.982,13	628,51	
other works	212.593,68	674,90	
Tubular packaging machine	20.086,63		466,30
Shovel machine	15.309,77		124,39
Biomass cost	235.800,18	748,57	
Salaries of the workforce	190.433,22	604,55	
Total	**1.190.784,14**		

5. The plant that transforms biomasses into electricity

To calculate the cost of transforming the biomasses into electricity we must also take into consideration the expenses incurred for such machinery. The installation consists in a boiler and a generator ORC. We took into consideration individual entries: the cost of the workforce engineers, bricklayers, electricians to install and connect the electrical network. We also considered the tubular packaging machine[19] to salt the grape marcs for their conservation and the forklift to move the packages.

Tab. 8 – *System features.*

Items		
Electric power production	950	KW
Hours worked	7.560	Hours
Coefficient of thermal efficiency boiler	950	KW
Coefficient of electrical performance generator	80%	
PCI Grape marcs =	22%	
PCI Pruning residues =	9.740	Kj/Kg
Quantity of grape skins	12.870	Kj/Kg
Quantity of pruning residues	8.000.000	Kg
Total calorific value of grape marcs (J)=	5.370.000	Kg
Total calorific value of pruning residues (J)=	77.920.000.000.000	Joule
Total calorific value (J)=	69.111.900.000.000	Joule
1KWh = 10^3w * 1h = 10^3w * 3600 secondi = 3,6 * 10^6 J		
Kwh theoretical producible =	40.842.194	Kwh
Heat produced =	32.673.756	Kwh
Electricity produced =	7.188.226,22	Kwh
Total value of electricity =	1.051.169,28	**€**
Cost per Kwh =	**0,146**	**€/Kwh**
Cost of biomasses =	**78,62**	**€/t**

Table 9 – *Economic evaluation.*

	Without financial incentives (PSR 2007-2013)	With financial incentives (PSR 2007-2013)
Electricity consumed by the winery (Kw)	5.800.000	5.800.000
Average Costs of Electricity GSE (€/Kw)	0,155	0,155
A = Annual electricity cost (€)	**-900.740,00**	**-900.740,00**
Electricity produced from biomass sources (Kw)	7.188.226	7.188.226
Selling price electricity (€/Kw)	0,28	0,28
Economic value of energy produced (€)	**2.012.703,34**	**2.012.703,34**
Total cost of the transformation process (€)	**-1.051.169,28**	**-1.246.576,26**
B = Balance (€)	961.534,06	766.127,09
Annual electricity cost with electricity produced from biomass (€) = A+B	**60.794,06**	**-134.612,91**

Apart from the costs referring to the running of the plant we must add the cost of the availability of the biomasses (residues from vine pruning) and the workforce necessary for the running of the plant.

From the sum of the different entries we will obtain the total cost of the transformation of the biomasses into electricity (tab. 7)

The plant provides for a period of operation equal to 7,560 hours per year to power about 950 kW, producing about 7.2 million kWh (Table 8). Consequently, the cost per unit of energy produced (cost per kilowatt hour) is € 0.146 / kWh.

The biomass input into the process as a whole (skins and pruning residues) is 13,370 tons, and the cost of its transformation is equal to € 78.62 / t.

In the absence of financial incentives provided by the Sicily RDP 2017-2013, the cost of biomass harvest increases by about 13%, rising from € 1.21 per bale raising to € 1.37. Instead, the production cost per kWh increases from € 0.146 / kWh to € 0.173 / kWh, an increase of almost 18%.

Consequently, the cost per ton of biomass changed from € 78.75 / t to € 93.20 / t.

So, without the financial incentives for the construction of the plant, the cost of biomass harvest in the field increases by about 13%, rising from € 1.21 per bale raising to € 1.37. The production cost per kWh increases from € 0.146 / kWh to € 0.173 / kWh, an increase of almost 18%. Of course, the cost per ton of biomass used increases from € 78.75 / t to € 93.20 / t.

Conclusions

Settesoli Winery consumes on average about 5.800.000 Kw[20] *annually.* Due to the installation of a co-generator of electricity (transformation plant of vineyard pruning residues), the winery produces 7.192.289 Kw per year at a cost of about € 0,146 a Kw. Enforcing the aforementioned project of reconversion, the company is in the position to satisfy not only its annual needs but has a surplus quantity.

In such a context the winery continues to buy electricity to run the plant at €0,16[21] per kwh and then sell to GSE the energy produced from the biomasses at the price of €0,28. The results are that the electricity expenses will diminish from about €900 thousand to about €85 thousand.

The economic value of annual energy output – compared

[19] *The Tubular Packager is a machine that allows to package the recyclables into tunnels of plastic (diameter 2-2,4 metres).*
[20] *Source Settesoli Wineries.*
[21] *Gas and Electric Authority – average price for energy given to industries.*

to state subsidy of € 0.28 kWh – will be more than two million euros, compared with a processing cost of biomass used oscillating between 1 million and 1 million and two hundred thousand euro, with a profit of between 961,000 and 766,000 euro which will cover the cost of energy supply, equivalent to about € 900,000 per year.

In this context, the winery will buy the electricity for the operation of its plants at about € 0.16 per kWh; the GSE will sell the energy produced from the biomass, at about € 0.28. In this way, the result would change: the cost of the energy would turn from negative to positive, from about € -900,000 to € +60.000, with the funds of RDP 2007-2013 Sicily; or (without financial incentives), it would reduce the negative balance of the energy bill, from about € -900,000 € to -134,000 year (table 9).

Moreover, with the cogeneration plant, annual disposal of 13,370 tons of waste from wine production will be guaranteed: 8,000 tons of grape marcs and 5,370 tons of pruning residues (corresponding to 192,000 bales, each weighing about 28 kg), products from about 2,400 hectares of vineyards, which represent a cost for winemakers and bottlers.

Apart from the economic convenience, we must consider how the public image has increased due to the decrease of CO_2 emissions which was one of their objectives. The kilowatts produced during the transformation of the biomasses would bring the decrease in CO_2 emissions: in fact, 7.188.226 Kwh produced would correspond to about 3.780 tons of CO_2 emissions no longer discharged into the air[22], every year.

The plant will also allow the use of 11 workers, including 3 employees in outsourcing for the collection of pruning residues and 8 for the packaging operation, power supply and control.

In addition to the economic and environmental benefits, the company will also have a benefit for its image.

References

A cura dell'Ufficio Statistiche Gestore Servizi Energetici (GSE), 2009, *Le biomasse e i rifiuti - Dati Statistici al 31 dicembre 2008*.

A cura di Porceddu P.R., 2008, *Meccanizzazione per le filiere bioenergetiche. Tecnologie esistenti e sviluppo di innovazioni tecnologiche e tipologiche* - Dipartimento di Scienze Agrarie e Ambientali - Università degli Studi di Perugia.

Beccali M., Columba P., D'Alberti V., Franzitta V., 2009, *Assessment of bioenergy potential in Sicily: A GIS-based support methodology* – Biomass and Bioenergy Volume 33, Issue 1- selected, 1-162 (January 2009).

Cavalaglio G., Cotana S., Barbanera M., Giraldi D., 2007, *Valorizzazione energetica degli scarti di potatura dei vigneti* - Centro di Ricerca sulle Biomasse, 7° Congresso Nazionale Ciriaf – Perugia.

Cioffi A., 2009, *Rilievo indici di relazione tra produzioni agricole e biomassa residuale associata, analisi del mercato della biomassa residuale nelle province delle regioni: Molise, Campania, Puglia, Basilicata, Calabria, Sicilia, Sardegna* – Ministero dello sviluppo economico e Enea, Portici.

Cotana F., Bidini G., Fantozzi F., Buratti C., Costarelli I., Crisostomi L., *2006, Il laboratorio per la caratterizzazione energetica delle biomasse del centro di ricerca sulle biomasse* - Centro di Ricerca sulle Biomasse 61° Congresso Nazionale ATI – Perugia 12-15 Settembre 2006.

Cotana F., Cavalaglio G., 2008, *Impianto pilota per la conversione energetica degli scarti di potatura dei vigneti* - Centro di Ricerca sulle Biomasse, in Atti dell'8° Congresso Nazionale CIRIAF.

C.R.P.A., 2005, Costo di esercizio delle macchine agricole 1° e 2° parte – Centro ricerche produzioni animali – Opuscoli 5.44 – N. 5/2005 e 5.45 – N. 6/2005.

Duvia A., Gaia M., 2004, *Cogenerazione a biomassa mediante Turbogeneratori OCR Turboden: tecnologia, efficienza, esperienze pratiche ed economia* – in www.

Gelleti R., Jodice R., Mauro G., Migliardi D., Picco D., Pin M., Tomasinsig E., Tommasoni L., Chinese D., Monaco B., Nardin G., Simeoni P., 2006, *Energia dalle biomasse - Le tecnologie, i vantaggi per i processi produttivi, i valori economici e ambientali* – Centro di Ecologia Teorica ed Applicata di Gorizia (C.E.T.A.), Università degli Studi di Udine - Dipartimento di Energetica e Macchine, Trieste.

Guercio A., 2009, *Impianti di piccola taglia:condizioni ideali* – Rivista "L'Ambiente" n. 4., Editore I.C.S.A.

INPS, *Contributi dovuti dalle aziende agricole per gli operai a tempo determinato e a tempo indeterminato per l'anno 2009*- in www.inps.it.

Meglioraldi S., Storchi M., Bacchiavini M., Bondavalli R., 2009, *Gestione dei residui di potatura* - Consorzio per la Promozione dei Marchi Storici dei Vini Reggiani, in www.vinireggiani.it.

Metelli E., 2009, *Impianti di cogenerazione, un metodo di calcolo oggettivo dei costi unitari di produzione* – in La Termotecnica pp. 63-68 (giugno 2009).

Ministero dell'Ambiente e della Tutela del Territorio, 2003, *Le biomasse per l'energia e l'ambiente, Rapporto 2003.*

Ministero per le Politiche Agricole, 1998, *Macchine Agricole, parametri tecnico-economici,* C.R.P.A. – Centro Ricerche Produzioni Animali, Parma.

Rapporto preparato dall'Ufficio Centrale del CTI, 2000, *Impianti a biomasse per la produzione di energia elettrica* - Comitato Termotecnico Italiano – Energia Ambiente (www.cti2000.it).

Spinelli R., Nati C., Magagnotti N., Civitarese V., 2006, *Produrre Biomassa dai Sarmenti di Vite* - *L'informatore Agrario*, vol. 28, pp 36-39.

Vieri M., Spinelli R., Nati C., Magagnotti N., 2007, *Recupero energetico da vigneti e oliveti*. PTU. Quaderno ARSIA.

Infascelli R., Faugno S., Pindozzi S., Boccia L. , 2009, *Disponibilità di biomasse agro-forestali e residui di potature in Campania* - IX Convegno Nazionale dell'Associazione Italiana di Ingegneria Agraria Ischia Porto, 12-16 settembre 2009 - memoria n. 6-40.

ANPA - Unit. Normativa Tecnica ,2001, *I rifiuti del comparto agro-alimentare* - Rapporti 11/2001, ISBN 88-448-0242.

[22] *Considering as a conversion 1. TEP of diesel = 2,9 tons of CO2.*