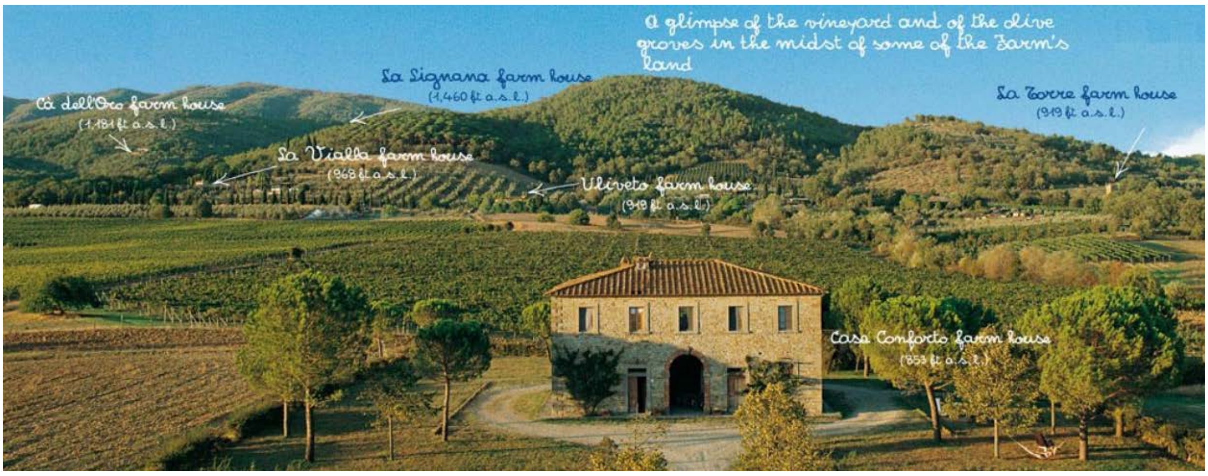
CO_2 Emissions Report

La Fattoria La Vialla



Arezzo

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Introduction

This report presents the findings of an ongoing study carried out to quantify the emissions of carbon dioxide and other greenhouse gases - expressed in carbon dioxide equivalents (CO_2-eq) – that are associated with the activities at Fattoria La Vialla, situated in Località Poggiolo Castiglion Fibocchi – Arezzo, Tuscany, for the year 2012.

Besides the calculation of carbon dioxide that is directly or indirectly produced by the estate, the report includes the contributions of all greenhouse gases generated on the basis of the respective values of global warming potential (GWP), which is the index that represents the contribution of a climate changing gas in proportion to the characteristic contributions of carbon dioxide, whose GWP value is equal to 1. According to the Kyoto Protocol, every greenhouse gas has a corresponding equivalent in CO_2.

The emission parameters published by the Intergovernmental Panel on Climate Change (IPCC Emission Factor Database, 2007) were used to calculate the CO_2 equivalents and the authentication of the analysis was done through the software Simapro and methods of impact valuation updated to version 3.3 of the calculation codes. When necessary, the secondary elements were sourced from the Ecoinvent database version 2.2. La Vialla grows produce according to the principles of biodynamic agriculture, respecting the cyclical nature and the vitality of the soil system; extending over more than 2,000 hectares, of which 613 are cultivated, 206 are currently in a phase of conversion, 759 are woodland (prevalently various types of oaks) and 536 are devoted to vines and olive trees.

La Vialla is has a phyto purification system for the treatment of domestic water waste and several solar panel systems for the production of renewable electric energy reaching an overall installed power capacity of about 400 kWp. The paper and cardboard used for advertising and packaging is recycled and the compensation of CO_2 emissions from their production is calculated on the basis of a dedicated certification system, specified below.

Reference system used

The system was considered stationary for the calculation of emissions
The analysis only included the material and energy inputs necessary for the production activities of the farm, while the phase of production of the plant and machinery was not included. The calculation of environmental side effects is hence relative to the flows that enter (raw materials and energy) and exit the system (finished products) during the activity carried out over the year in question.
The reference time for the life of processes is 20 years. The land that is under transformation from traditional to organic farming has been given a maturity period of 8 years, in which time the organic nature of the land tends first to increase and then to stabilise.

1. Analysis of data and emissions

As an agricultural concern, La Vialla is pledged to the production of organically made foodstuffs; both in the production and transformation of the product and in its packaging and labelling. In particular the farm produces wine, oil, dairy products and fruit and vegetable preserves. Glass bottles and jars, paper, cardboard and plastic film are the materials used for the packaging and packing of the products.

La Vialla's consumption is listed in the table below: energetic consumption (electric and thermal), consumption of materials (paper, cardboard, plastic and glass), consumption used in agricultural production (fertilizers and transport of agricultural machinery) and consumption used in transport (petrol and diesel, agricultural machinery).

Emissions 2012

Macro Areas	Quantity	Unit	Emissions	Unit	%
Energetic Consumption					
Electric (1)	1,105,240.00	kWh	643.25	$tCO_{2\ eq}$	12.55%
Thermal (Methane) (2)	183,000.00	m^3	358.68	$tCO_{2\ eq}$	7.00%
Thermal (Propane) (3)	14,000.00	l	20.16	$tCO_{2\ eq}$	0.39%
Consumption of Materials					
Paper (4)	635,180.00	kg	536.73	$tCO_{2\ eq}$	10.47%
Cardboard (5)	852,100.00	kg	836.76	$tCO_{2\ eq}$	16.32%
Plastic (6)	50,136.63	kg	135.47	$tCO_{2\ eq}$	2.64%
Transparent Glass (7)	478,258.90	kg	335.26	$tCO_{2\ eq}$	6.54%
Semi Transparent Glass (7)	244,690.60	kg	163.70	$tCO_{2\ eq}$	3.19%
UVAG Glass (7)	989,422.00	kg	884.54	$tCO_{2\ eq}$	17.25%
Steel (8)	23,360.37	kg	103.72	$tCO_{2\ eq}$	2.02%
Aluminium (9)	2,676.84	kg	22.89	$tCO_{2\ eq}$	0.45%
Wood	33,775.58	kg	63.22	$tCO_{2\ eq}$	1.23%
Agricultural Production Consumption					
Fertilizers	1,284,872.00	kg	138.77	$tCO_{2\ eq}$	2.71%
Diesel for Agricultural Machines	63,500.00	l	168.28	$tCO_{2\ eq}$	3.28%
Transport Consumption					
Diesel	240,170.00	l	636.45	$tCO_{2\ eq}$	12.41%
Train	24,000.00	l	63.60	$tCO_{2\ eq}$	1.24%
Petrol	6,465.00	l	15.39	$tCO_{2\ eq}$	0.30%

Total Emissions in productive cycle	**5,126.85**	**$tCO_{2\ eq}$**

Table 1: Consumption and emissions at Fattoria La Vialla

As regards thermal consumption, Methane is used in data relating to heating of sanitary hot water and to process plant, with an annual consumption of 183,000 m3/year.

Every year La Vialla consumes 1,105,240 kWh of electric energy besides the energy self-produced from plant and renewable energy. This energy, which emits a total of 643.25 tCO_2 a year, is compensated by the REC certificates.

With respect to previous analyses, where paper and cardboard were the materials responsible for the majority of CO_2-eq emissions, in this case the higher impact material is UVAG glass, with a contribution of 17.25% (884.54 tCO_2) of total emissions due to materials consumption.

In second and third place as far as materials consumption is concerned, in terms of weight, it was observed that the consumption of paper and cardboard, in percentage terms, is higher than other materials and totals, respectively, approximately 10.47% and 16.32%. As specified below, this large emission quota is annually compensated by the purchase of Nature Office certification, a system that guarantees the compensation of CO_2-eq emissions through tree planting.

La Vialla uses biodynamic agricultural techniques that do not employ chemical fertilizers, but exclusively use natural raw materials. In this report there has been a liberal over estimation of the impact of fertilizers, transforming the mass of manure used in poultry dung equivalent and calculating the emissions of this last: despite such an overestimation, fertilizers have a bearing of no more than 2.8% for an overall emission of 138.77 tCO_2.

As regards the total consumption for transport fuel, it may be noted that diesel consumption is considerably superior to petrol given that the farm uses a predominance of this type of motor transport because, after an initial analysis of emissions, there was a decision to drop petrol vehicles in favour of those run on diesel.

In quantifying emissions associated with electrical consumption, we have taken into account the compensation deriving from the production of energy from a renewable source: indeed, La Vialla owns several photovoltaic (PV) systems producing a total of around 400 kWp a year.

Calculation of compensation

Energy from Vialla Ground PV System	152	kWp	182,400.00	kWh/year	106.16	$tCO_{2\ eq}$
Energy from Cerbara Falda PV System	35.52	Kwp	42,624.00	kWh/year	24.807168	$tCO_{2\ eq}$
Energy from Cerbara sched PV System	76.44	Kwp	91,728.00	kWh/year	53.385696	$tCO_{2\ eq}$
Energy from Cerbara Eurostir PV System	55.86	kWp	67,032.00	kWh/year	39.012624	$tCO_{2\ eq}$
Energy from Subbiano PV System	71.50	Kwp	85,800.00	kWh/year	49.9356	$tCO_{2\ eq}$

CO_2 Compensated by PV	273.30	$tCO_{2\ eq}$

Table 2: Compensation from renewable energy production

To quantify emissions related to thermal consumption, the consumption of Methane and liquefied petroleum gas was taken into account and in part compensated by the production of renewable thermal energy.

La Vialla is also fitted out with a solar thermal system with a cumulative power of 18.90 kWp, which can produce 27,234.90 thermal kWh a year with a total compensation of CO_2 equal to 7.03 tCO_2.

In total the emissions associated with the four macro areas: “Energy”, “Materials”, “Transport” and “Agricultural production” combine to make 5,126.85 tCO_2-eq.

Conducting an analysis of emissions divided into macro areas, materials account for the largest part with a percentage of 60.91% of the total.

Besides RECS compensation, the estate at La Vialla uses Nature Office certifications to compensate the emissions from paper and cardboard. In 2012 the total amount of CO_2 compensated was 3,307.08 tCO_2-eq. As regards packaging in 2012, the farm compensated 459.59 tCO_2-eq through Climate Protection certificates from Landbell.

CO_2 Compensated by PV		273.30	$tCO_{2\ eq}$
CO_2 Compensated by solar thermal energy		7.03	$tCO_{2\ eq}$
Compensations from paper and cardboard emissions	Nature Office Certified	3307.08	$tCO_{2\ eq}$
Compensations in packaging	Climate Protection Landbell	459.59	$tCO_{2\ eq}$

Table 3: Compensations

An important piece of data in the analysis is the consumption associated with transport both by road and train (the train is considered to represent an average saving of 70% with respect to the use of tyres), combining to make 13% of the total, corresponding to an emission of 715 tCO_2-eq.

As regards emissions linked to agricultural activities, prevalently associated with the use of manure for fertilization and the consumption of diesel fuel for agricultural machinery, the main impact comes to around 3.28% diesel for agricultural machinery and 2.71% from poultry dung equivalent, producing an accumulated total of 307 tCO_2-eq.

The absorption of CO_2 is given particular importance in the agricultural sector, woodland and soil.

2. Agricultural Sector, Woodland and Soil (10)

The management of the use of soil and its connected anthropic activities influence an ample variety of processes within the ecosystem that can lead to the production of greenhouse gases.

The main processes are photosynthesis, respiration, decomposition, nitrification and denitrification and biomass combustion. These processes imply the transformation of

carbon and nitrogen through organic processes (microrganisms, plants and animals) or physical processes (combustion, leaching and run-off).
The movement of CO_2 between the atmosphere and the ecosystem occurs principally through absorption due to photosynthesis and release due to respiration, decomposition and combustion of organic matter. N_2O is emitted mainly during the processes of nitrification and denitrification while CH_4 is emitted by methanogenesis in anaerobic conditions in the soil during the management of manure and, in smaller quantities, during the processes of combustion conducted where there is a lack of oxygen, for example during the burning of stubble. Many of these processes produce indirect greenhouse gases (e.g. combustion and leaching).

This section covers the accounting of CO_2 for the agricultural sector, woodland and soil at La Vialla.

In the model proposed by IPCC methodology, the ecosystems are subdivided into three categories for storing carbon: biomass, dead organic matter and soil.
To evaluate the variations of carbon stock in the three categories, or rather to measure the net balance between emissions and absorption of CO_2, the IPCC method is based on the assumption that changes in carbon stock in an ecosystem occur mainly through the exchange of CO_2 between the surface of the ground and the atmosphere, assuming, for example, that leaching is negligible. In this way a rise in carbon stock over time equates to a net removal of CO_2 from the atmosphere and a diminution of stock to a net emission into the atmosphere.
The IPCC guidelines in 2006 estimate all emissions and removal of greenhouse gases of anthropic origin in the AFOLU sector. This means recording all emissions and removals that occur in areas that are modified by anthropic activity, while those in natural zones unused by men are not recorded.
The approach of considering the areas used by man as *proxy* for anthropic effects is suggested in the guidelines of the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry* in 2003 (IPCC, 2003).
Here, the G*ain-Loss* method has been used to calculate trapped CO_2. It takes the variation of carbon stock to be the subtraction of the carbon in the removed biomass from the fixed carbon in the vegetable biomass during its annual increase.

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

ΔC_B = Annual variation of stock of C in biomass (epigeal and hypogeal), t C year^{-1}
ΔC_G = Annual increase of stock of C due to the increase of biomass of each category of soil use, t C year^{-1}
ΔC_L = Annual decrease of stock of C due to the loss of biomass of each category of soil use, t C year^{-1}

The estimation of the variation of carbon stock in the biomass was carried out for the categories of soil use in woody and cultivated areas. Having obtained the variation of carbon stock as the difference between fixed carbon and that lost, one can calculate the tons of CO_2 by multiplying the value obtained by ±44/12 (ratio between molecular weight of CO_2 and carbon), using a negative if it relates to absorption and a positive if it is a removal.

The analysis of emissions was carried out thanks to data provided by the farm and shown in the tables below.

Tree type	Surface area per type of wood	Annual increase of epigeal biomass	Biomass conversion and expansion factor	Ratio between hypogeal and epigeal biomass	Average annuel increase of epigeal and hypogeal biomass	Proportion of carbon	Total C	Total CO2
u.d.m. Sources	ha Farm data	m3/ha IFR	tbiomassa/m3 IPCC	- IPCC	t/ha eq.	% IPCC	tC/year eq.	tCO2/year eq
Chestnut	60.00	7.08	0.60	0.46	6.20	0.51	189.85	696.11
Pine	9.00	10.30	0.69	0.29	9.20	0.48	39.51	145.22
Oak	549.00	3.21	0.90	0.30	3.80	0.51	1,051.01	3,852.70
Turkey Oak	117.00	4.42	0.60	0.30	3.40	0.51	205.56	753.73
Bosco evo*	24.00	1.50	1.30	0.46	2.80	0.51	34.85	127.88

* values of Mediterranean scrub

Total absorption	**5,576.64**

Woody plantations	Plantation areas	Crop waste	Total biomass	Plant biomass	Humidity	Biomass	Annual increase of biomass	Proportion of biomass in C	Increase in C	Absorption in CO2
u.d.m.	ha	t/ha	t/ha	t/ha	%	t/ha	t	-	t/year	tCO2/year
Wineyard	282.82	2.90	3.63	0.73	35.00	0.25	71.77	0.50	35.88	131.57
Olive grove*	252.83	2.20	2.75	0.55	40.00	0.22	55.62	0.50	27.81	101.98

* considered 250 plants per hectare

Total absorption	**233.56**

Entrapment of CO_2 in ground	**4.24**	**$tCO_{2\ eq}$**

La Vialla has a total of around 759 hectares with an average active strength, of which: 549 are a mixture of different varieties of oak with an average soil coverage of 70%, 60 hectares are chestnut plantation with an average coverage of 65% and 9 hectares are pine with an average coverage of 85%. The undergrowth is predominantly heather and juniper.
Of the 613 hectares of land cultivated, 252 are dedicated to olive trees and 282 to vines. Both the vines and the olive trees are counted in the trapped CO_2-eq calculation.
The areas of forestry used in the calculation for annual absorption of CO_2 are those reported above.
The subdivision into cultivated species managed by growing tall trunks and coppicing was implemented using the proportions reported in data taken from the Regional Forestry Inventory (IFR, 1999).
The values of annual increase of biomass taken for tall trunk species are average values for productive woods in the Tuscan area, while incremental values in coppicing were obtained by dividing the specific value of the growing stock (increasing biomass) (IFR) by a coppicing cycle of 24 years, according to research into the condition of Tuscan forestry (CRA, 2002; ARSIA, 2006).
The forestry typology identified as coppiced refers to mixed oak coppice woods. The incremental values (growing stock) used in input are shown in the table below.

The annual increase of carbon includes the increase in total biomass, taken as the sum of the underground and aboveground biomass, while the loss of carbon derives from exploitation of the forest and lost biomass.

The annual increase of biomass from forestry was calculated using the following equation (Eq. IPCC 2.9, 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
Gtotal is the average growth of total biomass, t s.s. ha^{-1} year^{-1}
CF is the fraction of carbon in dry matter, t C (t s.s.)$^{-1}$ *i* forestry species

Default values were used for the fraction of carbon in the wood biomass of conifers and broad-leaved trees in the table IPCC 4.3, respectively entered as 0.48 and 0.51 t C (t s.s.)$^{-1}$. The average annual increase of the biomass, as a sum of the surface and root biomass, was calculated with the following equation, using Tier 2 (Eq. IPCC 2.10):

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

Where:
Iw is the average annual increase of specific vegetation, m3 ha^{-1} year^{-1}
$BCEF_I$ is the conversion and expansion factor used to estimate the root biomass,
t aerial biomass (m^3 of increase)$^{-1}$
R is the relationship between root and aerial biomass for specific vegetation.

The average annual growth factors in m^3/ha of the forestry species are taken from the Regional Forestry Inventory for Tuscany (Table 4). The values of the expansion factor of the biomass ($BCEF_I$) and of the ratio of roots to foliage (R) used are also IPCC default values. The choice of $BCEF_I$ values came from IPCC table 4.5 using the growing stock values contained in IFR (Table 5). The choice of values to represent the relationship between epigeal and hypogeal biomass were the default values used in table IPCC 4.4 referred to areas with a temperate climate and applying the base density value to convert the annual increase by m^3/ha a t s.s./ha., from the IFR values for growing stock.

Apart from wood plantations, cultivated areas with permanent cultivations must also be taken into account in carbon balance.
The quantity of carbon stocked or released by the biomass in permanent cultivation depends on the type of cultivation, the farming practices, soil and climate of the specific area of land. For example, in this way the annual cultivations (e.g. cereals and vegetables) harvested each year do not create an accumulation of carbon in the biomass; whereas, the cultivation of fruit trees, vines and olive trees can store a significant quantity of carbon in the woody biomass.
Hence the accumulation of carbon in the woody biomass of cultivated tree species such as vines, olives and fruit trees is taken from ISTAT data for areas cultivating woody plants. Making use of data and literature valid for the centre of Italy (Centre of Biomass Research, University of Perugia) for the values of crop waste that it is possible to obtain from orchards, olive groves and vineyards, it was presumed that they correspond to 80% of total annual plant growth and therefore that 20% of the growth remains on the plant. This quantity was then multiplied by the average level of humidity of the wood (literature values) to obtain the tonnage of dry matter per hectare. This figure was then multiplied by the corresponding number of hectares of woody cultivation and by the IPCC carbon fraction that is typical for agrarian woody cultivation, at a rate of 0.5 t C per ton of dry matter.

Another factor to take into consideration in carbon fixation is the rise in organic matter in farmland deriving from organic farming.

In research carried out at La Vialla on land of varied nature and type making up the agricultural area used, the following functions of Organic Matter (OM) contained in the soil itself were highlighted:

- Cultivated soil that had adopted conventional farming systems for some years generally speaking showed OM values of 0.008 – 0.010 % which is to say 8 – 10 g/kg of analysed land.
- After four years of cultivating the same soil but after converting to organic and biodynamic systems, there was a shift of values to 0.015 – 0.018% or 15 - 18 g/kg with an average rise of around 80 – 100% from the original value, which indicates that the land had been put into a condition to abundantly cover the quota of OM lost annually by natural mineralization (2-3% annually) and used by the cultivation involved.
- After eight years of organic/biodynamic farming, it was observed that the same soil established an static equilibrium with regard to fixed-mineralized OM, on the strength of: its capacity to receive and accumulate, the type of farming practised and the soil and climate system in which it finds itself, reaching stable OM values that oscillate from 0.020 to 0.025% or 20 – 25 g/kg.

This suggests that in the eight years of organic and biodynamic management, the farm managed to fix in its cultivated soil layer (50 cm) 12–15 g of OM per kg of land beyond the annual losses due to the use of cultivation and direct mineralization.
Considering that the soil at La Vialla tends to the silty and sandy and the weight of the topsoil (apparent density) is around 1,200 kg/ dm^3, we can calculate the quantity of fixed OM over the eight years with the following operations:

- volume of 1 m² of soil: (1 m² = 100 dm²)
50 cm of soil (layer used by plants) = 5 dm x 100 dm² = 500 dm³ or 500 litres (L)

Bearing in mind that in 1 hectare there are 10.000 m², the volume of 50 cm of soil is equal to 5,000,000 dm³.

Now, multiplying the apparent density in the soil by the volume obtained, we find that the weight of 50 cm of a hectare of soil is equal to:

5,000,000 dm³ x 1,200 kg/dm³ = 6,000,000 kg

Knowing that in eight years we have fixed 12–15 g of SOM per kg of soil (average: 13.5 g/kg), we can conclude that the total quantity per hectare of fixed OM is equal to:

13.5 g/kg x 6,000,000 kg = 81,000,000 g = **81,000 kg/ha in 8 years = 10,125 kg/ha-year**

Beyond the eight years, the soil system manages to maintain the achieved quota of 20 – 25 g/kg, or at least the rise becomes much slower and hence difficult to quantify in the short to medium term.
Therefore, organic/biodynamic management annually ensures a reintegration of at least the amount lost through natural mineralization equal to: (using average indicated values)

22.5 g/kg x (– 2.5% loss) = 0.5625 g/kg x 6,000,000 kg = 3,375,000 g = **3,375 kg/ha a year**

With reference to the 613 cultivated hectares, the fixed organic matter will be equal to around 6,207 t of fixed OM in a year in the soil.
Considering that the percentage of carbon in dry matter is around 48%, we can confirm that 2,893 t of carbon were fixed, equivalent to 10,608 tCO_2-eq.

In the eight years of accumulation of organic matter, overall 84,861 tCO_2-eq were fixed.

To provide parameters to the value of the time taken into consideration for the general analysis (20 years) we can say that each year **4,243** tCO_2-eq are trapped.

The abovementioned entrapment occurs only if the land is used for organic farming. Prevalent intensive farming that uses chemical fertilizers tends to reduce notably the quantity of organic matter present in the soil and to eliminate microbial biodiversity, causing atrophy in the land in the long term.

The period taken into consideration in this analysis is twenty years.
During this time lapse the fixed CO_2 in the trees can be considered permanently trapped when compared with the life cycles of production at La Vialla.
To maintain and safeguard the woods over time, ensuring a constant contribution to the biomass, the operations carried out for the protection and conservation of the woodland are:

1. Firebreaks every 10 km.

2. The farm's fire control system comes into action during the dry periods (tractor with a pump for immediate intervention that patrols the area nightly to locate fires).

4. Comparison of fertilizers used in organic and traditional farming

The below comparison serves to demonstrate that fertilization used on a traditional farm, based on chemical fertilizers, is considerably more emissive than organic farming.

The parameters presented here quote energy data in terms of emission. By means of the Simapro programme, the energy side effects tied to production of fertilizers under examination have been calculated, converted into Toe and then into tons of carbon dioxide equivalent.

We have chosen poultry dung as fertilizer for organic farming.

POULTRY DUNG

Energy input per 1 kg of product		Unit	Conversion factors	Unit		Unit
Coal, brown, in ground	0.0052358	kg	9.9	MJ eq / kg	0.05183442	MJ
Coal, hard, unspecified, in ground	0.0051115	kg	19.1	MJ eq / kg	0.09762965	MJ
Energy, gross calorific value, in biomass					0.012518	MJ
Energy, gross calorific value, in biomass, primary forest					2.5607E-06	MJ
Energy, kinetic (in wind), converted					0.0030163	MJ
Energy, potential (in hydropower reservoir), converted					0.17965	MJ
Energy, solar, converted					0.00009629	MJ
Gas, mine, off-gas, process, coal mining/m3	0.000050713	m3	39.8	MJ eq / m3	0.002018377	MJ
Gas, natural, in ground	0.0036376	m3	38.3	MJ eq / m3	0.13932008	MJ
Oil, crude, in ground	0.02561	kg	45.8	MJ eq / kg	1.172938	MJ

Total Energy per kg of product	1.659023678	MJ

Conversion Table		
1 Toe	41,870.00	MJ
1 Toe	2.81	tCO_2

Toe equivalents	3.96E-05	Toe
CO_2 emission per 1 kg of product	0.11	kg

Fertilizer used on the farm	320,000.00	kg
CO_2 Emissions	35,629.19	kg

AMMONIUM PHOSPHATE

Energy input per kg of product		Unit	Conversion factors	Unit		Unit
Coal, brown, in ground	0.13785	kg	9.9	MJ eq / kg	1.364715	MJ
Coal, hard, unspecified, in ground	0.15322	kg	19.1	MJ eq / kg	2.926502	MJ
Energy, gross calorific value, in biomass					0.39291	MJ
Energy, gross calorific value, in biomass, primary forest					0.017942	MJ
Energy, kinetic (in wind), converted					0.056306	MJ
Energy, potential (in hydropower reservoir), converted					0.47946	MJ
Energy, solar, converted					0.00081555	MJ
Gas, mine, off-gas, process, coal mining/m3	0.0014886	m3	39.8	MJ eq / kg	0.07413228	MJ
Gas, natural, in ground	0.21314	m3	38.3	MJ eq / m3	8.163262	MJ
Oil, crude, in ground	0.15837	kg	45.8	MJ eq / kg	7.253346	MJ

Conversion Table		
1 Toe	41,870.00	MJ
1 Toe	2.81	tCO_2
Toe equivalents	4.95E-04	Toe
CO_2 emission per kg of produce	1.39	Kg

Fertilizer used on the farm	59,500.00	Kg
CO_2 Emissions	82,776.46	Kg

POTASSIUM SULPHATE

Energy input per kg of produce		Unit	Conversion factors	Unit		Unit
Coal, brown, in ground	0.1089	kg	9.9	MJ eq / kg	1.07811	MJ
Coal, hard, unspecified, in ground	0.13133	kg	19.1	MJ eq / kg	2.508403	MJ
Energy, gross calorific value, in biomass					0.30173	MJ
Energy, gross calorific value, in biomass, primary forest					0.000047062	MJ
Energy, kinetic (in wind), converted					0.043961	MJ
Energy, potential (in hydropower reservoir), converted					0.4179	MJ
Energy, solar, converted					0.00063736	MJ
Gas, mine, off-gas, process, coal mining/m3	0.0012766	m3	39.8	MJ eq / m3	0.05080868	MJ
Gas, natural, in ground	0.17643	m3	38.3	MJ eq / m3	6.757269	MJ
Oil, crude, in ground	0.26798	kg	45.8	MJ eq / kg	12.273484	MJ

Total energy per kg of produce	23.4323501	MJ

Conversion Table		
1 Toe	41,870.00	MJ
1 Toe	2.81	tCO_2
Toe equivalents	5.60E-04	Toe
CO_2 emissions per kg of produce	1.57	Kg

Fertilizer used on the farm	59,500.00	Kg
CO_2 emissions	93,569.90	Kg

AMMONIUM NITRATE

Energy input per kg of produce		Unit	Conversion factor	Unit		Unit
Coal, brown, in ground	0.12276	Kg	9.9	MJ eq / kg	1.215324	MJ
Coal, hard, unspecified, in ground	0.16718	Kg	19.1	MJ eq / kg	3.193138	MJ
Energy, gross calorific value, in biomass					0.40399	MJ
Energy, gross calorific value, in biomass, primary forest					0.000063658	MJ
Energy, kinetic (in wind), converted					0.049607	MJ
Energy, potential (in hydropower reservoir), converted					0.53423	MJ
Energy, solar, converted					0.00071211	MJ
Gas, mine, off-gas, process, coal mining/m3	0.0016257	m3	39.8	MJ eq / m3	0.06470286	MJ
Gas, natural, in ground	0.90467	m3	38.3	MJ eq / m3	34.648861	MJ
Oil, crude, in ground	0.40004	Kg	45.8	MJ eq / kg	18.321832	MJ

Total energy per kg of produce	58.43246063	MJ

Conversion Table		
1 Toe	41,870.00	MJ
1 Toe	2.81	tCO_2
Toe equivalents	1.40E-03	Toe
CO_2 emission per kg of produce	3.92	Kg

Fertilizer used on the farm	59,500.00	Kg
CO_2 emissions	233,332.11	Kg

The difference in amounts emitted between the use of poultry dung and the chemical equivalent divided into its three components - diammonium phosphate, potassium sulphate and ammonium nitrate - highlights the fact that CO_2-eq emissions from chemical fertilizers are greater.

CO_2 emitted in organic farming (poultry dung)	35,629.19	$kgCO_{2\ eq}$
CO_2 emitted in traditional farming (sum of chemical fertilizers)	409,678.47	$kgCO_{2\ eq}$

5. Conclusion

For some time now the estate at La Vialla has paid particular attention to the environment and has pledged itself to reduce its environmental impact to a minimum, installing renewable energy plants for electric and thermal energy production, using recyclable and certified materials (paper and cardboard) as packaging products and using natural substances to fertilize the soil, while also adopting biodynamic and organic growing methods.
Below is the summary of emissions calculated over the course of the present study.

CONCLUSION		
Emissions	5,126.85	$tCO_{2\ eq}$
PV energy production	273.30	$tCO_{2\ eq}$
Thermal energy production	7.03	$tCO_{2\ eq}$
RECS certified compensation	624.16	$tCO_{2\ eq}$
Nature Office compensation	3,307.08	$tCO_{2\ eq}$
Landbell compensation	459.59	$tCO_{2\ eq}$
Absorption in trees	5,576.64	$tCO_{2\ eq}$
Absorption in woody cultivations	233.56	$tCO_{2\ eq}$
Absorption in ground	4.24	$tCO_{2\ eq}$
Balance of CO_2	**-5,358.74**	$tCO_{2\ eq}$
Excluding CO_2 in ground	**-5,354.50**	$tCO_{2\ eq}$

Table 4: Table summarizing consumption and emissions at Fattoria La Vialla

The emissions generated by the consumption of primary, electrical and thermal energy, of packaging materials, the use of fertilizers for cultivation, the consumption of fuel for transport and agricultural machinery have all been analysed.
The largest emissions derive from the consumption of glass, paper and cardboard. These materials are used in large quantities for packaging products but they are recycled and certified so it is not possible (apart from the possibility of finding a packaging system that reduces specific consumption, or a rethink of the system of packaging as a whole) to reduce their emissions any further.

As can be deduced from the data in this report, even if we exclude carbon dioxide in the ground, the farm has a positive absorption cycle since the surrounding woodland compensate and trap external pollution produced by greenhouse gases in the twenty year cycle that we are taking into consideration.

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