HELLENIC REPUBLIC
MINISTRY OF ENVIRONMENT,
ENERGY & CLIMATE CHANGE
GENERAL SECRETARIAT FOR ENERGY & CLIMATE CHANGE

REPORT UNDER ARTICLE 19(2) OF DIRECTIVE 2009/28/EC

RESUBMISSION

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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

I. 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».

This Report from Greece *(3rd resubmission of November 2012)* fulfills the requirements of Article 19(2) of Directive 2009/28/EC.

II. Agricultural raw materials for BIODIESEL production

II.1. List of regions

Out of the thirteen (13) total NUTS-2 regions in Greece, in seven (7) of them, where energy crops for biodiesel production 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. Western Macedonia
4. East Macedonia and Thrace
5. Central Macedonia
6. Continental Greece & Euboea
7. Western Greece

II.2. Estimation

II.2.1 Relevant biomass raw materials

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

The following energy crops grown in Greece are used for biodiesel production and are relevant for the report under Article 19(2) of Directive 2009/28/EC:

a. Sunflower
b. Rapeseed
c. Soybean

Additionally, cottonseed (a byproduct of the cotton cultivation) is used in Greece for biodiesel production.

II.2.2 Approach

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

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 cultivation by means of accurately measured data.

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

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.

II.2.3. Dataset

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

- Field operations - Used to estimate the consumed diesel (l/ ha)
- Sown seed (kg/ ha)
- Fertilizers applied (kg/ ha) - Total quantity of N, P_2O_5 and K_2O fertilizer used per hectare
- Pesticide (kg/ ha) - Total quantity of pesticides applied per hectare per year (herbicides or insecticides)
- Number of irrigations (If applied) – including the horsepower of the pump and the hours of each irrigation
- Raw material yields (kg/ ha)

II.2.4 Step by step estimations

i. Emissions from diesel consumption

The consumed energy and the respective emissions derived from the diesel consumption were estimated by aggregating the diesel consumption for each field operation. The result was multiplied to diesel's least heating value (LHV) to estimate the energy which was finally converted to emissions, using diesel's emission factor.

- Diesel consumption (l/ ha) x diesel density (kg/ m^3)= Diesel consumption in kg/ ha
- Diesel consumption (kg/ ha) x LHV (MJ/ kg)= Energy consumed (MJ/ ha)
- Energy consumed (MJ/ ha) x Diesel emission factor (g $CO_{2\ eq}$/ MJ)=

=Diesel Emissions (g $CO_{2\ eq}$/ ha)

The diesel consumption was based on tractors' horsepower used under Greek condition (90-110 hp) and on the majority of the soil types (medium soils) met in the studied regions.

Soil texture* for each region (%)

Region	Heavy	Medium	Medium-Heavy	Medium-Light	Light
Thessaly	0,5	20,3	73,9	5,3	
East Macedonia and Thrace	2,9	8,4	30,1	57,2	1,4
Central Macedonia	11,0	16,4	33,6	38,8	0,2
Western Macedonia	6,3	25,3	29,6	35,1	3,9
Epirus	13,7	38,4	44,1	3,2	0,7
Western Greece	9,2	41,4	28,3	19,8	1,5
Continental Greece & Euboea	0	100	0	0	0

** According to soil analyses performed for several purposes throughout the years*

ii. Emissions from input production

The estimation of the emissions during the input production takes place by multiplying the input rate to the respective emission factor.

- Input rate (kg/ ha) x emission factor (g $CO_{2\ eq}$/ kg)=

=Input Production Emissions (g $CO_{2\ eq}$/ ha)

Since the soybean seed emission factor was not provided by the Biograce tool, it was estimated by taking into account the sown seed/ final seed yield rate, multiplied to the total emissions. Actually, the amount of additional needed land to produce the amount of seed needed to sow 1 ha of soybean was estimated.

- Soybean seed factor = seed sown (kg/ ha)/ seed yield (kg/ ha) + 1 (ha)

iii. N_2O Emissions

Nitrous oxide emissions from the use of N fertilizer were estimated using the tool provided by Biograce (www.Biograce.net) that includes both direct and indirect emissions and follows the IPCC 2006

(http://www.biograce.net/content/ghgcalculationtools/excelghgcalculations).

The result taken from the tool is converted to g and then to $CO_{2\ eq}$ using the global warming potential (GWP).

- N_2O emissions (kg N_2O/ ha year) x 1000 (g/ kg) x Global Warming Potential (g $CO_{2\ eq}$/ g)= N_2O emissions (g CO_{2_eq}/ ha)

iv. Irrigation emissions

- Energy content of 1 KW/ h (MJ) x Pump horsepower (KW) x Hours of irrigation (h) x Number of irrigations x Electricity emission factor (g $CO_{2\ eq}$/ MJ)=

=Irrigation Emissions (g CO_{2_eq}/ ha)

v. Total emissions

Total emissions (g CO_{2_eq}/ ha)= Diesel Emissions + Input Production Emissions + N_2O emissions + Irrigation Emissions

vi. Typical cultivation emissions estimation

- Seed yield dry (kg/ ha) = Seed yield fresh (kg/ ha) x [(100 - seed moisture %)/ 100]
- Oil yield (kg/ ha) = Biodiesel yield (kg/ ha) = Seed yield (kg/ ha) x Oil content (%)
- Biodiesel energy (MJ/ ha) = Biodiesel yield (kg/ ha) x Biodiesel LHV (MJ/ kg)
- Typical cultivation emissions (g $CO_{2\ eq}$/ $MJ_{Biodiesel}$)= [Total emissions (g $CO_{2\ eq}$/ ha) / Biodiesel energy (MJ/ ha)] x Allocation factor (%)

Seed and oil yields per region

	Sunflower	Rapeseed	Soybean	Cottonseed
Year of data	***2008****	***2009 -2010****	***2010*****	***2010****
Region	**Seed Yields (kg/ ha)**			
Thessaly	3600	-	3500	2000
Epirus	2900	-		
Western Macedonia	2800	-		
East Macedonia and Thrace	2900	2000		
Central Macedonia	3200	2500		
Continental Greece & Euboea	3000	-		
Western Greece	3250[+]	-		
Seed moisture content (%)	***10***	***10***	***12***	*10*
Oil Yields (%)	**42.5**	**42.6**	**22**	14
	Sunflower	**Rapeseed**	**Soybean**	**Cottonseed**

[+] *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.*

vii. Default values needed to proceed to final estimations (Biograce):

Factor*	***Unit***	***Value***
Diesel density	kg/ m^3	832
Diesel LHV	MJ/ kg	43.1
Diesel EF	g $CO_{2\ eq}$/ MJ	87.64
Sunflower Seed EF	g $CO_{2\ eq}$/ kg	733.7
Rapeseed Seed EF	g $CO_{2\ eq}$/ kg	733.7
Nitrogen	g $CO_{2\ eq}$/ kg	5,917.2
Phosphorous	g $CO_{2\ eq}$/ kg	1,013.5
Potassium	g $CO_{2\ eq}$/ kg	579.2
Pesticides	g $CO_{2\ eq}$/ kg	11,025.7
Electricity EF	g $CO_{2\ eq}$/ MJ	128.25
Biodiesel LHV	MJ/ kg	37.2
Sunflower cultivation AF	%	62.9
Rapeseed cultivation AF	%	58.6
Soybean cultivation AF	%	32.9

**EF stands for emission factor while AF stands for allocation factor*

II.3. Results

Typical values calculated for greenhouse gas emissions from the cultivation of energy crops used for biodiesel production, by NUTS-2 region in Greece, are presented in the following table:

	Sunflower	***Rapeseed***	***Soybean***	***Cottonseed***
Year of data	***2008****	***2009-2010****	***2010*****	***2010****
Region	**g $CO_{2\ eq}$/ MJ of Biodiesel (FAME)**			
Thessaly	17.50	-	18.97	0
Epirus	16.19	-	18.97	0
Western Macedonia	17.39	-	18.97	0
East Macedonia and Thrace	15.33	26.10	18.97	0
Central Macedonia	17.52	26.10	18.97	0
Continental Greece & Euboea	17.73	-	18.97	0
Western Greece	17.46[+]	-	18.97	0
Disaggregated default values e_{ec}	***18***	***29***	***19***	***-***

[+] *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.*

Emissions were not estimated for cottonseed, since it constitutes a byproduct of cotton-plant cultivation. For that reason, the emissions during the cultivation phase for cottonseed are equal to 0.

II.4. Conclusion

The calculation of greenhouse gas emissions from cultivation of energy crop is always based on the mass in kg of the raw material used for biodiesel production (sunflower, rapeseed, soybean, cottonseed). 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 $CO_{2\ eq}$/ kg of agricultural product' converted in a further stage into 'g of $CO_{2\ eq}$/ 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 *(emissions given under the heading 'Disaggregated default values for cultivation' in Annex V Part D of Directive 2009/28/EC).* It turned out that, **in all cases, the regional values for the greenhouse gas emissions of the agricultural raw materials used for biodiesel production (sunflower, rapeseed, soybean) are below the respective control values.**

III. Agricultural raw materials for BIOETHANOL production

III.1. List of regions

Out of the thirteen (13) total NUTS-2 regions in Greece, in eight (8) of them, where energy crops suitable for bioethanol production are cultivated, the typical greenhouse gas emissions from the cultivation of agricultural raw materials are below (corn and winter wheat) or above (sugar beet) 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. Western Macedonia
4. East Macedonia & Thrace
5. Central Macedonia
6. Continental Greece & Euboea
7. Western Greece
8. Peloponnese

III.2. Estimation

III.2.1 Relevant biomass raw materials

Bioethanol in Greece could be produced using raw materials from locally produced energy crops. Currently in Greece, bioethanol is not produced locally.
The following energy crops grown in Greece could be used for bioethanol production and are relevant for the report under Article 19(2) of Directive 2009/28/EC:

a. Corn
b. Winter wheat
c. Sugar beet

In addition, the cultivation of other energy crops for bioethanol production, not listed currently in Annex V Part D of Directive 2009/28/EC, like sweet sorghum, could be foreseen in certain NUTS-2 regions in Greece, where test cultivation result are very promising.

III.2.2 Approach

The procedures followed throughout, were in accordance with the ones described for same purposes by BioGrace (http://www.biograce.net).
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 cultivation by means of accurately measured data.
All data for the input parameters were made in mass units on the basis of the area unit (e.g. diesel, kg/ ha).
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. The functional unit used in calculations was 1 MJ of bioethanol.

III.2.3. Dataset

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

- Field operations - Used to estimate the consumed diesel (l/ ha)
- Sown seed (kg/ ha)
- Fertilizers applied (kg/ ha) - Total quantity of N, P_2O_5 and K_2O fertilizer used per hectare
- Pesticides (kg/ ha) - Total quantity of pesticides applied per hectare per year (herbicides or insecticides)
- Number of irrigations (If applied) – including the horsepower of the pump and the hours of each irrigation
- Raw material yields (kg/ ha)

III.2.4 Step by step estimations

i. Emissions from diesel consumption

The consumed energy and the respective emissions derived from the diesel consumption were estimated by aggregating the diesel consumption for each field operation. The

result was multiplied to diesel's least heating value (LHV) to estimate the energy which was finally converted to emissions, using diesel's emission factor.

- Diesel consumption (l/ ha) x diesel density (kg/ m^3) = Diesel consumption in kg/ ha
- Diesel consumption (kg/ ha) x LHV (MJ/ kg)= Energy consumed (MJ/ ha)
- Energy consumed (MJ/ ha) x Diesel emission factor (g $CO_{2\ eq}$/ MJ)=

=Diesel Emissions (g $CO_{2\ eq}$/ ha)

The diesel consumption was based on tractors' horsepower used under Greek condition (90-110 hp) and on the majority of the soil types (medium soils) met in the studied regions.

Soil texture for each region (%)

Region	Heavy	Medium	Medium-Heavy	Medium-Light	Light
Thessaly	0,5	20,3	73,9	5,3	
East Macedonia and Thrace	2,9	8,4	30,1	57,2	1,4
Central Macedonia	11,0	16,4	33,6	38,8	0,2
Western Macedonia	6,3	25,3	29,6	35,1	3,9
Epirus	13,7	38,4	44,1	3,2	0,7
Western Greece	9,2	41,4	28,3	19,8	1,5
Continental Greece & Euboea	0	100	0	0	0
Peloponnese	0	61,5	23,1	7,7	0

** According to soil analyses performed for several purposes throughout the years*

ii. Emissions from input production

The estimation of the emissions during the input production takes place by multiplying the input rate to the respective emission factor.

- Input rate (kg/ ha) x emission factor (g $CO_{2\ eq}$/ kg)=

=Input Production Emissions (g $CO_{2\ eq}$/ ha)

Since the corn seed emission factor was not provided by the Biograce tool, it was estimated by taking into account the sown seed/ final seed yield rate, multiplied to the total emissions. Actually, the amount of additional needed land to produce the amount of seed needed to sow 1 ha of corn was estimated.

- Corn seed factor = seed sown (kg/ ha)/ seed yield (kg/ ha) +1 (ha)

iii. N_2O Emissions

Nitrous oxide emissions from the use of N fertilizer were estimated using the tool provided by Biograce (www.Biograce.net) that includes both direct and indirect emissions and follows the IPCC 2006 (http://www.biograce.net/content/ghgcalculationtools/excelghgcalculations).

The result taken from the tool is converted to g and then to $CO_{2\ eq}$ using the global warming potential (GWP).

- N_2O emissions (kg N_2O/ ha year) x 1000 (g/ kg) x Global Warming Potential (g $CO_{2\ eq}$/ g)= N_2O emissions (g $CO_{2\ eq}$/ ha)

iv. Irrigation emissions

- Energy content of 1 KW/ h (MJ) x Pump horsepower (KW) x Hours of irrigation (h) x Number of irrigations x Electricity emission factor (g $CO_{2\ eq}$/ MJ)=

  =Irrigation Emissions (g $CO_{2\ eq}$/ ha)

v. Total emissions

Total emissions (g $CO_{2\ eq}$/ ha)= Diesel Emissions + Input Production Emissions + N_2O emissions + Irrigation Emissions

vi. Typical cultivation emissions estimation

- Seed yield dry (kg/ ha) = Seed yield fresh (kg/ ha) x [(100 - seed moisture %)/ 100]
- Bioethanol yield (kg/ ha) for corn and winter wheat =

  = Seed yield (kg/ ha) x seed moisture (%) x starch yield (%) x Glucose yield from starch (180/162) x Bioethanol yield from glucose (51%)
- Bioethanol yield (kg/ ha) for sugar beet = root yield (kg/ ha) x Sugar yield (%) x Bioethanol yield from sugar (49%)
- Bioethanol Energy (MJ/ ha)= Bioethanol yield (kg/ ha) x Bioethanol LHV (MJ/ kg)
- Typical cultivation emissions (g $CO_{2\ eq}$/ $MJ_{Bioethanol}$)= [Total emissions (g $CO_{2\ eq}$/ ha) / Bioethanol energy (MJ/ ha)] x Allocation factor (%)

Yields per region

	Corn	Wheat	Sugar beet
	Yields (kg/ ha)		
	(seed yield)	*(seed yield)*	*(root yield)*
Year of data	***2009***	***2009***	***2004***
Region			
Thessaly	11000	3050	71000
Epirus	9300	2550	-
Western Macedonia	10500	2700	50000
East Macedonia and Thrace	10500	2600	67500
Central Macedonia	10600	2300	58000
Continental Greece & Euboea	9700	2500	-
Western Greece	10000	2900	-
Peloponnese	6800	2800	-
Moisture content (%)	***16***	***11***	***75***
Sugar content (%)	-	-	**13-15.5**
Starch content (%)	**73**	**72**	-
	Corn	**Wheat**	**Sugar beet**

Source: Hellenic Statistical Authority (ELSTAT)

vii. Default values needed to proceed to final estimations (BioGrace):

Factor	***Unit***	***Value***
Diesel density	kg/ m^3	832
Diesel LHV	MJ/ kg	43.1
Diesel EF	g $CO_{2\ eq}$/ MJ	87.64
Sugar beet seed EF	g $CO_{2\ eq}$/ kg	3557,9
Winter wheat seed EF	g $CO_{2\ eq}$/ kg	277,3
Nitrogen	g $CO_{2\ eq}$/ kg	5,917.2
Phosphorous	g $CO_{2\ eq}$/ kg	1,013.5
Potassium	g $CO_{2\ eq}$/ kg	579.2
Pesticides	g $CO_{2\ eq}$/ kg	11,025.7
Electricity EF	g $CO_{2\ eq}$/ MJ	128.25
Bioethanol LHV	MJ/ kg	37.2
Sugar beet cultivation AF	%	71.3
Winter wheat cultivation AF	%	59.5
Corn cultivation AF	%	54.6

**EF stands for emission factor, while AF stands for allocation factor*

III.3. Results

Typical values calculated for greenhouse gas emissions from the cultivation of energy crops used for bioethanol production, by NUTS-2 region in Greece, are presented in the following table:

	Corn	***Wheat***	***Sugar beet***
Year of data (ELSTAT)	***2009***	***2009***	***2004***
Region	**g $CO_{2\ eq}$/ MJ of Bioethanol**		
Thessaly	19.33	19.54	20.10
Epirus	19.73	20.50	-
Western Macedonia	19.79	20.28	21.62
East Macedonia and Thrace	19.81	20.42	17.93
Central Macedonia	20	21.18	22.02
Continental Greece & Euboea	19.77	20.57	-
Western Greece	19.80	21.01	-
Peloponnese	19.98	20.23	-
Disaggregated default values e_{ec}	***20***	***23***	***12***

III.4. Conclusion

The regional values for the greenhouse gas emissions were compared with the control values set by the 2009/28/EC directive *(emissions given under the heading 'Disaggregated default values for cultivation' in Annex V Part D).* It turned out that, **in the cases of corn and winter wheat, the regional values for the greenhouse gas emissions were below or equal to the respective control values**.

To the contrary, **the respective values for sugar beet exceeded the prescribed limits**. Modifications in current cultivation practices for sugar beet could allow for an emission reduction so as to achieve the desirable levels.

ANNEX

Analytical calculations of greenhouse gas emissions from cultivation of each energy crop per NUTS-2 Region in Greece

GHG EMISSIONS ESTIMATION FOR THESSALY

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	88
Sum (kg/ha)	73,22

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3155,61	276557,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	40	236688
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		294261,9

N_2O emissions (g CO_2e/ ha)	610900

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)
3,6	44	12	1	1

E_{IR}	1900,8	MJ/ ha
Emissions (g CO_2/ ha)		243777,6

Total Emissions (g CO_2e/ ha)	1425497,13

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
3600	3240	1377	1377	51224,4	27,83	**17,50**

GHG EMISSIONS ESTIMATION FOR EPIRUS

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	103
Sum (kg/ha)	85,70

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3693,50	323698,13

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	40	236688
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		294261,9

N_2O emissions (g CO_2e/ ha)	444020

Total Emissions (g CO_2e/ ha) **1061980,03**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
2900	2610	1109,25	1109,25	41264,1	25,74	**16,19**

GHG EMISSIONS ESTIMATION FOR WEST MACEDONIA

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	88
Sum (kg/ha)	73,22

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3155,61	276557,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	20	118344
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		175917,9

N_2O emissions (g CO_2e/ ha)	405280

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	12	1	1	E_{IR}	1900,8	MJ/ ha
					Emissions (g CO_2/ ha)		243777,6

Total Emissions (g CO_2e/ ha) **1101533,13**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
2800	2520	1071	1071	39841,2	27,65	**17,39**

GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA AND THRACE

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	103
Sum (kg/ha)	85,70

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3693,50	323698,13

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	35	207102
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		264675,9

N_2O emissions (g CO_2e/ ha)	417200

Total Emissions (g CO_2e/ ha) **1005574,03**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
2900	2610	1109,25	1109,25	41264,1	24,37	**15,33**

GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	103
Sum (kg/ha)	85,70

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3693,50	323698,13

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	30	177516
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		235089,9

N_2O emissions (g CO_2e/ ha)	506600

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	1	1	E_{IR}	1584	MJ/ ha
					Emissions (g CO_2/ ha)		203148

Total Emissions (g CO_2e/ ha) **1268536,03**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
3200	2880	1224	1224	45532,8	27,86	**17,52**

GHG EMISSIONS ESTIMATION FOR CONTINENTAL GREECE & EUBOEA

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	88
Sum (kg/ha)	73,22

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3155,61	276557,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	30	177516
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		235089,9

N_2O emissions (g CO_2e/ ha)	488720

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)
3,6	44	10	1	1

E_{IR}	1584	MJ/ ha
Emissions (g CO_2/ ha)		203148

Total Emissions (g CO_2e/ ha) **1203515,53**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
3000	2700	1147,5	1147,5	42687	28,19	**17,73**

GHG EMISSIONS ESTIMATION FOR WESTERN GREECE

Sunflower production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
hoeing	15
Harvesting	20
Sum	88
Sum (kg/ha)	73,22

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3155,61	276557,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	30	177516
P_2O_5	30	30405
K_2O	30	17376
pesticide	2	22051,4
Sum		251016,9

N_2O emissions (g CO_2e/ ha)	512560

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	12	1	1	E_{IR}	1900,8	MJ/ ha
					Emissions (g CO_2/ ha)		243777,6

Total Emissions (g CO_2e/ ha) **1283912,13**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
3250	2925	1243,125	1243,125	46244,25	27,76	**17,46**

GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA & THRACE

Rapeseed production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
Harvesting	20

			Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
Sum	73			
Sum (kg/ha)	60,74		2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	70	414204
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		471777,9

N_2O emissions (g CO_2e/ ha)	569180

Total Emissions (g CO_2e/ ha) **1270375,02**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
2000	1800	766,8	766,8	28524,96	44,54	**26,10**

GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA

Rapeseed production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
Harvesting	20
Sum	88
Sum (kg/ha)	73,22

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3155,61	276557,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	5	3668,5
N	90	532548
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		590121,9

N_2O emissions (g CO_2e/ ha)	721160

Total Emissions (g CO_2e/ ha) **1587839,53**

Typical Emissions

seed yield (kg/ ha)	moisture (10%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (MJ/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
2500	2250	958,5	958,5	35656,2	44,53	**26,10**

GHG EMISSIONS ESTIMATION FOR ALL REGIONS

Soybean production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
Harrowing	15
sowing	8
fertilizing	2
hoeing	15
Harvesting	20
Sum	105
Sum (kg/ha)	87,36

Irrigations	h/ha	MJ/(KW h)	Pump Power(KW)	Irig. Energy(MJ/ ha)
4	10	3,6	44	6336

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
10101,22	885270,57

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	20	118344
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		172249,4

N_2O emissions (g CO_2e/ ha)	381440

Seed factor

Seed	Yield	Seed Factor
35	3500	1,010

Total Emissions (g CO_2e/ ha) **1453349,57**

Typical Emissions

seed yield (kg/ ha)	moisture (12%)	oil yield (kg/ ha)	biodiesel yield (kg/ ha)	biodiesel energy (Mj/ ha)	Typical cultivation emissions (g CO2/ MJ_{Fame})	Typical cultivation emissions (Allocation) (g CO2/ MJ_{Fame})
3500	3080	677,6	677,6	25206,72	57,66	**18,97**

GHG EMISSIONS ESTIMATION FOR THESSALY

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing	15
sowing+ preem_herb	8
fertilizing	2
hoeing	15
harvesting	20
Sum	105
Sum (kg/ha)	87,36

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3765,22	329983,53

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	140	828408
P_2O_5	50	50675
K_2O	20	11584
pesticide	2	22051,4
Sum		912718,4

N_2O emissions (g CO_2e/ ha)	1388680

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	11000	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	5	1	E_{IR}	7920	MJ/ ha
					Emissions (g CO_2/ ha)		1015740

Total Emissions (g CO_2e/ ha) **3654416,17**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
11000	9240	6745,2	7494,7	3822,28	103201,56	35,41	**19,33**

GHG EMISSIONS ESTIMATION FOR EPIRUS

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
Harrowing	15
sowing + fert+preem herb	8
hoeing	15
harvesting	20
Sum	103
Sum (kg/ha)	85,70

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3693,50	323698,13

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	110	650892
P_2O_5	30	30405
K_2O	30	17376
pesticide	2	22051,4
Sum		720724,4

N_2O emissions (g CO_2e/ ha)	1126440

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	9300	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	12	4	1	E_{IR}	7603,2	MJ/ ha
					Emissions (g CO_2/ ha)		975110,4

Total Emissions (g CO_2e/ ha) **3153415,02**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
9300	7812	5702,76	6336,4	3231,56	87252,23	36,14	**19,73**

GHG EMISSIONS ESTIMATION FOR WESTERN MACEDONIA

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
ripping	30
tilling	15
harrowing	15
sowing + fert+preem herb	8
hoeing	15
harvesting	20
Sum	133
Sum (kg/ha)	110,66

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4769,27	417979,14

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	145	857994
P_2O_5	40	40540
K_2O	25	14480
pesticide	2	22051,4
Sum		935065,4

N_2O emissions (g CO_2e/ ha)	1397620

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	10500	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	4	1	E_{IR}	6336	MJ/ ha
					Emissions (g CO_2/ ha)		812592

Total Emissions (g CO_2e/ ha) **3570722,41**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
10500	8820	6438,6	7154,0	3648,54	98510,58	36,25	**19,79**

GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA & THRACE

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing	15
sowing+ preem_herb	8
fertilizing	2
hoeing	15
harvesting	20
Sum	90
Sum (kg/ha)	74,88

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3227,33	282843,03

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	150	887580
P_2O_5	40	40540
K_2O	20	11584
pesticide	2	22051,4
Sum		961755,4

N_2O emissions (g CO_2e/ ha)	1427420

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	10500	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	11	4	1	E_{IR}	6969,6	MJ/ ha
					Emissions (g CO_2/ ha)		893851,2

Total Emissions (g CO_2e/ ha) **3573340,97**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
10500	8820	6438,6	7154,0	3648,54	98510,58	36,27	**19,81**

GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
ripping	30
tilling	15
sowing+ preem_herb	8
fertilizing	2
hoeing	15
harvesting	20
Sum	120
Sum (kg/ha)	99,84

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4303,10	377124,03

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	130	769236
P_2O_5	30	30405
K_2O	20	11584
pesticide	2	22051,4
Sum		833276,4

N_2O emissions (g CO_2e/ ha)	1308220

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	10600	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	11	5	1	E_{IR}	8712	MJ/ ha
					Emissions (g CO_2/ ha)		1117314

Total Emissions (g CO_2e/ ha) **3643480,71**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
10600	8904	6499,92	7222,1	3683,29	99448,78	36,64	**20,00**

GHG EMISSIONS ESTIMATION CONTINENTAL GREECE & EUBOEA

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing	15
sowing + fert+preem herb	8
hoeing	15
harvesting	20
Sum	103
Sum (kg/ha)	85,70

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3693,50	323698,13

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	135	798822
P_2O_5	20	20270
K_2O	20	11584
pesticide	2	22051,4
Sum		852727,4

N_2O emissions (g CO_2e/ ha)	1299280

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	9700	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	4	1	E_{IR}	6336	MJ/ ha
					Emissions (g CO_2/ ha)		812592

Total Emissions (g CO_2e/ ha) **3295755,52**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
9700	8148	5948,04	6608,9	3370,56	91005,01	36,22	**19,77**

GHG EMISSIONS ESTIMATION FOR WESTERN GREECE

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
Ripping	30
tilling	15
sowing + fert+preem herb	8
hoeing	15
harvesting	20
Sum	118
Sum (kg/ha)	98,18

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4231,39	370838,63

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	130	769236
P_2O_5	40	40540
K_2O	30	17376
pesticide	2	22051,4
Sum		849203,4

N_2O emissions (g CO_2e/ ha)	1281400

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	10000	1,002

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	11	4	1	E_{IR}	6969,6	MJ/ ha
					Emissions (g CO_2/ ha)		893851,2

Total Emissions (g CO_2e/ ha) **3402762,88**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
10000	8400	6132	6813,3	3474,80	93819,60	36,27	**19,80**

GHG EMISSIONS ESTIMATION FOR PELOPONNESE

Corn production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing	15
sowing+ preem_herb	8
fertilizing	2
hoeing	15
harvesting	20
Sum	90
Sum (kg/ha)	74,88

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3227,33	282843,03

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
N	70	414204
P_2O_5	18	18243
K_2O	20	11584
pesticide	2	22051,4
Sum		466082,4

N_2O emissions (g CO_2e/ ha)	765860

Seed factor

Seed (kg/ha)	Yield (kg/ha)	Seed Factor
22	6800	1,003

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	4	1	E_{IR}	6336	MJ/ ha
					Emissions (g CO_2/ ha)		812592

Total Emissions (g CO_2e/ ha) **2334907,18**

Typical Emissions

seed yield (kg/ ha)	moisture (16%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions (g CO_2/$MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
6800	5712	4169,76	4633,1	2362,86	63797,33	36,60	**19,98**

GHG EMISSIONS ESTIMATION FOR THESSALY

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
Pre-em herb	2
sowing + fertilizing	8
Harvesting	20
Sum	60
Sum (kg/ha)	49,92

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2151,55	188562,02

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	180	49914
N	45	266274
P_2O_5	20	20270
K_2O	0	0
pesticide	2	22051,4
Sum		358509,4

N_2O emissions (g CO_2e/ ha)	435080

Total Emissions (g CO_2e/ ha) **982151,42**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
3050	2714,5	1954,44	2171,6	1107,52	29902,93	32,84	**19,54**

GHG EMISSIONS ESTIMATION FOR EPIRUS

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	180	49914
N	35	207102
P_2O_5	20	20270
K_2O	0	0
pesticide	0	0
Sum		277286

N_2O emissions (g CO_2e/ ha)	354620

Total Emissions (g CO_2e/ ha) **861323,12**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2550	2269,5	1634,04	1815,6	925,96	25000,81	34,45	**20,50**

GHG EMISSIONS ESTIMATION FOR WESTERN MACEDONIA

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	180	49914
N	35	207102
P_2O_5	30	30405
K_2O	0	0
pesticide	2	22051,4
Sum		309472,4

N_2O emissions (g CO_2e/ ha)	363560

Total Emissions (g CO_2e/ ha) **902449,52**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2700	2403	1730,16	1922,4	980,42	26471,45	34,09	**20,28**

GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA & THRACE

Wintewr wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	120	33276
N	35	207102
P_2O_5	25	25337,5
K_2O	0	0
pesticide	2	22051,4
Sum		287766,9

N_2O emissions (g CO_2e/ ha)	357600

Total Emissions (g CO_2e/ ha) **874784,02**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2600	2314	1666,08	1851,2	944,11	25491,02	34,32	**20,42**

GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
sowing	8
fertilizing	2
Harvesting	20
Sum	75
Sum (kg/ha)	62,40

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2689,44	235702,52

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	160	44368
N	30	177516
P_2O_5	10	10135
K_2O	0	0
pesticide	2	22051,4
Sum		254070,4

N_2O emissions (g CO_2e/ ha)	312900

Total Emissions (g CO_2e/ ha) **802672,92**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2300	2047	1473,84	1637,6	835,18	22549,75	35,60	**21,18**

GHG EMISSIONS ESTIMATION FOR CONTINENTAL GREECE & EUBOEA

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	140	38822
N	35	207102
P_2O_5	20	20270
K_2O	0	0
pesticide	0	0
Sum		266194

N_2O emissions (g CO_2e/ ha)	351640

Total Emissions (g CO_2e/ ha) **847251,12**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2500	2225	1602	1780,0	907,80	24510,60	34,57	**20,57**

GHG EMISSIONS ESTIMATION FOR WESTERN GREECE

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	180	49914
N	45	266274
P_2O_5	10	10135
K_2O	0	0
pesticide	2	22051,4
Sum		348374,4

N_2O emissions (g CO_2e/ ha)	426140

Total Emissions (g CO_2e/ ha) **1003931,52**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2900	2581	1858,32	2064,8	1053,05	28432,30	35,31	**21,01**

GHG EMISSIONS ESTIMATION FOR PELOPONNESE

Winter wheat production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
Harvesting	20
Sum	73
Sum (kg/ha)	60,74

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
2617,72	229417,12

Input Production emissions

	Quantity (kg/ ha)	Emissions per ha
seed	140	38822
N	40	236688
P_2O_5	10	10135
K_2O	0	0
pesticide	2	22051,4
Sum		307696,4

N_2O emissions (g CO_2e/ ha)	396340

Total Emissions (g CO_2e/ ha) **933453,52**

Typical Emissions

seed yield (kg/ ha)	moisture (11%)	Starch yield (kg/ ha)	Glucose yield (kg/ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
2800	2492	1794,24	1993,6	1016,74	27451,87	34,00	**20,23**

GHG EMISSIONS ESTIMATION FOR THESSALY

Sugarbeet production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
harrowing+Pre-em herb	15
sowing + fertilizing	8
Spraying x 6	12
hoeing	15
Harvesting	20
Sum	100
Sum (kg/ha)	83,20

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
3585,92	314270,03

Input Production emissions

	Quantity (kg/ ha)	Emissions/ ha
seed	2,5	8894,75
N	125	739650
P_2O_5	100	101350
K_2O	15	8688
pesticide	3,8	41897,66
Sum		900480,41

N_2O emissions (g CO_2e/ ha)	1415500

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	4	1	E_{IR}	6336	MJ/ ha
					Emissions (g CO_2/ ha)		812592

Total Emissions (g CO_2e/ ha) **3442842,44**

Typical Emissions

Yield (kg/ ha)	Sugar yield (kg/ ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
71000	9230	4522,70	122112,90	28,19	**20,10**

GHG EMISSIONS ESTIMATION FOR WESTERN MACEDONIA

Sugarbeet production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
Spraying x 5	10
hoeing	15
Harvesting	20
Sum	113
Sum (kg/ha)	94,02

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4052,09	355125,13

Input Production emissions

	Quantity (kg/ ha)	Emissions/ ha
seed	2,5	8894,75
N	120	710064
P_2O_5	100	101350
K_2O	20	11584
pesticide	3,5	38589,95
Sum		870482,7

N_2O emissions (g CO_2e/ ha)	1233720

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	8	4	1	E_{IR}	5068,8	MJ/ ha
					Emissions (g CO_2/ ha)		650073,6

Total Emissions (g CO_2e/ ha) **3109401,43**

Typical Emissions

Yield (kg/ ha)	Sugar yield (kg/ ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
50000	7750	3797,50	102532,50	30,33	**21,62**

GHG EMISSIONS ESTIMATION FOR EAST MACEDONIA & THRACE

Sugarbeet production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
Spraying x 7	14
hoeing	15
Harvesting	20
Sum	117
Sum (kg/ha)	97,34

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4195,53	367695,93

Input Production emissions

	Quantity (kg/ ha)	Emissions/ ha
seed	2,5	8894,75
N	115	680478
P_2O_5	90	91215
K_2O	5	2896
pesticide	4,1	45205,37
Sum		828689,12

N_2O emissions (g CO_2e/ ha)	1329080

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	9	4	1	E_{IR}	5702,4	MJ/ ha
					Emissions (g CO_2/ ha)		731332,8

Total Emissions (g CO_2e/ ha)	3256797,85

Typical Emissions

Yield (kg/ ha)	Sugar yield (kg/ ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
67500	9787,5	4795,88	129488,63	25,15	17,93

GHG EMISSIONS ESTIMATION FOR CENTRAL MACEDONIA

Sugarbeet production emissions

Diesel Consumption

Operation	Consumption (l/ ha)
ploughing	30
tilling	15
harrowing+Pre-em herb	15
sowing + fertilizing	8
Spraying x 5	10
hoeing	15
Harvesting	20
Sum	113
Sum (kg/ha)	94,02

Fuel energy consumed (MJ/ ha)	Emissions (g CO_2/ ha)
4052,09	355125,13

Input Production emissions

	Quantity (kg/ ha)	Emissions/ ha
seed	2,5	8894,75
N	120	710064
P_2O_5	95	96282,5
K_2O	10	5792
pesticide	3,5	38589,95
Sum		859623,2

N_2O emissions (g CO_2e/ ha)	1290340

Irrigation

MJ/ KW h	Horsepower (KW)	Hours	Numb. Irrig	Area (ha)			
3,6	44	10	4	1	E_{IR}	6336	MJ/ ha
					Emissions (g CO_2/ ha)		812592

Total Emissions (g CO_2e/ ha) **3317680,33**

Typical Emissions

Yield (kg/ ha)	Sugar yield (kg/ ha)	bioethanol yield (kg/ha)	bioethanol energy (MJ/ ha)	Typ. Cult. Emissions ($gCO_2/MJ_{bioethanol}$)	Typical cultivation emissions (Allocation) (g CO_2/ $MJ_{Bioethanol}$)
58000	8120	3978,80	107427,60	30,88	**22,02**