

**Report from Greece under Article 19(2) of Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC**

**1. Preface**

Article 19(2) of Directive 2009/28/EC reads as follows:

*By 31 March 2010, Member States shall submit to the Commission a report including a list of those areas on their territory classified as level 2 in the nomenclature of territorial units for statistics (NUTS) or as a more disaggregated NUTS level in accordance with Regulation (EC) No 1059/2003 of the European Parliament and of the Council of 26 May 2003 on the establishment of a common classification of territorial units for statistics (NUTS), where the typical greenhouse gas emissions from cultivation of agricultural raw materials can be expected to be lower than or equal to the emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to this Directive, accompanied by a description of the method and data used to establish that list. That method shall take into account soil characteristics, climate and expected raw material yields.*

**2. List of regions**

Out of the 13 total NUTS2 Regions in Greece, in 7 of them, where energy crops are cultivated, the typical greenhouse gas emissions from the cultivation of agricultural raw materials are below the emissions given under the heading 'Disaggregated default values for cultivation' in Annex V Part D of Directive 2009/28/EC.

These Regions are as follows:

1. Thessaly
2. Epirus
3. West Macedonia
4. East Macedonia & Thrace
5. Central Macedonia
6. Continental Greece & Euboea
7. Western Greece

### **3. Calculation**

#### **3.1 Relevant biomass raw materials**

Currently in Greece only biodiesel is produced using raw materials from locally produced energy crops.

As a result, the following energy crops grown in Greece are relevant for the report under Article 19(2) of Directive 2009/28/EC:

- Sunflower
- Oilseed rape
- Soybean

#### **3.2 Approach**

The procedures followed throughout, were in accordance with the ones described for same purposes by BioGrace (<http://www.biograce.net/content/ghgcalculationtools/overview>).

The greenhouse gas emissions were calculated by including emissions from the cultivation and harvesting of energy crops, as well as greenhouse gas emissions from the material and energy inputs used for production and for cultivation by means of accurately measured data.

The main product is the product of a stage of the production chain from which the biofuel or the liquid biomass is produced in the subsequent stages of the production chain.

All data for the input parameters were made in mass units on the basis of the area unit (e.g. diesel [kg]/hectare).

The allocation factor (AF) is the proportion of emissions allocated to the main product. Using the allocation factor, emissions 'de-allocated' from crop to by-products of later stages of the process were re-allocated to crop. To convert the reference MJ of refined oil to the reference kg of the crop, the conversion factor CF is required. The conversion factor for  $e_{ec}$  indicates the quantity of each crop (in kg) required for 1 MJ of refined oil.

The functional unit used in calculations was 1 MJ of biodiesel.

### **4. Data Basis**

The following data were required to calculate the regional greenhouse gas emissions during cultivation:

- Diesel [l/(ha\*yr)] - Total quantity of diesel used (e.g. for tractors) per hectare and year
- Lower heating value (MJ/kg) of diesel (*Biograce*)

- Emission factor for diesel [g of CO<sub>2</sub>/MJ of diesel] (*Biograce*)
- Seed [kg/ha] – Total quantity of sown seed
- Emission factor for seed production [g of CO<sub>2</sub>/kg of seed]
- Fertilizer [kg/(ha\*yr)] - Total quantity of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O fertilizer used per hectare and year
- Emission factor for fertilizer production [g of CO<sub>2</sub>/kg of N fertilizer] (*Biograce*)
- Pesticide [kg/(ha\*yr)] – Total quantity of pesticides applied per hectare per year (herbicides or insecticides)
- Emission factor for pesticide production [g of CO<sub>2</sub>/kg of pesticide] (*Biograce*)
- N<sub>2</sub>O Emissions. Nitrous oxide emissions from the use of fertilizer were estimated using the following equation that includes both direct and indirect emissions:  

$$N_2O [t] = 0.0125 \times N \text{ applied [t]} + 0.01 (NH_3 + NO) \text{ emitted [t]}$$
- Crop yield [kg of crop yield/(ha\*yr)] – Annual yield in kg per hectare and year.
- Biodiesel production [kg of biodiesel/(ha\*yr)]
- Lower heating value (MJ/kg) of biodiesel (*Biograce*)
- Allocation factors (AF) were taken from the BioGrace GHG emissions calculator.
- Drying costs were not taken into account due to low post harvest moisture content for both sunflower and oilseed rape in Greece.
- Emission factors for the production and use of diesel and fertilizer:

<b>Factor</b>	<b>Unit</b>	<b>Value</b>	<b>Source</b>
Diesel	g of CO <sub>2</sub> eq/MJ	87.64	<i>Biograce (2010)</i>
Seed	g of CO <sub>2</sub> eq/kg	729.9	
Nitrogen	g of CO <sub>2</sub> eq/kg of N	5,880.6	
Phosphorous	g of CO <sub>2</sub> eq/kg of P <sub>2</sub> O <sub>5</sub>	1,010.7	
Potassium	g of CO <sub>2</sub> eq/kg of K <sub>2</sub> O	576.1	
Pesticides	g of CO <sub>2</sub> eq/kg	10,971.3	
LHV <sub>diesel</sub>	MJ/kg	43.1	
LHV <sub>biodiesel</sub>	MJ/kg	37.2	
Sunflower cultivation AF	%	62.9	
Oilseed rape cultivation AF	%	58.6	
Soybean cultivation AF	%	32.9	

## 5. Results

Typical values calculated for greenhouse gas emissions from the cultivation of energy crops by NUTS2 region in Greece are presented in the following table:

<i>Energy crop</i>		<i>Sunflower</i>	<i>Oilseed rape</i>	<i>Soybean</i>
<i>Year of data</i>		<i>2008*</i>	<i>2009-2010**</i>	<i>2010***</i>
<i>No</i>	<i>NUTS2 region</i>	<i>gr of CO<sub>2</sub>eq/MJ of FAME</i>		
1	Thessaly	17.55	-	17.36
2	Epirus	17.55	-	17.36
3	West Macedonia	17.39	-	17.36
4	East Macedonia & Thrace	16.92	28.19	17.36
5	Central Macedonia	16.19	27.64	17.36
6	Continental Greece & Euboea	17.91		17.36
7	Western Greece	17.25 <sup>†</sup>	-	17.36
<b>Disaggregated default values e<sub>ec</sub></b>		<b>18</b>	<b>29</b>	<b>19</b>

\* Actual data from relevant operators (no statistical data officially available).

† Data derived from the Hellenic Statistical Authority.

\*\* Average actual data from relevant operators (no statistical data officially available).

\*\*\* Average actual data from relevant operators in 2010 (no statistical data officially available), as well as historical data from pilot cultivation in the 80's.

## 6. Conclusion

The calculation of greenhouse gas emissions from cultivation of energy crop is always based on the mass in kg of the raw material (sunflower, rape seed, soybean). However, the default values of Directive 2009/28/EC were calculated on the basis of the energy content of biodiesel, which is only obtained after further conversion processes. The conversion from a mass-based value to an energy-based value depends essentially on the further stages of these processes and the resulting by-products (the values primarily presented in 'kg of CO<sub>2</sub> eq/kg of agricultural product' converted in a further stage into 'g of CO<sub>2</sub>eq/MJ of biodiesel'). To that end, where available, the conversion rates and allocation factors were derived from the BioGrace tables.

The regional values for the greenhouse gas emissions were then compared with these control values. It turned out that, **in all cases, the regional values for the greenhouse gas emissions are below the control value.**

# GHG Emissions Calculation Tool

## Sunflower

Greece

### Estimation of GHG Emissions Reduction

#### Steps

- 1) Estimation of the consumed fossil fuel per hectare during the whole cultivation period (l/ha).
- 2) Conversion of the fossil fuel consumed into energy (MJ/ha), and subsequent conversion to emissions, using the fossil fuel emission factor (g CO<sub>2</sub>/ha).
- 3) Estimation of the emissions, occurring during the production of inputs, by using the applied quantities and the respective emission factors (g CO<sub>2</sub>/ha). At the same step, N<sub>2</sub>O emission calculation takes place using an equation that takes into account both direct and indirect emissions.
- 4) Summation of the estimated emissions.
- 5) Estimation of the biofuel produced per hectare.
- 6) Estimation of typical GHG emissions (g CO<sub>2</sub>/ MJ<sub>of biofuel</sub>)
- 7) Emissions occurring after harvest and until the filling station stage (derived from the BioGrace example) are summed up so as to calculate the final typical GHG emissions.
- 8) Finally the GHG emissions reduction (%) is estimated (compared to the replaced fossil fuel).

**GHG EMISSIONS ESTIMATION FOR THE SSO REGION**

Feedstock production emissions for Sunflower

Operation	Consumption (t/ha)	Emissions (g CO <sub>2</sub> e/kg)
ploughing	40	
ripping		
cultivating	15	
roffing		
sowing	8	
fertilizing		
spraying	2	
hoeing	15	
Harvesting	20	
Sum	100	
Sum (kg/ha)	83.20	
		Fuel energy consumed (MJ/ha)
		3585,92
		Emissions (g CO <sub>2</sub> e/ha)
		314270,03

Input Production emissions

Quantity (kg/ha)	Emissions (g/ha)
seed	3649,5
N	26462,7
P <sub>2</sub> O <sub>5</sub>	20214
K <sub>2</sub> O	11522
pesticide	4388,52
Sum	304401,02

Total Emissions (g CO<sub>2</sub>e/ha) **788767,45**

Typical Emissions

seed yield (kg/ha)	oil yield (kg/ha)	bio-diesel yield (kg/ha)	bio-diesel energy (MJ/ha)	Typical cultivation emissions (g CO <sub>2</sub> e/ha <sub>seed</sub> )	Typical cultivation emissions (Allocation) (g CO <sub>2</sub> e/ha <sub>oil</sub> )
2000	760	760	28272	27,90	37,65

**Default Values**

	Density (kg/m <sup>3</sup> )	LHV (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> e/MJ)
Diesel Default Values	823	45,1	37,64
Biodiesel Default Values	890	37,2	

  

Agro Inputs	Emission Coefficient (g CO <sub>2</sub> e/kg)	Global Warming Potential (GWPs)	g CO <sub>2</sub> e/g
Sunflower seed	729,9	CO <sub>2</sub>	1
Oilseed rape seed	729,9	N <sub>2</sub> O	296
Soybean seed			
Pesticides	10921,3		
N	5880,6		
P <sub>2</sub> O <sub>5</sub>	1010,7		
K <sub>2</sub> O	570,1		

**Values (European crop emission allocation tool)**

	g CO <sub>2</sub> /MJ	Sunflower	Oilseed rape	Soybean
Seed transport (50km)	0,28	0,3	0,3	
Oil extraction	6,05	6,5	29,07	
Oil refining	1,06	1,06	1,06	
Esterification	17,51	17,51	17,51	
FAME transport (300km)	0,82	0,82	0,82	
Filling station	0,44	0,44	0,44	
Sum	26,16	26,63	49,2	

  

Crop	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31,5
Soybean	57,8

  

	Cultivation Allocation Factor (%)
Sunflower	62,9
Oilseed rape	38,6
Soybean	32,9

**GHG EMISSIONS ESTIMATION FOR EURUS REGION**

**Feedstock production emissions for Sunflower**

Diesel Consumption	
Operation	Consumption (l/ha)
ploughing	40
ripping	-
cultivating	15
rolling	-
sowing	8
fertilizing	-
spraying	2
hoing	15
Harvesting	20
Sum	100
Fuel energy consumed (MJ/ha)	
	3585.92
Sum (kg/ha)	63.20
Emissions (g CO <sub>2</sub> /ha)	
	314270.03

Input Production emissions	
Quantity (kg/ha)	Emissions per ha
seed	3649.5
N	264627
P <sub>2</sub> O <sub>5</sub>	20214
K <sub>2</sub> O	11522
pesticide	4386.52
Sum	304401.02
<b>Total Emissions (g CO<sub>2</sub>-e/ha)</b>	
	<b>788767.45</b>

N<sub>2</sub>O emissions (g CO<sub>2</sub>-e/ha) = 170096.4

Typical Emissions					
seed yield (kg/ha)	oil yield (kg/ha)	biodiesel yield (kg/ha)	biodiesel energy (MJ/ha)	Typical cultivation emissions (g CO <sub>2</sub> -e/ha)	Typical cultivation emissions (Allocation) (g CO <sub>2</sub> -e/ha <sub>seed</sub> )
2000	760	760	28272	27.90	17.55

Default Values	
Diesel Default Values	Emission Coefficient (g CO <sub>2</sub> -e/MJ)
832	43.1
890	37.2

  

Agro Inputs	Emission Coefficient (g CO <sub>2</sub> -e/kg)	Global Warming Potential (GWP's)	g CO <sub>2</sub> -e/g
Sunflower seed	729.9	CO <sub>2</sub>	1
Oilseed rape seed	729.9	N <sub>2</sub> O	296
Soybean seed	10971.3		
Pesticides	5883.6		
N	1010.7		
P <sub>2</sub> O <sub>5</sub>			
K <sub>2</sub> O	576.1		

  

Values (Biospace GHG emissions calculator tool)	
g CO <sub>2</sub> /MJ	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31.5
Soybean	37.8
Cultivation Allocation Factor (%)	
Sunflower	62.9
Oilseed rape	58.6
soybean	32.9

### GHG EMISSIONS ESTIMATION FOR WEST MACDONIA REGION

#### Feedstock production emissions for Sunflower

Diesel Consumption		
Operation	Consumption (l/ha)	
ploughing	40	
ripping		
cultivating	15	
rolling		
sowing	8	
fertilizing		
spraying	2	
hoing	15	
Harvesting	20	
Sum	100	
Sum (kg/ha)	83,20	Fuel energy consumed (MJ/ha)
		3585,92
		Emissions (t CO <sub>2</sub> e/ha)
		3142,70,03

Input Production emissions		
Quantity (kg/ha)	Emissions per ha	
seed	3649,5	
N	117612	
P <sub>2</sub> O <sub>5</sub>	20214	
K <sub>2</sub> O	11522	
pesticide	4388,52	
Sum	157386,02	
<b>Total Emissions (t CO<sub>2</sub>e/ha)</b>		<b>547254,45</b>

N<sub>2</sub>O emissions (t CO<sub>2</sub>e/ha) **75598,4**

Typical Emissions				
seed yield (kg/ha)	oil yield (kg/ha)	biodiesel yield (kg/ha)	biodiesel energy (MJ/ha)	Typical cultivation emissions (Allocation) (t CO <sub>2</sub> e/ha <sub>seed</sub> )
1400	532	532	19790,4	27,65
				<b>17,39</b>

#### Default Values

Diesel Default Values	Density (kg/m <sup>3</sup> )	LHV (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> e/g MJ)
	832	43,1	87,64
Biodiesel Default Values	890	37,2	

  

Agro inputs	Emission Coefficient (g CO <sub>2</sub> e/g)	Global Warming Potential (GWPs)	g CO <sub>2</sub> e/g
Sunflower seed	729,9	CO <sub>2</sub>	1
Oilseed rape seed	729,9	N <sub>2</sub> O	296
Soybean seed	10971,3		
Pesticides	5880,6		
N	1020,7		
P <sub>2</sub> O <sub>5</sub>	576,1		
K <sub>2</sub> O			

Values (biodiesel, GHG emission calculation tool)

Seed transport (50km)	g CO <sub>2</sub> /MJ		Total Allocation Factor (%)
	Sunflower	Oilseed rape	Soybean
Oil extraction	0,28	0,3	25
Oil refining	6,05	6,5	31,5
Esterification	1,06	1,06	57,8
FAME transport (300km)	17,51	17,51	
Filling station	0,82	0,82	Cultivation Allocation Factor (%)
Sum	26,56	26,63	Sunflower 62,9
			Oilseed rape 58,6
			Soybean 32,9



**GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA & THRACE REGION**

**Feedstock production emissions for Sunflower**

Diesel Consumption		
Operation	Consumption (l/ha)	
ploughing	40	
ripping		
cultivating	15	
rolling		
sowing	8	
fertilizing		
spraying	2	
hoeing	15	
Harvesting	20	
Sum	100	Field energy consumed (MJ/ha)
Sum (kg/ha)	83,20	3585,92
		Emissions (g CO <sub>2</sub> /ha)
		314270,03

Input Production emissions		
Quantity (kg/ha)	Emissions per ha	
seed	3649,5	
N	205821	
P <sub>2</sub> O <sub>5</sub>	20214	
K <sub>2</sub> O	11522	
pesticide	4388,52	
Sum	245595,02	
<b>Total Emissions (g CO<sub>2</sub>-e/ha)</b>		<b>692162,25</b>

N<sub>2</sub>O emission (g CO<sub>2</sub>-e/ha) 132297,2

Typical Emissions		
seed yield (kg/ha)	oil yield (kg/ha)	biogas yield (kg/ha)
1820	691,6	691,6
		25727,52
Typical cultivation emissions (g CO <sub>2</sub> -e/ha)		25,90
Typical cultivation emissions (Allocation) (g CO <sub>2</sub> -e/ha)		15,92

**Default Values**

	Density (kg/ m <sup>3</sup> )	LHV (MJ/ ha)	Emission coefficient (g CO <sub>2</sub> -e/ MJ)
Diesel Default Values	832	43,1	87,64
Biodiesel Default Values	890	37,2	
Emission Coefficient (g CO <sub>2</sub> -e/ kg)			
Agro inputs			
Sunflower seed	729,9		
Oilseed rape seed	729,9		
Soybean seed			
Pesticides	10971,3		
N	3880,6		
P <sub>2</sub> O <sub>5</sub>	1010,7		
K <sub>2</sub> O	576,1		

**Global Warming Potential (GWP's)**

	CO <sub>2</sub>	N <sub>2</sub> O
Global Warming Potential (GWP's)	1	296

**Values for the GHG emission calculation tool**

	Sunflower	Oilseed rape	Soybean
Seed transport (50km)	0,28	0,3	0,3
Oil extraction	6,05	6,5	23,07
Oil refining	1,06	1,06	1,06
Esterification	17,51	17,51	17,51
FAME transport (300km)	0,82	0,82	0,82
Filling station	0,44	0,44	0,44
Sum	26,16	26,63	43,2

Crop	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31,5
Soybean	57,8
Cultivation Allocation Factor (%)	
Sunflower	62,9
Oilseed rape	59,6
Soybean	32,9

**GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA REGION**

**Feedstock production emissions for Sunflower**

Diesel Consumption		
Operation	Consumption (l/ha)	
ploughing	40	
ripping		
cultivating	15	
rolling		
sowing	8	
fertilizing		
spraying	2	
hoeing	15	
Harvesting	20	
Sum	100	
Sum (kg/ha)	83,20	
		Fuel energy consumed (MJ/ha)
		3585,92
		Emissions (g CO <sub>2</sub> /ha)
		314270,03

Input Production emissions		
Quantity (kg/ha)	Emissions per ha	
seed	5	3649,5
N	50	294030
P <sub>2</sub> O <sub>5</sub>	20	20214
K <sub>2</sub> O	20	11522
pesticide	0,4	4388,52
Sum		333804,02
<b>Total Emissions (g CO<sub>2</sub>e/ha)</b>		<b>837070,05</b>

N<sub>2</sub>O emissions (g CO<sub>2</sub>e/ha) 188996

Typical Emissions		
seed yield (kg/ha)	oil yield (kg/ha)	bio-diesel yield (kg/ha)
2300	874	874
		bio-diesel energy (MJ/ha)
		32512,8
		Typical cultivation emissions (g CO <sub>2</sub> /MJ <sub>bio-diesel</sub> )
		25,75
		Typical cultivation emissions (Allocation) (g CO <sub>2</sub> /MJ <sub>bio-diesel</sub> )
		35,39

**Default Values**

	Density (kg/m <sup>3</sup> )	LHV (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> e/g MJ)
Diesel Default Values	832	43,1	87,64
Biodiesel Default Values	890	37,2	
Agro inputs	Emission Coefficient (g CO <sub>2</sub> e/g)		Global Warming Potential (GWP <sup>100</sup> )
Sunflower seed	729,9		CO <sub>2</sub>
Oilseed rape seed	729,9		N <sub>2</sub> O
Soybean seed	-		
Pesticides	10971,3		
N	5880,6		
P <sub>2</sub> O <sub>5</sub>	1010,7		
K <sub>2</sub> O	576,1		

**Values (logistics GHG emission calculation tool)**

	g CO <sub>2</sub> /MJ			Total Allocation Factor (%)
	Sunflower	Oilseed rape	Soybean	
Seed transport (500km)	0,28	0,3	0,3	25
Oil extraction	6,05	6,5	23,07	31,5
Oil refining	1,06	1,06	1,06	57,8
Esterification	17,51	17,51	17,51	
FAME transport (300km)	0,82	0,82	0,82	
Filling station	0,44	0,44	0,44	
Sum	26,16	26,63	43,2	

Crop	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31,5
Soybean	57,8

	g CO <sub>2</sub> /MJ		
	Sunflower	Oilseed rape	Soybean
Seed transport (500km)	0,28	0,3	0,3
Oil extraction	6,05	6,5	23,07
Oil refining	1,06	1,06	1,06
Esterification	17,51	17,51	17,51
FAME transport (300km)	0,82	0,82	0,82
Filling station	0,44	0,44	0,44
Sum	26,16	26,63	43,2

	g CO <sub>2</sub> e/g	
	Sunflower	Oilseed rape
Allocation Factor (%)	52,9	58,6
Sum	32,9	

**GHG EMISSIONS ESTIMATION FOR CONTINENTAL AFRICA & EUROPA REGION**

**Feedstock production emissions for Sunflower**

Diesel Consumption	
Operation	Consumption (l/ha)
ploughing	40
ripping	-
cultivating	15
rolling	-
sowing	8
fertilizing	2
spraying	15
hoing	20
Harvesting	100
Sum	83,20
Sum (kg/ha)	3585,92
	Fuel energy consumed (MJ/ha)
	314270,03

Input Production emissions	
Quantity (kg/ha)	Emissions per ha
seed	3649,5
N	176418
P <sub>2</sub> O <sub>5</sub>	20214
K <sub>2</sub> O	11522
pesticide	4388,52
Sum	216192,02
<b>Total Emissions (g CO<sub>2</sub>-e/ ha)</b>	<b>643859,65</b>

N<sub>2</sub>O emissions (g CO<sub>2</sub>-e/ha) 113397,6

Typical Emissions					
seed yield (kg/ha)	oil yield (kg/ha)	biogas yield (kg/ha)	biogas energy (MJ/ha)	Typical cultivation emissions (g CO <sub>2</sub> -e/ha <sub>seed</sub> )	Typical cultivation emissions (Allocation) (g CO <sub>2</sub> -e/ha <sub>seed</sub> )
1600	608	608	22617,6	28,47	17,91

**Default Values**

	Density (kg/ m <sup>2</sup> )	LHV (MJ/ ha)	Emission Coefficient (g CO <sub>2</sub> -e/ MJ)
Diesel Default Values	832	43,1	87,64
Biodiesel Default Values	890	37,2	

Agro Inputs	Emission Coefficient (g CO <sub>2</sub> -e/ kg)	Global Warming Potential (GWPP's)	g CO <sub>2</sub> -e/ g
Sunflower seed	729,9	CO <sub>2</sub>	1
Oilseed rape seed	729,9	N <sub>2</sub> O	296
Soybean seed			
Pesticides	10971,3		
N	3890,6		
P <sub>2</sub> O <sub>5</sub>	1010,7		
K <sub>2</sub> O	576,1		

**Values (Programs) GHG emission calculation tool**

	g CO <sub>2</sub> / MJ		Total Allocation Factor (%)
	Sunflower	Oilseed rape	Soybean
Seed transport (50km)	0,28	0,3	0,3
Oil extraction	0,05	0,5	23,07
Oil refining	1,06	1,06	1,06
Esterification	17,51	17,51	17,51
FAME transport (300km)	0,82	0,82	0,82
Filling station	0,44	0,44	0,44
Sum	26,16	26,63	43,2

Crop	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31,5
Soybean	37,8
Sunflower	
Oilseed rape	
Soybean	

**GHG EMISSIONS ESTIMATION FOR WESTERN GREAT REGION**

**Feedstock production emissions for Sunflower**

Diesel Consumption	
Operation	Consumption (l/ha)
ploughing	40
ripping	-
cultivating	15
trolling	-
sowing	8
fertilizing	2
spraying	15
hoeing	20
Harvesting	100
Sum (kg/ha)	83.20

  

Quantity consumed (kg/ha)	Relative energy consumed (MJ/kg)	Emissions (t CO <sub>2</sub> /ha)
3585.92		314270.03

Input Production emissions	
Quantity (kg/ha)	Emissions per ha
seed	3649.5
N	294030
P <sub>2</sub> O <sub>5</sub>	30321
K <sub>2</sub> O	17283
pesticide	4388.52
Sum	349672.02

  

<b>Total Emissions (t CO<sub>2</sub>e/ha)</b>	<b>852938.05</b>
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<b>H<sub>2</sub>O emissions (t CO<sub>2</sub>e/ha)</b>	<b>188996</b>
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Typical Emissions			
seed yield (kg/ha)	oil yield (kg/ha)	bio-diesel yield (kg/ha)	bio-diesel energy (MJ/ha)
2200	836	836	31099.2

  

Typical cultivation emissions (Allocation)	
emissions (t CO <sub>2</sub> /MJ <sub>fuel</sub> )	emissions (Allocation) (t CO <sub>2</sub> /MJ <sub>fuel</sub> )
27.43	37.25

Default Values	
Diesel Default Values	Biodiesel Default Values
832	890
43.1	37.2

  

Density (kg/m <sup>3</sup> )	LHV (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> -eq/MJ)
832	43.1	87.84

  

Agro inputs	Emission Coefficient (g CO <sub>2</sub> -eq/kg)	Global Warming Potential (GWP <sub>100</sub> )	t CO <sub>2</sub> -eq/g
Sunflower seed	729.9	CO <sub>2</sub>	1
Oilseed rape seed	729.9	N <sub>2</sub> O	296
Pesticides	10973.3		
N	9880.6		
P <sub>2</sub> O <sub>5</sub>	1010.7		
K <sub>2</sub> O	576.1		

  

Typical (ploughless) GHG emission calculation (t/ha)	
g CO <sub>2</sub> /MJ	Total Allocation Factor (%)
Sunflower	25
Oilseed rape	31.5
Soybean	57.3
Sum	62.9

  

Cultivation Allocation Factor (%)	
Crop	Allocation Factor (%)
Sunflower	58.6
Oilseed rape	32.9
Soybean	43.2

# GHG Emissions Calculation Tool

## Oilseed rape

Greece

### Estimation of GHG Emissions Reduction

#### Steps

- 1) Estimation of the consumed fossil fuel per hectare during the whole cultivation period (l/ha).
- 2) Conversion of the fossil fuel consumed into energy (MJ/ha), and subsequent conversion to emissions, using the fossil fuel emission factor (g CO<sub>2</sub>/ha).
- 3) Estimation of the emissions, occurring during the production of inputs, by using the applied quantities and the respective emission factors (g CO<sub>2</sub>/ha).  
At the same step, N<sub>2</sub>O emission calculation takes place using an equation that takes into account both direct and indirect emissions.
- 4) Summation of the estimated emissions.
- 5) Estimation of the biofuel produced per hectare.
- 6) Estimation of typical GHG emissions (g CO<sub>2</sub>/ MJ<sub>of biofuel</sub>)
- 7) Emissions occurring after harvest and until the filling station stage (derived from the BioGrace example) are summed up so as to calculate the final typical GHG emissions.
- 8) Finally the GHG emissions reduction (%) is estimated (compared to the replaced fossil fuel).

**GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA - THRACE**

**Feedstock production emissions for Oilseed rape**

Diesel Consumption		
Operation	Consumption (l/ha)	
ploughing	40	
ripping	30	
cultivating	-	
rolling	15	
sowing	8	
fertilizing	-	
spraying	2	
hoeing	-	
Harvesting	20	
Sum	115	
Sum (kg/ha)	95,68	Fuel energy consumed (MJ/ha)
	4123,81	Emissions (g CO <sub>2</sub> /ha)
		361410,53

Input Production emissions		
Quantity (kg/ha)	Emissions per ha	
seed	5	3649,5
N	100	588060
P <sub>2</sub> O <sub>5</sub>	20	20214
K <sub>2</sub> O	20	11522
pesticide	0,4	4388,52
Sum		627834,02
<b>Total Emissions (g CO<sub>2</sub>-e/ha)</b>		<b>1367236,55</b>

N<sub>2</sub>O emissions (g CO<sub>2</sub>-e/ha) 377992

Typical Emissions		
seed yield (kg/ha)	oil yield (kg/ha)	biodiesel yield (kg/ha)
2000	764	764
		biodiesel energy (MJ/ha)
		28420,8
Typical cultivation emissions (g CO <sub>2</sub> /MJ <sub>feedst</sub> )		48,11
Typical cultivation emissions (allocation) (g CO <sub>2</sub> /MJ <sub>feedst</sub> )		25,19

Default Values			
	Density (kg/ m <sup>3</sup> )	LHV (MJ/ ha)	Emission Coefficient (g CO <sub>2</sub> -eq/ MJ)
Diesel Default Values	832	43,1	87,64
Biodiesel Default Values	890	37,2	-
Agro inputs	Emission Coefficient (g CO <sub>2</sub> -eq/ kg)		Global Warming Potential (g CO <sub>2</sub> -eq/g (GWPs))
Sunflower seed	729,9		CO <sub>2</sub>
Oilseed rape seed	729,9		N <sub>2</sub> O
Soybean seed			
Pesticides	10971,3		
N	5880,6		
P <sub>2</sub> O <sub>5</sub>	1010,7		
K <sub>2</sub> O	576,1		

Values (Biotrade GHG emission calculation tool)

	g CO <sub>2</sub> / MJ		Crop	Total Allocation Factor (%)
	Sunflower	Oilseed rape		
Seed transport (50km)	0,28	0,3	Sunflower	25
Oil extraction	6,05	6,5	Oilseed rape	31,5
Oil refining	1,06	1,06	Soybean	57,8
Esterification	17,51	17,51		
FAME transport (300km)	0,82	0,82	Sunflower	62,9
Filling station	0,44	0,44	Oilseed rape	58,6
Sum	26,16	26,63	Soybean	32,9

**GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA REGION**

Feedstock production emissions for Oilseed rape

Diesel Consumption Operation	Consumption (l/ha)	Emissions (g CO <sub>2</sub> e/ha)
ploughing	-	-
ripping	-	-
cultivating	15	127,50
rolling	15	127,50
sowing	8	66,24
fertilizing	-	-
spraying x 2	4	33,12
hoeing	15	127,50
Harvesting	20	170,00
Sum	77	635,76
Sum (kg/ha)	64,06	512,48
Sum (kg/ha)	2761,16	241987,92

Input Production emissions	Quantity (kg/ha)	Emissions per ha
seed	5	3649,5
N	120	705672
P <sub>2</sub> O <sub>5</sub>	20	20214
K <sub>2</sub> O	20	11572
pesticide	0,4	4388,52
Sum		745446,02
Total Emissions (g CO <sub>2</sub> e/ha)		1441024,34

N<sub>2</sub>O emissions (g CO<sub>2</sub>e/ha) = 453590,4

Typical Emissions	seed yield (kg/ha)	oil yield (kg/ha)	biodiesel yield (kg/ha)	biodiesel energy (MJ/ha)	Typical cultivation emissions (g CO <sub>2</sub> /MJ <sub>seed</sub> )	Typical cultivation emissions (Allocation) (g CO <sub>2</sub> /MJ <sub>seed</sub> )
2150	821,3	821,3	821,3	30552,36	47,17	27,64

**Default Values**

Default Values	Density (kg/m <sup>3</sup> )	LHV (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> e/MJ)
Diesel Default Values	832	43,1	87,64
Biodiesel Default Values	880	37,2	-

Agro inputs	Emission Coefficient (g CO <sub>2</sub> e/kg)	Global Warming Potential (GWPs)	g CO <sub>2</sub> e/g
Sunflower seed	729,9	CO <sub>2</sub>	1
Oilseed rape seed	729,9	N <sub>2</sub> O	296
Soybean seed	-	-	-
Pesticides	10971,3	-	-
N	5680,6	-	-
P <sub>2</sub> O <sub>5</sub>	3010,7	-	-
K <sub>2</sub> O	576,1	-	-

Values (g/kg) as GHG emission calculation tool

	g CO <sub>2</sub> /MJ		Total Allocation Factor (%)	
	Sunflower	Oilseed rape	Soybean	
Seed transport (50km)	0,28	0,2	0,1	25
Oil extraction	6,05	6,5	23,07	31,5
Oil refining	1,06	1,06	3,06	57,8
Esterification	17,51	17,51	17,51	
FAME transport (300km)	0,82	0,82	0,82	Cultivation Allocation factor (%)
Filling station	0,44	0,44	0,44	Sunflower
Sum	26,16	26,63	43,2	Oilseed rape
				Soybean

# GHG Emissions Calculation Tool

Soybean (non irrigated)

Greece

## Estimation of GHG Emissions Reduction

### Steps

- 1) Estimation of the consumed fossil fuel per hectare during the whole cultivation period (l/ha).
- 2) Conversion of the fossil fuel consumed into energy (MJ/ha), and subsequent conversion to emissions, using the fossil fuel emission factor (g CO<sub>2</sub>/ ha).
- 3) Estimation of the emissions, occurring during the production of inputs ,by using the applied quantities and and the respective emission factors (g CO<sub>2</sub>/ ha). At the same step, N<sub>2</sub>O emission calculation takes place using an equation that takes into account both direct and indirect emissions.
- 4) Summation of the estimated emissions.
- 5) Estimation of the biofuel produced per hectare.
- 6) Estimation of typical GHG emissions (g CO<sub>2</sub>/ MJ<sub>of biofuel</sub>)
- 7) Emissions occurring after harvest and until the filling station stage (derived from the BioGrace example) are summed up so as to calculate the final typical GHG emissions.
- 8) Finally the GHG emissions reduction (%) is estimated (compared to the replaced fossil fuel).



**GHG EMISSIONS ESTIMATION FOR ALL APPLICABLE REGIONS**

Feedstock production emissions for Soybean (non-irrigated)

Diesel Consumption	
Operation	Consumption (l/ha)
ploughing	40
ripping	30
cultivating	15
rolling	15
sowing	8
fertilizing	2
spraying	2
hoeing	15
Harvesting	20
Sum	147
Sum (kg/ha)	122,30
	Fuel energy consumed (MJ/ha)
	5271,30
	Emissions (g CO <sub>2</sub> /ha)
	461976,94

Input Production emissions	
Quantity (kg/ha)	Emissions per ha
seed	385000
N	0
P <sub>2</sub> O <sub>5</sub>	20214
K <sub>2</sub> O	11522
pesticide	4388,52
Sum	421124,52
<b>Total Emissions (g CO<sub>2</sub>e/ha)</b>	
	<b>883101,46</b>

N<sub>2</sub>O emissions (g CO<sub>2</sub>e/ha) 0

Typical Emissions			
seed yield (kg/ha)	oil yield (kg/ha)	biogas yield (kg/ha)	biogas energy (MJ/ha)
1800	450	450	16740
Typical cultivation emissions (g CO <sub>2</sub> /M <sub>1,seed</sub> )		Typical cultivation emissions (Allocation) (g CO <sub>2</sub> /M <sub>1,seed</sub> )	
52,75		37,36	

Default Values		
Diesel Default Values	LNW (MJ/ha)	Emission Coefficient (g CO <sub>2</sub> e/MJ)
832	43,1	87,64
Biodiesel Default Values	Density (kg/m <sup>3</sup> )	Emission Coefficient (g CO <sub>2</sub> e/kg)
896	729,9	729,9
Agro Inputs	Emission Coefficient (g CO <sub>2</sub> e/kg)	Global Warming Potential (GWPs)
Sunflower seed	729,9	CO <sub>2</sub>
Soybean seed	729,9	N <sub>2</sub> O
Pesticides	10971,3	
N	5880,6	
P <sub>2</sub> O <sub>5</sub>	1010,7	
K <sub>2</sub> O	576,1	

  

Values (Biodiesel GHG emissions calculation tool)	
g CO <sub>2</sub> /MJ	Total Allocation Factor (%)
Sunflower (Biodiesel rapeseed)	25
Soybean	31,5
Oil extraction	57,8
Oil refining	
Esterification	
FAME transport (300km)	
Filling station	
Sum	

  

Cultivation Allocation Factor (%)	
Crop	Allocation Factor (%)
Sunflower	25
Oilseed rapeseed	31,5
Soybean	57,8
Sunflower	62,9
Oilseed rapeseed	56,6
Soybean	32,9