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1. INTRODUCTION

1.1 Utilization of olive waste products

Olive fruit processing produces large amount of by-products, including liquid and solid wastes arising from olive oil extraction and the production of table olives. The disposal without any treatment of the olive waste is known to cause serious environmental problems. But, olive mill wastes are valuable by-products and could be used:

- as fertilizer or soil conditioner
- as herbicide or pesticide
- as animal feed or in human consumption
- for residual oil recovery
- organic compounds recovery (pectin, antioxidants, enzymes)
- for production of various products (alcohols, biosurfactants, biopolymers, activated carbons)
- for energy generation.

1.2 Generation of energy

Waste treatment technologies aimed at energy recovery may represent an interesting alternative for a sustainable disposal of residues from olive oil production, able to reduce the environmental impact and to generate electric energy for sale or satisfy the needs of olive-mills.

The residual biomass of olive processing with potential energy use is classified in two groups. The first group is constituted by residual biomass produced during olive tree culture (pruning and harvest residues). The second group is constituted by residual biomass produced during the various stages of olive oil extraction. Depending on the extraction system the available energy from the by-product is different. For instance, exhausted olive
cake and 2POMW (2-phase olive mill waste) are characterized by an average heating value of 19,000 and 14,000 kJ/kg, respectively. The by-product of both group present, from an energy point of view, favorable aspects in their use are ensured annual production, relative concentration in a place, proper humidity conditions, low sulfur content, and other harmful emissions, and finally, high thermal value. However, an appropriate technology must be employed to avoid the production of pollutants and other problems, while maximizing process efficiency.

There are three main thermo-chemical methods by which this renewable energy source can be utilized, namely gasification, briquetting and combustion (direct firing) or co-combustion (co-firing). Another type of gasification involves the generation of biogas (methane) by the anaerobic degradation of olive-mill wastes.

Gasification is a thermo-chemical process that converts biomass into combustible gas called producer gas (syngas). Producer gas contains carbon monoxide, hydrogen, water vapor, carbon dioxide, tar vapour and ash particles and can be used in many combustion system such as boiler, furnaces and gas engines. The gasification technology is in development stage. The main drawback from such an approach is the high cost associated with initial setup and operation of these facilities.

Briquetting is a low-cost technique used to agglomerate a wide range of materials into fuel blocks to be transported and utilized as a solid fuel. Different biomass products have been considered for biobriquetting including solid olive-mill waste. In such an approach one needs to consider five main issues, namely, shattering index, compressive strength, water resistance, combustion characteristics, and emission of pollutants. Solid olive residues have low compression strength and shattering index, but one way to improve these properties of briquettes from olive residues is to add paper waste, which contains fibrous material increasing in this way the shattering index. Olive residues have reasonable water resistance when compared to other biomass products. Emission from the combustion of briquettes can vary substantially. Burning is usually undertaken in a relatively uncontrolled environment and can be very harmful to the environment. However, considering that the need for alternative fuels will increase in the near future, briquettes offer a substantially better alternative to coal.
Co-combustion (co-firing) of solid olive-mill waste refers to the use of one or more addition fuels (e.g. wood or coal) simultaneously in the same combustion chamber of a power plant. Co-combustion of these olive residues with coal is generally viewed as the most cost-effective approach. Solid olive-mill residues have similar density, heat release and general burning characteristics as that of coal.

The olive cake can be considered as an alternatively fuel, which contain small amount of sulfur (0.05-0.1%). The olive cake is quite dense and has a calorific value of 12500-21000kJ/kg. It is comparable with the calorific values of wood and soft coal, which are 17,000 and 23,000 kJ/kg, respectively.

2POMW is also a potential fuel with calorific value. Drying of 2POMW should always be a previous operation for combustion by reducing its moisture content.

Anaerobic biogas production is an effective process for converting a broad variety of biomass to methane to substitute natural gas and medium calorific gases. For instance, biogas obtained by the anaerobic treatment of 1m³ of OMWW (olive-mill waste water) contains 60-80 kWh of energy. The process can be carried out in relatively inexpensive and simple reactor designs and operating procedures.

Efficient use of olive cake in energy production solves two problems in one step: clean energy production and acceptable disposal of olive oil mill waste.
2. IDENTIFIED BEST PRACTICES IN SPAIN, GREECE AND ITALY

Spain, Italy, and Greece represent more than three-fourths of the total olive oil output in the world. These countries, with long olive growing and olive oil producing tradition are also leading in developing appropriate olive-mill waste treatment technologies, particularly aimed at energy recovery.

Considering low market development and quantities of olive-oil produced in other partner’s countries (Croatia and Slovenia), they are grouped in two groups: the first one represented by Spain, Greece and Italy and second one represented by Croatia and Slovenia.

In Spain, Greece and Italy project partners identified 13 best practices in total, while other partners selected 4 practices in their countries. In total, 17 best practices were chosen.

2.1 Best practices in Spain

Best practices in Spain were chosen using available official information and also by contacting installation companies.

Selected best practices are located in provinces of Córdoba and Jaén (No 1 and 2, respectively), Andalusia region on the south of Spain, as shown in Figure 1.
Following best practices (BP) were chosen:

- **BP1**: GEOLIT CLIMATIZACIÓN S.L. District heating and cooling central system with biomass, Mengíbar (Jaén)
- **BP2**: ENERGÍA LA LOMA S.A., Villanueva del Arzobispo (Jaén)
- **BP3**: BIOMASA PUENTE GENIL, Puente Genil (Córdoba)
- **BP4**: HOTEL & SPA SIERRA CAZORLA, La Inuela (Jaén)
- **BP5**: Public buildings’ (schools) boilers, province of Jaén
BP1: GEOLIT CLIMATIZACIÓN S.L. District heating and cooling central system with biomass. Mengíbar (Jaén), Spain

GEOLIT is the name of science and technology park devoted to the olive industry in Jaén. This park has a district heating and cooling network to provide air conditioning to all the park buildings. The heat is provided by two biomass boilers with a total capacity of 6,000 kW. The cooling capacity using absorption chillers is 4,000 kW. The Council of Innovation (Consejería de Innovación) has approved one requests of subvention for its construction by an amount to 2,3 millions Euros. By now plant investment is 5,2 millions Euros. Detailed description of selected practice is given in Figure 2. More information can be found at http://www.geolit.es and http://www.agener.es.

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Figure 2. Detailed content of technology used in BP1 (Jaén, Spain)

GEOLIT CLIMATIZACIÓN S.L.
District Heating and Cooling Central System with Biomass

La Cal Herrera, J.A.; Muñoz Jiménez, J.; Heredia Galán, B.

**CENTRAL HEATING AND COOLING**

**Absorption machines**
By means of three simple effect absorption machines cool water with 5 – 6°C is produced and distributed to the final users through a red of pipes. In the process it is necessary a refrigeration tower.

**Complete cycle**

- Absorption machines
- Buildings to be conditioned
- Refrigerations towers

**Boiler**

**CHIMNEY**
Cleaning air go out

**MULTICYCLONE FILTER**
The air from the boiler is placed here and form small cyclones which orish with the walls, and the ashes fall down

**WATER**
The water pipes past on the top where the water is heating and leave to the Park

**BOILER**
Inside the boiler take place the combustion of the biomass

**STORAGE PIT**
Place to store the biomass. It’s filling outside the building

**FILTERS SLEEVES**
The sleeves capture rest of ashes that the multicyclones don’t capture. Afterwards, with compressed air the ashes fall, and the air go out clean

**PIPECY**
Through these pipes go out the ashes generated in the boiler. The ashes is used to produce cement and fertilizers.

The biomass fall and come into the boiler
BP2: ENERGÍA LA LOMA S.A. Villanueva del Arzobispo (Jaén)

ENERGÍA LA LOMA S.A.: Endesa Cogeneración y Renovables have promoted and built this plant (Figure 3) for energy production through combustion of depleted olive pomace. The main elements are: a kind grade combustion boiler and a condensing steam turbo-alternator set, formed by a steam turbine (using Rankine cycle) connected to an alternator. The plant is planned to function 24 hours a day, during all year, except an annual stopping for plant maintenance. The plant works in total 7,884 hours/year, estimating an unavailability of 10% above a total of 8,760 hours/year of theoretical functioning.

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Figure 3. ENERGÍA LA LOMA S.A. plant (BP2) in Jaén (Spain)

Type of biomass (fuel): Depleted olive pomace
Power installed in the plant: 16 MW
Biomass processes: 100,000 tons/year
Energy production: 126,144,000 kWh/year
Energy export: 113,201,620 kWh/year
BP3: BIOMASA PUENTE GENIL, Puente Genil (Córdoba)

BIOMASA PUENTE GENIL: The biomass plant (Figure 4) generate electricity from olive pomace (orujillo) in Córdoba, the technology used for obtaining electricity is the vapour cycle. The electrical power is 9.7 MW that is produced by means of steam turbine. The consumption of biomass is 71.000 tons/year. The Council of Innovation (Consejería de Innovación) has approved two requests of subvention for its construction by an amount superior to 800.000 Euros each. Total plant investment 46 million Euros.

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Figure 4. BIOMASA PUENTE GENIL plant (BP3) in Córdoba (Spain)
BP4: HOTEL & SPA SIERRA CAZORLA, La Iruela (Jaén)

HOTEL & SPA SIERRA CAZORLA: Hotel (Figure 5) uses biomass (pit/stone) for heating and producing sanitary hot water (thermal application). The technology used for obtaining thermal energy consists of two boilers (400 kW) (Figure 6). The Council of Innovation (Consejería de Innovación) has approved one request for subvention for its installation by an amount 100,800 Euros. Total installation investment costs are 230,000 Euros. This installation is unique in Andalucía (España).

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Figure 5. Hotel Sierra de Cazorla**** (BP4) in Jaén (Spain)
Figure 6. Biomass installation (BP4) in Jaén (Spain)
**BP5: PUBLIC BUILDINGS’ (SCHOOLS’) BOILERS, province of Jaén**

**PUBLIC BUILDINGS’ (SCHOOLS’) BOILERS**: The biomass (olive waste) is used for thermal energy production used for heating in public buildings. This application is a result of the initiative aimed at changing gas-oil boilers with biomass boilers (Figure 7), and is supported by The Provincial Deputation in Jaén, Counselling and Education (Junta de Andalucía) and the City Council of township. It is funded by The Provincial Deputation (60%) and the Andalusia Energy Agency (Junta de Andalucía 40%).

From the economic point of view, a boiler of 200 kW of power that works with splinters of olive trees has an energetic cost of 47,9 €/MWh. For 1500 working hours/year, the total cost is 14.366,49 €/year including cost of investment, maintenance and operation. While the same boiler but with gasoil, which has a total cost of 26.416,55 €/year, with energetic cost of 88,1 €/MW, which is 83,92% of costs more. Not considering any public support, all money spent can be regained within two years.

*Figure 7. Biomass boiler used for heating in public buildings (BP5), Jaén (Spain)*

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2.2 Best practices in Greece

Selected best practices in Greece are located in the region of Chania on the island of Crete (Figure 8). In Chania most companies which exploit solid oil residues, use them to extract pomace oil and heat buildings with olive pits/stones. Chosen BP’s can be easily implemented in the region and may be useful as energy solutions for Chania in the near future.

Figure 8. Location of chosen BP in Greece. Region of Chania on island Crete

The following best practices (BP) were chosen:

- **BP6**: ABEA. Pits are used as an energy source for heating facilities and are also used for pomace oil extraction. Located at Chania / Agrokipio

- **BP7**: BIOMEL. Oil extracting system from pomace and trading pomace to the UK. Located at Chania / Achlades, Keramia

- **BP8**: Giannoulis craft-based unit. District central heating system based on pits, for heating factory buildings. Located at Chania / Chania
ABEA is the company which extracts oil from pomace, located in Chania / Agrokipio (Figure 9). At first, pomace has a relative humidity of 50 – 65 %. After oil extraction, the pomace is dried to obtain pits used in pomace oil extraction process as heat source.

More information could be found at [www.abea.gr](http://www.abea.gr).

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Figure 9. ABEA - heating system with biomass and oil extracting system from pomace, Greece (BP 6)
**BP7: BIOMEL pomace oil extracting system using pits and pits trade to the UK. Chania / Achlades, Keramia (Greece)**

**BIOMEL** is the company which uses olive pits/stones for heating and also trades olive pits to London, in the UK. This company purchases 80,000 t/year of pomace from olive mills and produces cca 35,000 – 50,000 t/y olive pits used for heating the factory building. Part of it is also traded to the UK.

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BP8: GIANNOULIS CRAFT – BASED UNIT. District heating central system in buildings with pits. Chania / Chania (Greece)

GIANNOULIS CRAFT – BASED UNIT: uses pits for the heating system, for boiling water and for pomace drying.

From 1972 the company established a factory for refining olive oil and olive pomace oil. In the early nineties the company shifted to packaging and selling olive oil products and pits for heating.

Giannoulis craft – based unit shows a great exporting activity for both packaged and bulk olive and pomace oil products. European Union, U.S.A., Canada, Australia and China are some of our products destinations. Giannoulis craft – based unit marketing policy is focusing on entering new markets and establishing new collaborations that can lead us to successful results.

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2.3 Best practices in Italy

In Italy the BP have been investigated in this way:

1. **best practices in Liguria**: COREFLI (regional coordination of millers) has contacted the millers and submitted the questionnaire to those who are carrying out any activities related to energy use of residues. Partner managed to get the questionnaire completed by 10 mills.

2. **best practices in Italy**: partners have contacted all the millers associations existing in Italy and they have also performed a web search for any interesting experience of energy use of residues. The search has turned out being very time consuming (wrong phone numbers, difficulty in identifying the right person in each organization and the right moment of the day). Most millers associations are very secretive, and declare they do not know of any significant energy use of residues. Nevertheless, all of them say they are very interested and they want to be kept informed. Some of them are starting to think about planning a power plant fuelled by olive residues. As for the web search, it allowed partner to identify the big power plant in Calabria, which is not owned nor run by millers and the plant in Latium. Other BP have been identified through networking or existing contacts. Partner managed to get the questionnaire completed by 4 Italian BP.

As for the disadvantages, partners have felt that the questionnaire in any case is not a complete tool, as most information is given orally on the phone; most people are very secretive and would not say the same things on paper and on the phone. However, it has not been very easy on the phone either. Some BP turned out being very jealous of their experience.

The dark side of the power plants found in Italy is that are quite bigger than what we can afford in Liguria in terms of available fuel. Nevertheless, they are important for the information provided, in terms of kind of agreements signed, costs, fuel performance, etc.
Following best practices (BP) were chosen:

- BP9: District heating Arnasco, Liguria, Arnasco
- BP10: Lucchi & Guastalli Mill, Liguria, Santo Stefano Magra
- BP11: Associazione Laziale Frantoi Oleari (milers association of Latium region), Latium, Campodimele – Latina
- BP12: Matraia Mill, Tuscany, Lucca
- BP13: Rossano Calabro power plant, Calabria, Rossano Calabro

Figure 10. Location of chosen best practices in Italy
DISTRICT HEATING ARNASCO is a small district heating system running with olive nut separated at source by the local cooperative olive mill. It’s the only of the kind in Liguria. The district heating is made of a olive nut fuelled high temperature 69,8 kW boiler and a 60 mts pipeline. Quantity of nut used each year is 14,3 tons to heat up 700 m³ (Church and annexed building). Nut is supplied by the local cooperative mills. There is also a gas fuelled 28 kW boiler which may be used during the maintenance of the main boiler or if a problem occurs.

**Nut cost**: 180 €/ton.

**Total cost of plant**: € 9,500.

**Year cost**: 2,500 €/y.

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Phone. +39 0182761178  
[http://www.coopolivicolarnasco.it/](http://www.coopolivicolarnasco.it/)
BP 10: LUCCHI & GUASTALLI MILL, LIGURIA, SANTO STEFANO MAGRA (ITALY)

LUCCHI & GUASTALLI MILL disposes 2-phase mill pomace through innovative systems which adds calcium oxide in the pomace to dry it up. The mill uses a new technique invented in 2005 by Unieco, an Italian waste treatment company. This technique only applies to 2 phase pomace with 65% humidity and consists in pouring some quantity (ab. 5%) of calcium oxide into pomace to make it basic, stable, no-odor and with 55% humidity. Then it can be used as compost or as fuel in a biomass plant (apparently it has a calorific value of 4700 kcal/kg). The described solution comprises the problem of waste waters.

The revenue deriving from pomace selling to the biomass plant, deducted of transport costs, is shared between Unieco and the miller.

This system requires a specific technology (silo, pourer and mixer) which, for treating 1800 kg/h, had a cost of 100.000 € (+, in this case, the miller’s cost of conversion from a 3-phases system to a 2-phases system).

More information’s could be found at http://www.unieco.it/ from the company which has invented the technique of calcium adding and which collects the dried pomace to be delivered to a biomass power plant.

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Località Vicinella 19037 Santo Stefano Magra, Italy
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http://www.frantoiolg.com
BP11: ASSOCIAZIONE LAZIALE FRANTOI OLEARI (MILLERS ASSOCIATION OF LATIUM REGION), LATIUM, CAMPODIMELE - LATINA (ITALY)

ASSOCIAZIONE LAZIALE FRANTOI OLEARI is millers association of Latium region. Their plant consists of a pomace dryer (thermal capacity, 1.1 MW at about), a pomace gasifier and a power unit for electrical energy production (power: 1 MW). Referring to the last one, a careful analysis is caring out to evaluate the most streamlined and economical solution between a gas engine and a gas turbine employment.

The electric energy produced is reintroduced in the network of the local provider (ACEA). The plant can work either with 3 phases pomace or two phases pomace; Latium is promoting the system conversion from 3 phases to 2 phases because this technique does not imply vegetable waters. Their spreading is difficult because of the property segmentation.

Dried pomace (15 % humidity) coming from the dryer is stocked by proper warehouses for two months: a small part (250 kg/h at about) is burnt to supply heat for the dryer (auto-consumption), while the remaining part fuels the gasifier. A technical scheme of the plant is reported below in Figure 11.

The plant testing has been scheduled by the next autumn; if expected results are reached, Latium will realize new four similar plants, one for each province.

In the future, photovoltaic modules will be installed on the roofs of the warehouses to increase electrical energy production.

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http://www.frantoilazio2080.com/
Figure 11. Technical scheme of the plant - pomace dryer + pomace gasifier + power unit (BP11)
**BP12: MATRAIA MILL, TUSCANY, LUCCA (ITALY)**

MATRAIA MILL produces pellets from pomace (nut and pulp together). It is an interesting solution. More information could be given at [http://www.frantoiodimatraia.it/](http://www.frantoiodimatraia.it/).

**Contact:** Frantoio di Matraia  
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[http://www.frantoiodimatraia.it/](http://www.frantoiodimatraia.it/)

**BP 13: ROSSANO CALABRO POWER PLANT, CALABRIA, ROSSANO CALABRO (ITALY)**

ROSSANO CALABRO POWER PLANT is a pomace gasifier + CHP plant (4,2 MWe, 23 MWth), running with 8571 t/MWe year. The pomace is supplied by the surroundings (Puglia and Calabria). The objective of the plant is to reach a conversion ratio of 1.05 kWh per 1 kg of biomass. This will be translated into a global electric efficiency of 24 % (currently efficiency is 17 %).

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3. PRACTICES IN SLOVENIA AND CROATIA

3.1 Best practices in Slovenia

The selection of chosen BP was based on the fact that these are the only two best practice cases of olive residues use for energy purpose in Slovenian Istria region. BPs were acquired on data given by olive millers who use olive residues for energy purpose.

Following best practices (BP) were chosen:

- BP14: AGAPITO olive mill, production of heat for his private house heating and water heating

- BP15: KROŽERA olive mill, production of heat for his private house heating and water heating

Figure 12. Location of chosen best practices in Slovenia
BP14: AGAPITO OLIVE MILL, PRODUCTION OF HEAT FOR HIS PRIVATE HOUSE HEATING AND WATER HEATING

AGAPITO OLIVE MILL - Olive miller uses olive residues mostly for production of heat for his private house heating and water heating (cca. 140 m²)

Description of BP14:

Mill type: 3-phase mill

Technology used: ALFA LAVAL

Amount of olive residues produced: approx. 60 tons/year

Usage of olive residues: Olive miller uses olive residues mostly for production of heat for his private house heating and water heating.

After olive oil extraction (3-phase mill) olive residues are to wet to burn immediately and therefore disposed to the field/meadow behind the house. Olive residues are left to dry on the open space. Olive residues are mixed up/turned up side down several times to speed up the drying process. After certain time they are collected and loaded into big wooden containers and stored in the shed next to boiler room. Dried olive residues are used directly for burning/combustion in the stove.

The rest of olive residues is used for dunging/fertilisation of his olive fields / oliveyards.

Stove: D’Alessandro Termomeccanica, model CS 40, nominal power of the stove is 40KW, heating power is 47 KW. The company D’Alessandro Termomeccanica is an Italian firm with thirty years of experience in manufacturing heating generators that utilize solid combustibles.

Technology of the stove: Stove model CS 40 is a three-ways smoke steel boiler with water production for heating and sanitary use, with these features:

- Boiler shell with tube nest;
- Doors for internal inspection and boiler cleaning;
- Cast iron burner with mechanical screw firebox;
- Panel with control devices;
- Inverter for combustible flow regulation;
- Primary and secondary combustion air system;
- Smoke stopping return device in the hopper.
Combustible use: Solid combustible originated by renewable energetic sources: pellets, crushed shells and fruit stones, olive husks, etc.

**Olive residues consumption and energy value:** Official data about average consumption of the stove at maximum regime is 12 kg/h of olive residues.

In everyday practice actual consumption is 170 dm³ (0,17 m³) of olive residues in 3-4 days. Annual consumption of the olive residues is between 10 and 11 m³. With this quantity they heat 140 m² of the apartment with the temperature 23ºC and they heat also 300 l water boiler through the whole year.

**Purchase costs:** 3.000 €+costs of instalation. Stove was bought 2 years ago.

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BP15: KROŽERA OLIVE MILL, PRODUCTION OF HEAT FOR HIS PRIVATE HOUSE HEATING AND WATER HEATING

KROŽERA OLIVE MILL - Olive miller uses olive residues only for energy purposes; production of heat for heating private house and olive mill (ca. 250 m²).

Description of BP15:
Mill type: traditional
Technology used: PIERALISI traditional system
Amount of olive residues produced: approx. 60 tons/year
Usage of olive residues: In past they have been putting olive residues back in olive fields. Today they put them directly to wooden box in order to dry them on open air (but under roof) and use them only for energy purposes; production of heat for heating private house and olive mill (ca. 250 m²).

Stove: Kondor, Casacalendia, Italy
Italian company with long tradition in stove production and more then 20 years in production of stove use bio combustible.

Technology of the stove: The system of the stove has been working for 20 years using dry olive skins from Italy. In the last 5 years the boiler has been using other ecological materials as pellets, almonds, nuts and seed, shells mixed with at least 50% corn.
The alimentation of combustible is composed from motors, reduction gear, centrifugal valve and electronic system that automatically control the noiseless transfer of the combustible to the burning area.

Olive residues consumption and energy value: In everyday practice actual consumption is 200 dm³ of dry olive residues in 2 days. Annual consumption is approx. 18 m³ of dry olive residues per season (from beginning of November to the end of April). With this quantity they produce heat for 250 m² of the apartment and olive mill and water heating.

Purchase costs: 4.500 € + costs of installation. Stove was bought 1 year ago.
3.2 Best practices in Croatia

The area of research was the whole Istrian Region. Only two olive mills in Istria use olive residues for energy purpose and they were chosen as BPs (Figure 12). BPs description was acquired on data given by olive millers, who use olive residues for energy purpose through the use of questionnaires and telephone interviews with owners. The largest difficulty is the inexistence of adequate good practice.

Following best practices (BP) were chosen:

- BP16: PAŠUTIĆI - olive mill, production of heat for private house

- BP17: OLEA D’ ORO - olive mill, production of heat for private house and for soil fertilization

Figure 12. Location of chosen best practices in Istria (Croatia)
**BP16: PAŠUTIĆI - OLIVE MILL, production of heat for private house**

**PAŠUTIĆI - OLIVE MILL** - Olive miller uses olive residues mostly for production of heat for his private house heating and for sanitary water heating.

**Description of BP16:**
- **Mill type:** 2-phase mill
- **Technology used:** PIERALISI 250
- **Amount of olive producing capacity:** Approx. 400 kg/hour, yearly production 70 tons.
- **Usage of olive residues:** Olive miller uses olive residues mostly for production of heat for his private house heating and water heating. After olive oil production, olive residues are pressed and left to dry ion the open space. Dried olive residues are used directly for burning/combustion in the stove.
- **Stove:** TVT Maribor d.d., nominal power of the stove is 33KW. These installed stoves are 8 year old. The company TVT Maribor d.d. is an Slovenian firm with many years of experience.
- **Technology of the stove:** Unknown, insufficiently data from the owner.
- **Olive residues consumption and energy value:** The miller heats 120 m² of the house with the temperature 21ºC and he heats also 120 l water boiler through the major part of the year.
- **Purchase costs:** All costs are approx. 3.000 € with costs of installation.

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BP17: OLEA D’ ORO - OLIVE MILL, production of heat for private house and for soil fertilization

OLEA D’ ORO - OLIVE MILL - Olive miller uses olive residues mostly for production of heat for his private house heating and for sanitary water heating.

Description of BP17:

Mill type: 3-phase mill
Technology used: Vitone V2 (max. production 2 tons/hour)
Amount of olive producing capacity: Approx. 1500 kg/hour, yearly production 400 tons.
Usage of olive residues: Olive miller uses olive residues mostly for production of heat for his private house heating and water heating. After olive oil extraction (3-phase mill), olive residues are stored 10 kilometres from the olive mill to dry on the field. Olive residues are mixed up/turned upside down several times to speed up the drying process.

Stove: It is Italian stove. Nominal power of the stove is 100,000 cal.
Technology of the stove: Unknown, insufficiently data from the owner.

Olive residues consumption and energy value: The miller heats 500 m² of the house with the temperature 22°C and heats also 1000-l water boiler through the major part of the year.
Purchase costs: 10,000 € in total. The stove is new. It is in the process of import from Italy.

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4. LESSONS LEARNED - CONCLUSION

SPAIN

Nowadays it is important to improve the thermal use of the biomass in general, because the efficiency and the saving obtained by the user are higher with the installation of a biomass boiler for heating facilities and producing sanitary hot water (SHW). Spain will reach the objectives established in the Kyoto Protocol promoting biomass installations for thermal use.

GREECE

Nowadays it is very important to gain energy from renewable resources, especially from biomass. Olive residues are a kind of biomass which has not been considered for exploitation until now, for producing thermal energy for example, in order to produce sanitary hot water and for heating buildings. Scientists should teach people how to get energy from biomass and make them use it. From now on, energy derived from residual biomass must be introduced in everyday life in order to protect the environment from pollution. It is necessary to help people understand that exploitation of biomass leads to energy saving, in order to make them use it in everyday life. Also, people that want to start with biomass (solid residues from oil) exploitation, need to get benefits.

ITALY

From the investigation conducted in the olive sector in Italy, next conclusions are drawn:

1. Separation of olive nut in olive oil production and its use for heating (or selling) is quite a common practice.

2. Virgin pomace is absolutely not advisable for burning in any whatsoever plant.

3. According to Italian law, pomace can be considered waste or byproduct, with different chances for its application.

4. In Liguria only virgin pomace is produced. A feasible and sustainable way for virgin pomace treatment and its application for energy production must be found.

5. It is very important to set up a supply chain to guarantee the appropriate provision of pomace.
6. Setting up a pomace supply chain in Liguria is difficult because the quantity of pomace available each year is quite small and because of the characteristics of Liguria territory locations of the pomace are quite scattered.

7. Pellet production seems to be a reasonable solution considering the possibilities of drying, degreasing and transporting pomace. However, Italy still doesn’t have a qualitative standard for pomace pellets.

8. It is therefore advisable to think of a heating plant, possibly matching the needs of seasonal users (such as greenhouses).

9. The use of residues from olive tree pruning could help to increase the amount of raw material available for biomass derived energy production.

10. In Liguria, only 60-70% of the olive market potential is used. This means that in future, there is a possibility to increase the amount of raw material available.

**SLOVENIA**

The chosen BPs produce heat for olive mill owners’ private houses and are the only practices that use olive residues for energy purpose. The BP show currently the best and the easiest way of using olive residues for energy purpose in this region. In Slovenia, there are is a small number of olive mills and all of them can use olive residue in the same way with small investments for installation and stove. In this way the use of olive residues for energy purpose in this region could be increased (in order to not treating olive residues as waste) and reduce oil/gas consumption, lessen CO2 exhaust, save money and contribute to better, cleaner environment.

**CROATIA**

In Croatia, the use of olive residues for energy production is in its primary phase of development. Only two examples of olive residues usage for energy production in the region Istria (Croatia) were found and chosen as examples of best practice. The chosen examples use thermal energy produced from olive residues, for heating in private houses. It needs to be stressed that olive mills in Croatia, in this moment, produce relatively small amount of residues and the production is dislocated. But in line with the increase of renewable sources
of energy as one of the main goals of Croatian energy development sector, these BPs could be considered as positive initiatives and a possible optimal solution for Croatian millers.

5. GENERAL CONCLUSION

Olive fruit processing results in large amounts of residues also considered as waste, although olive mill residues are valuable by-products and can further be used in many different ways. Above that, uncontrolled disposal of olive residues, without any treatment, is known to cause serious environmental problems. Waste treatment technologies aimed at energy recovery may represent an interesting alternative for a sustainable disposal of residues from olive oil production, able to generate energy and reduce the negative impact on the environment.

There are many practical solutions for producing energy from solid olive residues, evident in the collection of 17 best practices in five European olive producing countries. Countries like Spain, Italy and Greece with intense olive and olive oil production, and consequently, olive residues production, showed how olive residues are being used for production of electrical and thermal energy. Usually, the best practices described involve large energy producing biomass plants. The energy produced is used directly for central heating and cooling of several buildings by means of a pipeline network (factory, school, church, hotel facilities), for conducting the technology process and for sanitary water heating. In some regions in these countries, the dimensions of installed energy production plants are too large for existing resources, but are expected to function with full capacity in the future. When planning bigger power units it is very important to set up a supply chain to guarantee the appropriate provision of pomace. Examples of best practices in partner countries which are considered to be small olive producing countries, Slovenia and Croatia, are a result of initiative by individual olive mill owners. Residual olive biomass is easily treated and used as fuel. They installed a relatively simple technology for producing thermal energy which is used for heating owners’ private houses and sanitary water heating.

Comparing partner regions is difficult because of different circumstances; consequently, a more specific analysis is needed. It is necessary to outline and pick up the key parts that are repeatable.

Solid olive residues as a raw material differs in water and oil content, depending mostly on the technology used. Before it is being used as an energy source, these residues must be
classified based on their composition and technology characteristics. A different classification of these residues among Member States came into evidence as well as the necessity of harmonization of the terminology used among partners. Common classification would ease the communication and comparisons.

Information obtained by the main actors (olive mill/factory owners, experts, engineers) is fundamental for further development of the olive residues market and technologies of olive residues usage for energy purposes.

The conclusions of the project MORE should be used for bringing up the problem of complex regulatory and legislative frameworks in some countries and nonexistent in others, when dealing with olive by-products. Useful practical information collected and conclusions of this project should be considered when setting up regulations.
Anex I. BP questionnaire

Project: M.o.r.e.
Date:_____________

QUESTIONNAIRE ON OLIVE PROCESSING AND RESIDUE MANAGEMENT

The extremely polluting residues generated by the production of olive oil pose serious problems in _______________ (insert the name of the country or region) and other EU countries. The management of olive residues in most countries is still not properly regulated. The aim of this questionnaire is to collect information on olive processing and residues quantities and recognize the best practices of olive residues management in _______________ (insert the name of the country or region) with a special emphasis on using olive milling residues for energy purposes. We would kindly ask you to help us with your answers and contribute to realization of Project M.o.r.e. Your personal information will be used only for purposes of this investigation.

1. The olive mill title and address?

2. Your mill is:
   - □ private SME
   - □ private large company
   - □ cooperative
   - □ public company
   - □ mixed ownership

3. How long does your mill work?

4. What is the capacity of your mill? kg per hour
5. What kind of oil-processing methods do you use?

- Traditional processing (pressing)
- 2 phases centrifugal system
- 3 phases centrifugal system
- Other

6. Do you use your mill only for your purposes of olive oil production or you offer your services to other olive growers? In which ratio (%)?  

7. Which area of olive production is covered by your services (distance)?

- narrow (up to 10 km)
- wider (10-20 km)
- broad (more than 20 km)

8. Which quantity (in tons) of olives is processed seasonally in your mill?  

9. Average yield of oil in harvest 2007 in your mill was  

10. How do you manage waste waters produced in olive oil producing process?

- by means of company specialized for waste management
- using adequate purification treatment
- deposite in mill surrounding
- other ________________

11. How do you treat the pomace generated in olive oil producing process?

- deposite in the mill vicinity
- donate
- use for composting
- use as energent
- deposit it on waste landfill
- other

Please, explain briefly the treatment applied and why do you prefere it .
12. Do you know some other useful ways of pomace usage?
   □ yes  explain here
   □ no

13. Do you know somebody who uses the pomace in such ways?
   □ yes  who?
   □ no

14. Do you planned to increase the capacity of your mill in the next 5 years?
   □ yes  indicate the % of increasement  %
   □ no

15. Do you planned to invest in modernization of olive oil processing and waste management technologies in the next 5 years?
   □ yes  in amount  EUR
   □ no

16. What could motivate you to use the olive milling residues for energy purposes?
   □ national legislation
   □ national financial stimulation (regional/national/EU grants)
   □ tax relief
   □ I’m not interested in it

Thank you for your cooperation!