Calculation annex

for provision of information in accordance with Article19(2) of Directive 2009/28/EC

On the basis of the production technologies referred to in the table containing the disaggregated values established in respect of the e_{ec} value in point D of Annex V, and in view of the country's climatic conditions, Hungary can produce the following biofuel raw material plants:

(a) sugar beet
(b) wheat
(c) maize
(d) rapeseed
(e) sunflower.

The list of territories and the relevant calculation method has therefore been established for the above crops.

Table 1 summarises the amount of biofuel that may be produced from the various raw materials on the basis of the typical content value for the various crops (sugar, starch and oil content), the specific technologies and the technological parameters of the projects planned in the near future. Using these technological coefficients and the calorific values mentioned in the Directive, the last column of *Table 1* shows the maximum CO_2 equivalent emission value per raw material unit at which the typical value would remain below or equal to the limit under the Directive.

Table 1: Specific e_{ec} CO_{2eq} per tonne of product on the basis of technological coefficients commonly applied in Hungary, calculated from the typical values in accordance with the Directive

Method of production of biofuel and bioliquid	**Default greenhouse gas emissions (gCO_{2eq}/MJ)**	**Technological coefficient (litre of biofuel/tonne of product)**	**Calorific value (MJ/litre)**	**Specific CO_2 equivalent ($kgCO_{2eq}$/ tonne of product)**
Sugar beet ethanol	12	105	21	26.46
Wheat ethanol	23	380	21	183.54
Maize ethanol, Community produced	20	400	21	168.00
Rapeseed biodiesel	29	425	33	406.72
Sunflower biodiesel	18	450	33	267.30
Hydrotreated vegetable oil from rapeseed	30	397	34	404.94
Hydrotreated vegetable oil from sunflower	18	457	34	279.68
Pure vegetable oil from rapeseed	30	440	34	448.80

The average use of chemicals in Hungary for producing the various crops was determined on the basis of the average values for 2006-2008 resulting from the survey of basis farms

conducted by the Agricultural Research Institute (Agrárgazdasági Kutatóintézet (AKI)) (Table 2). Basis farms cover all farms with more than 2 ESUs, and the values contain average data (many – mainly smaller and medium-sized – farms do not use P and K fertilisers every year).

As regards energy sources used as fuels, 95 litres of diesel per hectare are most commonly used in Hungary. The CO_{2eq} emission of diesel was calculated as 74.07 gCO_{2eq}/MJ.

Data from the Joint Research Centre of the European Commission (Biofuels pathways RED method 14 Nov 2008) were used to calculate N2O values for crops.

The data for the quantity of by-product and the related energy content were calculated using the values of the Institute of Agricultural Engineering (Mez• gazdasági Gépesítési Intézet).

The above factors and the CO_{2eq} emission values for the various crops with regard to these factors are summarised in Table 2.

Table 2: Average specific input use in Hungary for 2006-2008 and the relevant CO_2 equivalent emission values

Crop	Wheat	Maize	Rapeseed	Sunflower	Sugar beet
N-fertiliser (kg/ha)	77.6	89.2	73.3	45	48
P-fertiliser (kg/ha)	1.6	1.8	2.8	1	1
K-fertiliser (kg/ha)	2.1	4.8	6.9	4	38
Plant protection products (kg/ha)	11.1	6.6	18.7	8	27
Diesel (l/ha)	95	95	95	95	95
Seed (kg/ha)	220	18	10	10	9
N2O from soil cultivation (kg/ha)	1.41	0.80	1.59	0.95	0.74
Production emissions per product+by-product (kgCO2eq/ha)	1 171.42	1 010.26	1 224.33	820.16	890.27
Production emissions per by-product (kgCO2eq/ha)	439.79	400.59	456.64	289.86	144.83
Production emissions (kgCO2eq/ha)	731.63	609.67	767.69	530.30	745.44

On the basis of the data from *Table 1 and Table 2* for the various biofuel production methods, in addition to the above-mentioned production technology widely used in Hungary, the average yields listed in *Table 3* must be reached for the CO_2 equivalent emission to be equal to the disaggregated value of the Directive.

Table 3: Average yield corresponding to the e_{ec} disaggregated values under the Directive required on the basis of the technology and cultivation emissions applied in Hungary

Method of production of biofuel and bioliquid	**Specific CO_2 equivalent ($kgCO_{2eq}$/tonne of product)**	**Cultivation emission ($kgCO_{2eq}$/ha)**	**Minimum average yield (t/ha)**
Sugar beet ethanol	26.46	745.44	28.17
Wheat ethanol	183.54	731.63	3.99
Maize ethanol, Community produced	168	609.67	3.63
Rapeseed biodiesel	406.72	767.69	1.89
Sunflower biodiesel	267.3	530.30	1.98
Hydrotreated vegetable oil from rapeseed	404.94	550.33	1.06
Hydrotreated vegetable oil from sunflower	279.68	428.54	1.53
Pure vegetable oil from rapeseed	448.8	626.30	1.40

Table 4 shows the yield at NUTS II level on the basis of the annual average for the crops in question between 2004 and 2008.

Table 4: Average yield of biofuel raw materials in Hungary at NUTS II level between 2004 and 2008

Source: Central Statistical Office unit of measurement: kg/ha

Region/Crop NUTS II code	**Wheat**	**Maize**	**Sunflower**	**Rapeseed**	**Sugar beet**
Közép-Magyarország [Central Hungary] HU10	4 110	6 032	2 188	2 138	50 927
Észak-Alföld [North Great Plain] HU32	4 190	6 358	2 232	2 268	54 908
Dél-Alföld [South Great Plain] HU33	4 546	6 230	2 356	2 372	53 506
Észak-Magyarország [North Hungary] HU31	4 160	5 670	2 186	2 234	50 946
Nyugat-Dunántúl [West Transdanubia] HU22	4 438	6 470	2 412	2 714	49 230
Közép-Dunántúl [Central Transdanubia] HU21	4 592	6 752	2 446	2 596	57 408
Dél-Dunántúl [South Transdanubia] HU23	4 942	7 040	2 536	2 742	60 274

On the basis of the data calculated in *Table 3 and Table 4* it can be established that, taking into consideration the CO_2 emission values according to the agrotechnology applied in

Hungary and the technological coefficients, the average yields in all NUTS II areas exceed the value required for the emission units to be kept below the e_{ec} disaggregated values under the Directive. **In light of the above, the total area cultivated on 1 January 2008 complies with the disaggregated value under point D of Annex V of the Directive.**

Crop	Wheat	Maize	Rapeseed, biodiesel	Rapeseed, hydro-treated vegetable oil	Rapeseed, vegetable oil	Sunflower, biodiesel	Sunflower, hydro-treated vegetable oil	Sugar beet
N-fertiliser (kg/ha)	77.6	89.2	73.3	73.3	73.3	45	45	8
P-fertiliser (kg/ha)	1.6	1.8	2.8	2.8	2.8	1	1	1
K-fertiliser (kg/ha)	2.1	4.8	6.9	6.9	6.9	4	4	38
Plant protection products (kg/ha)	11.1	6.6	18.7	18.7	18.7	8	8	27
Seed	220	18	10	10	10	10	10	9
Chemical emission kgCO2 eq/ha	482.28	522.12	503.18	503.18	503.18	289.46	289.46	424.13
Diesel l/ha	95.00	95.00	95.00	95.00	95.00	95.00	95.00	95.00
Diesel emission (kgCO2 eq/ha)	246.48	246.48	246.48	246.48	246.48	246.48	246.48	246.48
Production without seed (kgCO2 eq/ha)	728.76	768.60	749.65	749.65	749.65	535.94	535.94	670.61
Seed (kgCO2 eq/ha)	25.30	4.86	4.03	4.03	4.03	3.02	3.02	0.62
N2O from soil cultivation (kg/ha)	1.41	0.80	1.59	1.59	1.59	0.95	0.95	0.74
Soil cultivation equivalent value (kgCO2eq/ha)	417.36	236.80	470.64	470.64	470.64	281.20	*281.20*	219.04
Production emissions per product+by-product (kgCO2eq/ha)	1 171.42	1 010.26	1 224.33	1 224.33	1 224.33	820.16	820.16	890.27
Production emissions per by-product (kgCO2eq/ha)	439.79	400.59	456.64	674.00	598.03	289.86	391.62	144.83
Production emissions for biofuel (kgCO2eq/ha)	**731.63**	**609.67**	**767.69**	**550.33**	**626.30**	**530.30**	**428.54**	**745.44**

Seed drying, cleaning (MJ/t)	1.44	1.44	1.44	1.44	1.44	1.44	1.44	1
Seed average yield (t/ha)	4.425	6.364	2.336	2.336	2.336	2.437	2.437	53.89
Seed production (kgCO2 eq/t)	80.784	80.784	80.784	80.784	80.784	80.784	80.784	56.1
Minimum average yield (t/ha)	3.99	3.63	1.89	1.06	1.40	1.98	1.53	28.17

178.2 kg of CO2/t of maize

229.0 kg of CO2/t of maize (Joanneum)

Description	CO2eq	
N-fertiliser	5.414	kgCO2eq/kg
P-fertiliser	0.71	kgCO2eq/kg
K-fertiliser	0.46	kgCO2eq/kg
Plant protection products	5.41	kgCO2eq/kg
Wheat seed	0.12	kgCO2eq/kg
Maize seed	0.27	kgCO2eq/kg
Rapeseed	0.403077627	kgCO2eq/kg
Sunflower seed	0.30160797	kgCO2eq/kg
Sugar beet seed	0.068546164	kgCO2eq/kg
Diesel	74.07	kgCO2eq/GJ
Natural gas	56.1	kgCO2eq/GJ

Method of production of biofuel and bioliquid	Default greenhouse gas emissions (gCO2eq/MJ)	Technological coefficient (litre of biofuel/tonne of product)	Calorific value (MJ/l)	Fuel calorific value (MJ/t of product)	Co-product energy content (MJ/t of product)	Total energy content (MJ/t of product)	Rate of co-product	Specific CO2 equivalent (gCO2/t of product)
Sugar beet ethanol	12	105	21	2 205	428.4	2 633	0.16	26.46
Wheat ethanol	23	380	21	7 980	4 796.8	12 777	0.38	183.54
Maize ethanol, Community produced	20	400	21	8 400	5 519.2	13 919	0.40	168
Rapeseed biodiesel	29	425	33	14 025	8 342.43	22 367	0.37	406.725
Sunflower biodiesel	18	450	33	14 850	8 116.94	22 967	0.35	267.3
Hydrotreated vegetable oil from rapeseed	30	397	34	13 498	16 531.36	30 029	0.55	404.94
Hydrotreated vegetable oil from sunflower	18	457	34	15 538	14 199.52	29 738	0.48	279.684
Pure vegetable oil from rapeseed	30	440	34	14 960	14 284.8	29 245	0.49	448.8

Source

24 MJ/kg of sunflower and rapeseed pellet with approximately 12% oil content from pressing only

18 MJ/kg of extracted meal with 1-2% oil content

extraction residue is released with 8-10% dry matter content but it is approximately 16MJ/kg per dry matter

Density kg/l	Quantity kg/t	Calorific value MJ/kg	Quantity kg/t of glycerine	Calorific value MJ/kg		Quantity kg/t of maize germ	Calorific value MJ/kg		
0.79	63	6.8							
0.79	299.8	16							
0.79	284	16				100			
0.88	626	18	63.75	17					
0.88	604	18	67.5	17					
0.88	650.64	18							
0.88	597.84	18							
0.92	595.2	24							
					reference to sugar beet data				maize germ
http://www.biomasszaklaszter.hu/files/Cikk%20bioenergia%202007%2004%2015.pdf	Ethanol expressed as dry matter, added to oil-cake in mucous ethanol separated in the pressing works, calculated on the basis of the formation of 300 kg/t of CO2		The density of 1.26 kg/l for crude oil is 150 l/t. According to the Hungarian Petroleum Association, it cannot be burned in power plants because of its low calorific value		http://www.bdbe.de/downloads/PDF/fachinformationen/Artikel_Kunz_Klenk.pdf	In addition to 9% humidity content	Sugar beet tops with 75% humidity content during harvesting	The germ part is therefore 10% http://www.dhhskft.hu/media/document/publ3.pdf	I did not find any data on calorific value

	Energiegehalt MJ	Energieaufwendung MJ	Klimagasemission kg CO_{2eq}
1 kg BIODIESEL	37,1	15,73	0,748
1 kg Rapsschrot	16,36	4,38	0,258
1 kg Glyzerin	17,0	7,22	0,343

http://www.inaro.de/deutsch/Rohstoff/Energie/Oele/Biodiesel-Bilanz.htm

Name	Technological coefficient (litre of biofuel per tonne of product)	By-product energy equivalent (MJ/t of product)	By-product 1			
			Name	Quantity (kg/t)	Specific energy content (MJ/t)	Energy content (MJ)
Sugar beet ethanol	105	428.4	Sugar beet pulp (dry matter)	63	6 800	428.4
Wheat ethanol	380	4 796.8	Extraction residue	299.8	16 000	4 796.8
Maize ethanol, Community-produced	400	5 519	CGF	222	16 500	3 668.5
Rapeseed biodiesel	425	8 342.43	Glycerine	63.75	17 000	1 083.75
Sunflower biodiesel	450	8 116.94	Glycerine	67.8	17 000	1 152.6
Hydro-treated vegetable oil from rapeseed	397	16 531.36	Pressing residue	650.64	24 000	15 615.36
Hydro-treated vegetable oil from sunflower	457	14 199.52	Pressing residue	597.84	18 000	10 761.12
Pure vegetable oil from rapeseed	440	14 284.8	Pressing residue	595.2	24 000	14 284.8

333.7212052

Biodiesel from rapeseed oil	95%	403.75	
Soapy water production biodiesel in %	15.60%	62.985	
Biodiesel from sunflower oil	90%	396	
Soapy water production biodiesel in %	15.60%	61.776	

By-product 2				By-product 3				By-product 4		
Name	Quantity (kg/t)	Specific energy content (MJ/t)	Energy content (MJ)	Name	Quantity (kg/t)	Specific energy content (MJ/t)	Energy content (MJ)	Name	Quantity	Specific energy content (MJ/t)
Maize germ	64.1	16 700	1 071	Maize gluten	47.3	16 500	780.1630435			
Rapeseed meal	600	10 700	6 420	Soapy water	58	7 230	419.34	Soapy water	58	7 230
Sunflower meal	400	10 400	4 160	Sunflower top	150	15 900	2 385	Soapy water	58	7 230
Propane	20	45 800	916							
Propane	23	45 800	1 053.4	Sunflower top	150	15 900	2 385			

		By-product 5		
Energy content (MJ)	Name	Quantity	Specific energy content (MJ/t)	Energy content (MJ)
419.34				
419.34				

Annex 3

Method of production	kgCO2eq/t of product	Production kgCO2eq/ha	Min. average yield (t/ha)	Min. according to KSH (Central Statistical Office)
Sugar beet ethanol	26.46	745.44	28.17	49.23
Wheat ethanol	183.54	731.63	3.99	4.11
Maize ethanol	168	609.67	3.63	5.67
Rapeseed biodiesel	406.725	767.69	1.89	2.138
Sunflower biodiesel	267.3	530.30	1.98	2.188
Hydrotreated vegetable oil from rapeseed	404.94	428.54	1.06	2.138
Hydrotreated vegetable oil from sunflower	279.684	428.54	1.53	2.188
Pure vegetable oil from rapeseed	448.8	626.30	1.40	2.138