Mediambiente
Formazione
Servizi

CO_2 Emissions Balance Evaluation

Fattoria La Vialla, 2013-2014

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Introduction

This report is the continuation of the study to quantify the emissions of carbon dioxide and other greenhouse gases, expressed in carbon dioxide equivalent (CO_2eq), associated with the activities of Fattoria La Vialla, located in Poggiolo Castiglion Fibocchi - Arezzo, Tuscany for the years 2013 and 2014.

In addition to the calculation of the carbon dioxide directly or indirectly produced by the considered activities, we have included all the greenhouse gases generated by the system based on the respective values of GWP (global warming potential), namely the index that represents the contribution of climate-changing greenhouse gases in proportion to the characteristic contribution of carbon dioxide, whose GWP is considered equal to 1. According to the Kyoto Protocol, any greenhouse gas has a CO_2 equivalent quantity.

To calculate the CO_2 equivalent we used the emission factors published by the Intergovernmental Panel on climate change (IPCC Emission Factor Database: http://www.ipcc-nggip.iges.or.jp/EFDB/main.php). The validation of the analysis was carried out by using the Simapro software updated to version 8.0.4 and the latest version of the impacts assessment methods contained in the calculation code. When necessary, the secondary data were found in the database Ecoinvent versions 2.2 and 3.1.

Fattoria La Vialla grows its products according to the principles of biodynamic agriculture, respecting the cycles and vitality of the “soil” system.

Fattoria La Vialla is equipped with a system of constructed wetlands for the treatment of domestic water and various photovoltaic systems for the production of renewable electrical energy. We have considered that the paper and the cardboard used for communication and packaging are recycled and the offsetting of CO_2 emissions for their realization is calculated on the basis of a dedicated certification system, as specified below.

Fattoria La Vialla is a farm engaged in the production of organic food products. In addition to production, it deals with the transformation of the product, packaging and labeling. In particular, it produces wine, oil, dairy products and vegetable preserves. Glass jars and bottles, paper and cardboard are used for the packaging of the products, and plastic films for stretch packaging.

The references regarding the emission coefficients adopted for the calculation are given in the following text with a number in parentheses and explicitly stated in the Bibliography and Database section.

System of reference

For the calculation of emissions we have considered the system in steady state.

In the analysis we consider only the inputs of matter and energy necessary for production operations of the company while the construction phase of the plant and equipment is not included in the system boundaries. The calculation of environmental externalities is therefore relative to inflows (raw materials and energy) and outflows (finished products) from the system for the work carried out in the reference year.

The reference time for the life of the processes is 20 years. For land plots being transformed from traditional farming to organic farming we have considered a maturation period of eight years, during which the organic content of the soil tends to rise and then stabilize.

It is worth noting that the comparison between the emission profiles of the two years, 2013 and 2014, are not directly comparable with that of 2012, because it was decided to change certain assumptions and methodological approaches in order to carry out the analysis according to the latest criteria for the calculation of greenhouse gas emissions, with particular reference to those generated by the fertilization phase, as discussed in detail below.

1. Data and emissions analysis

The table below shows the consumption of Fattoria La Vialla grouped into: energy consumption (electrical and thermal), consumption of materials (paper, cardboard, plastic, glass, steel, aluminum and wood), consumption for agricultural production (fertilizers and transport of agricultural machinery) and fuel consumption for transport (cars with petrol and diesel engines, agricultural machinery).

Emissions Calculation 2013

Macro Areas	Quantities	Unit	Emissions	Unit	%
Energy Consumption					
Electrical (1)	1.070.976,98	kWh	623,31	$tCO_{2\ eq}$	7,39%
Thermal (methane) (2)	216.074,77	m^3	423,51	$tCO_{2\ eq}$	5,02%
Thermal (LPG) (3)	14.675,00	m^3	21,13	$tCO_{2\ eq}$	0,25%
Material Consumption					
Paper (4)	1.034.130,00	kg	873,84	$tCO_{2\ eq}$	10,36%
Cardboard (5)	1.919.210,00	kg	1.884,66	$tCO_{2\ eq}$	22,35%
Plastics (6)	39.850,00	kg	107,67	$tCO_{2\ eq}$	1,28%
White Glass (7)	727.731,54	kg	555,99	$tCO_{2\ eq}$	6,59%
Half-white Glass (7)	413.036,82	kg	315,56	$tCO_{2\ eq}$	3,74%
Uvag Glass (7)	826.073,64	kg	491,51	$tCO_{2\ eq}$	5,83%
Steel (8)	34.390,00	kg	152,69	$tCO_{2\ eq}$	1,81%
Aluminum (9)	3.310,00	kg	28,30	$tCO_{2\ eq}$	0,34%
Wood	64.770,00	kg	121,23	$tCO_{2\ eq}$	1,44%
Agricultural Production Consumption					
Fertilizers	497.405,00	kg	1.441,41	$tCO_{2\ eq}$	17,09%
Diesel Agricultural Machinery	56.000,00	l	148,40	$tCO_{2\ eq}$	1,76%
Transport Consumption					
Diesel Transport	87.461,00	l	231,77	$tCO_{2\ eq}$	2,75%
Petrol Transport	5.746,00	l	13,68	$tCO_{2\ eq}$	0,16%
Truck Transport	799,00		998,75	$tCO_{2\ eq}$	11,84%
Rail Transport	0,00	l	0,00	$tCO_{2\ eq}$	0,00%

Productive Cycle Total Emissions 8.433,41 $tCO_{2\ eq}$

Table 1: Consumption and emissions of Fattoria La Vialla year 2013

Applying a cut-off for contributions that are below 5% of the balance, the emission impacts in order of priority are distributed as follows:

Year 2013

Cardboard	1.884,66 tCO_2eq	22,35%
Fertilizers	1.441,41 tCO_2eq	17,09%
Transport on trucks	998,75 tCO_2eq	11,84%
Paper	873,84 tCO_2eq	10,36%
Electrical	623,31 tCO_2eq	7,39%
White Glass	555,99 tCO_2eq	6,59%
Uvag Glass	491,51 tCO_2eq	5,83%
Thermal (natural gas)	423,51 tCO_2eq	5,02%

Emissions Calculation 2014

Macro Areas	Quantities	Unit	Emissions	Unit	%
Energy Consumption					
Electrical (1)	1.050.157,87	kWh	611,19	$tCO_{2\ eq}$	7,63%
Thermal (methane) (2)	214.093,90	m^3	419,62	$tCO_{2\ eq}$	5,24%
Thermal (LPG) (3)	11.727,00	m^3	16,89	$tCO_{2\ eq}$	0,21%
Material Consumption					
Paper (4)	1.067.740,00	kg	902,24	$tCO_{2\ eq}$	11,27%
Cardboard (5)	1.579.600,00	kg	1.551,17	$tCO_{2\ eq}$	19,37%
Plastics (6)	34.361,00	kg	92,84	$tCO_{2\ eq}$	1,16%
White Glass (7)	827.835,41	kg	632,47	$tCO_{2\ eq}$	7,90%
Half-white Glass (7)	469.852,53	kg	358,97	$tCO_{2\ eq}$	4,48%
Uvag Glass (7)	939.705,06	kg	559,12	$tCO_{2\ eq}$	6,98%
Steel (8)	48.120,00	kg	213,65	$tCO_{2\ eq}$	2,67%
Aluminum (9)	4.319,00	kg	36,93	$tCO_{2\ eq}$	0,46%
Wood	180.175,00	kg	337,23	$tCO_{2\ eq}$	4,21%
Agricultural Production Consumption					
Fertilizers	274.729,00	kg	796,71	$tCO_{2\ eq}$	9,95%
Diesel Agricultural Machinery	64.003,00	l	169,61	$tCO_{2\ eq}$	2,12%
Transport Consumption					
Diesel Transport	102.248,45	l	270,96	$tCO_{2\ eq}$	3,38%
Petrol Transport	4.937,83	l	11,75	$tCO_{2\ eq}$	0,15%
Truck Transport	797,00		996,25	$tCO_{2\ eq}$	12,44%
Rail Transport	80,00		30,00	$tCO_{2\ eq}$	0,37%

Productive Cycle Total Emissions 8.007,61 $tCO_{2\ eq}$

Table 2: Consumption and emissions of Fattoria La Vialla year 2014

<u>Year 2014</u>

Cardboard	1.551,17 tCO_2eq	19,37%
Transport on trucks	996,25 tCO_2eq	12,44%
Paper	902,24 tCO_2eq	11,27%
Fertilizers	796,71 tCO_2eq	9,95%
White Glass	632,47 tCO_2eq	7,90%
Electrical	611,19 tCO_2eq	7,63%
Uvag Glass	559,12 tCO_2eq	6,98%
Thermal (natural gas)	419,62 tCO_2eq	5,24%

<u>Cardboard</u>

In both years 2013 and 2014 the consumption of cardboard has the biggest impact, with emissions respectively of 22,35% in 2013 and 19,37% in 2014 (1).
These emissions - as we will see - have been compensated with emission certificates.

<u>Fertilizers</u>

The entry Fertilizers in 2013 is the second emission factor with 17.09% of the total. In 2014 it moved to the fourth place with 9.95%. The difference is due to the amount used according to the production cycles of the company: in 2013 twice the amount of fertilizers and soil conditioners were used compared to 2014.
La Vialla uses biodynamic farming techniques without using synthetic mineral fertilizers and chemical pesticides, but only raw materials of natural origin. Fertilizers and soil conditioners of biodynamic nature, in line with that reported in the related scientific literature, do not contribute to the emission balance since their environmental impact in terms of greenhouse gases is compensated according to natural cycles. The same approach was used for the

contribution to the balance of greenhouse gases made by natural insecticides and fungicides used by the company.
The calculation of emissions generated by the use of fertilizers was therefore carried out considering solely the contribution of organic foliar fertilizers according to the content of nitrogen, the quantities used (produced as such or dissolved in water) and agricultural areas over which the product was distributed, as reported in the most recent scientific literature (2,3).
A major cause that contributes significantly to greenhouse gas emissions in agriculture is the natural release of N_2O from fertilized soils. This gas, generated by microbial processes of nitrification and denitrification in the soil after fertilization, has a climate-power equal to 298 times the potential of CO_2 in terms of contribution to the greenhouse effect (slight variations can occur depending on the conditions of soil and climate in the areas of distribution of nitrogen fertilizers) and therefore has an extremely high impact compared to the CO_2 produced by the activity of distribution of the fertilizers.
Based on this updated methodology, the phase of fertilization accounts for 17,09% in 2013 and 9,95% in 2014, an overall emission contribution of 1.441,41 tCO_2 and 796,71 tCO_2, respectively.

Transport on trucks
In 2013 it is the third entry with a percentage of 11,84%, in 2014 it is the second entry with an impact of 12,44%.
For the calculation of the impact of transport on trucks, we considered as a reference the use of Euro 5 goods trucks with a maximum capacity of 40 t (4) which travel 870 km with a load of 17 t.
As regards to the total fuel consumption for traction, we note a significant increase of the diesel consumption in the year 2014 compared to 2013, in comparison to a progressive decrease of the petrol consumption given that the company's cars have a preponderance of this type of engine. Compared with diesel consumption for transport on trucks, that remains virtually unchanged during the two years of reference with a contribution that varies between 11% and 12%, in the year 2014, we have calculated the contribution due to transport by train that accounts for 0,37% of the overall emission balance.

Paper
Paper consumption is the fourth entry of 2013 with 10,36% of the emissions (1).
In 2014 it is in third place with an impact of 11,27%.
The company has purchased certificates to compensate emissions also for this entry.

White glass
Sixth entry in 2013 with 6,59% and fifth entry in 2014 with 7,9%.

Electricity consumption
Fifth entry in 2013 with 7,39% and the sixth entry in 2014 with 7,63% (5,6).
Part of the electricity consumption was compensated by the purchase of certified green energy as we will see in the compensation chapter.

Uvag glass
Positions realign between 2013 and 2014 emissions from the entry which in 2013 accounted for 5,83% and in 2014 for 6,98% (1).

Thermal Natural Gas

In eighth place in both years it accounts for 5,02% of the total in 2013 and for 5,24 in 2014 (5,6).

In 2014 La Vialla also starts to use rail transport, as well as road transport, with 80 trips a year covering 780 km, for a total of 30 tCO_2eq of emissions, which was 0,37% of the total (based on an emission factor for the rail freight 70% lower compared to road transport) (4).

1.1 Electrical and thermal energy from renewable sources

Over time, the company has equipped itself with power plants for producing renewable energy and more specifically with a nominal power, as far as the photovoltaic plants are concerned, equal to a total of 402,6 kWp. They have also installed 26,35 m^2 of solar heating plants for domestic hot water production (DHW), heat pump on the olive mill for 42 kWt, with nominal COP of 3,62. The heat pump is dedicated to supply heat to the water of kneaders for the processing of olives and to add it to the production of DHW. Also a warm/cold geothermal pump on the olive oil mill for 15,7 kWt, with COP 4,13 and absorbed power of 3,8 kW. The geothermal heat pump with probes in trenches heats and cools the rooms according to seasonal needs.

For the calculation of emissions we have considered only the production of photovoltaic and thermal energy plants.
The remaining renewable energy plants do not carry out the production of energy for direct use as their primary function, but have the main purpose of reducing the consumption over time and therefore lowering electrical and thermal consumption.

Renewable Energy Productions		Real specific production	1102,681 kWh/kWp		
PV Plant Vialla on ground	152	kWp	167.607,50	kWh/year	97,55 $tCO_{2\,eq}$
PV Plant Cerbara Falda	35,52	kwp	39.167,23	kWh/year	22,79533 $tCO_{2\,eq}$
PV Plant Cerbara sched	76,44	kwp	84.288,93	kWh/year	49,05616 $tCO_{2\,eq}$
PV Plant Cerbara Eurostir	55,86	kWp	61.595,76	kWh/year	35,84873 $tCO_{2\,eq}$
PV Plant Subbiano	71,50	kwp	78.841,69	kWh/year	45,88586 $tCO_{2\,eq}$
PV Plant Olive Oil Mill Castiglion Fibocchi	11,28	kwp	12.438,24	kWh/year	24,37895 $tCO_{2\,eq}$
	Renewable Energy Production year 2013		443939,4 kWh		
		CO2 Compensated by PV			275,51 $tCO_{2\,eq}$
Thermal Plant on Olive Oil Mill 26,4 m2	18,90	m2	27.234,90	kWh/year	53,3804 $tCO_{2\,eq}$
Solar Thermal Plant on cheese factory 10,64 m2	7,45	m2	10.732,57	kWh/year	21,03583 $tCO_{2\,eq}$
		CO2 Compensated by Solar Thermal			74,42 $tCO_{2\,eq}$

Table 3: Production of renewable Energy of Fattoria La Vialla year 2013

Renewable Energy Productions		Real specific production	1037,933801 kWh/kWp		
PV Plant Vialla on ground	152	kWp	157.765,94	kWh/year	91,82 $tCO_{2\,eq}$
PV Plant Cerbara Falda	35,52	kwp	36.867,41	kWh/year	21,45683 $tCO_{2\,eq}$
PV Plant Cerbara sched	76,44	kwp	79.339,66	kWh/year	46,17568 $tCO_{2\,eq}$
PV Plant Cerbara Eurostir	55,86	kWp	57.978,98	kWh/year	33,74377 $tCO_{2\,eq}$
PV Plant Subbiano	71,50	kwp	74.212,27	kWh/year	43,19154 $tCO_{2\,eq}$
PV Plant Olive Oil Mill Castiglion Fibocchi	11,86	kwp	12.309,89	kWh/year	24,12739 $tCO_{2\,eq}$
	Renewable Energy Production year 2014		418474,15 kWh		
		CO2 Compensated by PV			260,51 $tCO_{2\,eq}$
Thermal Plant on Olive Oil Mill 26,4 m2	18,90	m2	27.234,90	kWh/year	53,3804 $tCO_{2\,eq}$
Solar Thermal Plant on cheese factory 10,64 m2	7,45	m2	10.732,57	kWh/year	21,03583 $tCO_{2\,eq}$
		CO2 Compensated by Solar Thermal			74,42 $tCO_{2\,eq}$

Table 4: Production of renewable Energy of Fattoria La Vialla year 2014

Compensation year 2013 349,93 tCO_2eq
Compensation year 2014 334,93 tCO_2eq

For calculating compensation of the photovoltaic plant we have considered the CO_2 that would have been produced if the emission data of the Italian energy mix had been considered (5,6).

For the solar thermal plant a nominal capacity of 0,7 kW per m^2 (26,35 m^2 corresponds to about 8 panels); considering 1441 hours of operation per year, the energy produced by the plants is equal to 27.234,9 kWh in a year.
For the calculation of emissions, we considered the natural gas consumption avoided for heating using the same conversion factor as for the "Thermal (natural gas)" consumption (5,6).

2. Agriculture, Forests, Soil Sector (10)

The management of land use and human activities related to it affects a wide variety of processes within an ecosystem, which can lead to the formation of greenhouse gases.
The main processes are photosynthesis, respiration, decomposition, nitrification and denitrification and biomass burning. These processes involve the transformation of carbon and nitrogen with biological processes (microorganisms, plants and animals) or physical processes (combustion, leaching and discharge).

The CO_2 fluxes between the atmosphere and ecosystems are primarily controlled by absorption through photosynthesis and release through respiration, decomposition and combustion of organic matter. The N_2O is emitted mainly by the processes of nitrification and denitrification, while CH_4 is emitted by methanogenesis under anaerobic conditions in the soil during the management of manure and, to a lesser amount, during combustion processes carried out under oxygen deficiency, for example during the burning of stubble. Many of these processes also generate indirect greenhouse gases (e.g. combustion and leaching).

This section considers the record of CO_2 for the Agriculture, forests and soil sector of Fattoria La Vialla.

The ecosystems are divided in the scheme proposed by the IPCC methodology in three categories that can store carbon: biomass, dead organic matter (litter) and soil.
To evaluate changes in carbon stock in the three categories, namely to assess the net balance between emissions and absorption of CO_2, the IPCC methodology is based on the assumption that changes in carbon stocks in an ecosystem will occur mainly through the exchange of CO_2 between the land surface and the atmosphere, assuming, for example, leaching as negligible. In this way an increase in carbon stocks over time is equivalent to a net removal of CO_2 from the atmosphere and a reduction in the stock is equivalent to net emission into the atmosphere.

The 2006 IPCC Guidelines estimate all emissions and removals of greenhouse gases from human activities in the AFOLU sector. This means recording all emissions and removals that occur on areas that are altered by human activity, while those occurring in natural areas not used by man are not reported.
The approach of using the areas used by man as *proxy* for human effects was suggested in the IPCC Guidelines "*Good Practice Guidance for Land Use, Land-Use Change and Forestry*" in 2003 (8).

For the calculation of the trapped CO_2 we have used the method "*Gain-Loss*", which foresees that the change in carbon stocks is calculated by subtracting from the carbon fixed into biomass during the annual growth the carbon of the biomass removed.

$$\Delta C_B = \Delta C_G - \Delta C_L$$

$\Delta C_B =$ Annual change of Carbon stock in the biomass (above and below-ground), t C year^{-1}
$\Delta C_G =$ Annual gain of Carbon stock due to growth of biomass in each category of land use, t C year^{-1}
$\Delta C_L =$ Annual loss of Carbon stock due to loss of biomass in each category of land use, t C year^{-1}

The estimate of the change in carbon stocks in the biomass was carried out for the categories of land use of wooded and cultivated areas. Once obtained the variation in the stock of carbon as the difference between the fixed carbon and that lost, the tons of CO_2 can be obtained by multiplying the value by ± 44/12 (ratio of molecular weights of CO_2 and carbon), with a negative sign if it is absorption and a positive sign if it is removal.

The emission analysis was carried out using data provided by the company as shown in the tables below.

The variation of the land plots dedicated to forest, pasture and arable land have changed over the years due to the modifications made in production processes of the company and their respective surveys cannot be compared because the input data have changed over time.

Arboreal Absorption

Wood Type	Surface by wood type	Yearly increase of foliar biomass	Biomass conversion and expansion factor	Ratio between root and foliar biomass	Average yearly growth of root and foliar biomass	Carbon fraction	Total C	Total CO2
u.d.m. Resources	ha Company Data	m3/ha IFR	tbiomass/m3 IPCC	tbi/tbe IPCC	t/ha Eq.	% IPCC	tC/year Eq.	tCO2/year Eq.
Chestnut	42,00	7,08	0,60	0,46	6,20	0,51	132,88	487,24
Pine	0,88	10,30	0,69	0,29	9,20	0,48	3,87	14,20
Oak	384,27	3,21	0,90	0,30	3,80	0,51	735,65	2.697,37
Turkey Oak	81,89	4,42	0,60	0,30	3,40	0,51	143,88	527,57
Olive Oil Tree	16,80	1,80	0,90	0,30	2,10	0,51	18,05	66,17

Total Absorption	**3.792,55**

Wood farming	Wood farming areas	Farming residues	Total biomass	Biomass on plant	Humidity	Biomass	Biomass yearky increase	C fraction in biomass	C increase	CO2 Absorption
u.d.m.	ha	t/ha	t/ha	t/ha	%	t/ha	t	-	t/year	tCO2/year
Vineyard	271,14	2,90	3,63	0,73	35,00	0,25	68,80	0,50	34,40	126,14
Olive Grove	300,65	2,20	2,75	0,55	40,00	0,22	66,14	0,50	33,07	121,27

Total Absorption	**247,41**

CO_2 trapping in soil	**4,24**	**$tCO_{2\ eq}$**

Table 5: Absorption forest, soil year 2013

Arboreal Absorption

Wood Type	Surface by wood type	Yearly increase of foliar biomass	Biomass conversion and expansion factor	Ratio between root and foliar biomass	Average yearly growth of root and foliar biomass	Carbon fraction	Total C	Total CO2
u.d.m.	ha	m3/ha	tbiomass/m3	tbi/tbe	t/ha	%	tC/year	tCO2/year
Resouces	Company Data	IFR	IPCC	IPCC	Eq.	IPCC	Eq.	Eq.
Chestnut	42,00	7,08	0,60	0,46	6,20	0,51	132,88	487,24
Pine	0,88	10,30	0,69	0,29	9,20	0,48	3,87	14,20
Oak	384,27	3,21	0,90	0,30	3,80	0,51	735,65	2.697,37
Turkey Oak	81,89	4,42	0,60	0,30	3,40	0,51	143,88	527,57
Olive Oil Tree	16,80	1,80	0,90	0,30	2,10	0,51	18,05	66,17

Total Absorption	3.792,55

Wood farming	Wood farming areas	Farming residues	Total biomass	Biomass on plant	Humidity	Biomass	Biomass yearky increase	C fraction in biomass	C increase	CO2 Absorption
u.d.m.	ha	t/ha	t/ha	t/ha	%	t/ha	t	-	t/year	tCO2/year
Vineyard	271,14	2,90	3,63	0,73	35,00	0,25	68,80	0,50	34,40	126,14
Olive Grove	335,65	2,20	2,75	0,55	40,00	0,22	73,84	0,50	36,92	135,39

Total Absorption	261,53

CO2 trapping in soil	4,24	$tCO_{2\ eq}$

Table 6: Absorption forest, soil year 2014

In the calculation of the arboreal absorption we considered the most significant crops: forest, olive grove, vineyard.

The data provided by the company showed a distribution of about 525,84 hectares of forest. For the distribution of tree species we have maintained the distribution of 2012 equal to 8% chestnut, 73,2% oak,15,6% turkey oak, 3,2% mature woodland.
The forest distribution remained unchanged in 2013 and 2014.

For Vine and Olive tree crops we have a distribution in 2013 equal to 271,14 hectares of vineyard that remain unaltered also in 2014 and a distribution of 300,65 hectares of olive trees rising to 335,65 hectares in 2014.

In 2013 we have a distribution of approximately 1.097,63 hectares for arboreal absorption.
In 2014 we have a distribution of 1,132,63 hectares for arboreal absorption.

The breakdown by form of management of the species grown both as high forest or as coppice was carried out using the proportions present in the data of the IFR-Regional Forest Inventory (9).

The values of annual increase in biomass of the species governed as high forest have averages values of productive forests in the Region of Tuscany, while the values of the coppice growth were obtained by dividing the value of the growing stock (biomass growth) specific (IFR data) for years of the cutting rotation which was considered of 24 years, as reported in the survey on the state of the forests of Tuscany (10,11).

The forest type identified as coppice refers to coppice of mixed oak woods. The values of growth (growing stock) used as input are shown in the table below.

The annual increase of carbon includes the growth of the total biomass, as the sum of above-ground and underground biomass, while the loss of carbon results from forest harvesting and lost biomass.

The annual increase of forest biomass was calculated from the following equation (Eq. 2.9 IPCC, Vol 4):

$$\Delta C_G = \sum_i (A_i \bullet G_{total_i} \bullet CF_i)$$

Where:
A is the area of a forest type, ha
G_{total} is the average growth of the total biomass, t d.m. ha^{-1} $year^{-1}$
CF is the fraction of carbon in the dry matter, t C (t d.m.)$^{-1}$ *i* forest species

We used the *default* values of the fraction of carbon in woody biomass of conifers and deciduous trees of the IPCC Table 4.3, respectively 0.48 and 0.51 t C (t d.m.)$^{-1}$. The average annual increase in biomass, as the sum of the aerial and radical biomass, was calculated with the following equation, using the Tier 2 (Eq. 2.10 IPCC):

$$G_{total} = \sum \{ I_W \bullet BCEF_I \bullet (1+R) \}$$

Where:
Iw is the average annual increase for a specific vegetation, m^3 ha^{-1} $year^{-1}$
$BCEF_I$ is the conversion and expansion factor used to estimate the root biomass, t aerial biomass (m^3 increase)$^{-1}$
R is the ratio between the root biomass and aerial biomass for a specific vegetation.

The average annual growth factors in m^3/ha of forest species originate from the Regional Forest Inventory of Tuscany (Table 4). The values of the expansion factor of biomass (BCEFI) and the ratio root/crown (R) used are by default IPCC. For the selection of values BCEFI the IPCC values of table 4.5 have been chosen, by using the values of growing stock in the Regional Forest Inventory (Table 5). For the choice of the values of the ratio between underground and aboveground biomass we have used the default values of the table 4.4 IPCC reported in temperate climates by applying the basal density value for the conversion of the annual increase from m^3/ha to t d.m./ha., starting from the values of growing stock in the Regional Forest Inventory.

In the carbon balance, besides forest crops we need to consider those areas cultivated with permanent cultures.

The amount of carbon stored or released from the biomass of perennial crops depends on the type of crop, agricultural practices, soil and climate of a particular area. For example, annual crops (e.g. cereals, vegetables) are harvested each year; this way there is no accumulation of carbon in biomass. On the contrary, tree crops such as orchards, vineyards and olive groves, can store significant amounts of carbon in woody biomass.

We have therefore considered the accumulation of carbon in woody biomass of tree species grown, such as vineyards, olive groves using ISTAT data of surface cultivated with wood species. Using literature data available to central Italy (Centre for Biomass Research, University of Perugia) for the values of crop residues that can be achieved by orchards, olive groves and vineyards, we have then assumed that they correspond to 80% of the total annual growth of the plant, and therefore, 20% of the growth remains on the plant.

This quantity was then multiplied by the value of the average moisture of the wood (literature value) to obtain the tons of dry matter per hectare. This value was then multiplied by the hectares of corresponding woody crop and by the fraction of carbon IPCC typical to tree crops, which is equal to 0,5 t C per ton of dry matter.

Another factor to take into account for fixing the carbon is the increase of organic matter in the soil of the farm resulting from organic farming; we considered the figure calculated in 2012 valid, including all the assumptions made in the previous report.

Parameterizing the value at the time taken into account in the general analysis (20 years) we can say that every year **4.243** t CO_2eq are trapped.

3. Compensation through certificates

The compensation certificates below have been acquired by Fattoria La Vialla from third parties. They were considered as such and included as avoided emissions in the balance; it was not possible to verify in detail the characteristics of production of green energy purchased from Heracom.

Compensation Certificates		
Nature Office cardboard and print	3.010,42	$tCO_{2\ eq}$
Nature Office glass	1.363,00	$tCO_{2\ eq}$
Go Green - for DHL shipping	36,30	$tCO_{2\ eq}$
Shipping in Netherlands	1,15	$tCO_{2\ eq}$
Landbell	0,45	$tCO_{2\ eq}$
Co2 compensated for trucks	661,57	$tCO_{2\ eq}$
Green energy purchased from Heracom	577,77	$tCO_{2\ eq}$
Total Compensations	**5.650,67**	**$tCO_{2\ eq}$**

Table 7: Compensation through certificates year 2013

Compensation Certificates		
Nature Office cardboard and print	3.655,00	$tCO_{2\ eq}$
Nature Office glass	1.551,00	$tCO_{2\ eq}$
Go Green - for DHL shipping	186,18	$tCO_{2\ eq}$
Shipping in Netherlands	1,25	$tCO_{2\ eq}$
Landbell	0,53	$tCO_{2\ eq}$
Co2 compensated for trucks	659,92	$tCO_{2\ eq}$
Green energy purchased from Heracom	586,71	$tCO_{2\ eq}$
Total Compensations	**6.640,58**	**$tCO_{2\ eq}$**

Table 8: Compensation through certificates year 2014

As we can see the company has compensated mainly in 2014 with a difference of emissions equal to 989.91 tCO_2eq principally deriving from compensatory cardboard and printing Nature Office certificates and Glass Nature Office certificates.

4. Conclusions

Fattoria La Vialla has long demonstrated a particular focus on the environment and is committed to minimizing its environmental impact, by installing renewable energy plants for the production of electricity and thermal energy, using recycled materials and certificates (paper and cardboard) for product packaging and using natural substances for fertilization of the soil, using also methods of organic and biodynamic agriculture.

The summary below shows the emissions calculated during our study.

CONCLUSIONS		
Emissions	8.433,41	$tCO_{2\ eq}$
PV Avoided Emissions	275,51	$tCO_{2\ eq}$
Solar Thermal Avoided Emissions	74,42	$tCO_{2\ eq}$
Compensation through certificates	5.650,67	$tCO_{2\ eq}$
Arboreal Absorption	3.792,55	$tCO_{2\ eq}$
Wood Farming Absorption	247,41	$tCO_{2\ eq}$
Soil Absorption	4,24	$tCO_{2\ eq}$
CO2 Balance	**-1.611,38**	$tCO_{2\ eq}$
Without CO_2 in soil	**-1.607,14**	$tCO_{2\ eq}$

Table 9: Summary table, consumption and emissions of Fattoria La Vialla year 2013

CONCLUSIONS		
Emissions	8.007,61	$tCO_{2\ eq}$
PV Avoided Emissions	260,51	$tCO_{2\ eq}$
Solar Thermal Avoided Emissions	74,42	$tCO_{2\ eq}$
Compensation through certificates	6.640,58	$tCO_{2\ eq}$
Arboreal Absorption	3.792,55	$tCO_{2\ eq}$
Wood Farming Absorption	261,53	$tCO_{2\ eq}$
Soil Absorption	4,24	$tCO_{2\ eq}$
CO2 Balance	**-3.026,22**	$tCO_{2\ eq}$
Without CO_2 in soil	**-3.021,98**	$tCO_{2\ eq}$

Table 10: Summary table, consumption and emissions of Fattoria La Vialla year 2014

As we can see from the two tables emissions from 2013 to 2014 have decreased mainly thanks to the reduction of the fertilizers entry and from 2013 to 2014 compensation through certificates have increased.
In 2013, the Company absorbed 1.607,14 tCO2eq.
In 2014, the Company absorbed 3.021,98 tCO2eq.

Analyzing the emissions and dividing them in the respective macro areas, we can see that the farm has issued in 2013:

Energy consumption	1.067,95 tCO2eq	equal to	12,66%
Material consumption	4.531,46 tCO2eq	equal to	53,73%
Agricultural Production consumption	1.589,81 tCO2eq	equal to	18,85%
Transport consumption	1.224,42 tCO2eq	equal to	14,75%

Analyzing the emissions and dividing them in the respective macro areas, we can see that the farm has issued in 2014:

Energy Consumption	1.047,07 tCO2eq	equal to	13,08%
Material consumption	4.684,62 tCO2eq	equal to	58,50%
Agricultural Production consumption	966,32 tCO2eq	equal to	12,07%
Transport consumption	1.308,96 tCO2eq	equal to	16,35 %

It can immediately be noticed that the material consumption section is the macro area that emits more.
The entry with the highest impact, after the consumption of paper and cardboard that the company compensates with emission certificates, is the consumption of glass.
The glass is mainly used for packaging preserves and products that the company sells; working with another type of packaging could further reduce the emissions.

Purely as an example, using a container the size of a classic can for reference (assuming that it weighs 365 g if made of glass, 54 g if made of PET, 40 g if made of aluminum), the values of CO_2 emissions in the entire time span of the container's life:

- Glass (virgin): 256 g of CO_2-eq
- Glass (80% recycled content): 217 g of CO_2-eq
- Aluminum (virgin): 521 g of CO_2-eq
- Aluminum (100% recycled content): 37 g of CO_2-eq
- PET (virgin): 139 g of CO_2-eq

Since it was not specifically mentioned we considered aluminum as virgin in our analysis and took the maximum emissions data.
From the above, it is clear that to achieve a significant reduction in emissions from the packaging entry, the most effective solutions would be, in order:

- 100% recycled Aluminum
- Virgin PET
- 80% recycled glass

Within the overall quantity of packaging by the company, the virgin glass has a minor CO_2 emissions impact than virgin aluminum. In this context, the possible use of tin for food use would not improve the emissivity profile of the company: as it is actually steel sheets plated with tin to avoid phenomena of corrosion and oxidation of the containers, the presence of composite material would not provide environmental advantages unless using certified recycled material.

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