MedStrategy Project - Integrated Strategy for Sustainable Development of Mediterranean Rural Areas
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C5 – STRATEGIC PLANNING IN MED RURAL AREAS

Phase 3 – Identification of Key Interventions

Final Report on Key Intervention (4) “Exploitation of biomass-type residues and by-products in the greater Archanon-Asterousion Municipality in an integrated plant and expected synergies”

- *Executive summary*

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MEDSTRATEGY: INTEGRATED STRATEGY FOR SUSTAINABLE DEVELOPMENT OF MEDITERRANEAN RURAL AREAS

Υποστήριξη συμμετοχικού προγραμματισμού για την βιώσιμη εφαρμογή τεχνολογιών ΑΠΕ στον αγροτικό τομέα του Δήμου Αρχανών – Αστερουσίων Κρήτης (πρώην δήμο Ν.Καζαντζάκη) - Εντοπισμός και σχεδιασμός ενός πιλοτικού έργου

Support for the participatory programming for sustainable applications of renewable technologies in the agricultural sector of the Arhanes-Asterousia Municipality (former N. Kazantzakis Municipality) – Identification and design of a pilot project

EXECUTIVE SUMMARY

ΣΕΠΤΕΜΒΡΙΟΣ 2012

PROPOSED INTERVENTIONS FOR THE EXPLOITATION OF BIOMASS-TYPE RESIDUES AND BY-PRODUCTS IN THE GREATER ARCHANES-ASTEROUSIA MUNICIPALITY IN AN INTEGRATED PLANT AND EXPECTED SYNERGIES

EXECUTIVE SUMMARY

1. Objective of the proposed intervention

In the framework of the MED-strategy programme, it is proposed to develop a concept for the rural development of the Archanes-Asteroussia Municipality (AAM) and the greater region (e.g. Gortyna and Festos Municipalities-GFM, where the Messara valley – the richest olive tree orchard in Crete – is extended).

The proposed concept will focus on the development of an Integrated Plant for the energy exploitation of by-products and residues derived from two of the region's most important agricultural activities, namely:

- the olive oil producing sector (mainly), and
- the wine-making sector.

The synergies from the proposed overall management of the majority of the organic biomass-type residues in the proposed Integrated Plant are expected to lead to significant benefits in the socio-economic life of the AAM and GFM, since:

1. it will generate a viable activity through the production of final energy products (dry biomass fuels) of added value to be sold in the energy market
2. it will combine treatment of different residues in an integrated activity to achieve economies of scale and reduction of operational costs
3. it will generate renewable electricity to be directly exported to the Grid
4. it will provide long-term employment opportunities to local population and contribute to the improvement of social cohesion
5. it will secure environmental protection in the greater AAM and GFM region and, indirectly, upgrade the entire touristic significance of the greater area.

2. Biomass resources in the region

The AAM and adjacent GFM territory is characterised by its dynamic agricultural production, especially in the fields of olive oil and wine-making production.

The above extensive agricultural activities generate significant amounts of residues and by-products. More specifically:

The olive oil production in the greater AAM area (including the adjacent Gortyna & Festos Municipalities-GFM) is estimated to **≈15.500 tons/year**, while more than **65.000 tons OME/year** (Olive Mill Wastewater/Effluents or OMW/OME) are also generated. Due to the fact that the OME are heavily polluting and that the vast majority of OME is currently disposed unregulated, there exists a double problem for the rural society, namely:

- the consumption of huge quantities of water, and
- the pollution of the soil and water recipients.

Currently, due to technological and financial constraints, the olive mill owners cannot apply a simple OME treatment method at olive mill level, a problem which results to the continuation of the environmental degradation of all regions in the vicinity of the olive oil producing mills.

Besides the above, significant quantities of biomass are produced in the AAM and GFM from the olive prunings generated annually from the agricultural practices in the olive tree orchards.

Similarly, the vineyards area in the AAM area is also extended, while two significant by-products are generated, namely: vineyard prunings which are left over to the fields after harvest, and grape pomace (gr. *stemfyla*) from the wine making process in the wineries (private or belonging to Agricultural Co-operatives, such as this of Peza).

It is noted that the vineyards prunings have a much less significance than the olive tree prunings and have not been considered in the Integrated Plant sizing process, however, all residues quantities can easily be utilised in the plant considered.

In the following, a simple modification in the olive mills operation mode combined with a central treatment method of the resulting olive mill by-products/residues to alleviate the environmental problem of current OME disposal practices, create business opportunities and also contribute to job creation and improvement of rural economy, is proposed and briefly analysed.

3. Elements of the OME problem and proposed intervention

As mentioned above, the major intervention proposed refers to the rational exploitation of the organic, biomass-type by-products and residues of the Archanes-Asterousia Municipality and Gortyna & Festos Municipalities (AAM & GFM), to produce dry biomass and electrical energy.

The majority of the olive mills operate basically in the so-called <u>three-phase centrifugation mode</u>, producing huge amounts of wastewater (Olive Mill Wastewater/Effluents or OMW/OME, gr. *katsigaros*), corresponding to 1-1,6 m^3/ton olives. Introducing the <u>two-phase centrifugation mode</u> of operation, today extensively used in Spain – where the two-phase process has replaced the traditional three-phase one to >90%, a watery sludge (in Spanish *alperujo*) with a moisture content of ~65% wt is derived instead of OME, as schematically depicted in **Figure 1** below.

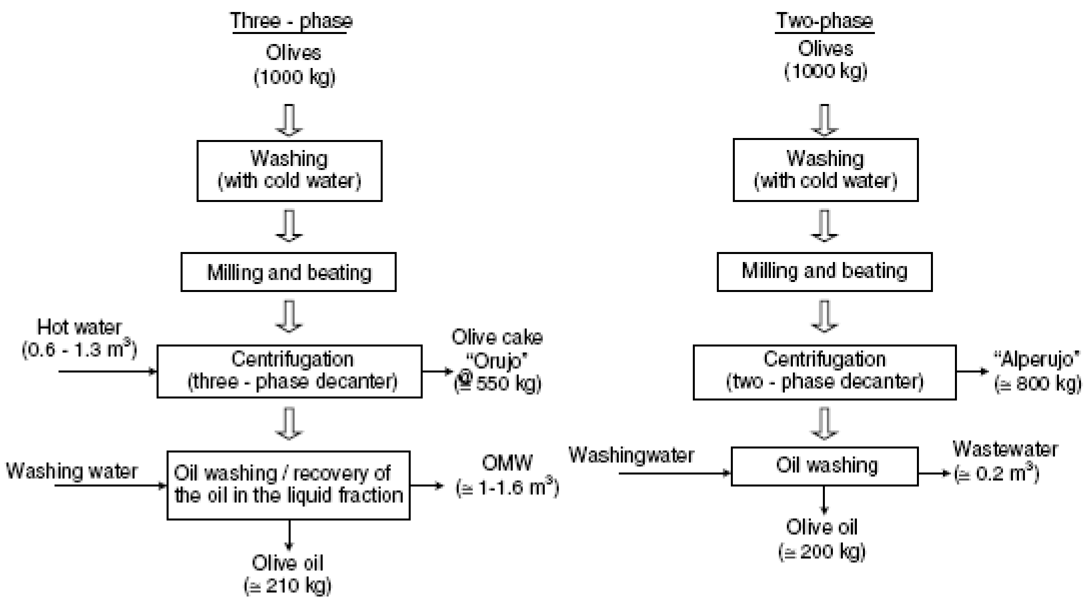

Figure 1: The three- and two-phase centrifugation mode of operation for olive oil production

In the following, *alperujo* (i.e. 2-phase Olive Husk or 2P-OH) is guided to central processing plants (so called "repasso" plants), where the residual oil is extracted and an oil-exhausted sludge, the exhausted olive husk or EOH (in Spanish *alpechin*) is produced, with a moisture content of ~65-70 % wt.

The proposed intervention - besides the extraction of the residual oil (secondary olive oil) - exploits the energy content of the resulting EOH, whereby significant environmental advantages and a positive financial result is expected, namely:

1. once the olive mills have switched from the three- to the two-phase mode of operation, the OME are virtually eliminated and, hence, the associated severe environmental pollution caused by the uncontrolled spreading of such effluents to water and soil recipients is avoided
2. vast water shavings are achieved, since the two-phase requires only ≈50% of the water used in the three-phase mode of operation (refer to **Figure 1** above)
3. slightly higher yields and a better oil quality are produced, since the water-soluble polyphenols (which are known antioxidants) are retained in the oil-phase
4. an environmentally sound solution for the disposal of the noxious OME is provided

Moreover, side-activities with positive economic results are developed, since – once the proposed integrated intervention for the processing of 2P-OH is implemented – the derived dry olive husk (with a moisture content of ~10-15% wt) can be directly utilized, sold as dry biomass, upgraded to pellets or guided for electricity generation or co-generation. In case a co-generation plant (or a Combined Heat & Power/CHP plant) is employed, where the energy potential of the resulting dry biomass from the dryer is exploited, the thermal requirements of the dryer could partially be covered utilizing the energy content of flue gases of the CHP plant. The resulting Integrated Plant, depicted in **Figure 2** below, combines the treatment of olive mills residues (2P-OH, Cycle-1) and the exploitation of agricultural residues (prunings, Cycle-2).

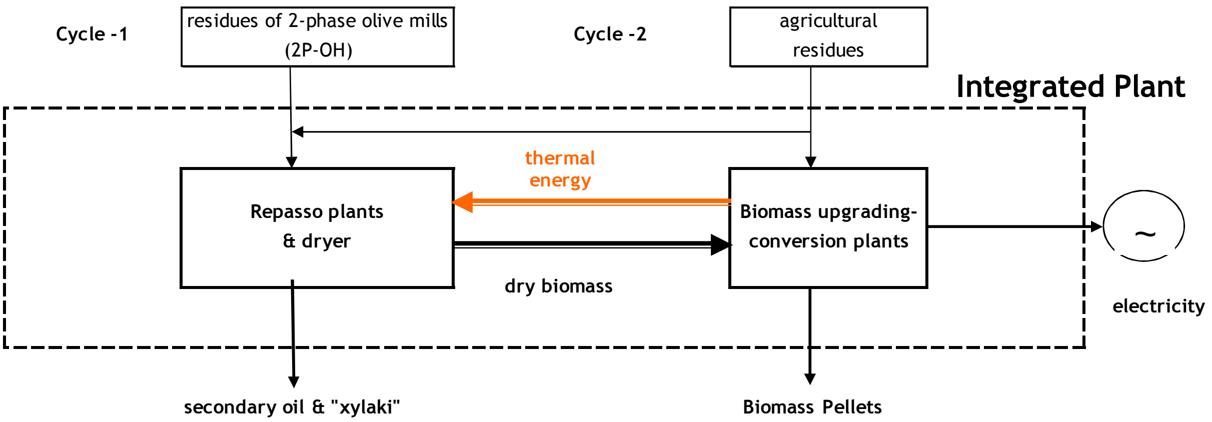

Figure 2: Simplified diagram of the proposed integration of olive mills residues treatment (Cycle-1) to dry biomass upgrading=tp=energy plants (Cycle-2)

The resulting Integrated Plant for the processing of 2P-OH and other biomass-type residues, combines the coupling of 2P-OH processing in a repasso plant with husk extruder (Unit 1) to produce also olive pit, drying of the resulting exhausted olive husk (EOH) in a combined dryer-boiler (Units 2 & 3) and utilization of the dry olive husk (DOH) in an adjacent biomass pellet plant (Unit 4) and a Combined Heat and Power (CHP) plant (Unit-5) based on biomass gasification technology. The different components (units) of the Integrated Plant for the treatment of 2P-OH and exploitation of resulting dry biomass are shown in **Figure 3** below.

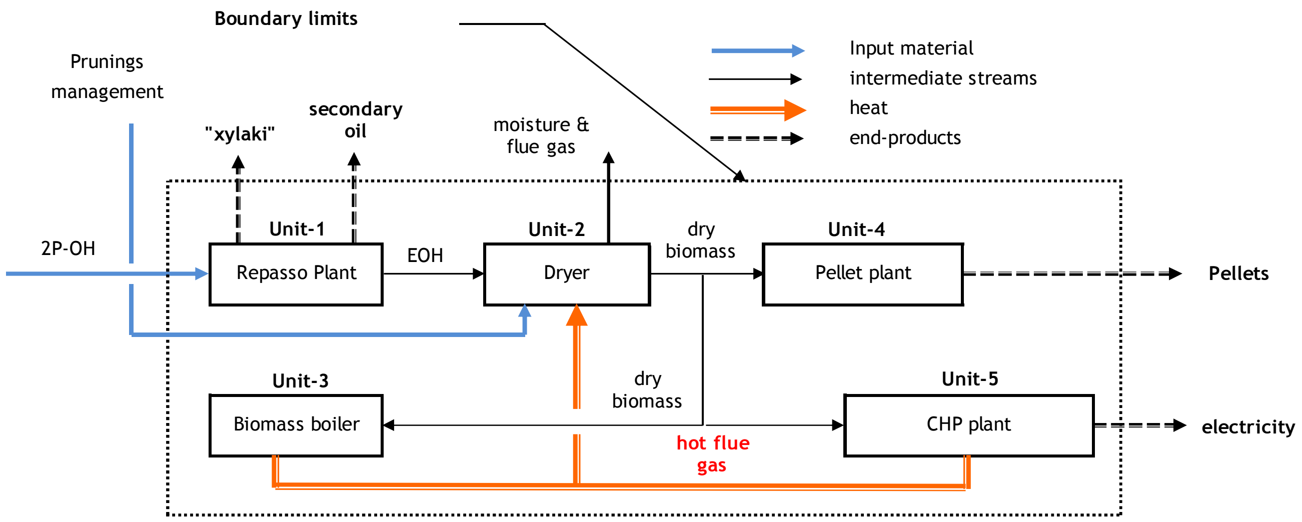

Figure 3: Simplified diagram of the proposed Integrated Plant for the exploitation of biomass-type residues and by-products employing: a) treatment of 2P-OH in a repasso plant (Unit 1), where also olive pit ("xylaki") is produced, b) drying of exhausted olive husk (EOH), prunings and grape pomace in a dryer-boiler (Units 2 & 3), and c) utilization of resulting dry biomass in a pellet plant (Unit 4) and a CHP plant (Unit 5)

In the above energy utilization scheme (where a biomass pellet plant and a CHP plant are employed as the final processing/upgrading stage of the dry biomass product of the dryer plant, a number of related biomass-type by-products and residues are ideally co-utilized, including:

- 2-phase olive husk (2P-OH) from the associated olive mills
- leaves and twigs from the olive mills
- olive tree prunings from olive tree orchards
- vineyards prunings after harvest
- grape pomace as a by-product of wineries.

In the proposed Integrated Plant, the biomass supply chain is closely associated with the extensive agricultural activities in the AAM & GFM areas. The synergies between the winemaking and the olive oil production sectors are particularly important for the improvement of the economy of the proposed intervention since they serve a double purpose, improving:

– the fuel security, due to input of additional fuel sources, which minimizes the risk for temporary shortages and extends the operation period for the integrated plant, and

– the economy of the entire utilization scheme, due to the achieved economies of scale.

Besides the significant biomass-type quantities that are saved and can be diverted to pellet production, the proposed coupling exports renewable electricity to the Grid (paid at favourable prices) and secondary olive oil. Thus, the carbon-cycle in the AAM and GFM regions is significantly improved and economies in various sectors of the economy are achieved.

4. Opportunities for the proposed investment

The market for the energy utilisation of biomass fuel in the European Union (EU) is huge given the political will of all Member States to secure a significant share for Renewable Energy Sources (RES) in Europe's energy balance, as dictated by the Directive 29/2008/EC. Today, this is particularly stressed by the increasing trade of bioenergy products (i.e. dry biomass-chips and pellets) between EU and related biomass exporters (Brazil, Canada, Russia, etc.). Moreover, there is an increasing interest for the implementation of international projects, including bioenergy applications, in developing countries (in Asia, Africa or Latin America) supported by financial institutions (i.e. World Bank, EBRD, etc.) and mechanisms such as the Clean Development Mechanism (CDM) and the Joint Implementation (JI) schemes in the framework of the United Nations Convention for Climate Change (UNFCCC).

Apart from the political incentives, bioenergy applications are also driven by financial motivation. For example, the recent rush of oil prices has resulted in a significant increase of bioenergy share in Central European countries, marked by a gradual shift of residential heating from oil-based to pellet-based systems in countries like Germany, Austria, Sweden, etc. This significantly increased the demand for standardised biofuels in a European level.

Moreover, due to the imposed and future fines on CO_2-emissions (the free CO_2-allowances are terminated in 2013) derived mainly from the electricity sector, a higher demand for incorporating dry biomass, in the co-firing mode, in existing power plants based on conventional fuels (e.g. in central coal- or lignite-fired power plants) is anticipated in the near future. This practice is already in full deployment in the UK, Scandinavia, Belgium and other Member States.

It is also noted that in order to enhance the role of bioenergy in Greece – as dictated by the recent Law 3851/04.06.2010 for the promotion of RES – favourable pricing for electricity generated by biomass are valid. For the proposed application, a 220 €/MWh_e for the CHP with an installed power < 1 MW_e is anticipated.

Hence, the secure absorption of the end-products from the proposed investment, whether it be:

- dry biomass for direct fossil fuel replacement in energy applications in local SMEs and reduction of CO_2-emissions in fossil fuel powered plants (co-combustion)
- densified biofuels (pellets or briquettes) for residential heating or medium-size industrial applications (greenhouse heating, hotel heating, etc.), and
- electricity or cogeneration (combined heat-and-power) in dedicated bioenergy plants through exploitation of dry biomass in the AAM and GFM regions

is highly secured given the lack of base-case renewable fuels in Europe and the strong favour towards the significant increase of the share of Renewable Energy Sources (RES) in the European Union in general and in Greece in particular.

It is also stressed out that the <u>duplication effect for the proposed intervention is very significant</u>. Besides Greece, where such integrated schemes for the processing of the wet 2-phase olive husk (2P-OH) and other biomass-type byproducts and residues can be immediately and successfully implemented in 4-5 regions (Messinia-Lakonia-Ilia in Peloponnese, Heraklion-Chania in Crete, Corfu and Western Greece), other European Mediterranean countries – such as Italy, Croatia as well as all main olive oil producers, i.e., Turkey, Tunisia, Morocco and Middle-East countries (Lebanon, Jordan and Syria) -, can be greatly benefited from the adoption of similar applications.

5 Examination of key techno-economic parameters for the Integrated Plant

Moving from the above concept towards the examination of the viability of the considered Integrated Plant, the most important key elements of the proposed intervention have been examined and are referred to below:

- the availability of biomass (2PO, olive-tree & vineyard prunings as well as grape pomace and, eventually, other biomass-type residues and by-products), based on the existing situation in the olive (mostly) and wine production sectors in the AAM and GFM regions, was estimated through a dedicated assessment of such biomass resources and is provided in **Table 1** below

Table 1: Available (on a technical & economical basis) biomass potential for the Integrated Plant in the AAM and GFM regions

Biomass types(1)	**Quantities**(2) (tons/year)	**Avail.**(3) (%)	**Quant.** (tons/ year)	**Avail.** (%)(4)	**Quant** (tons year)(5)	**Moisture** (% wt)(6)
Archanes-Asterousia Municipality (AAM) and Gortyna & Festos Municipalities (GFM) regions						
Two-phase olive husk (2P-OH)	54.453	100,0%	54.453	**86%**	46.686	**65%**
Biomass-1 (prunings)	76.524	27,5%	21.044	**73%**	16.238	**40%**
Biomass-2 (leaves & twigs)	1.657	75,0%	1.242	**73%**	905	**40%**
Totals	**132.633**		**76.739**		**63.830**	

Remarks**:**
(1): biomass types of interest to the Integrated Plant
(2): theoretically available biomass quantities (from primary sources)
(3): availability due to economic constraints and competitive uses
(4): final technical availability due to restrictions in the supply chain
(5): finally available biomass quantities to be used in the Integrated Plant
(6): % wt moisture content

- the size of the Integrated Plant (input and output streams) as depicted in **Table 2** below

Table 2: Input, output an intermediate streams in the Integrated Plant

Input streams		
Two-phase olive husk (2P-OH)	tons/year	36.000
Olive-tree prunings (to the dryer)	tons/year	9.525
Dry olive pit (to the boiler for additional heat)	tons/year	5.644
Intermediate streams (dryer related)		
Dry biomass out of the dryer	tons/year	17.312
moisture removed	tons/year	23.533
from the dryer to the pellet plant	tons/year	10.588
from the dryer to the CHP plant	tons/year	6.723
Output streams		
dry olive pit ("xylaki")	tons/year	3.600
secondary oil	tons/year	540
Pellets	tons/year	10.059
Electricity	MWh_e/year	6.196

- the estimation of the key technical (sizing, key operational parameters, availability of units, etc.) and economical (CAPEX-OPPEX) parameters of the necessary investments as given in **Tables 3** to **5** below

Table 3: Key technical parameters of the Integrated Plant and its units

Parameter	Unit	Value
Capacity of the repasso plant (Unit-1)	tons 2P-OH/year	11,11
Operating hours of the repasso plant	hours/year	3240,00
Production of the repasso plant	tons 2P-OH/year	36.000
Capacity of the dryer plant (Unit-2)	tons H_2O evap./h	3,39
Operating hours of the dryer	hours/year	6.948
Removal of moisture form the dryer	tons H_2O/year	23.533
Thermal efficiency of the dryer plant	%	76%
Capacity of the pellet plant	tons/h	1,91
Capacity of the biomass boiler (Unit-3)	kg/h	812
Operating hours of the biomass boiler	hours/year	6.948
Biomass consumption in the biomass boiler	tons/year	5.644
Thermal efficiency of the biomass boiler	%	85%
Thermal input of the boiler plant	MW_{th}	3,50
Production of the pellet plant (Unit-4)	tons/year	10.059
Capacity of the CHP plant (gasification)	tons/h	903
Biomass consumption in the CHP plant (Unit-5)	tons/year	6.723
Operating hours of the CHP plant	hours/year	7.446
Thermal input of the CHP plant (gasifier)	MW_{th}	3,89
Thermal efficiency of the gasifier plant (flue gases)	%	19,44%
Electrical efficiency of the CHP plant (net)	%	25,68%
Installed capacity of the CHP plant	kW_e	999
Self-consumption of the CHP plant	%	15,00%
Electricity exported to the Grid (PPC)	MWh_e/year	6.196

Table 4: CAPEX of the different components of the Integrated Plant for treatment of 2P-OH and olive-tree prunings

	Component of the Integrated Plant	€	% of CAPEX
1	Repasso plant/Unit-1(1)	700.000	9,05%
2	Dryer and boiler/Unit-2 & Unit-3(1)	800.000	10,34%
3	Pellet plant/Unit-4(2)	1.156.765	14,95%
4	CHP plant/Unit-5(3)	3.720.000	48,07%
5	Interconnection to the Grid(4)	100.000	1,29%
6	Basin for the 2P-OY(4)	150.000	1,94%
7	Civils(5)	979.015	12,65%
8	COntingency(6)	132.535	1,71%
	Total	**7.738.315**	**100,00%**

Remarks:
(1): budget quotation from PIERALISI Hellas S.A.
(2): budget quotation of Amandus Kahl GmbH
(3): budget quotation for a ≈1 MW_e CHP plant from EqTEC Iberia S.A.
(4): estimate
(5): ≈15% of items 1-6
(6): ≈2% of items 1-6

Table 5: OPPEX allocation for the Integrated Plant

#	OPPEX Component	(%)	(€/year)
A	Personnel and overheads	5,80%	144.788
B	Operation & Maintenance (O&M)	10,21%	255.071
C	Electricity and diesel costs	10,25%	256.054
D	Consumables	11,48%	286.712
E-1	Acquisition cost of prunings	30,36%	758.441
E-2	Transportation cost for 2P-OH	8,24%	205.900
F	Reciprocative fees (on electricity sales)	1,64%	40.896
G	Insirance of Integrated Plant	1,55%	38.731
H	Contingency	1,57%	39.232
I	Loan amortisation	18,90%	472.120
OPPEX		**100,00%**	**2.497.944**

- the total sales for the end-products of the Integrated Plant are shown in **Table 6** below

Table 6: Total sales of the end-products of the Integrated Plant

End-product	Derived from	Unit	Value	Sale price (€/unit)	Sales (€/year)
"Xylaki"	Unit-1	tons/year	3.400	90,00	306.000
Secondary oil	Unit-1	tons/year	540	900,00	486.000
Pellets	Unit-4	tons/year	10.059	135,00	1.357.941
Electricity	Unit-5	MWh_e/year	6.196	220,00	1.363.189
Total sales (€/year)					**3.513.131**

- based on the above findings, the key financial parameters and indicators (such as IRR, NPV and pay-back time) of the Integrated Plant are given in **Tables 7** and **8** that follow

Table 7: Major financial parameters of the Integrated Plant

Cost for key components (Table 4)	Unit	Value
Repasso plant (Unit-1)	(€)	700.000
Dryer + biomass boiler (Unit-2 & Unit-3)	(€)	800.000
Civils-special basin for 2P-OH	(€)	150.000
Pellet plant (Unit-4)	(€)	1.156.765
CHP plant (Unit-5)	(€)	3.720.000
Civils	(€)	979.015
Interconnection	(€)	100.000
COntingency	(€)	132.535
CAPEX	**(€)**	**7.738.315**
PROJECT FINANCING	(%)	
Own capital	25,85%	2.000.000
Subsidy	35,00%	2.708.410
Loan	39,15%	3.029.905
TOTAL FINANCING SCHEME	**100,00%**	**7.738.315**
OPERATIONAL RESULTS(Tables 5 & 6)		
Total sales	(€/year)	3.531.131
OPPEX (-loan amortization)	(€/year)	1.871.102
EBIDTA	**(€/year)**	**1.660.029**

Table 8: Key financial indicators of the Integrated Plant

Financial Indicators	Unit	Value
Discount rate (%)	%	12,00%
Internal Rate of Return (IRR), 10-years	%	24,45%
Internal Rate of Return (IRR), 20-years	%	27,71%
Simple payback (έτη)	years	4,30
Pay-back time	years	5,35
Net Present Value (NPV), 10-years	(€)	8.105
Net Present Value (NPV), 20-years	(€)	11.373

- a sensitivity analysis has been performed identifying the sale price for the pellets and the acquisition price for the olive prunings as being the most critical parameters for project viability
- a SWOT analysis has been performed and the opportunities and threats for the implementation of the considered Integrated Plant have been identified
- the social and environmental benefits for the farmers and the associated stakeholders (olive oil mill owners, winemaking industry, agricultural co-operatives, etc.) have been identified
- the possibilities and opportunities to obtain additional financing incentives and subsidies for the implementation of the proposed investments have been examined
- the existing institutional framework with regard to environmental liabilities and full absorption of end-products (dry biomass/CO_2-emissions, upgraded densified biofuels-residential heating or bioelectricity) has been undertaken.

6. Roadmap for the implementation of the proposed investment

The implementation of the proposed intervention is expected to follow the proposed roadmap, further analysed below:

1. Twinning of the AAM with a competent Consultant to from the Initial Partnership (IP) for the development of the conceived intervention. The IP will –through the Consultant's know-how and the support of the Local Authority – undertake all efforts and studies for the issuance of all necessary permits.
2. Siting of the Integrate Plant through a scrutinized examination of the local conditions and extensive discussions with all employed parties (*stakeholders*) for the acceptance of the most appropriate solution.
3. Additional studies to obtain the Installation permit for all-side units and activities of the proposed Integrated Plant.
4. Voluntary agreements with the olive mill owners and the farmers and preparation of necessary agreements and contracts for fuel procurement (Fuel-supply Contracts).
5. Examination of submission of proposals in order to secure capital subsidies for the Integrated Plant or close-related side activities. Examination of Loan conditions with commercial banks and financing institutions.
6. Selection of key technology providers for the Integrated Plant separate units and detailed costing of alternative solutions. Preliminary agreements with equipment providers and agreement with an (Engineering-Procurement-Construction) General Contractor-Service Provider (GC-SP) for the actual erection-implementation and operation of the Integrated Plant.

7. Following the issuance of all permits, the finalization of Fuel-supply Contracts, the preparation of equipment contracts and the securing of subsidy thorough search of the appropriate Investor/Shareholder for the financial support and backing of the project. In this stage the IP (step 1 above) is transformed to the Final Partnership (FP) and the AMM (and the Consultant) are benefited for the already maturation of the project. The above named GC-SP can also form a part of the FP.
8. Operation of the supply chain (logistics), identification of problems and drawbacks and adoption of proper measures to remove them.
9. Implementation of the investment (construction-erection), commissioning and troubleshooting of the different components (units) and commercial operation of the Integrated Plant and the related activities.