CLIMATE CHANGE MITIGATION THROUGH A SUSTAINABLE SUPPLY CHAIN FOR THE OLIVE OIL SECTOR

LIST OF SUTAINABLE PRACTICES TO DEVELOP THE CERTIFICATION STANDARD

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THEIR MITIGATION POTENTIAL IN TERMS OF TON OF CO_2 EQUIVALENT

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1. EXECUTIVE SUMMARY

The project OLIVE4CLIMATE was developed observing the great impact of the agricultural sector in the total emissions produced by human activities. The attention was then focused on the olive groves since this cultivation is an essential part of the agricultural sector of the European Union, especially in the Mediterranean area.

On this context, the project wants to highlight the strong connection between sustainable agricultural techniques and climate change mitigation through the evaluation of the Carbon Footprint (CF) associated to the production of 1 liter of extra virgin olive oil. This process is going to be tested in the Mediterranean countries with heterogeneous environmental conditions and with significant olive cultivation records, in three heterogeneous geographical contexts: Italy, Greece and Israel.

With a few additional data, also the carbon sequestration (sink) realized by the olive groves will be evaluated. This allow to determine the break-even point after which the amount of carbon sequestered exceeds the emissions related to human activities and, therefore, the corresponding carbon credits generated by this system. From this perspective, the Carbon Footprint and the evaluation of the Carbon sequestration can become important "green" marketing tools for the olive cultivation that could be included in the voluntary carbon market.

In this document, several strategies for creating a sustainable olive oil sector and promoting products deriving from integrated and organic cultivation methods will be presented. The objective of these techniques will be the improvement of the net balance between absorbed and emitted CO_2 and then determine the capability of the olive groves as an instrument for climate change mitigation.

2. GENERAL INFORMATION AND BACKGROUND

Olive tree (Olea europaea L.) is one of the most widespread agricultural tree species in the world, reaching 10.2 Mha of cultivated area (data referred to 2012), especially in Europe. In recent years olive cultivation has been also successfully introduced in other countries such as California, Australia, Argentina and South Africa.

For the Europe Union, the olive sector is an essential part of the agricultural sector. In particular, it represents a significant share of the agricultural economy in the southern Europe countries. The EU is also the world leader in the olives production (almost 70% of the total worldwide production coming from Europe) and it is the first exporter in the countries that do not produce olive. In terms of area, the olive trees occupy 8-9% of the total cultivated land in Spain, Italy and Portugal and 20% in Greece. There are more than 1.8 million farms dedicated to the production of olives in the EU, representing 60% of all farms in Greece and 40% in Spain and Italy.

Since the agriculture sector is responsible for 9.9% of the emissions of greenhouse gases in the EU, it is obvious the relationship between agriculture and climate change. The agricultural sector is also particularly vulnerable to the climate change effects and, consequently, it has to face the combined challenge of mitigation and adaptation to climate change under the new climate scenarios that are expected to arise as a result of global warming. One of the challenges of the Common Agricultural Policy 2014-2020 (CAP) is to fully exploit the agriculture potential to mitigate climate change and adapt to its consequences, increasing the positive contribution of the sector to the carbon sequestration.

However, even though olive production is widely diffused, there is still little knowledge regarding the fixation capacity of atmospheric CO^2 of the olive groves and their greenhouse gases mitigation effect. In particular, while the quantification of the carbon sequestered by the forestry sector has been object of extensive studies, information about the carbon amount from agricultural systems is extremely limited, because usually is considered only their productive role and not their ecological role.

For the carbon sequestration, another phenomenon that has to be considered, is the desertification. This phenomenon is a direct consequence of climate change and it affects very large areas where the land has lost its productive capacity as a consequence of both to human activities and natural causes. According to the European environmental policy, to support the increasing soil carbon content, the project aims to define the olive groves as a land management technique that can be applied for climate change mitigation which is able to restore its organic matter and, therefore, to operate to absorb CO_2. The adoption of agricultural techniques that cause an increase of the carbon content in the soil (e.g. green cover), allow to get other indirect benefits including the reduction of inputs of fertilizers.

Along with different soil management solutions, the project aims to define alternative strategies that can be adopted for the extraction phase, including the use of renewable sources, the increase of the energy efficiency of the machines, the recovery and reuse of the production wastes or by-products (such as pruning and pomace) in order to reduce the emissions associated to the transformation stages realized in the olive mill.

Therefore, there would be a consequent big repercussion on the overall trees cultivation and in particular on olive-growing because there would be significant potentialities of carbon sequestration (deriving also from the longevity of the olive trees), the possibility of preserving olive groves with important environmental and landscape functions, but with low profitability, thanks to the incentives connected to the selling of carbon credits.

3. THE PROJECT ACTION: DEVELOPMENT OF A CARBON CREDIT CERTIFICATION STANDARD FOR SUSTAINABLE OLIVE GROVE MANAGEMENT

Aim

The main objective of this action is the development of the standard for carbon credits certification generated from the sustainable management of olive groves. This action is planned to assess the potential climate change mitigation action of the olive groves in terms of ton of $CO_{2\text{-}e}$.

The definition of carbon credits arising from the sustainable management of olive grove is one of the strategies that it will be implement to achieve the recognition of ecosystem services of olive groves as contributor to climate change mitigation. In particular, through the value given to the most representative ecosystem service performed by olive groves (the carbon sequestration), the value generated from the agro-ecosystems in the economic field will increased. In particular, it will be created a standard that will offer visibility to the effect of the carbon sequestration obtained by the sustainable management of olive groves in term of corresponding generated carbon credits.

The evaluation of such Carbon credits can be an important competitive and green marketing tools that can include olive cultivation in the perspective of climate change mitigation.

The method

This activity will be carried out according to the following Tasks:

• Task 1: Estimation of the potential climate change mitigation action in the olive grove management. This estimation of the mitigation potential and of emission reductions due to the direct action of mitigation will be enlarged to the Mediterranean olive groves.

• Task 2: Elaboration of the technical documentation of the standard for carbon credits certification generated from the sustainable management of olive groves; in particular this Task will elaborate a) the normative procedure of a internationally recognized standard, and b) the “report guidelines” to be implemented in the company pilot areas.

All the documents will be based on the evaluation of the impact of sustainable management practices, that will allow a quantitative assessment of the carbon sink and related carbon credits, and according to the relative International Standard Organization standard for auditing and for Green House Gasses certification (ISO 14000 technical norms).

• Task 3: Training of company staff aimed to implement the certification standard into the project selected pilot companies, selected as stakeholders; task includes dissemination and communication among stakeholders, with a final public consultation about the certification standard for sustainable olive grove management.

• Task 4: Creation of a “suppliers and buyers register” for voluntary carbon credits generated by sustainable olive groves management.

In compliance with the action aim, in the following paragraphs, a list of sustainable management techniques with their mitigation potential is reported.

4. REDUCTION OF THE USE OF FERTILIZERS

Description

Balanced Nutrition contributes significantly to achieving a good relationship between vegetative and reproductive activity of plants. The olive absorbs most of the nutrients necessary for its development from the ground. The main purpose of fertilization is to improve or to preserve the fertility of the soil, including the administration of some deficient nutrients using low environmental impact products (such as those allowed in organic agriculture).

The fertilizer composition is determined taking into account the fertility level of soil, nutritional status of plants and factors which affecting their nutritional needs (eg plant age, tree productive potential, irrigation, etc.). Useful tools to determine the amount of nutrients are soil analysis, foliar diagnostics, calculations of trees removal and visual observation of plants.

A proper fertilization also considers how the absorption of the various nutrients changes during the vegetative season:

- nitrogen is absorbed throughout the vegetative season, with a greater intensity from full bloom to hardening of the stone;
- phosphorus is absorbed especially in the first part of the vegetative season (the need is generally modest);
- Potassium, although it is absorbed since the beginning of vegetative season, is used in a high amount also during fruit growth and oil synthesis.

Nitrogen fertilizers are the most commonly used fertilizers with a consequent greater impact on the environment.

Calculation method

Nitrogen emissions (N_2O) deriving from the use of fertilizers are distinguished by direct and indirect emissions and are calculated and converted into equivalent CO_2 based on the methodologies and on the emission factors provided by the IPCC (2006). Direct emissions are calculated on the basis of the quantities of nitrates fertilizers used (IPCC, 2006 - Vol. 4, Chapter 11 - Equation 11.1). Indirect emissions are calculated by taking into account two processes: 1) the NH_3 and NO_x volatilization due to fertilizer application and the subsequent rendering of these gases such as NH_4^+ and NO_3- in soils and waters (IPCC, 2006 - Vol. 4 Chapter 11 - Equation 11.9); 2) NO_3-SO_2 emissions following leaching and surface sliding (IPCC, 2006 - Vol. 4, Chapter 11 - Equation 11.10).

According to the information contained in various Integrated Production Disciplines, for the purpose of limiting the pollution of water by excess fertilizer elements, the maximum quantity of fertilizer usable for the main crops of the territory is defined respecting the minimum quantity required to obtain quantitatively and qualitatively acceptable productions. Table 1 (first column) shows average nitrogen fertilizer values currently used in olive cultivation.

For the purpose of applying this activity in the context of sustainable farming practices, it is proposed a 15% reduction of this limit (Table 1, second column) respect to the values reported in the Integrated Production Disciplinaries, that with later described sustainable practices (management of pruning material and/or green cover and/or conservation tillage) will not reduce production expected quantities.. This additional reduction in the use of nitrogen fertilizers compared to the quantities currently used would further reduce N_2O emissions and would ensure compliance with the principle of additionality with respect to Business as Usual (BAU).

Tab.1 Credits generated by the 15% reduction in the use of nitrogen fertilizers from the average values currently used

Amount of fertilizers used kg N/ha	**Proposed reduction (15%) kg N/ha**	**Credits generable t CO_2/ha/anno**
60	51	**0,06**

- **Positive impacts:** reduction of emissions in the production and transport of fertilizers; reduction of water pollution; savings in the purchase and consumption of fertilizers.
- **Negative impacts:** potential risk of production reduction/yields/hectare.
- **Environmental synergies:** reduction of N leaching and pressure would improve biodiversity water and air quality (ND, NEC Directive, WFD, Habitats Directive).

5. MANAGEMENT OF PRUNING MATERIAL

Description

Agronomic practices commonly used in olive growing include annual or biennial pruning operations. The amount of biomass resulting from the pruning operations is extremely variable depending on the variety, the training system, the density of plants per hectare, the pruning timing and the reference geographic area. Table 2 shows the average biomass values annually produced by pruning operations derived from existing literature (CARBIUS Project Report, May 2010; Facini et al., 2007; Sofo et al., 2004; Sofo et al., 2005).

Generally, the resulting wood residues are burnt on site or chipped and released on the ground or underground. The pruning burned into the field must be considered as a carbon loss by the ecosystem, otherwise if these residues are left into the ground with mulch and fertilizer function, the carbon balance is improved. Another strategy for reduction of the gas emissions in the atmosphere is represented by the use of such residues for energy purposes instead of fossil fuels. This activity changes the destination use of annual waste generated by perennial tree crops compared from the Business as Usual (BAU) to the energy production. This change of use of prunings results in a reduction of use fossil fuels adoption with a consequent reduction of CO_2 emissions in the atmosphere.

Calculation method

The CO_2 avoided emissions by the use of pruning as biomass for energy purposes are calculated on the basis of the methodologies and emission factors existing in the literature. The amount of wood biomass annually retrievable by pruning operations expressed in t s.s./ha is associated with a coefficient which expresses the calorific value of the orchard biomass, indicated at 4.300-4.400 kcal / kg d.m. (source: ENEA 2008). The energy generated from waste biomass produced per hectare is calculated using a conversion factor from kcal to KWh (1 kWh corresponds to 859,8 kcal).

The CO_2 avoided emissions are calculated as a result of pruning biomass use for energy purposes, a reference emission factor of 410.3 g CO2 / KWh (ISPRA, 2011) is calculated for the thermoelectric power industry in Italy, taking in consideration the emissions for pruning transportation. Tab. 2 Usable pruning residues, energy production and credits generated by avoided emissions due to the use of pruning for energy production (the avoided emission also take in account the pruning transport and chipping)

Tab. 2 - Utilizable biomasses, energy production and credits generated by emissions avoided by management of olive pruning materials for energy production.

Annual pruning material (t s.s./ha)	Energy production from biomass (kW/ha/anno)	Avoided emissions (t CO_2/ha/anno)
1,7	8.502	3,49

- **Positive impacts:** reduction of emissions from combustion (considering replacing the practice of residuals burning on site), soil organic improvement or reduction of soil disturbance (considering replacing the practice of digging residues); increased biodiversity.

- **Negative impacts:** risk of increased operating costs due to the chipping and transport of pruning material; lower organic matter return into the ground if it is alternative to the practice of chipping residues..
- **Environmental synergies:** Next to the avoiding CO2 emissions, another benefit would be the reduction of fuel-related costs and independence regarding energy prices for farmers. This measure is directly linked to the EU climate and energy package (20-20-20 strategy).

6. GREEN COVER

Description

A permanent grove is required to maintain the chemical-physical and microbiological fertility of the soil and the reduction of superficial erosion, which are extremely dangerous for soil loss and nutrient leaching. A periodic or perennial green cover is an action applicable to the soil management when the olive grove area is not affected by water scarcity.. Green cover can be considered as a real lawn covering the soil in the tree crops, where all biomass is periodically shed and left on the ground. In addition to the significant ecological benefits (eg limiting nitrate leakage losses by adjusting the availability of nitrogen in the soil, improving soil structure, promoting water absorption, increasing soil porosity and bearing capacity, increase of biodiversity, higher system stability with reduction of phytosanitary measuresetc.), green cover allows to maintain and increase the level of organic matter in soils. This results in a moderate increase in soil organic carbon (SOC), positively influencing the carbon balance in respect to BAU, with a contribution up to 50% to the main crop in some orchards / vineyards (Libro bianco, 2012). Permanent and natural green cover (to be preferred) provides soil cover for the entire vegetative cycle and it is never destroyed by mechanical machining, it is particularly suitable in loose soil (with good drainage) in and sloping soils, it can be made of spontaneous species or plant with a shallow root system to prevent water and nutrient competition with the olive roots(eg *Poa pratensis* and *Poa annua*). Natural green cover has to be preferred because it reduces the emission due to soil working and seed transport.

Calculation method

The increase in CO_2 absorption generated by the application of the natural green coverage is estimated on the basis of organic carbon data in the soils (SOC) derived from literature that reported a range from 0.32 ± 0.08 to 0.6 t C / ha / year (Freibauer et al., 2014; Poeplau and Don, 2015; Libro bianco, 2012).

The practice of green cover in olive groves generates an increase in organic carbon in soils (SOC), which ranges on average from 1.17 to 2.20 tonnes of CO_2 / ha / year (IPCC, 2006 – Vol. 4 cap. 2 – Eq. 2.25)

- **Positive impacts:** Soil stabilization and consolidation and increased water reserves; reduction of nitrate leakage losses by adjusting the availability of nitrogen in the soil; minor soil disturbance due to minor soil work; Improvement of structure, soiliness and soil bearing capacity; increased biodiversity.
- **Negative impacts:** potential risk related to competition with the main species. Increase of emissions due to artificial introduction of cover crop species, due to soil working, transport of seeds, etc)

7. CONSERVATION TILLAGE

Description

Sustainable soil management is required to maintain the chemical-physical and microbiological fertility of the soil and to reduce the superficial erosion, which are extremely harmful to soil loss and nutrient leaching. Minimal and superficial processing (conservation tillage) are some actions that are applicable for an optimum soil management, where green cover cannot be applied due to poor rainfall. The adoption of conservative agronomic practices reduce the CO2 emissions by increasing the stock of organic matter in the soil. Studies show the beneficial effect of Conservative Agriculture on the rate of organic matter into the ground (White Paper, 2012). In addition to mitigating effects on global warming, carbon storage in the soil is a desirable objective to support crop production and growth, to improve product quality, to increase water efficiency, to recover degraded soils, promoting ecosystem health (White paper, 2012).

Among the sustainable land management practices, with particular reference to the reduction of machining, the following activities is the minimun tillage. the 30% of soil remains covered by residues deriving from cover crop mowing. Soil is undisturbed between the harvesting and the subsequent sowing. The soil processing proposed are:

- simple surface machining with disc harrow or deep milling 8-20 cm;
- milling or machining with disk harrow only on the row (strips from 5 to 10 to 20-30 cm) between rows there are not worked, the depth varies from 30 to 5 cm.

Calculation method

The increase in CO_2 absorption generated by the application of this activity is measured on the basis of the organic carbon data in the soils (SOC) derived from literature ranging from 0.15 to 0.3 t C / ha / year in the case of reduced processing (Freibauer et al., 2014; White paper, 2012).

The practice of minimum tillage in permanent crops generates an increase in organic carbon in soils (SOC), which ranges on average from 0.55 to 1.10 tonnes of CO2 / ha / year

- **Positive impacts:** higher stabilization and consolidation of the soils and increase of water reserves; low soil disturbance; improvement of the structure, porosity and bearing capacity of the soil; increased biodiversity.
- **Negative impacts:** potential risk associated with reduced productivity and greater competition of spontaneous herbs with culture.
- **Other benefits:** the added value of this measure is the reduction in expenditure for the Farmer (high petrol prices). This measure would be directly linked to the climate and energy package (Strategy 20-20-20).

8. OLIVE PITTING MACHINE

Description

Olive kernels or stones are usually considered a waste. In recent years, however, it is increasingly considered as a co-product obtained during the transformation process of the olive fruits through an olive pitting machine. In particular, kernels can be reintroduced into the life cycle of olive oil, or other products, with important environmental benefits. In fact, even if the introduction of a new machine along the production cycle can lead apparently to a worse condition, the use of the stones as "fuel" for the heating of the water used in the process constitutes a greater benefits by balancing the higher electrical consumptions.

To understand the impact of the olive pitting machine it is possible to observe the result obtained in a study conducted in some Umbrian companies (Italy).

The study shows that the machine has an average consumption of about 0.12 kWh per kilogram of kernel produced or, reporting the consumption to 1 liter of EVO oil, about 0.05 kWh per liter. This amount corresponds, on average, to an overall increase in energy consumption of approximately 25%.

Reporting this value in terms of primary energy, to remove 1 kg of stones are necessary 1.1 MJ. This conversion it is necessary to highlight the benefits of this process. Considering the lower calorific value (LCV), i.e. the amount of heat evolved when a unit weight of the fuel is completely burnt, the kernels have a LCV of about 16.5 MJ per kg of product.

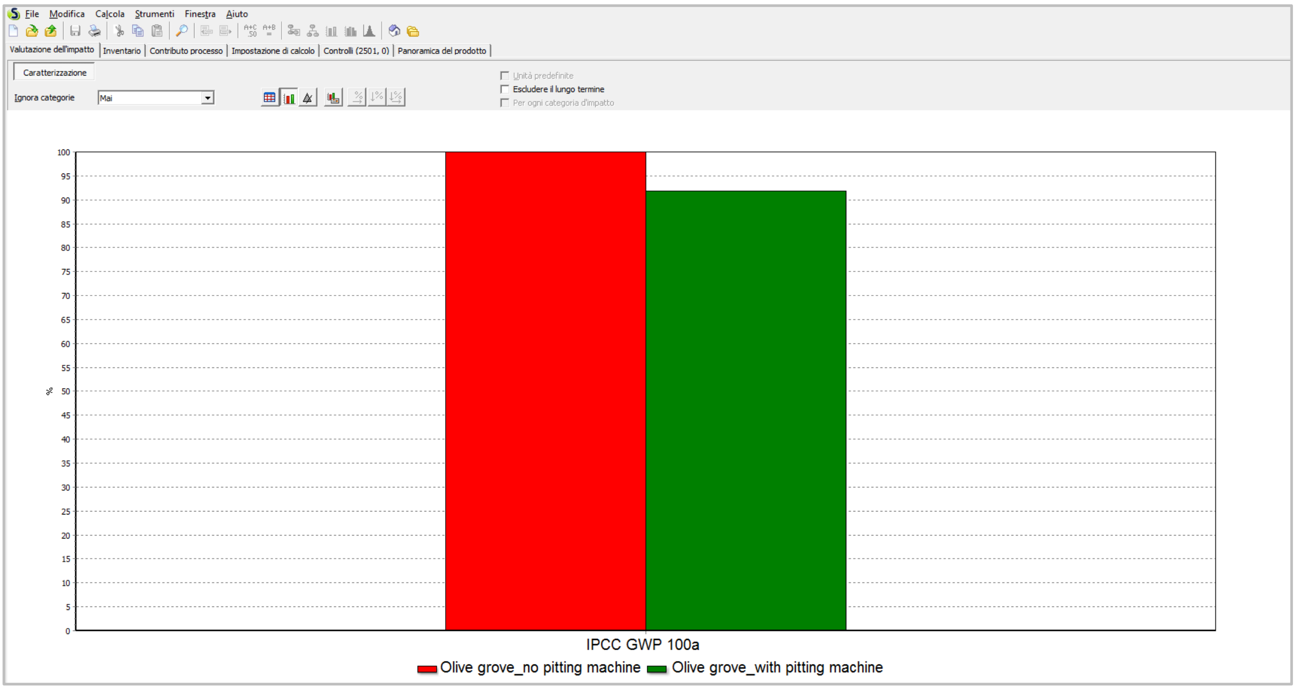
By comparing these values it is evident that the energy released through the combustion process of the material is much greater than the one required for its extraction. The process is therefore energetically very convenient.

By using the stones as a biomass for boiler feed and therefore for thermal energy production, it is possible to cancel the natural gas, or other conventional fuels, consumption with a significant reduction of the climate change gases emission and the energy demands of the production process.

Calculation method

The reduction of the CO2 emitted by the application of an olive pitting machine has been estimated using SimaPro software. The software allows to convert the energy consumption (thermal, electric, diesel, petrol, etc.), the total amount of raw materials, etc. in an equivalent amount of greenhouse gasses.

Two different models have been developed. In the first model, without the olive pitting machine, the thermal energy requirements has been covered by a traditional boiler using natural gas. In the second model, instead, the thermal energy requirements has been covered by burning the olive kernels in a biomass boiler. All the other processes were not changed.



Comparing the results obtained, the percentage reduction of CO_2 emissions is about 9%. In terms of tCO_2 equivalent the difference between the models is about 1.4 tCO_{2e} per year.

9. PHOTOVOLTAIC SYSTEM

A photovoltaic system, also PV system or solar power system, is a power system designed to supply usable solar power by means of photovoltaics. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity.

Farm buildings often have significant surface areas. Where there is exposition to solar radiation, photovoltaic panels could be installed to produce renewable electricity. Sometimes, electricity consumed from the grid could be replaced by the local renewable electricity produced (balance between the activity of the farm and the size of the installation).

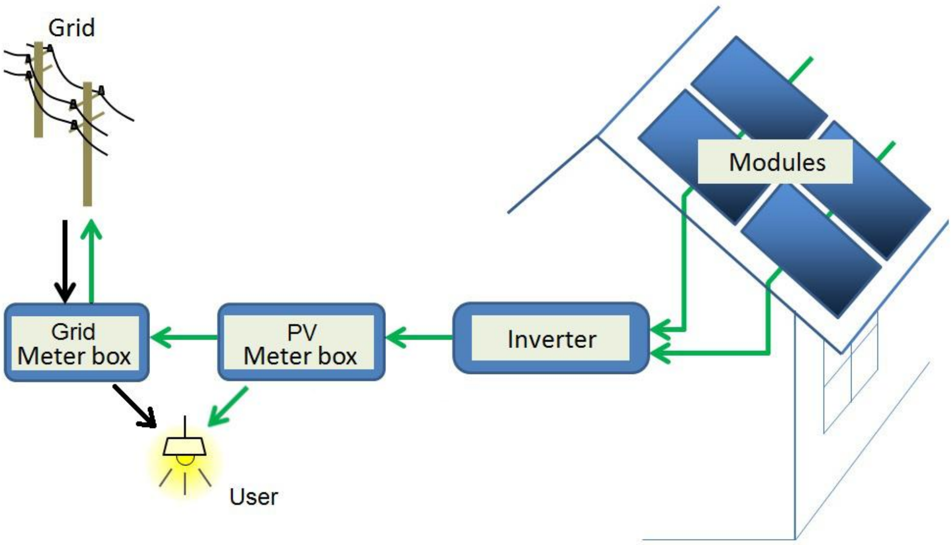
The advantages associated with this technology are:

- Absence of polluting emissions during operation (avoided emissions: 0.5 ÷ 0.7 kg CO2 per kWh product).
- Saves fossil fuels.
- Reliability of the systems since they have no moving parts.
- Minimized operating and maintenance costs.

The principal disadvantages are:

- Solar energy has intermittency issues.
- Solar energy panels require additional equipment (inverters) to convert direct electricity (DC) to alternating electricity (AC) in order to be used on the power network.
- Solar panels efficiency levels are relatively low (between 14%-25%).

The most commonly used solution, is the one connected to the national utility grid. In this solution the energy produced by the PV system can be shared with the national utility (if the energy produced is greater than the one consumed) and the user become a producer. Vice versa, if the consumption are greater than the production, the user can always covers the needs through the utility grid.

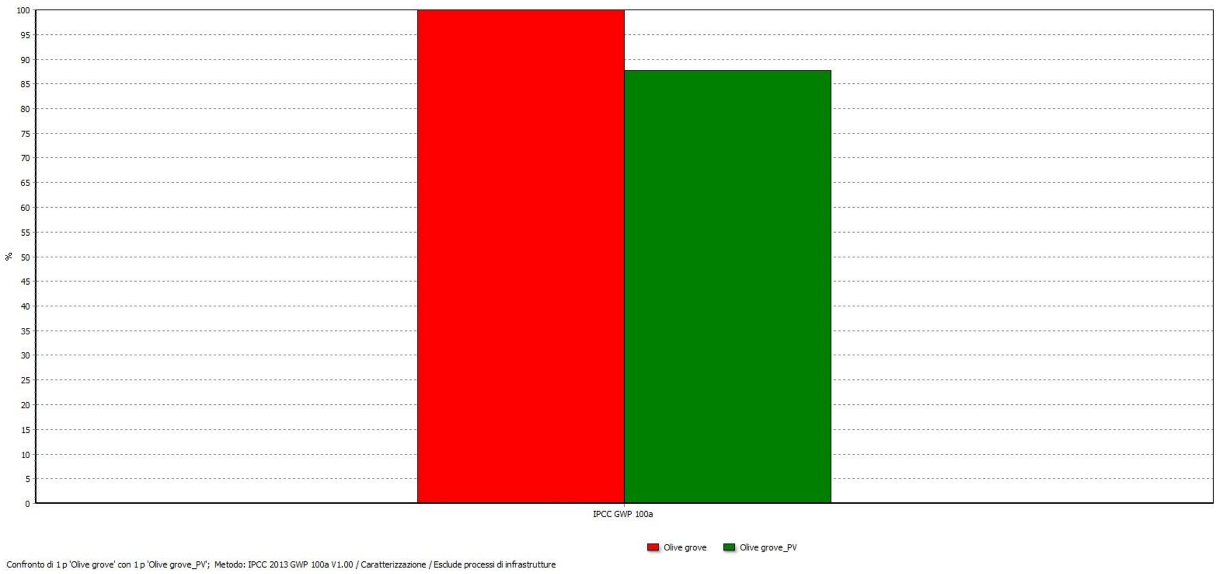


Calculation method

The potential cut of CO2 emission due to the application of a PV system has been determined using SimaPro software.

As aforementioned, two different models have been developed:

- The first one without PV system (red).
- The second one with a PV system (green) that covers all the electrical needs of the oil mill.



Comparing the results obtained, the percentage reduction of CO_2 emissions is about 12%. In terms of tCO_2 equivalent the difference between the models is about 8.8 tCO_{2e} per year[1].

However, this results are referred to specific geographical condition and, therefore, specific production. To determine exactly the % reduction of CO2 emission a specific study has to be performed for the area selected considering:

- The climate and geographical condition of the regional selected.
- The installation way and then the corresponding parameters.
- The real consumption of the user and therefore the total power of the plant.

[1] The data are referred to a PV system installed in Umbria region (Italy) with a pic power of 12.5kW, tilt angle 30°, facing south.