Council of the European Union

Brussels, 2 December 2016
(OR. en)

15120/16
ADD 1

Interinstitutional File:
2016/0382 (COD)

ENER 417
CLIMA 168
CONSOM 298
TRANS 479
AGRI 650
IND 261
ENV 757
IA 130
CODEC 1802

PROPOSAL

From:	Secretary-General of the European Commission, signed by Mr Jordi AYET PUIGARNAU, Director
date of receipt:	1 December 2016
To:	Mr Jeppe TRANHOLM-MIKKELSEN, Secretary-General of the Council of the European Union
No. Cion doc.:	COM(2016) 767 final - ANNEXES 1-12
Subject:	ANNEXES to the Proposal for a Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources (recast)

Delegations will find attached document COM(2016) 767 final - ANNEXES 1-12.

Encl.: COM(2016) 767 final - ANNEXES 1-12

EUROPEAN
COMMISSION

Brussels, 30.11.2016
COM(2016) 767 final

ANNEXES 1 to 12

ANNEXES

to the

Proposal for a Directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources (recast)

{SWD(2016) 416 final}
{SWD(2016) 417 final}
{SWD(2016) 418 final}
{SWD(2016) 419 final}

↓ 2009/28/EC
⇨ new

ANNEX I

National overall targets for the share of energy from renewable sources in gross final consumption of energy in 2020[1]

A. ***NATIONAL OVERALL TARGETS***

	Share of energy from renewable sources in gross final consumption of energy, 2005 (S_{2005})	Target for share of energy from renewable sources in gross final consumption of energy, 2020 (S_{2020})
Belgium	2,2 %	13 %
Bulgaria	9,4 %	16 %
Czech Republic	6,1 %	13 %
Denmark	17,0 %	30 %
Germany	5,8 %	18 %
Estonia	18,0 %	25 %
Ireland	3,1 %	16 %
Greece	6,9 %	18 %
Spain	8,7 %	20 %
France	10,3 %	23 %
⇨ Croatia ⇦	⇨ 12,6% ⇦	⇨ 20% ⇦
Italy	5,2 %	17 %
Cyprus	2,9 %	13 %
Latvia	32,6 %	40 %
Lithuania	15,0 %	23 %
Luxembourg	0,9 %	11 %

[1] In order to be able to achieve the national objectives set out in this Annex, it is underlined that the State aid guidelines for environmental protection recognise the continued need for national mechanisms of support for the promotion of energy from renewable sources.

Hungary	4,3 %	13 %
Malta	0,0 %	10 %
Netherlands	2,4 %	14 %
Austria	23,3 %	34 %
Poland	7,2 %	15 %
Portugal	20,5 %	31 %
Romania	17,8 %	24 %
Slovenia	16,0 %	25 %
Slovak Republic	6,7 %	14 %
Finland	28,5 %	38 %
Sweden	39,8 %	49 %
United Kingdom	1,3 %	15 %

~~**B.*INDICATIVE TRAJECTORY***~~

~~The indicative trajectory referred to in Article 3(2) shall consist of the following shares of energy from renewable sources:~~

~~S_{2005} + 0,20 (S_{2020} – S_{2005}), as an average for the two-year period 2011 to 2012;~~

~~S_{2005} + 0,30 (S_{2020} – S_{2005}), as an average for the two-year period 2013 to 2014;~~

~~S_{2005} + 0,45 (S_{2020} – S_{2005}), as an average for the two-year period 2015 to 2016; and~~

~~S_{2005} + 0,65 (S_{2020} – S_{2005}), as an average for the two-year period 2017 to 2018,~~

~~where~~

~~S_{2005} = the share for that Member State in 2005 as indicated in the table in part A,~~

~~and~~

~~S_{2020} = the share for that Member State in 2020 as indicated in the table in part A.~~

🡻 2009/28/EC

ANNEX II

Normalisation rule for accounting for electricity generated from hydropower and wind power

The following rule shall be applied for the purpose of accounting for electricity generated from hydropower in a given Member State:

$(Q_{N(norm)})(C_N[(/(i)(N 14))(Q_iC_i)] 15)$where:

N	=	reference year;
$Q_{N(norm)}$	=	normalised electricity generated by all hydropower plants of the Member State in year *N*, for accounting purposes;
Q_i	=	the quantity of electricity actually generated in year *i* by all hydropower plants of the Member State measured in GWh, excluding production from pumped storage units using water that has previously been pumped uphill;
C_i	=	the total installed capacity, net of pumped storage, of all hydropower plants of the Member State at the end of year *i*, measured in MW.

The following rule shall be applied for the purpose of accounting for electricity generated from wind power in a given Member State:

$(Q_{N(norm)})((C_N C_{N 1}2)((/(i)(Nn))Q_i(/(j)(Nn))(C_j C_{j 1}2)))$where:

N	=	reference year;
$Q_{N(norm)}$	=	normalised electricity generated by all wind power plants of the Member State in year *N*, for accounting purposes;
Q_i	=	the quantity of electricity actually generated in year *i* by all wind power plants of the Member State measured in GWh;
C_j	=	the total installed capacity of all the wind power plants of the Member State at the end of year *j*, measured in MW;
n	=	4 or the number of years preceding year *N* for which capacity and production data are available for the Member State in question, whichever is lower.

⬇ 2009/28/EC (adapted)
⇨ new

ANNEX III

Energy content of ~~transport~~ fuels

Fuel	Energy content by weight (lower calorific value, MJ/kg)	Energy content by volume (lower calorific value, MJ/l)
FUELS FROM BIOMASS AND/ OR BIOMASS PROCESSING OPERATIONS		
Bio-Propane	46	24
Pure vegetable oil (oil produced from oil plants through pressing, extraction or comparable procedures, crude or refined but chemically unmodified)	37	34
Biodiesel - fatty acid methyl ester (methyl-ester produced from oil of vegetable, animal or aquatic biomass origin)	37	33
Biodiesel - fatty acid ethyl ester (ethyl-ester produced from oil of vegetable, animal or aquatic biomass origin)	38	34
Biogas that can be purified to natural gas quality	50	-
Hydrotreated (thermochemically treated with hydrogen) oil of vegetable, animal or aquatic biomass origin, to be used for replacement of diesel	44	34
Hydrotreated (thermochemically treated with hydrogen) oil of vegetable, animal or aquatic biomass origin, to be used for replacement of petrol	45	30
Hydrotreated (thermochemically treated with hydrogen) oil of vegetable, animal or aquatic biomass origin, to be used for replacement of jet fuel	44	34
Hydrotreated oil (thermochemically treated with hydrogen) of vegetable, animal or aquatic	46	24

biomass origin, to be used for replacement of liquefied petroleum gas		
Co-processed oil (processed in a refinery simultaneously with fossil fuel) of vegetable, animal, aquatic biomass or pyrolysed biomass origin to be used for replacement of diesel	43	36
Co-processed oil (processed in a refinery simultaneously with fossil fuel) of vegetable, animal, aquatic biomass or pyrolysed biomass origin, to be used to replace petrol	44	32
Co-processed oil (processed in a refinery simultaneously with fossil fuel) of vegetable, animal, aquatic biomass or pyrolysed biomass origin, to be used to replace jet fuel	43	33
Co-processed oil (processed in a refinery simultaneously with fossil fuel) of vegetable, animal, aquatic biomass or pyrolysed biomass origin, to be used to replace liquefied petroleum gas	46	23
RENEWABLE FUELS THAT CAN BE PRODUCED FROM VARIOUS RENEWABLE ENERGY SOURCES INCLUDING WHILE NOT LIMITED TO BIOMASS		
Methanol from renewable energy sources	20	16
Ethanol from renewable energy sources	27	21
Propanol from renewable energy sources	31	25
Butanol from renewable energy sources	33	27
Fischer-Tropsch diesel (a synthetic hydrocarbon or mixture of synthetic hydrocarbons to be used for replacement of diesel)	44	34
Fischer-Tropsch petrol (a synthetic hydrocarbon or mixture of synthetic hydrocarbons produced from biomass, to be used for replacement of petrol)	44	33
Fischer-Tropsch jet fuel (a synthetic hydrocarbon or mixture of synthetic hydrocarbons produced from biomass, to be used for replacement of jet fuel)	44	33
Fischer-Tropsch liquefied petroleum gas (a synthetic hydrocarbon or mixture of synthetic hydrocarbons, to be used for replacement of	46	24

liquefied petroleum gas		
DME (dimethylether)	28	19
Hydrogen from renewable sources	120	-
ETBE (ethyl-tertio-butyl-ether produced on the basis of ethanol)	36 (of which 37% from renewable sources)	27 (of which 37% from renewable sources)
MTBE (methyl-tertio-butyl-ether produced on the basis of methanol)	35 (of which 22% from renewable sources)	26 (of which 22% from renewable sources)
TAEE (tertiary-amyl-ethyl-ether produced on the basis of ethanol)	38 (of which 29% from renewable sources)	29 (of which 29% from renewable sources)
TAME (tertiary-amyl-methyl-ether produced on the basis of ethanol)	36 (of which 18%c from renewable sources)	28 (of which 18%c from renewable sources)
THxEE (tertiary-hexyl-ethyl-ether produced on the basis of ethanol)	38 (of which 25% from renewable sources)	30 (of which 25% from renewable sources)
THxME (tertiary-hexyl-methyl-ether produced on the basis of ethanol)	38 of which 14% from renewable sources)	30 (of which 14% from renewable sources)
FOSSIL FUELS		
Petrol	43	32
Diesel	43	36

↓ 2009/28/EC

~~Fuel~~	~~Energy content by weight~~ ~~(lower calorific value, MJ/kg)~~	~~Energy content by volume~~ ~~(lower calorific value, MJ/l)~~
~~Bioethanol (ethanol produced from biomass)~~	~~27~~	~~21~~
~~Bio-ETBE (ethyl-tertio-butyl-ether produced on the basis of bioethanol)~~	~~36 (of which 37 % from renewable~~	~~27 (of which 37 % from renewable~~

	~~sources)~~	~~sources)~~
~~Biomethanol (methanol produced from biomass, to be used as biofuel)~~	~~20~~	~~16~~
~~Bio-MTBE (methyl-tertio-butyl-ether produced on the basis of bio-methanol)~~	~~35 (of which 22 % from renewable sources)~~	~~26 (of which 22 % from renewable sources)~~
~~Bio-DME (dimethylether produced from biomass, to be used as biofuel)~~	~~28~~	~~19~~
~~Bio-TAEE (tertiary-amyl-ethyl-ether produced on the basis of bioethanol)~~	~~38 (of which 29 % from renewable sources)~~	~~29 (of which 29 % from renewable sources)~~
~~Biobutanol (butanol produced from biomass, to be used as biofuel)~~	~~33~~	~~27~~
~~Biodiesel (methyl-ester produced from vegetable or animal oil, of diesel quality, to be used as biofuel)~~	~~37~~	~~33~~
~~Fischer-Tropsch diesel (a synthetic hydrocarbon or mixture of synthetic hydrocarbons produced from biomass)~~	~~44~~	~~34~~
~~Hydrotreated vegetable oil (vegetable oil thermochemically treated with hydrogen)~~	~~44~~	~~34~~
~~Pure vegetable oil (oil produced from oil plants through pressing, extraction or comparable procedures, crude or refined but chemically unmodified, when compatible with the type of engines involved and the corresponding emission requirements)~~	~~37~~	~~34~~
~~Biogas (a fuel gas produced from biomass and/or from the biodegradable fraction of waste, that can be purified to natural gas quality, to be used as biofuel, or wood gas)~~	~~50~~	~~—~~
~~Petrol~~	~~43~~	~~32~~
~~Diesel~~	~~43~~	~~36~~

⬇ 2009/28/EC

ANNEX IV

Certification of installers

The certification schemes or equivalent qualification schemes referred to in Article 18 ~~14~~(3) shall be based on the following criteria:

1. The certification or qualification process shall be transparent and clearly defined by the Member State or the administrative body they appoint.

2. Biomass, heat pump, shallow geothermal and solar photovoltaic and solar thermal installers shall be certified by an accredited training programme or training provider.

3. The accreditation of the training programme or provider shall be effected by Member States or administrative bodies they appoint. The accrediting body shall ensure that the training programme offered by the training provider has continuity and regional or national coverage. The training provider shall have adequate technical facilities to provide practical training, including some laboratory equipment or corresponding facilities to provide practical training. The training provider shall also offer in addition to the basic training, shorter refresher courses on topical issues, including on new technologies, to enable life-long learning in installations. The training provider may be the manufacturer of the equipment or system, institutes or associations.

4. The training leading to installer certification or qualification shall include both theoretical and practical parts. At the end of the training, the installer must have the skills required to install the relevant equipment and systems to meet the performance and reliability needs of the customer, incorporate quality craftsmanship, and comply with all applicable codes and standards, including energy and eco-labelling.

5. The training course shall end with an examination leading to a certificate or qualification. The examination shall include a practical assessment of successfully installing biomass boilers or stoves, heat pumps, shallow geothermal installations, solar photovoltaic or solar thermal installations.

6. The certification schemes or equivalent qualification schemes referred to in Article 18 ~~14~~(3) shall take due account of the following guidelines:

(a) Accredited training programmes should be offered to installers with work experience, who have undergone, or are undergoing, the following types of training:

(i) in the case of biomass boiler and stove installers: training as a plumber, pipe fitter, heating engineer or technician of sanitary and heating or cooling equipment as a prerequisite;

(ii) in the case of heat pump installers: training as a plumber or refrigeration engineer and have basic electrical and plumbing skills (cutting pipe, soldering pipe joints, gluing pipe joints, lagging, sealing fittings, testing for leaks and installation of heating or cooling systems) as a prerequisite;

(iii) in the case of a solar photovoltaic or solar thermal installer: training as a plumber or electrician and have plumbing, electrical and roofing skills, including knowledge of soldering pipe joints, gluing pipe joints, sealing fittings, testing for plumbing leaks, ability to connect wiring, familiar with basic roof materials, flashing and sealing methods as a prerequisite; or

(iv) a vocational training scheme to provide an installer with adequate skills corresponding to a three years education in the skills referred to in point (a), (b) or (c) including both classroom and workplace learning.

(b) The theoretical part of the biomass stove and boiler installer training should give an overview of the market situation of biomass and cover ecological aspects, biomass fuels, logistics, fire protection, related subsidies, combustion techniques, firing systems, optimal hydraulic solutions, cost and profitability comparison as well as the design, installation, and maintenance of biomass boilers and stoves. The training should also provide good knowledge of any European standards for technology and biomass fuels, such as pellets, and biomass related national and Community law.

(c) The theoretical part of the heat pump installer training should give an overview of the market situation for heat pumps and cover geothermal resources and ground source temperatures of different regions, soil and rock identification for thermal conductivity, regulations on using geothermal resources, feasibility of using heat pumps in buildings and determining the most suitable heat pump system, and knowledge about their technical requirements, safety, air filtering, connection with the heat source and system layout. The training should also provide good knowledge of any European standards for heat pumps, and of relevant national and Community law. The installer should demonstrate the following key competences:

(i) a basic understanding of the physical and operation principles of a heat pump, including characteristics of the heat pump circle: context between low temperatures of the heat sink, high temperatures of the heat source, and the efficiency of the system, determination of the coefficient of performance (COP) and seasonal performance factor (SPF);

(ii) an understanding of the components and their function within a heat pump circle, including the compressor, expansion valve, evaporator, condenser, fixtures and fittings, lubricating oil, refrigerant, superheating and sub-cooling and cooling possibilities with heat pumps; and

(iii) the ability to choose and size the components in typical installation situations, including determining the typical values of the heat load of different buildings and for hot water production based on energy consumption, determining the capacity of the heat pump on the heat load for hot water production, on the storage mass of the building and on interruptible current supply; determine buffer tank component and its volume and integration of a second heating system.

(d) The theoretical part of the solar photovoltaic and solar thermal installer training should give an overview of the market situation of solar products and cost and profitability comparisons, and cover ecological aspects, components, characteristics and dimensioning of solar systems, selection of accurate systems and dimensioning of components, determination of the heat demand, fire protection, related subsidies, as well as the design, installation, and maintenance of solar photovoltaic and solar thermal installations. The training should also provide good knowledge of any European standards for technology, and certification such as Solar Keymark, and related national and Community law. The installer should demonstrate the following key competences:

(i) the ability to work safely using the required tools and equipment and implementing safety codes and standards and identify plumbing, electrical and other hazards associated with solar installations;

(ii) the ability to identify systems and their components specific to active and passive systems, including the mechanical design, and determine the components' location and system layout and configuration;

(iii) the ability to determine the required installation area, orientation and tilt for the solar photovoltaic and solar water heater, taking account of shading, solar access, structural integrity, the appropriateness of the installation for the building or the climate and identify different installation methods suitable for roof types and the balance of system equipment required for the installation; and

(iv) for solar photovoltaic systems in particular, the ability to adapt the electrical design, including determining design currents, selecting appropriate conductor types and ratings for each electrical circuit, determining appropriate size, ratings and locations for all associated equipment and subsystems and selecting an appropriate interconnection point.

(e) The installer certification should be time restricted, so that a refresher seminar or event would be necessary for continued certification.

🡻 2009/28/EC (adapted)
⇨ new

ANNEX V

Rules for calculating the greenhouse gas impact of biofuels, bioliquids and their fossil fuel comparators

A.*TYPICAL AND DEFAULT VALUES FOR BIOFUELS IF PRODUCED WITH NO NET CARBON EMISSIONS FROM LAND-USE CHANGE*

Biofuel production pathway	Typical greenhouse gas emission saving	Default greenhouse gas emission saving
sugar beet ethanol ⇨ (no biogas from slop, natural gas as process fuel in conventional boiler) ⇦	~~61 %~~ ⇨ 67% ⇦	~~52~~ ⇨ 59 ⇦ %
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in conventional boiler) ⇦	⇨ 77% ⇦	⇨ 73% ⇦
⇨ sugar beet, ethanol (no biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 73% ⇦	⇨ 68 % ⇦
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 79 % ⇦	⇨ 76 % ⇦
⇨ sugar beet ethanol (no biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 58% ⇦	⇨ 46% ⇦
⇨ sugar beet ethanol (with biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 71% ⇦	⇨ 64% ⇦
~~wheat ethanol (process fuel not specified)~~	~~32 %~~	~~16 %~~
~~wheat ethanol (lignite as process fuel in CHP plant)~~	~~32 %~~	~~16 %~~
~~wheat ethanol (natural gas as process fuel in conventional boiler)~~	~~45 %~~	~~34 %~~
~~wheat ethanol (natural gas as process fuel in CHP plant)~~	~~53 %~~	~~47 %~~
~~wheat ethanol (straw as process fuel in CHP plant)~~	~~69 %~~	~~69 %~~
⇨ corn (maize) ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 48 % ⇦	⇨ 40 % ⇦
corn (maize) ethanol, ~~Community produced~~ (natural gas as process fuel in CHP plant ⇨ * ⇦)	~~56~~ ⇨ 55 ⇦ %	~~49~~ ⇨ 48 % ⇦
⇨ corn (maize) ethanol (lignite as process fuel in CHP plant*) ⇦	⇨ 40 % ⇦	⇨ 28 % ⇦

⇨ corn (maize) ethanol (forest residues as process fuel in CHP plant*) ⇦	⇨ 69 % ⇦	⇨ 68 % ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 47 % ⇦	⇨ 38 % ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in CHP plant *) ⇦	⇨ 53 % ⇦	⇨ 46 % ⇦
⇨ other cereals excluding maize ethanol (lignite as process fuel in CHP plant *) ⇦	⇨ 37 % ⇦	⇨ 24 % ⇦
⇨ other cereals excluding maize ethanol (forest residues as process fuel in CHP plant *) ⇦	⇨ 67 % ⇦	⇨ 67 % ⇦
sugar cane ethanol	⇨ 70 % ⇦	⇨ 70 % ⇦
the part from renewable sources of ethyl-tertio-butyl-ether (ETBE)	Equal to that of the ethanol production pathway used	
the part from renewable sources of tertiary-amyl-ethyl-ether (TAEE)	Equal to that of the ethanol production pathway used	
rape seed biodiesel	~~45~~ ⇨ 52 ⇦ %	~~38~~ ⇨ 47 ⇦ %
sunflower biodiesel	~~58~~ ⇨ 57 ⇦ %	~~51~~ ⇨ 52 ⇦ %
soybean biodiesel	~~40~~ ⇨ 55 ⇦ %	~~31~~ ⇨ 50 ⇦ %
palm oil biodiesel (⇨ open effluent pond ⇦ ~~process not specified~~)	~~36~~ ⇨ 38 ⇦ %	~~19~~ ⇨ 25 ⇦ %
palm oil biodiesel (process with methane capture at oil mill)	~~62~~ ⇨ 57 ⇦ %	~~56~~ ⇨ 51 ⇦ %
waste ⇨ cooking ⇦ ~~vegetable or animal~~* oil biodiesel	~~88~~ ⇨ 83 ⇦ %	~~83~~ ⇨ 77 ⇦ %
⇨ animal fats from rendering biodiesel ⇦	⇨ 79% ⇦	⇨ 72 % ⇦
hydrotreated vegetable oil from rape seed	51%	47%
hydrotreated vegetable oil from sunflower	⇨ 58 ⇦ ~~65~~ %	⇨ 54 ⇦ ~~62~~ %
⇨ hydrotreated vegetable oil from soybean ⇦	⇨ 55%⇦	⇨ 51 % ⇦
hydrotreated vegetable oil from palm oil (⇨ open effluent pond ⇦ ~~process not~~	40 %	⇨ 28 ⇦ ~~26~~ %

specified)		
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	⇨ 59 ⇦ 68 %	⇨ 55 ⇦ 65 %
⇨ hydrotreated vegetable oil from waste cooking oil ⇦	⇨ 90 %⇦	⇨ 87% ⇦
⇨ hydrotreated vegetable oil from animal fats from rendering ⇦	⇨ 87% ⇦	⇨ 83 % ⇦
pure vegetable oil from rape seed	⇨ 59 % ⇦ 58%	57%
⇨ pure vegetable oil from sunflower ⇦	⇨ 65% ⇦	⇨ 64% ⇦
⇨ pure vegetable oil from soybean ⇦	⇨ 62 % ⇦	⇨ 61 % ⇦
⇨ pure vegetable oil from palm oil (open effluent pond) ⇦	⇨ 46 % ⇦	⇨ 36 % ⇦
⇨ pure vegetable oil from palm oil (process with methane capture at oil mill) ⇦	⇨ 65 % ⇦	⇨ 63 % ⇦
⇨ pure vegetable oil from waste cooking oil ⇦	⇨ 98 % ⇦	⇨ 98 % ⇦
biogas from municipal organic waste as compressed natural gas	80 %	73 %
biogas from wet manure as compressed natural gas	84 %	81 %
biogas from dry manure as compressed natural gas	86 %	82 %

(*) Not including animal oil produced from animal by-products classified as category 3 material in accordance with Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules on animal by-products not intended for human consumption [12]

⇩ new

(*) Default values for processes using CHP are valid only if ALL the process heat is supplied by CHP.

2 Not including animal oil produced from animal by-products classified as category 3 material in accordance with Regulation (EC) No 1774/2002 of the European Parliament and of the Council of 3 October 2002 laying down health rules on animal by-products not intended for human consumption

↓ 2009/28/EC (adapted)
⇨ new

B. ***ESTIMATED TYPICAL AND DEFAULT VALUES FOR FUTURE BIOFUELS THAT WERE NOT ON THE MARKET OR WERE ON THE MARKET ONLY IN NEGLIGIBLE QUANTITIES IN ~~JANUARY 2008~~ ⌦ 2016 ⌫ , IF PRODUCED WITH NO NET CARBON EMISSIONS FROM LAND-USE CHANGE***

Biofuel production pathway	Typical greenhouse gas emission saving	Default greenhouse gas emission saving
wheat straw ethanol	~~87 %~~ ⇨ 85% ⇦	~~85 %~~ ⇨ 83% ⇦
~~waste wood ethanol~~	~~80 %~~	~~74 %~~
~~farmed wood ethanol~~	~~76 %~~	~~70 %~~
waste wood Fischer-Tropsch diesel ⇨ in free-standing plant ⇦	~~95 %~~⇨ 85% ⇦	~~95 %~~⇨ 85% ⇦
farmed wood Fischer-Tropsch diesel ⇨ in free-standing plant ⇦	~~93 %~~⇨ 78% ⇦	~~93 %~~⇨ 78% ⇦
⇨ waste wood Fischer-Tropsch petrol in free-standing plant ⇦	⇨ 85% ⇦	⇨ 85% ⇦
⇨ farmed wood Fischer-Tropsch petrol in free-standing plant ⇦	⇨ 78% ⇦	⇨ 78% ⇦
waste wood dimethylether (DME) ⇨ in free-standing plant ⇦	⇨ 86% ⇦ ~~95%~~	⇨ 86% ⇦ ~~95%~~
farmed wood dimethylether (DME) ⇨ in free-standing plant ⇦	⇨ 79% ⇦ ~~92%~~	⇨ 79% ⇦~~92%~~
waste wood methanol ⇨ in free-standing plant ⇦	~~94 %~~ ⇨ 86% ⇦	~~94 %~~ ⇨ 86% ⇦
farmed wood methanol ⇨ in free-standing plant ⇦	~~91 %~~ ⇨ 79% ⇦	~~91 %~~⇨ 79% ⇦
⇨ Fischer – Tropsch diesel from black-liquor gasification integrated with pulp mill ⇦	⇨ 89 % ⇦	⇨ 89 % ⇦
⇨ Fischer – Tropsch petrol from black-liquor gasification integrated with pulp mill ⇦	⇨ 89 % ⇦	⇨ 89 % ⇦
⇨ dimethylether DME from black-liquor gasification integrated with pulp	⇨ 89 % ⇦	⇨ 89 % ⇦

mill ⇦		
⇨ Methanol from black-liquor gasification integrated with pulp mill ⇦	⇨ 89 % ⇦	⇨ 89 % ⇦
the part from renewable sources of methyl-tertio-butyl-ether (MTBE)	Equal to that of the methanol production pathway used	

C. *METHODOLOGY*

1. Greenhouse gas emissions from the production and use of transport fuels, biofuels and bioliquids shall be calculated as ⌦ follows ⌫:

⇩ new

(a) greenhouse gas emissions from the production and use of biofuels shall be calculated as:

🡻 2009/28/EC (adapted)

$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$ ~~$- e_{ee}$~~,

where

E	=	total emissions from the use of the fuel;
e_{ec}	=	emissions from the extraction or cultivation of raw materials;
e_l	=	annualised emissions from carbon stock changes caused by land-use change;
e_p	=	emissions from processing;
e_{td}	=	emissions from transport and distribution;
e_u	=	emissions from the fuel in use;
e_{sca}	=	emission savings from soil carbon accumulation via improved agricultural management;
e_{ccs}	=	emission savings from carbon capture and geological storage; ⌦ and ⌫
e_{ccr}	=	emission saving from carbon capture and replacement.~~; and~~
~~e_{ee}~~	~~=~~	~~emission saving from excess electricity from cogeneration.~~

Emissions from the manufacture of machinery and equipment shall not be taken into account.

⇩ new

(b) Greenhouse gas emissions from the production and use of bioliquids shall be calculated as for biofuels (E), but with the extension necessary for including the energy conversion to electricity and/or heat and cooling produced, as follows:

(i) Energy installations delivering only heat:

$$EC_h = \frac{E}{\eta_h}$$

(ii) For energy installations delivering only electricity:

$$EC_{el} = \frac{E}{\eta_{el}}$$

where

$EC_{h,el}$ = Total greenhouse gas emissions from the final energy commodity.

E =Total greenhouse gas emissions of the bioliquid before end-conversion.

η_{el} = The electrical efficiency, defined as the annual electricity produced divided by the annual bioliquid input based on its energy content.

η_h = The heat efficiency, defined as the annual useful heat output divided by the annual bioliquid input based on its energy content.

(iii) For the electricity or mechanical energy coming from energy installations delivering useful heat together with electricity and/or mechanical energy:

$$EC_{el} = \frac{E}{\eta_{el}} \left(\frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

(iv) For the useful heat coming from energy installations delivering heat together with electricity and/or mechanical energy:

$$EC_h = \frac{E}{\eta_h} \left(\frac{C_h \cdot \eta_h}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

where:

$EC_{h,el}$ = Total greenhouse gas emissions from the final energy commodity.

E =Total greenhouse gas emissions of the bioliquid before end-conversion.

η_{el} = The electrical efficiency, defined as the annual electricity produced divided by the annual energy input based on its energy content.

η_h = The heat efficiency, defined as the annual useful heat output divided by the annual energy input based on its energy content.

C_{el} = Fraction of exergy in the electricity, and/or mechanical energy, set to 100 % (C_{el} = 1).

C_h = Carnot efficiency (fraction of exergy in the useful heat).

The Carnot efficiency, C_h , for useful heat at different temperatures is defined as:

$$C_h = \frac{T_h - T_0}{T_h}$$

where

T_{hv} = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

T_0 = Temperature of surroundings, set at 273 kelvin (equal to 0 °C)

For T_h , < 150 °C (423.15 kelvin), C_h can alternatively be defined as follows:

C_h = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of this calculation, the following definitions shall apply:

(a) "cogeneration" shall mean the simultaneous generation in one process of thermal energy and electricity and/or mechanical energy;

(b) "useful" heat shall mean heat generated to satisfy an economical justifiable demand for heat for heating and cooling purposes;

(c) "economically justifiable demand" shall mean the demand that does not exceed the needs of heat or cooling and which would otherwise be satisfied at market conditions.

🡻 2009/28/EC
⇨ new

2. Greenhouse gas emissions from ⇨ biofuels and bioliquids shall be expressed as follows: ⇦ ~~fuels, E, shall be expressed in terms of grams of CO_2 equivalent per MJ of fuel, gCO_{2eq}/MJ.~~

⇩ new

(a) greenhouse gas emissions from biofuels, E, shall be expressed in terms of grams of CO_2 equivalent per MJ of fuel, gCO_{2eq} /MJ.

(b) greenhouse gas emissions from bioliquids, EC, in terms of grams of CO_2 equivalent per MJ of final energy commodity (heat or electricity), gCO_{2eq} /MJ.

When heating and cooling are co-generated with electricity emissions shall be allocated between heat and electricity (as under 1(b)) irrespective if the heat is used for actual heating purposes or for cooling[3].

Where the greenhouse gas emissions from the extraction or cultivation of raw materials e_{ec} are expressed in unit g CO_{2eq}/dry-ton of feedstock the conversion to grams of CO_2 equivalent per MJ of fuel, gCO_{2eq} /MJ share be calculated as follows;

$$e_{ec} fuel_a \left[\frac{gCO_2eq}{MJ\ fuel}\right]_{ec} = \frac{e_{ec}\ feedstock_a \left[\frac{gCO_2eq}{t_{dry}}\right]}{LHV_a \left[\frac{MJ\ feedstock}{t\ dry\ feedstock}\right]} * Fuel\ feedstock\ factor_a * Allocation\ factor\ fuel_a$$

where

$$Allocation\ factor\ fuel_a = \left[\frac{Energy\ in\ fuel}{Energy\ fuel + Energy\ in\ co - products}\right]$$

$$Fuel\ feedstock\ factor_a = [Ratio\ of\ MJ\ feedstock\ required\ to\ make\ 1\ MJ\ fuel]$$

Emissions per dry-ton feedstock shall be calculated as follows:

$$e_{ec} feedstock_a \left[\frac{gCO_2eq}{t_{dry}}\right] = \frac{e_{ec}\ feedstock_a \left[\frac{gCO_2eq}{t_{moist}}\right]}{(1 - moisture\ content)}$$

↓ 2009/28/EC (adapted)

~~3. By derogation from point 2, for transport fuels, values calculated in terms of gCO_{2eq}/MJ may be adjusted to take into account differences between fuels in useful work done, expressed in terms of km/MJ. Such adjustments shall be made only where evidence of the differences in useful work done is provided.~~

~~4.~~ 3. Greenhouse gas emission savings from biofuels and bioliquids shall be calculated as ⌦ follows ⌫ :

⇩ new

(a) greenhouse gas emission savings from biofuels:

[3] Heat or waste heat is used to generate cooling (chilled air or water) through absorption chillers. Therefore, it is appropriate to calculate only the emissions associated to the heat produced per MJ of heat, irrespectively if the end-use of the heat is actual heating or cooling via absorption chillers.

⇩ 2009/28/EC ⇨ new

SAVING = ⇨ ($E_{F(t)} – E_B / E_{F(t)}$) ⇦ , ~~($E_F – E_B$)/$E_F$~~,

where

E_B	=	total emissions from the biofuel; and
$E_{F(t)}$	=	total emissions from the fossil fuel comparator ⇨ for transport ⇦

⇩ new

(b) greenhouse gas emission savings from heat and cooling, and electricity being generated from bioliquids:

SAVING = $(EC_{F(h\&c,el,)} – EC_{B(h\&c,el)})/EC_{F\ (h\&c,el)}$,

where

$EC_{B(h\&c,el)}$ = total emissions from the heat or electricity; and

$EC_{F(h\&c,el)}$ = total emissions from the fossil fuel comparator for useful heat or electricity.

⇩ 2009/28/EC (adapted) ⇨ new

~~5~~.4. The greenhouse gases taken into account for the purposes of point 1 shall be CO_2, N_2O and CH_4. For the purpose of calculating CO_2 equivalence, those gases shall be valued as follows:

CO_2	:	1
N_2O	:	296 ⇨ 298 ⇦
CH_4	:	23 ⇨ 25 ⇦

~~6~~.5. Emissions from the extraction or cultivation of raw materials, e_{ec}, shall include emissions from the extraction or cultivation process itself; from the collection, ⇨ drying and storage ⇦ of raw materials; from waste and leakages; and from the production of chemicals or products used in extraction or cultivation. Capture of CO_2 in the cultivation of raw materials shall be excluded. ~~Certified reductions of greenhouse gas emissions from flaring at oil production sites anywhere in the world shall be deducted.~~ Estimates of emissions from ⇨ agriculture biomass ⇦ cultivation may be derived from the use of ⇨ regional ⇦ averages ⇨ for cultivation emissions included in the reports referred to in Article 28 (4) and the information on the disaggregated default values for cultivation emissions included in this Annex, as an alternative to using actual values. In absence of relevant information in the before mentioned reports it is allowed to calculate averages based on local farming practises based for instance on data of a group of farms ⇦ calculated for smaller geographical areas than those used in the ~~calculation of the default values~~, as an alternative to using actual values.

⇩ new

6. For the purposes of the calculation referred to in point 3, emission savings from improved agriculture management, such as shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop management, and the use of organic soil improver (e.g. compost, manure fermentation digestate), shall be taken into account only if solid and verifiable evidence is provided that the soil carbon has increased or that it is reasonable to expect to have increased over the period in which the raw materials concerned were cultivated while taking into account the emissions where such practices lead to increased fertiliser and herbicide use.

🡻 2015/1513 Art. 2.13 and Annex II.1

7. Annualised emissions from carbon stock changes caused by land-use change, e_l, shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions, the following rule shall be applied:

$e_l = (CS_R – CS_A) \times 3{,}664 \times 1/20 \times 1/P – e_B$,[4]

where

e_l	=	annualised greenhouse gas emissions from carbon stock change due to land-use change (measured as mass (grams) of CO_2-equivalent per unit of biofuel or bioliquid energy (megajoules)). 'Cropland'[5] and 'perennial cropland'[6] shall be regarded as one land use;
CS_R	=	the carbon stock per unit area associated with the reference land-use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). The reference land-use shall be the land-use in January 2008 or 20 years before the raw material was obtained, whichever was the later;
CS_A	=	the carbon stock per unit area associated with the actual land-use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;
P	=	the productivity of the crop (measured as biofuel or bioliquid energy per unit area per year) and

[4] The quotient obtained by dividing the molecular weight of CO_2 (44,010 g/mol) by the molecular weight of carbon (12,011 g/mol) is equal to 3,664.

[5] Cropland as defined by IPCC.

[6] Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.

e_B	=	bonus of 29 gCO_{2eq}/MJ biofuel or bioliquid if biomass is obtained from restored degraded land under the conditions provided for in point 8.

↓ 2009/28/EC (adapted)
⇨ new

8. The bonus of 29 gCO_{2eq}/MJ shall be attributed if evidence is provided that the land:

(a) was not in use for agriculture or any other activity in January 2008; and

(b) ~~falls into one of the following categories:~~

~~(i)~~ ⌦ is ⌫ severely degraded land, including such land that was formerly in agricultural use;

~~(ii) heavily contaminated land.~~

The bonus of 29 gCO_{2eq}/MJ shall apply for a period of up to ~~10~~ ⇨ 20 ⇦ years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under (~~i~~ b) are ensured ~~and that soil contamination for land falling under (ii) is reduced~~.

9. ~~The categories referred to in point 8(b) are defined as follows:~~

~~(a)~~'~~severely~~ Severely degraded land' means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded;

~~(b)'hHeavily contaminated land' means land that is unfit for the cultivation of food and feed due to soil contamination.~~

~~Such land shall include land that has been the subject of a Commission decision in accordance with the fourth subparagraph of Article 18(4).~~

10. The Commission shall ~~adopt~~ ⌦ review ⌫ , by 31 December ~~2009~~ ⇨ 2020 ⇦ , guidelines for the calculation of land carbon stocks[7] drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — volume 4 ⇨ and in accordance with the Regulation (EU) No 525/2013[8] and the Regulation (INSERT THE NO AFTER THE ADOPTION[9]) ⇦ .

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[7] Commission Decision of 10 June 2010 (2010/335/EU) on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC, OJ L 151 17.06.2010.

[8] Regulation (EU) 525/2013 of the European Parliament and of the Council of 21 may 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC, OJ L 165/13, 18.06.2013

[9] Regulation of the European Parliament and of the Council (INSERT THE DATE OF ENTRY INTO FORCE OF THIS REGULATION) on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry into the 2030 climate and energy framework and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and other information relevant to climate change.

The Commission guidelines shall serve as the basis for the calculation of land carbon stocks for the purposes of this Directive.

11. Emissions from processing, e_p, shall include emissions from the processing itself; from waste and leakages; and from the production of chemicals or products used in processing.

In accounting for the consumption of electricity not produced within the fuel production plant, the greenhouse gas emission intensity of the production and distribution of that electricity shall be assumed to be equal to the average emission intensity of the production and distribution of electricity in a defined region. By derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant, if that plant is not connected to the electricity grid.

⇩ new

Emissions from processing shall include emissions from drying of interim – products and materials where relevant.

🡻 2009/28/EC (adapted)
⇨ new

12. Emissions from transport and distribution, e_{td}, shall include emissions from the transport ~~and storage~~ of raw and semi-finished materials and from the storage and distribution of finished materials. Emissions from transport and distribution to be taken into account under point ~~6~~ 5 shall not be covered by this point.

13. Emissions from the fuel in use, e_u, shall be taken to be zero for biofuels and bioliquids.

Emissions on non-CO_2 greenhouse gases (N_2O and CH_4) from the fuel in use shall be included in the e_u factor for bioliquids.

14. Emission saving from carbon capture and geological storage e_{ccs}, that have not already been accounted for in e_p, shall be limited to emissions avoided through the capture and ⇨ storage ⇦ ~~sequestration~~ of emitted CO_2 directly related to the extraction, transport, processing and distribution of fuel ⇨ if stored in compliance with Directive 2009/31/EC on the geological storage of carbon dioxide ⇦ .

15. Emission saving from carbon capture and replacement, e_{ccr} ⇨ , shall be related directly to the production of biofuel or bioliquid they are attributed to, and ⇦shall be limited to emissions avoided through the capture of CO_2 of which the carbon originates from biomass and which is used ⇨ in the energy or transport sector ⇦ ~~to replace fossil-derived CO_2 used in commercial products and services.~~

⇩ new

16. Where a cogeneration unit – providing heat and/ or electricity to a fuel production process for which emissions are being calculated – produces excess electricity and/or excess useful heat, the greenhouse gas emissions shall be divided between the electricity and the useful heat according to the temperature of the heat (which reflects the usefulness (utility) of the heat). The allocation factor, called Carnot efficiency C_h, is calculated as follows for useful heat at different temperatures:

$$C_h = \frac{T_h - T_0}{T_h}$$

where

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

T_0 = Temperature of surroundings, set at 273 kelvin (equal to 0°C)

For T_h , < 150°C (423.15 kelvin), C_h can alternatively be defined as follows:

C_h = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of this calculation, the actual efficiencies shall be used, defined as the annual mechanical energy, electricity and heat produced respectively divided by the annual energy input.

For the purposes of this calculation, the following definitions shall apply:

(a) "cogeneration" shall mean the simultaneous generation in one process of thermal energy and electrical or mechanical energy;

(b) "useful" heat shall mean heat generated to satisfy an economical justifiable demand for heat;

(c)"economically justifiable demand" shall mean demand that does not exceed the needs for heating and which would otherwise be satisfied at market conditions .

↓ 2009/28/EC (adapted)
⇨ new

~~16. Emission saving from excess electricity from cogeneration, e_{ee}, shall be taken into account in relation to the excess electricity produced by fuel production systems that use cogeneration except where the fuel used for the cogeneration is a co-product other than an agricultural crop residue. In accounting for that excess electricity, the size of the cogeneration unit shall be assumed to be the minimum necessary for the cogeneration unit to supply the heat that is needed to produce the fuel. The greenhouse gas emission saving associated with that excess electricity shall be taken to be equal to the amount of greenhouse gas that would be emitted when an equal amount of electricity was generated in a power plant using the same fuel as the cogeneration unit.~~

17. Where a fuel production process produces, in combination, the fuel for which emissions are being calculated and one or more other products (co-products), greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content (determined by lower heating value in the case of co-products other than electricity ⇨ and heat ⇦). ⇨ The greenhouse gas intensity of excess useful heat or excess electricity is the same as the greenhouse gas intensity of heat or electricity delivered to the fuel production process and is determined from calculating the greenhouse intensity of all inputs and emissions, including the feedstock and CH4 and N2O emissions, to and from the cogeneration unit, boiler or other apparatus delivering heat or electricity to the fuel production

process. In case of cogeneration of electricity and heat the calculation is performed following point 16. ⇦

18. For the purposes of the calculation referred to in point 17, the emissions to be divided shall be ~~e_{ec} + e_l + those fractions of e_p, e_{td} and e_{ee}~~ ⇨ e_{ec} + e_l + e_{sca} + those fractions of e_p, e_{td}, e_{ccs}, and e_{ccr} ⇦ that take place up to and including the process step at which a co-product is produced. If any allocation to co-products has taken place at an earlier process step in the life-cycle, the fraction of those emissions assigned in the last such process step to the intermediate fuel product shall be used for this purpose instead of the total of those emissions.

⇩ new

In the case of biofuels and bioliquids, all co-products that do not fall under the scope of point 17, shall be taken into account for the purposes of that calculation. No emissions shall be allocated to wastes and residues. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purpose of the calculation.

Wastes and residues, including tree tops and branches, straw, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) and bagasse, shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials irrespectively of whether they are processed to interim products before being transformed into the final product.

In the case of fuels produced in refineries, other than the combination of processing plants with boilers or cogeneration units providing heat and/or electricity to the processing plant, the unit of analysis for the purposes of the calculation referred to in point 17 shall be the refinery.

🡻 2009/28/EC (adapted)
⇨ new

~~In the case of biofuels and bioliquids, all co-products, including electricity that does not fall under the scope of point 16, shall be taken into account for the purposes of that calculation, except for agricultural crop residues, including straw, bagasse, husks, cobs and nut shells. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purpose of the calculation.~~

~~Wastes, agricultural crop residues, including straw, bagasse, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined), shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials.~~

~~In the case of fuels produced in refineries, the unit of analysis for the purposes of the calculation referred to in point 17 shall be the refinery.~~

19. For biofuels, for the purposes of the calculation referred to in point ~~4~~3, the fossil fuel comparator ~~E_F~~ ⇨ $E_{F(t)}$ ⇦ shall be ~~the latest available actual average emissions from the fossil part of petrol and diesel consumed in the Community as reported under Directive 98/70/EC. If no such data are available, the value used shall be 83,8~~ ⇨ 94 ⇦ gCO_{2eq}/MJ.

For bioliquids used for electricity production, for the purposes of the calculation referred to in point ~~4~~3, the fossil fuel comparator E_F shall be ~~91~~ ⇨ 183 ⇦ gCO_{2eq}/MJ.

For bioliquids used for ⇨ the production of useful ⇦ heat ⇨ , as well as for the production of heating and/or cooling ⇦ ~~production~~, for the purposes of the calculation referred to in point ~~4~~3, the fossil fuel comparator E_F⇨ $_{(h\&c)}$ ⇦ shall be ~~77~~ ⇨ 80 ⇦ gCO_{2eq}/MJ.

~~For bioliquids used for cogeneration, for the purposes of the calculation referred to in point 4, the fossil fuel comparator E_F shall be 85 gCO_{2eq}/MJ.~~

D. *DISAGGREGATED DEFAULT VALUES FOR BIOFUELS AND BIOLIQUIDS*

Disaggregated default values for cultivation: 'e_{ec}' as defined in part C of this Annex ⌦ including soil N_2O emissions ⌫

⇩ new

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO2eq/MJ)	Default greenhouse gas emissions (gCO2eq/MJ)
sugar beet ethanol	9.6	9.6
corn (maize) ethanol	25.5	25.5
other cereals excluding corn (maize) ethanol	27.0	27.0
sugar cane ethanol	17.1	17.1
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	32.0	32.0
sunflower biodiesel	26.1	26.1
soybean biodiesel	21.4	21.4
palm oil biodiesel	20.7	20.7
waste cooking oil biodiesel	0	0

animal fats from rendering biodiesel	0	0
hydrotreated vegetable oil from rape seed	33.4	33.4
hydrotreated vegetable oil from sunflower	26.9	26.9
hydrotreated vegetable oil from soybean	22.2	22.2
hydrotreated vegetable oil from palm oil	21.7	21.7
hydrotreated vegetable oil from waste cooking oil	0	0
hydrotreated vegetable oil from animal fats from rendering	0	0
pure vegetable oil from rape seed	33.4	33.4
pure vegetable oil from sunflower	27.2	27.2
pure vegetable oil from soybean	22.3	22.3
pure vegetable oil from palm oil	21.6	21.6
pure vegetable oil from waste cooking oil	0	0

⬇ 2009/28/EC (adapted)

~~Biofuel and bioliquid production pathway~~	~~Typical greenhouse gas emissions~~ ~~(gCO_{2eq}/MJ)~~	~~Default greenhouse gas emissions~~ ~~(gCO_{2eq}/MJ)~~
~~sugar beet ethanol~~	~~12~~	~~12~~
~~wheat ethanol~~	~~23~~	~~23~~
~~corn (maize) ethanol, Community produced~~	~~20~~	~~20~~
~~sugar cane ethanol~~	~~14~~	~~14~~

the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	29	29
sunflower biodiesel	18	18
soybean biodiesel	19	19
palm oil biodiesel	14	14
waste vegetable or animal* oil biodiesel	0	0
hydrotreated vegetable oil from rape seed	30	30
hydrotreated vegetable oil from sunflower	18	18
hydrotreated vegetable oil from palm oil	15	15
pure vegetable oil from rape seed	30	30
biogas from municipal organic waste as compressed natural gas	0	0
biogas from wet manure as compressed natural gas	0	0
biogas from dry manure as compressed natural gas	0	0

(*) Not including animal oil produced from animal by-products classified as category 3 material in accordance with Regulation (EC) No 1774/2002

⇩ new

Disaggregated default values for cultivation: 'e_{ec}' - for soil N_2O emissions only (these are already included in disaggregated values for cultivation emissions in 'e_{ec}' table)

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO$_{2eq}$/MJ)	Default greenhouse gas emissions (gCO$_{2eq}$/MJ)
sugar beet ethanol	4.9	4.9

corn (maize) ethanol	13.7	13.7
other cereals excluding corn (maize) ethanol	14.1	14.1
sugar cane ethanol	2.1	2.1
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	17.6	17.6
sunflower biodiesel	12.2	12.2
soybean biodiesel	13.4	13.4
palm oil biodiesel	16.5	16.5
waste cooking oil biodiesel	0	0
animal fats from rendering biodiesel	0	0
hydrotreated vegetable oil from rape seed	18.0	18.0
hydrotreated vegetable oil from sunflower	12.5	12.5
hydrotreated vegetable oil from soybean	13.7	13.7
hydrotreated vegetable oil from palm oil	16.9	16.9
hydrotreated vegetable oil from waste cooking oil	0	0
hydrotreated vegetable oil from animal fats from rendering	0	0
pure vegetable oil from rape seed	17.6	17.6
pure vegetable oil from sunflower	12.2	12.2

pure vegetable oil from soybean	13.4	13.4
pure vegetable oil from palm oil	16.5	16.5
pure vegetable oil from waste cooking oil	0	0

🡻 2009/28/EC (adapted)
⇨ new

Disaggregated default values for processing ~~(including excess electricity)~~: 'e_p ~~– e_{ee}~~' as defined in part C of this Annex

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO$_{2eq}$/MJ)	Default greenhouse gas emissions (gCO$_{2eq}$/MJ)
sugar beet ethanol~~-~~⇨ (no biogas from slop, natural gas as process fuel in conventional boiler) ⇦	~~19~~ ⇨ 18.8 ⇦	~~26~~ ⇨ 26.3 ⇦
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in conventional boiler) ⇦	⇨ 9.7 ⇦	⇨ 13.6 ⇦
⇨ sugar beet, ethanol (no biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 13.2 ⇦	⇨ 18.5 ⇦
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 7.6 ⇦	⇨ 10.6 ⇦
⇨ sugar beet ethanol (no biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 27.4 ⇦	⇨ 38.3 ⇦
⇨ sugar beet ethanol (with biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 15.7 ⇦	⇨ 22.0⇦
~~wheat ethanol (process fuel not specified)~~	~~32~~	~~45~~
~~wheat ethanol (lignite as process fuel in CHP plant)~~	~~32~~	~~45~~
~~wheat ethanol (natural gas as process fuel~~	~~21~~	~~30~~

in conventional boiler)		
wheat ethanol (natural gas as process fuel in CHP plant)	14	19
wheat ethanol (straw as process fuel in CHP plant)	1	1
⇨ corn (maize) ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 20.8 ⇦	⇨ 29.1 ⇦
corn (maize) ethanol, Community produced (natural gas as process fuel in CHP plant)	15 ⇨ 14.8 ⇦	21 ⇨ 20.8 ⇦
⇨ corn (maize) ethanol (lignite as process fuel in CHP plant*) ⇦	⇨ 28.6 ⇦	⇨ 40.1 ⇦
⇨ corn (maize) ethanol (forest residues as process fuel in CHP plant*) ⇦	⇨ 1.8 ⇦	⇨ 2.6 ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 21.0 ⇦	⇨ 29.3 ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in CHP plant *) ⇦	⇨ 15.1 ⇦	⇨ 21.1 ⇦
⇨ other cereals excluding maize ethanol (lignite as process fuel in CHP plant *) ⇦	⇨ 30.3 ⇦	⇨ 42.5 ⇦
⇨ other cereals excluding maize ethanol (forest residues as process fuel in CHP plant *) ⇦	⇨ 1.5 ⇦	⇨ 2.2 ⇦
sugar cane ethanol	1 ⇨ 1.3 ⇦	1 ⇨ 1.8 ⇦
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	16 ⇨ 11.7 ⇦	22 ⇨ 16.3 ⇦
sunflower biodiesel	16 ⇨ 11.8 ⇦	22 ⇨ 16.5 ⇦
soybean biodiesel	18 ⇨ 12.1 ⇦	26 ⇨ 16.9 ⇦
palm oil biodiesel (process not specified ⇨ open effluent pond ⇦)	35 ⇨ 30.4⇦	49 ⇨ 42.6 ⇦

palm oil biodiesel (process with methane capture at oil mill)	~~13~~ ⇨ 13.2 ⇦	~~18~~ ⇨ 18.5 ⇦
waste ⇨ cooking ⇦ ~~vegetable or animal~~[10] oil biodiesel	~~9~~ ⇨ 14.1 ⇦	~~13~~ ⇨ 19.7 ⇦
⇨ animal fats from rendering biodiesel ⇦	⇨ 17.8 ⇦	⇨ 25.0 ⇦
hydrotreated vegetable oil from rape seed	~~10~~ ⇨ 10.7 ⇦	~~13~~ ⇨ 15.0 ⇦
hydrotreated vegetable oil from sunflower	~~10~~ ⇨ 10.5 ⇦	~~13~~ ⇨ 14.7 ⇦
⇨ hydrotreated vegetable oil from soybean ⇦	⇨ 10.9 ⇦	⇨ 15.2 ⇦
hydrotreated vegetable oil from palm oil (~~process not specified~~ ⇨ open effluent pond ⇦)	~~30~~ ⇨ 27.8⇦	~~42~~ ⇨ 38.9 ⇦
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	~~7~~ ⇨ 9.7 ⇦	~~9~~ ⇨ 13.6 ⇦
⇨ hydrotreated vegetable oil from waste cooking oil ⇦	⇨ 7.6 ⇦	⇨ 10.6 ⇦
⇨ hydrotreated vegetable oil from animal fats from rendering ⇦	⇨ 10.4 ⇦	⇨ 14.5 ⇦
pure vegetable oil from rape seed	~~4~~ ⇨ 3.7 ⇦	~~5~~ ⇨ 5.2 ⇦
⇨ pure vegetable oil from sunflower ⇦	⇨ 3.8 ⇦	⇨ 5.4 ⇦
⇨ pure vegetable oil from soybean ⇦	⇨ 4.2 ⇦	⇨ 5.9 ⇦
⇨ pure vegetable oil from palm oil (open effluent pond) ⇦	⇨ 22.6 ⇦	⇨ 31.7 ⇦
⇨ pure vegetable oil from palm oil (process with methane capture at oil mill) ⇦	⇨ 4.7 ⇦	⇨ 6.5 ⇦
⇨ pure vegetable oil from waste cooking oil ⇦	⇨ 0.6 ⇦	⇨ 0.8 ⇦
~~biogas from municipal organic waste as compressed natural gas~~	~~14~~	~~20~~
~~biogas from wet manure as compressed natural gas~~	~~8~~	~~11~~

10 ~~Not including animal oil produced from animal by-products classified as category 3 material in accordance with Regulation (EC) No 1774/2002.~~

~~biogas from dry manure as compressed natural gas~~	~~8~~	~~11~~

⇩ new

Disaggregated default values for oil extraction only (these are already included in disaggregated values for processing emissions in 'e_p 'table)

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
rape seed biodiesel	3.0	4.2
sunflower biodiesel	2.9	4.0
soybean biodiesel	3.2	4.4
palm oil biodiesel (open effluent pond)	20.9	29.2
palm oil biodiesel (process with methane capture at oil mill)	3.7	5.1
waste cooking oil biodiesel	0	0
animal fats from rendering biodiesel	4.3	6.0
hydrotreated vegetable oil from rape seed	3.1	4.4
hydrotreated vegetable oil from sunflower	3.0	4.1
hydrotreated vegetable oil from soybean	3.3	4.6
hydrotreated vegetable oil from palm oil (open effluent pond)	21.9	30.7
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	3.8	5.4
hydrotreated vegetable oil from waste cooking oil	0	0

hydrotreated vegetable oil from animal fats from rendering	4.6	6.4
pure vegetable oil from rape seed	3.1	4.4
pure vegetable oil from sunflower	3.0	4.2
pure vegetable oil from soybean	3.4	4.7
pure vegetable oil from palm oil (open effluent pond)	21.8	30.5
pure vegetable oil from palm oil (process with methane capture at oil mill)	3.8	5.3
pure vegetable oil from waste cooking oil	0	0

Disaggregated default values for transport and distribution: 'e_{td}' as defined in part C of this Annex

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
sugar beet ethanol (no biogas from slop, natural gas as process fuel in conventional boiler)	2.4	2.4
sugar beet ethanol (with biogas from slop, natural gas as process fuel in conventional boiler)	2.4	2.4
sugar beet ethanol (no biogas from slop, natural gas as process fuel in CHP plant*)	2.4	2.4
sugar beet ethanol (with biogas from slop, natural gas as process fuel in CHP plant*)	2.4	2.4
sugar beet ethanol (no biogas from slop, lignite as process fuel in CHP	2.4	2.4

plant *)		
sugar beet ethanol (with biogas from slop, lignite as process fuel in CHP plant *)	2.4	2.4
corn (maize) ethanol (natural gas as process fuel in CHP plant*)	2.2	2.2
corn (maize) ethanol (natural gas as process fuel in conventional boiler)	2.2	2.2
corn (maize) ethanol (lignite as process fuel in CHP plant*)	2.2	2.2
corn (maize) ethanol (forest residues as process fuel in CHP plant*)	2.2	2.2
other cereals excluding maize ethanol (natural gas as process fuel in conventional boiler)	2.2	2.2
other cereals excluding maize ethanol (natural gas as process fuel in CHP plant *)	2.2	2.2
other cereals excluding maize ethanol (lignite as process fuel in CHP plant *)	2.2	2.2
other cereals excluding maize ethanol (forest residues as process fuel in CHP plant *)	2.2	2.2
sugar cane ethanol	9.7	9.7
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	1.8	1.8
sunflower biodiesel	2.1	2.1

soybean biodiesel	8.9	8.9
palm oil biodiesel (open effluent pond)	6.9	6.9
palm oil biodiesel (process with methane capture at oil mill)	6.9	6.9
waste cooking oil biodiesel	1.9	1.9
animal fats from rendering biodiesel	1.7	1.7
hydrotreated vegetable oil from rape seed	1.7	1.7
hydrotreated vegetable oil from sunflower	2.0	2.0
hydrotreated vegetable oil from soybean	9.1	9.1
hydrotreated vegetable oil from palm oil (open effluent pond)	7.0	7.0
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	7.0	7.0
hydrotreated vegetable oil from waste cooking oil	1.8	1.8
hydrotreated vegetable oil from animal fats from rendering	1.5	1.5
pure vegetable oil from rape seed	1.4	1.4
pure vegetable oil from sunflower	1.7	1.7
pure vegetable oil from soybean	8.8	8.8
pure vegetable oil from palm oil (open effluent pond)	6.7	6.7
pure vegetable oil from palm oil (process with methane capture at oil mill)	6.7	6.7

pure vegetable oil from waste cooking oil	1.4	1.4

↓ 2009/28/EC

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
sugar beet ethanol	2	2
wheat ethanol	2	2
corn (maize) ethanol, Community produced	2	2
sugar cane ethanol	9	9
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	
the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	1	1
sunflower biodiesel	1	1
soybean biodiesel	13	13
palm oil biodiesel	5	5
waste vegetable or animal oil biodiesel	1	1
hydrotreated vegetable oil from rape seed	1	1
hydrotreated vegetable oil from sunflower	1	1
hydrotreated vegetable oil from palm oil	5	5
pure vegetable oil from rape seed	1	1
biogas from municipal organic waste as compressed natural gas	3	3

~~biogas from wet manure as compressed natural gas~~	~~5~~	~~5~~
~~biogas from dry manure as compressed natural gas~~	~~4~~	~~4~~

⇩ new

Disaggregated default values for transport and distribution of final fuel only. These are already included in table of "transport and distribution emissions e_{td}" as defined in part C of this Annex, but the following values are useful if an economic operator wishes to declare actual transport emissions for crops or oil transport only).

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO$_{2eq}$/MJ)	Default greenhouse gas emissions (gCO$_{2eq}$/MJ)
sugar beet ethanol (no biogas from slop, natural gas as process fuel in conventional boiler)	1.6	1.6
sugar beet ethanol (with biogas from slop, natural gas as process fuel in conventional boiler)	1.6	1.6
sugar beet, ethanol (no biogas from slop, natural gas as process fuel in CHP plant *)	1.6	1.6
sugar beet ethanol (with biogas from slop, natural gas as process fuel in CHP plant *)	1.6	1.6
sugar beet ethanol (no biogas from slop, lignite as process fuel in CHP plant *)	1.6	1.6
sugar beet ethanol (with biogas from slop, lignite as process fuel in CHP plant *)	1.6	1.6
maize ethanol (natural gas as process fuel in conventional boiler)	1.6	1.6
maize ethanol (natural gas as process fuel in CHP plant *)	1.6	1.6
maize ethanol (lignite as process fuel in	1.6	1.6

CHP plant *)		
maize ethanol (forest residues as process fuel in CHP plant *)	1.6	1.6
other cereals excluding maize ethanol (natural gas as process fuel in conventional boiler)	1.6	1.6
other cereals excluding maize ethanol (natural gas as process fuel in CHP plant *)	1.6	1.6
other cereals excluding maize ethanol (lignite as process fuel in CHP plant *)	1.6	1.6
other cereals excluding maize ethanol (forest residues as process fuel in CHP plant *)	1.6	1.6
sugar cane ethanol	6.0	6.0
the part of ethyl-tertio-butyl-ether (ETBE) from renewable ethanol	Will be considered equal to that of the ethanol production pathway used	
the part of tertiary-amyl-ethyl-ether (TAEE) from renewable ethanol	Will be considered equal to that of the ethanol production pathway used	
rape seed biodiesel	1.3	1.3
sunflower biodiesel	1.3	1.3
soybean biodiesel	1.3	1.3
palm oil biodiesel (open effluent pond)	1.3	1.3
palm oil biodiesel (process with methane capture at oil mill)	1.3	1.3
waste cooking oil biodiesel	1.3	1.3
animal fats from rendering biodiesel	1.3	1.3
hydrotreated vegetable oil from rape seed	1.2	1.2
hydrotreated vegetable oil from sunflower	1.2	1.2
hydrotreated vegetable oil from soybean	1.2	1.2

hydrotreated vegetable oil from palm oil (open effluent pond)	1.2	1.2
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	1.2	1.2
hydrotreated vegetable oil from waste cooking oil	1.2	1.2
hydrotreated vegetable oil from animal fats from rendering	1.2	1.2
pure vegetable oil from rape seed	0.8	0.8
pure vegetable oil from sunflower	0.8	0.8
pure vegetable oil from soybean	0.8	0.8
pure vegetable oil from palm oil (open effluent pond)	0.8	0.8
pure vegetable oil from palm oil (process with methane capture at oil mill)	0.8	0.8
pure vegetable oil from waste cooking oil	0.8	0.8

🡻 2009/28/EC (adapted)
⇨ new

Total for cultivation, processing, transport and distribution

⇨ Biofuel and bioliquid production pathway ⇦	⇨ Typical greenhouse gas emissions (gCO2eq/MJ)⇦	⇨ Default greenhouse gas emissions (gCO2eq/MJ) ⇦
sugar beet ethanol ⇨ (no biogas from slop, natural gas as process fuel in conventional boiler) ⇦	~~33~~ ⇨ 30.8 ⇦	~~40~~ ⇨ 38.3 ⇦
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in conventional boiler) ⇦	⇨ 21.7 ⇦	⇨ 25.6 ⇦

⇨ sugar beet ethanol (no biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 25.2 ⇦	⇨ 30.5 ⇦
⇨ sugar beet ethanol (with biogas from slop, natural gas as process fuel in CHP plant*) ⇦	⇨ 19.6 ⇦	⇨ 22.6 ⇦
⇨ sugar beet ethanol (no biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 39.4 ⇦	⇨ 50.3 ⇦
⇨ sugar beet ethanol (with biogas from slop, lignite as process fuel in CHP plant *) ⇦	⇨ 27.7 ⇦	⇨ 34.0 ⇦
⇨ corn (maize) ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 48.5 ⇦	⇨ 56.8 ⇦
corn (maize) ethanol, ~~Community produced~~ (natural gas as process fuel in CHP plant)	~~37~~ ⇨ 42.5 ⇦	~~43~~ ⇨ 48.5 ⇦
⇨ corn (maize) ethanol (lignite as process fuel in CHP plant*) ⇦	⇨ 56.3 ⇦	⇨ 67.8 ⇦
⇨ corn (maize) ethanol (forest residues as process fuel in CHP plant*) ⇦	⇨ 29.5 ⇦	⇨ 30.3 ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in conventional boiler) ⇦	⇨ 50.2 ⇦	⇨ 58.5 ⇦
⇨ other cereals excluding maize ethanol (natural gas as process fuel in CHP plant *) ⇦	⇨ 44.3 ⇦	⇨ 50.3 ⇦
⇨ other cereals excluding maize ethanol (lignite as process fuel in CHP plant *) ⇦	⇨ 59.5 ⇦	⇨ 71.7 ⇦
⇨ other cereals excluding maize ethanol (forest residues as process fuel in CHP plant *) ⇦	⇨ 30.7 ⇦	⇨ 31.4 ⇦
sugar cane ethanol	~~24~~ ⇨ 28.1 ⇦	~~24~~ ⇨ 28.6 ⇦
the part from renewable sources of ETBE	Equal to that of the ethanol production pathway used	

the part from renewable sources of TAEE	Equal to that of the ethanol production pathway used	
rape seed biodiesel	~~46~~ ⇨ 45.5 ⇦	~~52~~ ⇨ 50.1 ⇦
sunflower biodiesel	~~35~~ ⇨ 40.0 ⇦	~~41~~ ⇨ 44.7 ⇦
soybean biodiesel	~~50~~ ⇨ 42.4 ⇦	~~58~~ ⇨ 47.2 ⇦
palm oil biodiesel (~~process not specified~~ ⇨ open effluent pond ⇦)	~~54~~ ⇨ 58.0 ⇦	~~68~~ ⇨ 70.2 ⇦
palm oil biodiesel (process with methane capture at oil mill)	~~32~~ ⇨ 40.8 ⇦	~~37~~ ⇨ 46.1 ⇦
waste ~~vegetable or animal~~ ⇨ cooking ⇦ oil biodiesel	~~10~~ ⇨ 16.0 ⇦	~~14~~ ⇨ 21.6 ⇦
⇨ animals fat from rendering biodiesel ⇦	⇨ 19.5 ⇦	⇨ 26.7 ⇦
hydrotreated vegetable oil from rape seed	~~41~~ ⇨ 45.8 ⇦	~~44~~ ⇨ 50.1 ⇦
hydrotreated vegetable oil from sunflower	~~29~~ ⇨ 39.4 ⇦	~~32~~ ⇨ 43.6 ⇦
hydrotreated vegetable oil from soybean	⇨ 42.2 ⇦	⇨ 46.5 ⇦
hydrotreated vegetable oil from palm oil ~~(process not specified)~~ ⇨(open effluent pond) ⇦	~~50~~ ⇨ 56.5 ⇦	~~62~~ ⇨ 67.6 ⇦
hydrotreated vegetable oil from palm oil (process with methane capture at oil mill)	~~27~~ ⇨ 38.4 ⇦	~~29~~ ⇨ 42.3 ⇦
⇨ hydrotreated vegetable oil from waste cooking oil ⇦	⇨ 9.4 ⇦	⇨ 12.4 ⇦
⇨ hydrotreated vegetable oil from animal fats from rendering ⇦	⇨ 11.9 ⇦	⇨ 16.0 ⇦
⇨ pure vegetable oil from rape seed ⇦	~~35~~ ⇨ 38.5 ⇦	~~36~~ ⇨ 40.0 ⇦
⇨ pure vegetable oil from sunflower ⇦	⇨ 32.7 ⇦	⇨ 34.3 ⇦
⇨ pure vegetable oil from soybean ⇦	⇨ 35.3 ⇦	⇨ 37.0 ⇦
⇨ pure vegetable oil from palm oil (open effluent pond) ⇦	⇨ 50.9 ⇦	⇨ 60.0 ⇦
⇨ pure vegetable oil from palm oil (process with methane capture at oil mill) ⇦	⇨ 33.0 ⇦	⇨ 34.8 ⇦

⇨ pure vegetable oil from waste cooking oil ⇦	⇨ 2.0 ⇦	⇨ 2.2 ⇦
~~biogas from municipal organic waste as compressed natural gas~~	~~17~~	~~23~~
~~biogas from wet manure as compressed natural gas~~	~~13~~	~~16~~
~~biogas from dry manure as compressed natural gas~~	~~12~~	~~15~~

⇩ new

(*) Default values for processes using CHP are valid only if ALL the process heat is supplied by CHP.

🡻 2009/28/EC (adapted)
⇨ new

E. *ESTIMATED DISAGGREGATED DEFAULT VALUES FOR FUTURE BIOFUELS AND BIOLIQUIDS THAT WERE NOT ON THE MARKET OR WERE ONLY ON THE MARKET IN NEGLIGIBLE QUANTITIES IN ~~JANUARY 2008~~ ⌦ 2016 ⌫*

Disaggregated default values for cultivation: 'e_{ec}' as defined in part C of this Annex ⌦ including N_2O emissions (including chipping of waste or farmed wood) ⌫

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO$_{2eq}$/MJ)	Default greenhouse gas emissions (gCO$_{2eq}$/MJ)
wheat straw ethanol	1.8	1.8
waste wood Fischer-Tropsch diesel in free-standing plant	3.3	3.3
farmed wood Fischer-Tropsch diesel in free-standing plant	12.4	12.4
waste wood Fischer-Tropsch petrol in free-standing plant	3.3	3.3

farmed wood Fischer-Tropsch petrol in free-standing plant	12.4	12.4
waste wood dimethylether (DME) in free-standing plant	3.1	3.1
farmed wood dimethylether DME in free-standing plant	11.4	11.4
waste wood methanol in free-standing plant	3.1	3.1
farmed wood methanol in free-standing plant	11.4	11.4
Fischer Tropsch diesel from black-liquor gasification integrated with pulp mill	2.5	2.5
Fischer Tropsch petrol from black-liquor gasification integrated with pulp mill	2.5	2.5
dimethylether DME from black-liquor gasification integrated with pulp mill	2.5	2.5
Methanol from black-liquor gasification integrated with pulp mill	2.5	2.5
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

~~Biofuel and bioliquid production pathway~~	~~Typical greenhouse gas emissions~~ ~~(gCO$_{2eq}$/MJ)~~	~~Default greenhouse gas emissions~~ ~~(gCO$_{2eq}$/MJ)~~
~~wheat straw ethanol~~	~~3~~	~~3~~
~~waste wood ethanol~~	~~1~~	~~1~~

~~farmed wood ethanol~~	~~6~~	~~6~~
~~waste wood Fischer-Tropsch diesel~~	~~1~~	~~1~~
~~farmed wood Fischer-Tropsch diesel~~	~~4~~	~~4~~
~~waste wood DME~~	~~1~~	~~1~~
~~farmed wood DME~~	~~5~~	~~5~~
~~waste wood methanol~~	~~1~~	~~1~~
~~farmed wood methanol~~	~~5~~	~~5~~
~~the part from renewable sources of MTBE~~	~~Equal to that of the methanol production pathway used~~	

⇩ new

Disaggregated default values for field N_2O emissions (included in disaggregated default values for cultivation emissions in 'e_{ec}' table)

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
wheat straw ethanol	0	0
waste wood Fischer-Tropsch diesel in free-standing plant	0	0
farmed wood Fischer-Tropsch diesel in free-standing plant	4.4	4.4
waste wood Fischer-Tropsch petrol in free-standing plant	0	0
farmed wood Fischer-Tropsch petrol in free-standing plant	4.4	4.4
waste wood dimethylether (DME) in free-standing	0	0

plant		
farmed wood dimethylether DME in free-standing plant	4.1	4.1
waste wood methanol in free-standing plant	0	0
farmed wood methanol in free-standing plant	4.1	4.1
Fischer-Tropsch diesel from black-liquor gasification integrated with pulp mill	0	0
Fischer-Tropsch petrol from black-liquor gasification integrated with pulp mill	0	0
dimethylether DME from black-liquor gasification integrated with pulp mill	0	0
Methanol from black-liquor gasification integrated with pulp mill	0	0
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

⇩ new

Disaggregated default values for processing: 'e_p' as defined in part C of this Annex

~~Biofuel and bioliquid production pathway~~	~~Typical greenhouse gas emissions (gCO2eq/MJ)~~	~~Default greenhouse gas emissions (gCO2eq/MJ)~~
~~wheat straw ethanol~~	~~5~~	~~7~~
~~wood ethanol~~	~~12~~	~~17~~
~~wood Fischer-Tropsch diesel~~	~~0~~	~~0~~
~~wood DME~~	~~0~~	~~0~~

~~wood methanol~~	~~0~~	~~0~~
~~the part from renewable sources of MTBE~~	~~Equal to that of the methanol production pathway used~~	
Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
wheat straw ethanol	4.8	6.8
waste wood Fischer-Tropsch diesel in free-standing plant	0.1	0.1
farmed wood Fischer-Tropsch diesel in free-standing plant	0.1	0.1
waste wood Fischer-Tropsch petrol in free-standing plant	0.1	0.1
farmed wood Fischer-Tropsch petrol in free-standing plant	0.1	0.1
waste wood dimethylether (DME) in free-standing plant	0	0
farmed wood dimethylether (DME) in free-standing plant	0	0
waste wood methanol in free-standing plant	0	0
farmed wood methanol in free-standing plant	0	0
Fischer - Tropsch diesel from black-liquor gasification integrated with pulp mill	0	0

Fischer – Tropsch petrol from black-liquor gasification integrated with pulp mill	0	0
dimethylether DME from black-liquor gasification integrated with pulp mill	0	0
methanol from black-liquor gasification integrated with pulp mill	0	0
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

Disaggregated default values for transport and distribution: 'e_{td}' as defined in part C of this Annex

⇩ new

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
wheat straw ethanol	7.1	7.1
waste wood Fischer-Tropsch diesel in free-standing plant	10.3	10.3
farmed wood Fischer-Tropsch diesel in free-standing plant	8.4	8.4
waste wood Fischer-Tropsch petrol in free-standing plant	10.3	10.3
farmed wood Fischer-Tropsch petrol in free-standing plant	8.4	8.4
waste wood dimethylether (DME) in free-standing	10.4	10.4

plant		
farmed wood dimethylether (DME) in free-standing plant	8.6	8.6
waste wood methanol in free-standing plant	10.4	10.4
farmed wood methanol in free-standing plant	8.6	8.6
Fischer - Tropsch diesel from black-liquor gasification integrated with pulp mill	7.7	7.7
Fischer – Tropsch petrol from black-liquor gasification integrated with pulp mill	7.9	7.9
DME from black-liquor gasification integrated with pulp mill	7.7	7.7
methanol from black-liquor gasification integrated with pulp mill	7.9	7.9
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

🡻 2009/28/EC (adapted)
⇨ new

~~Biofuel and bioliquid production pathway~~	~~Typical greenhouse gas emissions~~ ~~(gCO$_{2eq}$/MJ)~~	~~Default greenhouse gas emissions~~ ~~(gCO$_{2eq}$/MJ)~~
~~wheat straw ethanol~~	~~2~~	~~2~~
~~waste wood ethanol~~	~~4~~	~~4~~

~~farmed wood ethanol~~	~~2~~	~~2~~
~~waste wood Fischer-Tropsch diesel~~	~~3~~	~~3~~
~~farmed wood Fischer-Tropsch diesel~~	~~2~~	~~2~~
~~waste wood DME~~	~~4~~	~~4~~
~~farmed wood DME~~	~~2~~	~~2~~
~~waste wood methanol~~	~~4~~	~~4~~
~~farmed wood methanol~~	~~2~~	~~2~~
~~the part from renewable sources of MTBE~~	~~Equal to that of the methanol production pathway used~~	

Disaggregated default values for transport and distribution of final fuel only. These are already included in table of "transport and distribution emissions e_{td}" as defined in part C of this Annex, but the following values are useful if an economic operator wishes to declare actual transport emissions for feedstock transport only).

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
wheat straw ethanol	1.6	1.6
waste wood Fischer-Tropsch diesel in free-standing plant	1.2	1.2
farmed wood Fischer-Tropsch diesel in free-standing plant	1.2	1.2
waste wood Fischer-Tropsch petrol in free-standing plant	1.2	1.2
farmed wood Fischer-Tropsch petrol in free-standing plant	1.2	1.2

waste wood dimethylether (DME) in free-standing plant	2.0	2.0
farmed wood DME in free-standing plant	2.0	2.0
waste wood methanol in free-standing plant	2.0	2.0
farmed wood methanol in free-standing plant	2.0	2.0
Fischer Tropsch diesel from black-liquor gasification integrated with pulp mill	2.0	2.0
Fischer Tropsch petrol from black-liquor gasification integrated with pulp mill	2.0	2.0
DME from black-liquor gasification integrated with pulp mill	2.0	2.0
methanol from black-liquor gasification integrated with pulp mill	2.0	2.0
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

Total for cultivation, processing, transport and distribution

Biofuel and bioliquid production pathway	Typical greenhouse gas emissions (gCO_{2eq}/MJ)	Default greenhouse gas emissions (gCO_{2eq}/MJ)
wheat straw ethanol	13.7	15.7
waste wood Fischer-Tropsch diesel in free-standing plant	13.7	13.7
farmed wood Fischer-Tropsch diesel in free-	20.9	20.9

standing plant		
waste wood Fischer-Tropsch petrol in free-standing plant	13.7	13.7
farmed wood Fischer-Tropsch petrol in free-standing plant	20.9	20.9
waste wood dimethylether (DME) in free-standing plant	13.5	13.5
farmed wood dimethylether (DME) in free-standing plant	20.0	20.0
waste wood methanol in free-standing plant	13.5	13.5
farmed wood methanol in free-standing plant	20.0	20.0
Fischer - Tropsch diesel from black-liquor gasification integrated with pulp mill	10.2	10.2
Fischer – Tropsch petrol from black-liquor gasification integrated with pulp mill	10.4	10.4
dimethylether DME from black-liquor gasification integrated with pulp mill	10.2	10.2
methanol from black-liquor gasification integrated with pulp mill	10.4	10.4
the part from renewable sources of MTBE	Equal to that of the methanol production pathway used	

~~Biofuel and bioliquid~~	~~Typical greenhouse gas~~	~~Default greenhouse gas~~

~~production pathway~~	~~emissions (gCO2eq/MJ)~~	~~emissions (gCO2eq/MJ)~~
~~wheat straw ethanol~~	~~11~~	~~13~~
~~waste wood ethanol~~	~~17~~	~~22~~
~~farmed wood ethanol~~	~~20~~	~~25~~
~~Waste wood Fischer-Tropsch petrol~~	~~4~~	~~4~~
~~farmed wood Fischer-Tropsch petrol~~	~~6~~	~~6~~
~~waste wood DME~~	~~5~~	~~5~~
~~farmed wood DME~~	~~7~~	~~7~~
~~waste wood methanol~~	~~5~~	~~5~~
~~farm wood methanol~~	~~7~~	~~7~~
~~The part from renewable sources of MTBE~~	~~Equal to that of the methanol production pathway used~~	

⇩ new

ANNEX VI

Rules for calculating the greenhouse gas impact of biomass fuels and their fossil fuel comparators

A. TYPICAL AND DEFAULT VALUES OF GREENHOUSE GAS EMISSION SAVINGS FOR BIOMASS FUELS IF PRODUCED WITH NO NET-CARBON EMISSIONS FROM LAND-USE CHANGE

WOODCHIPS					
Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emission savings**		**Default greenhouse gas emission savings**	
		Heat	Electricity	Heat	Electricity
Woodchips from forest residues	1 to 500 km	93%	89%	91%	87%
	500 to 2500 km	89%	84%	87%	81%
	2500 to 10 000 km	82%	73%	78%	67%
	Above 10000 km	67%	51%	60%	41%
Woodchips from short rotation coppice (Eucalyptus)	2500 to 10 000 km	64%	46%	61%	41%
Woodchips from	1 to 500 km	89%	83%	87%	81%

short rotation coppice (Poplar - Fertilised)	500 to 2500 km	85%	78%	84%	76%
	2500 to 10 000 km	78%	67%	74%	62%
	Above 10000 km	63%	45%	57%	35%
Woodchips from short rotation coppice (Poplar – No fertilisation)	1 to 500 km	91%	87%	90%	85%
	500 to 2500 km	88%	82%	86%	79%
	2500 to 10 000 km	80%	70%	77%	65%
	Above 10000 km	65%	48%	59%	39%
Woodchips from stemwood	1 to 500 km	93%	89%	92%	88%
	500 to 2500 km	90%	85%	88%	82%
	2500 to 10 000 km	82%	73%	79%	68%
	Above 10000 km	67%	51%	61%	42%
Woodchips from industry residues	1 to 500 km	94%	92%	93%	90%
	500 to 2500 km	91%	87%	90%	85%
	2500 to 10 000 km	83%	75%	80%	71%
	Above 10000 km	69%	54%	63%	44%

WOOD PELLETS*

Biomass fuel production system		Transport distance	Typical greenhouse gas emission savings		Default greenhouse gas emission savings	
			Heat	Electricity	Heat	Electricity
Wood briquettes or pellets	Case 1	1 to 500 km	58%	37%	49%	24%
		500 to 2500 km	58%	37%	49%	25%

from forest residues		2500 to 10 000 km	55%	34%	47%	21%
		Above 10000 km	50%	26%	40%	11%
	Case 2a	1 to 500 km	77%	66%	72%	59%
		500 to 2500 km	77%	66%	72%	59%
		2500 to 10 000 km	75%	62%	70%	55%
		Above 10000 km	69%	54%	63%	45%
	Case 3a	1 to 500 km	92%	88%	90%	85%
		500 to 2500 km	92%	88%	90%	86%
		2500 to 10 000 km	90%	85%	88%	81%
		Above 10000 km	84%	76%	81%	72%
Wood briquettes or pellets from short rotation coppice (Eucalyptus)	Case 1	2500 to 10 000 km	40%	11%	32%	-2%
	Case 2a	2500 to 10 000 km	56%	34%	51%	27%
	Case 3a	2500 to 10 000 km	70%	55%	68%	53%
Wood pellets briquettes or from short rotation coppice (Poplar - Fertilised)	Case 1	1 to 500 km	54%	32%	46%	20%
		500 to 10 000 km	52%	29%	44%	16%
		Above 10 000 km	47%	21%	37%	7%
	Case 2a	1 to 500 km	73%	60%	69%	54%
		500 to 10 000 km	71%	57%	67%	50%
		Above 10	66%	49%	60%	41%

		000 km				
	Case 3a	1 to 500 km	88%	82%	87%	81%
		500 to 10 000 km	86%	79%	84%	77%
		Above 10 000 km	80%	71%	78%	67%
Wood briquettes or pellets from short rotation coppice (Poplar – No fertilisation)	Case 1	1 to 500 km	56%	35%	48%	23%
		500 to 10 000 km	54%	32%	46%	20%
		Above 10 000 km	49%	24%	40%	10%
	Case 2a	1 to 500 km	76%	64%	72%	58%
		500 to 10 000 km	74%	61%	69%	54%
		Above 10 000 km	68%	53%	63%	45%
	Case 3a	1 to 500 km	91%	86%	90%	85%
		500 to 10 000 km	89%	83%	87%	81%
		Above 10 000 km	83%	75%	81%	71%
Stemwood	Case 1	1 to 500 km	57%	37%	49%	24%
		500 to 2500 km	58%	37%	49%	25%
		2500 to 10 000 km	55%	34%	47%	21%
		Above 10000 km	50%	26%	40%	11%
	Case 2a	1 to 500 km	77%	66%	73%	60%
		500 to 2500 km	77%	66%	73%	60%
		2500 to 10 000 km	75%	63%	70%	56%
		Above	70%	55%	64%	46%

		10000 km				
	Case 3a	1 to 500 km	92%	88%	91%	86%
		500 to 2500 km	92%	88%	91%	87%
		2500 to 10 000 km	90%	85%	88%	83%
		Above 10000 km	84%	77%	82%	73%
Wood briquettes or pellets from wood industry residues	Case 1	1 to 500 km	75%	62%	69%	55%
		500 to 2500 km	75%	62%	70%	55%
		2500 to 10 000 km	72%	59%	67%	51%
		Above 10000 km	67%	51%	61%	42%
	Case 2a	1 to 500 km	87%	80%	84%	76%
		500 to 2500 km	87%	80%	84%	77%
		2500 to 10 000 km	85%	77%	82%	73%
		Above 10000 km	79%	69%	75%	63%
	Case 3a	1 to 500 km	95%	93%	94%	91%
		500 to 2500 km	95%	93%	94%	92%
		2500 to 10 000 km	93%	90%	92%	88%
		Above 10000 km	88%	82%	85%	78%

* Case 1 refers to processes in which a natural gas boiler is used to provide the process heat to the pellet mill. Power for the pellet mill is supplied from the grid;

Case 2a refers to processes in which a woodchips boiler, fed with pre-dried chips, is used to provide process heat. Power for the pellet mill is supplied from the grid;

Case 3a refers to processes in which a CHP, fed with pre-dried woodchips, is used to provide power and heat to the pellet mill.

AGRICULTURE PATHWAYS					
Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emission savings**		**Default greenhouse gas emission savings**	
		Heat	Electricity	Heat	Electricity
Agricultural Residues with density <0.2 t/m3*	1 to 500 km	95%	92%	93%	90%
	500 to 2500 km	89%	83%	86%	80%
	2500 to 10 000 km	77%	66%	73%	60%
	Above 10000 km	57%	36%	48%	23%
Agricultural Residues with density > 0.2 t/m3**	1 to 500 km	95%	92%	93%	90%
	500 to 2500 km	93%	89%	92%	87%
	2500 to 10 000 km	88%	82%	85%	78%
	Above 10000 km	78%	68%	74%	61%
Straw pellets	1 to 500 km	88%	82%	85%	78%
	500 to 10000 km	86%	79%	83%	74%
	Above 10000 km	80%	70%	76%	64%
Bagasse briquettes	500 to 10 000 km	93%	89%	91%	87%
	Above 10 000 km	87%	81%	85%	77%
Palm Kernel Meal	Above 10000 km	20%	-18%	11%	-33%
Palm Kernel Meal (no CH4 emissions from oil mill)	Above 10000 km	46%	20%	42%	14%

* This group of materials includes agricultural residues with a low bulk density and it comprises materials such as straw bales, oat hulls, rice husks and sugar cane bagasse bales (not exhaustive list)

** The group of agricultural residues with higher bulk density includes materials such as corn cobs, nut shells, soybean hulls, palm kernel shells (not exhaustive list).

BIOGAS FOR ELECTRICITY*				
Biogas production system		**Technological option**	**Typical greenhouse gas emission savings**	**Default greenhouse gas emission savings**
Wet manure[11]	Case 1	Open digestate[12]	146%	94%
		Close digestate[13]	246%	240%
	Case 2	Open digestate	136%	85%
		Close digestate	227%	219%
	Case 3	Open digestate	142%	86%
		Close digestate	243%	235%
Maize whole plant[14]	Case 1	Open digestate	36%	21%
		Close digestate	59%	53%
	Case 2	Open digestate	34%	18%
		Close	55%	47%

[11] The values for biogas production from manure include negative emissions for emissions saved from raw manure management. The value of esca considered is equal to -45 gCO2eq./MJ manure used in anaerobic digestion

[12] Open storage of digestate accounts for additional emissions of methane and N2O. The magnitude of these emissions changes with ambient conditions, substrate types and the digestion efficiency (see chapter 5 for more details).

[13] Close storage means that the digestate resulting from the digestion process is stored in a gas-tight tank and the additional biogas released during storage is considered to be recovered for production of additional electricity or biomethane. No emissions of GHG are included in this process.

[14] Maize whole plant should be interpreted as maize harvested as fodder and ensiled for preservation.

		digestate		
	Case 3	Open digestate	28%	10%
		Close digestate	52%	43%
Biowaste	Case 1	Open digestate	47%	26%
		Close digestate	84%	78%
	Case 2	Open digestate	43%	21%
		Close digestate	77%	68%
	Case 3	Open digestate	38%	14%
		Close digestate	76%	66%

* Case 1 refers to pathways in which power and heat required in the process are supplied by the CHP engine itself.

Case 2 refers to pathways in which the electricity required in the process is taken from the grid and the process heat is supplied by the CHP engine itself. In some Member States, operators are not allowed to claim the gross production for subsidies and Case 1 is the more likely configuration.

Case 3 refers to pathways in which the electricity required in the process is taken from the grid and the process heat is supplied by a biogas boiler. This case applies to some installations in which the CHP engine is not on-site and biogas is sold (but not upgraded to biomethane).

BIOGAS FOR ELECTRICITY – MIXTURES OF MANURE AND MAIZE				
Biogas production system		**Technological option**	**Typical greenhouse gas emission savings**	**Default greenhouse gas emission savings**
Manure – Maize 80% - 20%	Case 1	Open digestate	72%	45%
		Close digestate	120%	114%

	Case 2	Open digestate	67%	40%
		Close digestate	111%	103%
	Case 3	Open digestate	65%	35%
		Close digestate	114%	106%
Manure – Maize 70% - 30%	Case 1	Open digestate	60%	37%
		Close digestate	100%	94%
	Case 2	Open digestate	57%	32%
		Close digestate	93%	85%
	Case 3	Open digestate	53%	27%
		Close digestate	94%	85%
Manure – Maize 60% - 40%	Case 1	Open digestate	53%	32%
		Close digestate	88%	82%
	Case 2	Open digestate	50%	28%
		Close digestate	82%	73%
	Case 3	Open digestate	46%	22%
		Close digestate	81%	72%

BIOMETHANE FOR TRANSPORT*

Biomethane production system	**Technological options**	**Typical greenhouse gas emission** savings	**Typical greenhouse gas emission** savings
Wet manure	Open digestate, no-off gas combustion	117%	72%
	Open digestate, off gas combustion	133%	94%
	Close digestate, no-off gas combustion	190%	179%
	Close digestate, off gas combustion	206%	202%
Maize whole plant	Open digestate, no off-gas combustion	35%	17%
	Open digestate, off gas combustion	51%	39%
	Close digestate, no off-gas combustion	52%	41%
	Close digestate, off-gas combustion	68%	63%
Biowaste	Open digestate, no off-gas combustion	43%	20%
	Open digestate, off gas combustion	59%	42%
	Close digestate, no off-gas combustion	70%	58%
	Close digestate, off-gas combustion	86%	80%

*The savings for biomethane only refer to compressed biomethane relative to the fossil fuel comparator for transport of 94 gCO2 eq./MJ.

BIOMETHANE - MIXTURES OF MANURE AND MAIZE*			
Biomethane production system	**Technological options**	**Typical greenhouse gas emission** savings	**Default greenhouse gas emission** savings

Manure – Maize 80% - 20%	Open digestate, no-off gas combustion[15]	62%	35%
	Open digestate, off gas combustion[16]	78%	57%
	Close digestate, no-off gas combustion	97%	86%
	Close digestate, off gas combustion	113%	108%
Manure – Maize 70% - 30%	Open digestate, no off-gas combustion	53%	29%
	Open digestate, off gas combustion	69%	51%
	Close digestate, no off-gas combustion	83%	71%
	Close digestate, off-gas combustion	99%	94%
Manure – Maize 60% - 40%	Open digestate, no off-gas combustion	48%	25%
	Open digestate, off gas combustion	64%	48%
	Close digestate, no off-gas combustion	74%	62%
	Close digestate, off-gas combustion	90%	84%

*The greenhouse gas emission savings for biomethane only refer to compressed biomethane elative to the fossil fuel comparator for transport of 94 gCO2 eq./MJ.

B. METHODOLOGY

1. Greenhouse gas emissions from the production and use of biomass fuels, shall be calculated as follows:

[15] This category includes the following categories of technologies for biogas upgrade to biomethane: Pressure Swing Absorption (PSA), Pressure Water Scrubbing (PWS), Membranes, Cryogenic, and Organic Physical Scrubbing (OPS). It includes an emission of 0.03 MJCH4/MJbiomethane for the emission of methane in the off-gases.

[16] This category includes the following categories of technologies for biogas upgrade to biomethane: Pressure Water Scrubbing (PWS) when water is recycled, Pressure Swing Absorption (PSA), Chemical Scrubbing, Organic Physical Scrubbing (OPS), Membranes and Cryogenic upgrading. No methane emissions are considered for this category (the methane in the off gas is combusted, if any).

(a) Greenhouse gas emissions from the production and use of biomass fuels before conversion into electricity, heating and cooling, shall be calculated as:

$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} – e_{ccs} - e_{ccr}$,

Where

E = total emissions from the production of the fuel before energy conversion;

e_{ec} = emissions from the extraction or cultivation of raw materials;

e_l = annualised emissions from carbon stock changes caused by land use change;

e_p = emissions from processing;

e_{td} = emissions from transport and distribution;

e_u = emissions from the fuel in use;

e_{sca} = emission savings from soil carbon accumulation via improved agricultural management;

e_{ccs} = emission savings from carbon capture and geological storage; and

e_{ccr} = emission savings from carbon capture and replacement.

Emissions from the manufacture of machinery and equipment shall not be taken into account.

(b) In case of co-digestion of different substrates in a biogas plant for the production of biogas or biomethane the typical and default values of greenhouse gas emissions shall be calculated as:

$$E = \sum_1^n S_n \cdot E_n$$

where

E = GHG emissions per MJ biogas or biomethane produced from co-digestion of the defined mixture of substrates

S_n = Share of feedstock n in energy content

E_n = Emission in gCO_2/MJ for pathway n as provided in Part D of this document*

$$S_n = \frac{P_n \cdot W_n}{\sum_1^n P_n \cdot W_n}$$

where

P_n = energy yield [MJ] per kilogram of wet input of feedstock n**

W_n = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_1^n I_n} \cdot \left(\frac{1 - AM_n}{1 - SM_n}\right)$$

where:

I_n = Annual input to digester of substrate n [tonne of fresh matter]

AM_n = Average annual moisture of substrate n [kg water / kg fresh matter]

SM_n = Standard moisture for substrate n***.

* For animal manure used as substrate, a bonus of 45 gCO2eq./MJ manure (-54 kg CO2eq. / t fresh matter) is added for improved agricultural and manure management.

** The following values of P_n shall be used for calculating typical and default values:

P(Maize): 4.16 [$MJ_{biogas}/kg_{\text{wet maize @ 65 \% moisture}}$]

P(Manure): 0.50 [$MJ_{biogas}/kg_{\text{wet manure @ 90 \% moisture}}$]

P(Biowaste) 3.41 [$MJ_{biogas}/kg_{\text{wet biowaste @ 76 \% moisture}}$]

***The following values of the standard moisture for substrate SM_n shall be used:

SM(Maize): 0.65 [kg water/kg fresh matter]

SM(Manure): 0.90 [kg water/kg fresh matter]

SM(Biowaste): 0.76 [kg water/kg fresh matter]

(c) In case of co-digestion of n substrates in a biogas plant for the production of electricity or biomethane, actual greenhouse gas emissions of biogas and biomethane are calculated as follows:

$$E = \sum_{1}^{n} S_n \cdot \left(e_{ec,n} + e_{td,feedstock\ ,n} + e_{l,n} - e_{sca,n}\right) + e_p + e_{td,product} + e_u - e_{ccs} - e_{ccr}$$

where

E= total emissions from the production of the biogas or biomethane before energy conversion;

Sn = Share of feedstock n, in fraction of input to the digester

$e_{ec,n}$ = emissions from the extraction or cultivation of feedstock n;

$e_{td,feedstock,n}$ = emissions from transport of feedstock n to the digester;

$e_{l,n}$ = annualised emissions from carbon stock changes caused by land use change, for feedstock n;

e_{sca} = emission savings from improved agricultural management of feedstock n*;

e_p = emissions from processing;

$e_{td,product}$ = emissions from transport and distribution of biogas and/or biomethane;

e_u = emissions from the fuel in use, that is greenhouse gases emitted during combustion;

e_{ccs} = emission savings from carbon capture and geological storage; and

e_{ccr} = emission savings from carbon capture and replacement.

* For e_{sca} a bonus of 45 $gCO_{2eq.}$ / MJ manure shall be attributed for improved agricultural and manure management in case animal manure is used as a substrate for the production of biogas and biomethane.

(d) Greenhouse gas emissions from the use of biomass fuels in producing electricity, heating and cooling, including the energy conversion to electricity and/ or heat or cooling produced shall be calculated as follows:

(i) For energy installations delivering only heat:

$$EC_h = \frac{E}{\eta_h}$$

(ii) For energy installations delivering only electricity:

$$EC_{el} = \frac{E}{\eta_{el}}$$

where

$EC_{h,el}$ = Total greenhouse gas emissions from the final energy commodity.

E = Total greenhouse gas emissions of the fuel before end-conversion.

η_{el}= The electrical efficiency, defined as the annual electricity produced divided by the annual fuel input, based on its energy content.

η_h = The heat efficiency, defined as the annual useful heat output divided by the annual fuel input, based on its energy content.

(iii) For the electricity or mechanical energy coming from energy installations delivering useful heat together with electricity and/or mechanical energy:

$$EC_{el} = \frac{E}{\eta_{el}}\left(\frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h}\right)$$

(iv) For the useful heat coming from energy installations delivering heat together with electricity and/or mechanical energy:

$$EC_h = \frac{E}{\eta_h}\left(\frac{C_h \cdot \eta_h}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h}\right)$$

where:

$EC_{h,el}$ = Total greenhouse gas emissions from the final energy commodity.

E = Total greenhouse gas emissions of the fuel before end-conversion.

η_{el} = The electrical efficiency, defined as the annual electricity produced divided by the annual energy input, based on its energy content.

η_h = The heat efficiency, defined as the annual useful heat output divided by the annual energy input, based on its energy content.

C_{el} = Fraction of exergy in the electricity, and/or mechanical energy, set to 100 % (C_{el} = 1).

C_h = Carnot efficiency (fraction of exergy in the useful heat).

The Carnot efficiency, C_h, for useful heat at different temperatures is defined as:

$$C_h = \frac{T_h - T_0}{T_h}$$

where:

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

T_0 = Temperature of surroundings, set at 273.15 kelvin (equal to 0 °C)

For T_h , < 150 °C (423.15 kelvin), C_h can alternatively be defined as follows:

C_h = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of this calculation, the following definitions shall apply:

(i) "cogeneration" shall mean the simultaneous generation in one process of thermal energy and electricity and/or mechanical energy;

(ii) "useful" heat shall mean heat generated to satisfy an economical justifiable demand for heat, for heating or cooling purposes;

(iii) "economically justifiable demand" shall mean the demand that does not exceed the needs of heat or cooling and which would otherwise be satisfied at market conditions.

2. Greenhouse gas emissions from biomass fuels shall be expressed as follows

(a) greenhouse gas emissions from biomass fuels E, shall be expressed in terms of grams of CO_2 equivalent per MJ of biomass fuel, gCO_{2eq}/MJ.

(b) greenhouse gas emissions from heating or electricity, produced from biomass fuels, EC, shall be expressed in terms of grams of CO_2 equivalent per MJ of final energy commodity (heat or electricity), gCO_{2eq}/MJ.

When heating and cooling are co-generated with electricity, emissions shall be allocated between heat and electricity (as under 1(d)) irrespective if the heat is used for actual heating purposes or for cooling.[17]

Where the greenhouse gas emissions from the extraction or cultivation of raw materials e_{ec} are expressed in unit g CO_2eq/dry-ton of feedstock the conversion to grams of CO_2 equivalent per MJ of fuel, gCO_{2eq} /MJ share be calculated as follows;

[17] Heat or waste heat is used to generate cooling (chilled air or water) through absorption chillers. Therefore, it is appropriate to calculate only the emissions associated to the heat produced, per MJ of heat, irrespectively if the end-use of the heat is actual heating or cooling via absorption chillers.

$$e_{ec} fuel_a \left[\frac{gCO_2eq}{MJ\ fuel}\right]_{ec} = \frac{e_{ec}\ feedstock_a \left[\frac{gCO_2eq}{t_{dry}}\right]}{LHV_a \left[\frac{MJ\ feedstock}{t\ dry\ feedstock}\right]} * Fuel\ feedstock\ factor_a * \ Allocation\ factor\ fuel_a$$

Where

$$Allocation\ factor\ fuel_a = \left[\frac{Energy\ in\ fuel}{Energy\ fuel + Energy\ in\ co-products}\right]$$

$$Fuel\ feedstock\ factor_a = [Ratio\ of\ MJ\ feedstock\ required\ to\ make\ 1\ MJ\ fuel]$$

Emissions per dry-ton feedstock shall be calculated as follows:

$$e_{ec} feedstock_a \left[\frac{gCO_2eq}{t_{dry}}\right] = \frac{e_{ec}\ feedstock_a \left[\frac{gCO_2eq}{t_{moist}}\right]}{(1 - moisture\ content)}$$

3. Greenhouse gas emission savings from biomass fuels shall be calculated as follows:

(a) greenhouse gas emission savings from biomass fuels used as transport fuels:

$SAVING = (E_{F(t)} – E_{B(t)}/ E_F\ (t)$

where

$E_{B(t)}$ = total emissions from the biofuel or bioliquid; and

$E_{F(t)}$ = total emissions from the fossil fuel comparator for transport

(b) greenhouse gas emission savings from heat and cooling, and electricity being generated from biomass fuels as follows:

$SAVING = (EC_{F(h\&c,el)} – EC_{B(h\&c,el)})/EC_{F\ (h\&c,el)}$,

where

$EC_{B(h\&c,el)}$= total emissions from the heat or electricity,

$EC_{F(h\&c,el)}$ = total emissions from the fossil fuel comparator for useful heat or electricity.

4. The greenhouse gases taken into account for the purposes of point 1 shall be CO_2, N_2O and CH_4. For the purpose of calculating CO_2 equivalence, those gases shall be valued as follows:

CO_2: 1

N_2O: 298

CH_4: 25

5. Emissions from the extraction, harvesting or cultivation of raw materials, e_{ec}, shall include emissions from the extraction, harvesting or cultivation process itself; from the collection, drying and storage of raw materials; from waste and leakages; and from the production of chemicals or products used in extraction or cultivation. Capture of CO_2 in the cultivation of raw materials shall be excluded. Estimates of emissions from agriculture biomass cultivation may be derived from the regional averages for cultivation emissions included in the reports referred to in Article 28 (4) of this Directive and the information on the disaggregated default values for cultivation emissions included in this Annex, as an alternative to using actual values. In absence of relevant information in the before mentioned reports it is allowed to calculate averages based on local farming practises based for instance on data of a group of farms, as an alternative to using actual values.

Estimates of emissions from cultivation and harvesting of forestry biomass, may be derived from the use of averages for cultivation and harvesting emissions calculated for geographical areas at national level, as an alternative to using actual values.

6. For the purposes of the calculation referred to in point 3, emission savings from improved agriculture management, such as shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop management, and the use of organic soil improver (e.g. compost, manure fermentation digestate), shall be taken into account only if solid and verifiable evidence is provided that the soil carbon has increased or that it is reasonable to expect to have increased over the period in which the raw materials concerned were cultivated while taking into account the emissions where such practices lead to increased fertiliser and herbicide use.

7. Annualised emissions from carbon stock changes caused by land-use change, el, shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions the following rule shall be applied:

$e_l = (CS_R – CS_A) \times 3{,}664 \times 1/20 \times 1/P – e_B$,([18])

where

e_l = annualised greenhouse gas emissions from carbon stock change due to land-use change (measured as mass of CO_2-equivalent per unit biomass fuel energy). ‘Cropland’ ([19]) and ‘perennial cropland’ ( ) shall be regarded as one land use[20] ;

[18] The quotient obtained by dividing the molecular weight of CO_2 (44,010 g/mol) by the molecular weight of carbon (12,011 g/mol) is equal to 3,664

[19] Cropland as defined by IPCC

[20] Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.

CS_R = the carbon stock per unit area associated with the reference land use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever was the later;

CS_A = the carbon stock per unit area associated with the actual land use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier; and

P = the productivity of the crop (measured as biomass fuel energy per unit area per year).

e_B = bonus of 29 gCO_{2eq} /MJ biomass fuel if biomass is obtained from restored degraded land under the conditions provided for in point 8.

8. The bonus of 29 gCO_{2eq} /MJ shall be attributed if evidence is provided that the land:

(a) was not in use for agriculture in January 2008; and

(b) is severely degraded land, including such land that was formerly in agricultural use.

The bonus of 29 gCO_{2eq} /MJ shall apply for a period of up to 20 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under (b) are ensured.

9. 'Severely degraded land' means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded.

10 In accordance with Annex V, Part C, point 10 of this Directive guidelines for the calculation of land carbon stocks[21] adopted in relation to that Directive, drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories — volume 4, and in accordance with the Regulation (EU) No 525/2013[22] and the Regulation (INSERT THE NO AFTER THE ADOPTION[23]), shall serve as the basis for the calculation of land carbon stocks.

11. Emissions from processing, e_p, shall include emissions from the processing itself; from waste and leakages; and from the production of chemicals or products used in processing.

In accounting for the consumption of electricity not produced within the gaseous biomass fuel production plant, the greenhouse gas emission intensity of the production and

21 Commission Decision of 10 June 2010 (2010/335/EU) on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC, OJ L 151 17.06.2010

22 Regulation (EU) 525/2013 of the European Parliament and of the Council of 21 may 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC, OJ L 165/13, 18.06.2013

23 Regulation of the European Parliament and of the Council (INSERT THE DATE OF ENTRY INTO FORCE OF THIS REGULATION) on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry into the 2030 climate and energy framework and amending Regulation No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and other information relevant to climate change.

distribution of that electricity shall be assumed to be equal to the average emission intensity of the production and distribution of electricity in a defined region. By derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant, if that plant is not connected to the electricity grid.

In accounting for the consumption of electricity not produced within the solid biomass fuel production plant, the greenhouse gas emission intensity of the production and distribution of that electricity shall be assumed to be equal to the fossil fuel comparator ECF(el) set out in paragrpaph 19 of this Annex. By derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant, if that plant is not connected to the electricity grid.[24]

Emissions from processing shall include emissions from drying of interim- products and materials where relevant.

12. Emissions from transport and distribution, e_{td}, shall include emissions from the transport of raw and semi-finished materials and from the storage and distribution of finished materials. Emissions from transport and distribution to be taken into account under point 5 shall not be covered by this point.

13. Emissions of CO_2 from fuel in use, e_u, shall be taken to be zero for biomass fuels. Emissions of non-CO_2 greenhouse gases (CH_4 and N_2O) from the fuel in use shall be included in the e_u factor.

14. Emission saving from carbon capture and geological storage , e_{ccs}, that have not already been accounted for in e_p, shall be limited to emissions avoided through the capture and storage of emitted CO_2 directly related to the extraction, transport, processing and distribution of biomass fuel if stored in compliance with Directive 2009/31/EC on the geological storage of carbon dioxide.

15. Emission saving from carbon capture and replacement, e_{ccr}, shall be related directly to the production of biomass fuel they are attributed to, and shall be limited to emissions avoided through the capture of CO_2 of which the carbon originates from biomass and which is used to replace fossil-derived CO_2 used in the energy or transport sector.

16. Where a cogeneration unit – providing heat and/ or electricity to a biomass fuel production process for which emissions are being calculated - produces excess electricity and/or excess useful heat, the greenhouse gas emissions shall be divided between the electricity and the useful heat according to the temperature of the heat (which reflects the usefulness (utility) of the heat). The allocation factor, called Carnot efficiency Ch, is calculated as follows for useful heat at different temperatures:

$$C_h = \frac{T_h - T_0}{T_h}$$

where

[24] The solid biomass pathways consume and produce the same commodities at different stages of the supply chain. Using different values for electricity supply to solid biomass production plants and the fossil fuel comparator would assign artificial GHG savings to these pathways.

T_h = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

T_0 = Temperature of surroundings, set at 273.15 kelvin (equal to 0 °C)

For T_h , < 150 °C (423.15 kelvin), C_h can alternatively be defined as follows:

C_h = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of this calculation, the actual efficiencies shall be used, defined as the annual mechanical energy, electricity and heat produced respectively divided by the annual energy input.

For the purposes of this calculation, the following definitions shall apply:

(a) "cogeneration" shall mean the simultaneous generation in one process of thermal energy and electrical or mechanical energy;

(b) "useful" heat shall mean heat generated to satisfy an economical justifiable demand for heat;

(c) "economically justifiable demand" shall mean demand that does not exceed the needs for heating and which would otherwise be satisfied at market conditions

17. Where a biomass fuel production process produces, in combination, the fuel for which emissions are being calculated and one or more other products ("co-products"), greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content (determined by lower heating value in the case of co-products other than electricity and heat). The greenhouse gas intensity of excess useful heat or excess electricity is the same as the greenhouse gas intensity of heat or electricity delivered to the biomass fuel production process and is determined from calculating the greenhouse intensity of all inputs and emissions, including the feedstock and CH_4 and N_2O emissions, to and from the cogeneration unit, boiler or other apparatus delivering heat or electricity to the biomass fuel production process . In case of cogeneration of electricity and heat the calculation is performed following point 16.

18. For the purposes of the calculations referred to in point 17, the emissions to be divided shall be e_{ec} + e_l + e_{sca} + those fractions of e_p, e_{td}, e_{ccs} and e_{ccr} that take place up to and including the process step at which a co-product is produced. If any allocation to co-products has taken place at an earlier process step in the life-cycle, the fraction of those emissions assigned in the last such process step to the intermediate fuel product shall be used for this purpose instead of the total of those emissions.

In the case of biogas and biomethane, all co-products that do not fall under the scope of point 7 shall be taken into account for the purposes of that calculation. No emissions shall be allocated to wastes and residues. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purpose of the calculation.

Wastes and residues, including tree tops and branches, straw, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) and bagasse, shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials irrespectively of whether they are processed to interim products before being transfromed into the final product.

In the case of biomass fuels produced in refineries, other than the combination of processing plants with boilers or cogeneration units providing heat and/or electricity to the processing plant, the unit of analysis for the purposes of the calculation referred to in point 17 shall be the refinery.

19. For biomass fuels used for electricity production, for the purposes of the calculation referred to in point 3, the fossil fuel comparator $EC_{F(el)}$ shall be 183 $gCO2_{eq}$/MJ electricity.

For biomass fuels used for useful heat, for heating and/or cooling production, for the purposes of the calculation referred to in point 3, the fossil fuel comparator $EC_{F(h)}$ shall be 80 gCO2eq/MJ heat.

For biomass fuels used for useful heat production, in which a direct physical substitution of coal can be demonstrated, for the purposes of the calculation referred to in point 3, the fossil fuel comparator $EC_{F(h)}$ shall be 124 gCO_{2eq}./MJ heat.

For biomass fuels, used as transport fuels for the purposes of the calculation referred to in point 3, the fossil fuel comparator $EC_{F(t)}$ shall be 94 gCO_{2eq}/MJ.

C. *DISAGGREGATED DEFAULT VALUES FOR BIOMASS FUELS*

Wood briquettes or pellets

Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emissions (gCO2 eq./MJ)**				**Default greenhouse gas emissions (g CO2eq/MJ)**			
		Cultiva-tion	Processing	Transport	Non-CO_2 emissions from the fuel in use	Cultivation	Processing	Transport	Non-CO_2 emissions from the fuel in use
Wood chips from forest residues	1 to 500 km	0.0	1.6	3.0	0.4	0.0	1.9	3.6	0.5
	500 to 2500 km	0.0	1.6	5.2	0.4	0.0	1.9	6.2	0.5
	2500 to 10000 km	0.0	1.6	10.5	0.4	0.0	1.9	12.6	0.5
	Above 10000 km	0.0	1.6	20.5	0.4	0.0	1.9	24.6	0.5
Wood chips from SRC (Eucalyptus)	2500 to 10000 km	13.1	0.0	11.0	0.4	13.1	0.0	13.2	0.5
Wood chips from SRC (Poplar – fertilized)	1 to 500 km	3.9	0.0	3.5	0.4	3.9	0.0	4.2	0.5
	500 to 2500 km	3.9	0.0	5.6	0.4	3.9	0.0	6.8	0.5
	2500 to 10000 km	3.9	0.0	11.0	0.4	3.9	0.0	13.2	0.5

	Above 10000 km	3.9	0.0	21.0	0.4	3.9	0.0	25.2	0.5
Wood chips from SRC (Poplar – Not fertilized)	1 to 500 km	2.2	0.0	3.5	0.4	2.2	0.0	4.2	0.5
	500 to 2500 km	2.2	0.0	5.6	0.4	2.2	0.0	6.8	0.5
	2500 to 10000 km	2.2	0.0	11.0	0.4	2.2	0.0	13.2	0.5
	Above 10000 km	2.2	0.0	21.0	0.4	2.2	0.0	25.2	0.5
Wood chips from stemwood	1 to 500 km	1.1	0.3	3.0	0.4	1.1	0.4	3.6	0.5
	500 to 2500 km	1.1	0.3	5.2	0.4	1.1	0.4	6.2	0.5
	2500 to 10000 km	1.1	0.3	10.5	0.4	1.1	0.4	12.6	0.5
	Above 10000 km	1.1	0.3	20.5	0.4	1.1	0.4	24.6	0.5
Wood chips from wood industry residues	1 to 500 km	0.0	0.3	3.0	0.4	0.0	0.4	3.6	0.5
	500 to 2500 km	0.0	0.3	5.2	0.4	0.0	0.4	6.2	0.5
	2500 to 10000 km	0.0	0.3	10.5	0.4	0.0	0.4	12.6	0.5
	Above 10000 km	0.0	0.3	20.5	0.4	0.0	0.4	24.6	0.5

Wood briquettes or pellets

Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emissions (gCO2 eq./MJ)**				**Default greenhouse gas emissions (gCO2 eq./MJ)**			
		Cultiva-tion	Processing	Transport & distribution	Non-CO_2 emissions from the fuel in use	Cultiva-tion	Processing	Transport & distribution	Non-CO_2 emissions from the fuel in use
Wood briquettes or pellets from forest residues (case 1)	1 to 500 km	0.0	25.8	2.9	0.3	0.0	30.9	3.5	0.3
	500 to 2500 km	0.0	25.8	2.8	0.3	0.0	30.9	3.3	0.3
	2500 to 10000 km	0.0	25.8	4.3	0.3	0.0	30.9	5.2	0.3
	Above 10000 km	0.0	25.8	7.9	0.3	0.0	30.9	9.5	0.3
Wood briquettes or pellets from forest residues (case 2a)	1 to 500 km	0.0	12.5	3.0	0.3	0.0	15.0	3.6	0.3
	500 to 2500 km	0.0	12.5	2.9	0.3	0.0	15.0	3.5	0.3
	2500 to 10000 km	0.0	12.5	4.4	0.3	0.0	15.0	5.3	0.3
	Above 10000 km	0.0	12.5	8.1	0.3	0.0	15.0	9.8	0.3
Wood briquettes or pellets	1 to 500 km	0.0	2.4	3.0	0.3	0.0	2.8	3.6.	0.3
	500 to 2500 km	0.0	2.4	2.9	0.3	0.0	2.8	3.5	0.3

from forest residues (case 3a)	2500 to 10000 km	0.0	2.4	4.4	0.3	0.0	2.8	5.3	0.3
	Above 10000 km	0.0	2.4	8.2	0.3	0.0	2.8	9.8	0.3
Wood briquettes from short rotation coppice (Eucalyptus – case 1)	2500 to 10 000 km	11.7	24.5	4.3	0.3	11.7	29.4	5.2	0.3
Wood briquettes from short rotation coppice (Eucalyptus – case 2a)	2500 to 10 000 km	14.9	10.6	4.4	0.3	14.9	12.7	5.3	0.3
Wood briquettes from short rotation coppice	2500 to 10 000 km	15.5	0.3	4.4	0.3	15.5	0.4	5.3	0.3

(Eucalyptus – case 3a)									
Wood briquettes from short rotation coppice (Poplar – Fertilised – case 1)	1 to 500 km	3.4	24.5	2.9	0.3	3.4	29.4	3.5	0.3
	500 to 10 000 km	3.4	24.5	4.3	0.3	3.4	29.4	5.2	0.3
	Above 10000 km	3.4	24.5	7.9	0.3	3.4	29.4	9.5	0.3
Wood briquettes from short rotation coppice (Poplar – Fertilised – case 2a)	1 to 500 km	4.4	10.6	3.0	0.3	4.4	12.7	3.6	0.3
	500 to 10 000 km	4.4	10.6	4.4	0.3	4.4	12.7	5.3	0.3
	Above 10000 km	4.4	10.6	8.1	0.3	4.4	12.7	9.8	0.3
Wood briquettes from short	1 to 500 km	4.6	0.3	3.0	0.3	4.6	0.4	3.6	0.3
	500 to 10 000 km	4.6	0.3	4.4	0.3	4.6	0.4	5.3	0.3

rotation coppice (Poplar – Fertilised – case 3a)	Above 10000 km	4.6	0.3	8.2	0.3	4.6	0.4	9.8	0.3
Wood briquettes from short rotation coppice (Poplar – no fertilisation – case 1)	1 to 500 km	2.0	24.5	2.9	0.3	2.0	29.4	3.5	0.3
	500 to 2500 km	2.0	24.5	4.3	0.3	2.0	29.4	5.2	0.3
	2500 to 10 000 km	2.0	24.5	7.9	0.3	2.0	29.4	9.5	0.3
Wood briquettes from short rotation coppice (Poplar – no fertilisation – case 2a)	1 to 500 km	2.5	10.6	3.0	0.3	2.5	12.7	3.6	0.3
	500 to 10 000 km	2.5	10.6	4.4	0.3	2.5	12.7	5.3	0.3
	Above 10000 km	2.5	10.6	8.1	0.3	2.5	12.7	9.8	0.3

Wood briquettes from short rotation coppice (Poplar – no fertilisation– case 3a)	1 to 500 km	2.6	0.3	3.0	0.3	2.6	0.4	3.6	0.3
	500 to 10 000 km	2.6	0.3	4.4	0.3	2.6	0.4	5.3	0.3
	Above 10000 km	2.6	0.3	8.2	0.3	2.6	0.4	9.8	0.3
Wood briquettes or pellets from stemwood (case 1)	1 to 500 km	1.1	24.8	2.9	0.3	1.1	29.8	3.5	0.3
	500 to 2500 km	1.1	24.8	2.8	0.3	1.1	29.8	3.3	0.3
	2500 to 10000 km	1.1	24.8	4.3	0.3	1.1	29.8	5.2	0.3
	Above 10000 km	1.1	24.8	7.9	0.3	1.1	29.8	9.5	0.3
Wood briquettes or pellets from stemwood (case 2a)	1 to 500 km	1.4	11.0	3.0	0.3	1.4	13.2	3.6	0.3
	500 to 2500 km	1.4	11.0	2.9	0.3	1.4	13.2	3.5	0.3
	2500 to 10000 km	1.4	11.0	4.4	0.3	1.4	13.2	5.3	0.3
	Above 10000	1.4	11.0	8.1	0.3	1.4	13.2	9.8	0.3

	km								
Wood briquettes or pellets from stemwood (case 3a)	1 to 500 km	1.4	0.8	3.0	0.3	1.4	0.9	3.6	0.3
	500 to 2500 km	1.4	0.8	2.9	0.3	1.4	0.9	3.5	0.3
	2500 to 10000 km	1.4	0.8	4.4	0.3	1.4	0.9	5.3	0.3
	Above 10000 km	1.4	0.8	8.2	0.3	1.4	0.9	9.8	0.3
Wood briquettes or pellets from wood industry residues (case 1)	1 to 500 km	0.0	14.3	2.8	0.3	0.0	17.2	3.3	0.3
	500 to 2500 km	0.0	14.3	2.7	0.3	0.0	17.2	3.2	0.3
	2500 to 10000 km	0.0	14.3	4.2	0.3	0.0	17.2	5.0	0.3
	Above 10000 km	0.0	14.3	7.7	0.3	0.0	17.2	9.2	0.3
Wood briquettes or pellets from wood industry residues (case 2a)	1 to 500 km	0.0	6.0	2.8	0.3	0.0	7.2	3.4	0.3
	500 to 2500 km	0.0	6.0	2.7	0.3	0.0	7.2	3.3	0.3
	2500 to 10000 km	0.0	6.0	4.2	0.3	0.0	7.2	5.1	0.3
	Above 10000 km	0.0	6.0	7.8	0.3	0.0	7.2	9.3	0.3

Wood briquettes or pellets from wood industry residues (case 3a)	1 to 500 km	0.0	0.2	2.8	0.3	0.0	0.3	3.4	0.3
	500 to 2500 km	0.0	0.2	2.7	0.3	0.0	0.3	3.3	0.3
	2500 to 10000 km	0.0	0.2	4.2	0.3	0.0	0.3	5.1	0.3
	Above 10000 km	0.0	0.2	7.8	0.3	0.0	0.3	9.3	0.3

Agriculture pathways

Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emissions (gCO2 eq./MJ)**				**Default greenhouse gas emissions (gCO2 eq./MJ)**			
		Cultivation	Processing	Transport & distribution	Non-CO_2 emissions from the fuel in use	Cultivation	Processing	Transport & distribution	Non-CO_2 emissions from the fuel in use
Agricultural Residues with density <0.2 t/m3	1 to 500 km	0.0	0.9	2.6	0.2	0.0	1.1	3.1	0.3
	500 to 2500 km	0.0	0.9	6.5	0.2	0.0	1.1	7.8	0.3
	2500 to 10 000 km	0.0	0.9	14.2	0.2	0.0	1.1	17.0	0.3
	Above 10000 km	0.0	0.9	28.3	0.2	0.0	1.1	34.0	0.3
Agricultural Residues with	1 to 500 km	0.0	0.9	2.6	0.2	0.0	1.1	3.1	0.3

density > 0.2 t/m3	500 to 2500 km	0.0	0.9	3.6	0.2	0.0	1.1	4.4	0.3
	2500 to 10 000 km	0.0	0.9	7.1	0.2	0.0	1.1	8.5	0.3
	Above 10000 km	0.0	0.9	13.6	0.2	0.0	1.1	16.3	0.3
Straw pellets	1 to 500 km	0.0	5.0	3.0	0.2	0.0	6.0	3.6	0.3
	500 to 10000 km	0.0	5.0	4.6	0.2	0.0	6.0	5.5	0.3
	Above 10000 km	0.0	5.0	8.3	0.2	0.0	6.0	10.0	0.3
Bagasse briquettes	500 to 10 000 km	0.0	0.3	4.3	0.4	0.0	0.4	5.2	0.5
	Above 10 000 km	0.0	0.3	8.0	0.4	0.0	0.4	9.5	0.5
Palm Kernel Meal	Above 10000 km	21.6	21.1	11.2	0.2	21.6	25.4	13.5	0.3
Palm Kernel Meal (no CH4 emissions from oil mill)	Above 10000 km	21.6	3.5	11.2	0.2	21.6	4.2	13.5	0.3

Disaggregated default values for biogas for electricity production

Biomass fuel production system		Technology	TYPICAL [$gCO_{2\ eq.}/MJ$]					DEFAULT [$gCO_{2\ eq.}/MJ$]				
			Cultiva-tion	Proces-sing	Non-CO_2 emissions from the fuel in use	Trans-port	Manure credits	Cultiva-tion	Proces-sing	Non-CO_2 emissions from the fuel in use	Trans-port	Manure credits
Wet manure[25]	case 1	Open digestate	0.0	69.6	8.9	0.8	-107.3	0.0	97.4	12.5	0.8	-107.3
		Close digestate	0.0	0.0	8.9	0.8	-97.6	0.0	0.0	12.5	0.8	-97.6
	case 2	Open digestate	0.0	74.1	8.9	0.8	-107.3	0.0	103.7	12.5	0.8	-107.3
		Close digestate	0.0	4.2	8.9	0.8	-97.6	0.0	5.9	12.5	0.8	-97.6
	case 3	Open digestate	0.0	83.2	8.9	0.9	-120.7	0.0	116.4	12.5	0.9	-120.7
		Close digestate	0.0	4.6	8.9	0.8	-108.5	0.0	6.4	12.5	0.8	-108.5
Maize whole plant[26]	case 1	Open digestate	15.6	13.5	8.9	0.0[27]	-	15.6	18.9	12.5	0.0	-
		Close digestate	15.2	0.0	8.9	0.0	-	15.2	0.0	12.5	0.0	-
	case 2	Open digestate	15.6	18.8	8.9	0.0	-	15.6	26.3	12.5	0.0	-

25 The values for biogas production from manure include negative emissions for emissions saved from raw manure management. The value of e_{sca} considered is equal to -45 gCO2eq./MJ manure used in anaerobic digestion

26 Maize whole plant should be interpreted as maize harvested as fodder and ensiled for preservation.

27 Transport of agricultural raw materials to the transformation plant is, according to the methodology in COM(2010) 11, included in the 'cultivation' value. The value for transport of maize silage accounts for 0.4 $gCO_{2\ eq.}/MJ$ biogas.

		Close digestate	15.2	5.2	8.9	0.0	-	15.2	7.2	12.5	0.0	-
	case 3	Open digestate	17.5	21.0	8.9	0.0	-	17.5	29.3	12.5	0.0	-
		Close digestate	17.1	5.7	8.9	0.0	-	17.1	7.9	12.5	0.0	-
Biowaste	case 1	Open digestate	0.0	21.8	8.9	0.5	-	0.0	30.6	12.5	0.5	-
		Close digestate	0.0	0.0	8.9	0.5	-	0.0	0.0	12.5	0.5	-
	case 2	Open digestate	0.0	27.9	8.9	0.5	-	0.0	39.0	12.5	0.5	-
		Close digestate	0.0	5.9	8.9	0.5	-	0.0	8.3	12.5	0.5	-
	case 3	Open digestate	0.0	31.2	8.9	0.5	-	0.0	43.7	12.5	0.5	-
		Close digestate	0.0	6.5	8.9	0.5	-	0.0	9.1	12.5	0.5	-

Disaggregated default values for biomethane

Biomethane production system	Technological option		TYPICAL [$gCO_{2\ eq.}$/MJ]						DEFAULT [$gCO_{2\ eq.}$/MJ]					
			Cultiva-tion	Proces-sing	Up-grading	Trans-port	Compres-sion at filling station	Manure credits	Cultiva-tion	Proces-sing	Up-grading	Trans-port	Compres-sion at filling station	Manure credits
Wet	Open	no off-gas combustion	0.0	84.2	19.5	1.0	3.3	-124.4	0.0	117.9	27.3	1.0	4.6	-124.4

manure	digestate	off-gas combustion	0.0	84.2	4.5	1.0	3.3	-124.4	0.0	117.9	6.3	1.0	4.6	-124.4
	Close digestate	no off-gas combustion	0.0	3.2	19.5	0.9	3.3	-111.9	0.0	4.4	27.3	0.9	4.6	-111.9
		off-gas combustion	0.0	3.2	4.5	0.9	3.3	-111.9	0.0	4.4	6.3	0.9	4.6	-111.9
Maize whole plant	Open digestate	no off-gas combustion	18.1	20.1	19.5	0.0	3.3	-	18.1	28.1	27.3	0.0	4.6	-
		off-gas combustion	18.1	20.1	4.5	0.0	3.3	-	18.1	28.1	6.3	0.0	4.6	-
	Close digestate	no off-gas combustion	17.6	4.3	19.5	0.0	3.3	-	17.6	6.0	27.3	0.0	4.6	-
		off-gas combustion	17.6	4.3	4.5	0.0	3.3	-	17.6	6.0	6.3	0.0	4.6	-
Biowaste	Open digestate	no off-gas combustion	0.0	30.6	19.5	0.6	3.3	-	0.0	42.8	27.3	0.6	4.6	-
		off-gas combustion	0.0	30.6	4.5	0.6	3.3	-	0.0	42.8	6.3	0.6	4.6	-
	Close digestate	no off-gas combustion	0.0	5.1	19.5	0.5	3.3	-	0.0	7.2	27.3	0.5	4.6	-
		off-gas combustion	0.0	5.1	4.5	0.5	3.3	-	0.0	7.2	6.3	0.5	4.6	-

D. TOTAL TYPICAL AND DEFAULT GREENHOUSE GAS EMISSION VALUES FOR BIOMASS FUEL PATHWAYS

Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emissions (gCO2 eq./MJ)**	**Default greenhouse gas emissions (gCO2 eq./MJ)**
Woodchips from forest residues	1 to 500 km	5	6
	500 to 2500 km	7	9
	2500 to 10 000 km	12	15
	Above 10000 km	22	27
Woodchips from short rotation coppice (Eucalyptus)	2500 to 10 000 km	25	27
Woodchips from short rotation coppice (Poplar - Fertilised)	1 to 500 km	8	9
	500 to 2500 km	10	11
	2500 to 10 000 km	15	18
	2500 to 10 000 km	25	30
Woodchips from short rotation coppice (Poplar – No fertilisation)	1 to 500 km	6	7
	500 to 2500 km	8	10
	2500 to 10 000 km	14	16
	2500 to 10 000 km	24	28
Woodchips from stemwood	1 to 500 km	5	6
	500 to 2500 km	7	8
	2500 to 10 000 km	12	15
	2500 to 10 000 km	22	27
Woodchips from industry residues	1 to 500 km	4	5
	500 to 2500 km	6	7
	2500 to 10 000 km	11	13
	Above 10000 km	21	25
Wood briquettes or pellets from forest residues (case 1)	1 to 500 km	29	35
	500 to 2500 km	29	35

	2500 to 10000 km	30	36
	Above 10000 km	34	41
Wood briquettes or pellets from forest residues (case 2a)	1 to 500 km	16	19
	500 to 2500 km	16	19
	2500 to 10000 km	17	21
	Above 10000 km	21	25
Wood briquettes or pellets from forest residues (case 3a)	1 to 500 km	6	7
	500 to 2500 km	6	7
	2500 to 10000 km	7	8
	Above 10000 km	11	13
Wood briquettes or pellets from short rotation coppice (Eucalyptus – case 1	2500 to 10 000 km	41	46
Wood briquettes or pellets from short rotation coppice (Eucalyptus – case 2a)	2500 to 10 000 km	30	33
Wood briquettes or pellets from short rotation coppice (Eucalyptus – case 3a)	2500 to 10 000 km	21	22
Wood briquettes or pellets from short rotation coppice (Poplar – Fertilised – case 1)	1 to 500 km	31	37
	500 to 10000 km	32	38
	Above 10000 km	36	43
Wood briquettes or pellets from short rotation coppice (Poplar – Fertilised – case 2a)	1 to 500 km	18	21
	500 to 10000 km	20	23
	Above 10000 km	23	27
Wood briquettes or pellets from short rotation coppice (Poplar – Fertilised – case 3a	1 to 500 km	8	9
	500 to 10000 km	10	11
	Above 10000 km	13	15
Wood briquettes or pellets from	1 to 500 km	30	35

short rotation coppice (Poplar – no fertilisation – case 1)	500 to 10000 km	31	37
	Above 10000 km	35	41
Wood briquettes or pellets from short rotation coppice (Poplar – no fertilisation – case 2a)	1 to 500 km	16	19
	500 to 10000 km	18	21
	Above 10000 km	21	25
Wood briquettes or pellets from short rotation coppice (Poplar – no fertilisation – case 3a	1 to 500 km	6	7
	500 to 10000 km	8	9
	Above 10000 km	11	13
Wood briquettes or pellets from stemwood (case 1)	1 to 500 km	29	35
	500 to 2500 km	29	34
	2500 to 10000 km	30	36
	Above 10000 km	34	41
Wood briquettes or pellets from stemwood (case 2a)	1 to 500 km	16	18
	500 to 2500 km	15	18
	2500 to 10000 km	17	20
	Above 10000 km	21	25
Wood briquettes or pellets from stemwood (case 3a)	1 to 500 km	5	6
	500 to 2500 km	5	6
	2500 to 10000 km	7	8
	Above 10000 km	11	12
Wood briquettes or pellets from wood industry residues (case 1)	1 to 500 km	17	21
	500 to 2500 km	17	21
	2500 to 10000 km	19	23
	Above 10000 km	22	27
Wood briquettes or pellets from wood industry residues (case 2a)	1 to 500 km	9	11
	500 to 2500 km	9	11
	2500 to 10000 km	10	13

	Above 10000 km	14	17
Wood briquettes or pellets from wood industry residues (case 3a)	1 to 500 km	3	4
	500 to 2500 km	3	4
	2500 to 10000	5	6
	Above 10000 km	8	10

Case 1 refers to processes in which a Natural Gas boiler is used to provide the process heat to the pellet mill. Process electricity is purchased from the grid.

Case 2 refers to processes in which a boiler fuelled with wood chips is used to provide the process heat to the pellet mill. Process electricity is purchased from the grid.

Case 3 refers to processes in which a CHP, fuelled with wood chips, is used to provide heat and power to the pellet mill.

Biomass fuel production system	**Transport distance**	**Typical greenhouse gas emissions (gCO2 eq./MJ)**	**Default greenhouse gas emissions (gCO2 eq./MJ)**
Agricultural Residues with density <0.2 t/m3[28]	1 to 500 km	**4**	**4**
	500 to 2500 km	**8**	**9**
	2500 to 10 000 km	**15**	**18**
	Above 10000 km	**29**	**35**
Agricultural Residues with density > 0.2 t/m3[29]	1 to 500 km	**4**	**4**
	500 to 2500 km	**5**	**6**
	2500 to 10 000 km	**8**	**10**
	Above 10000 km	**15**	**18**
Straw pellets	1 to 500 km	**8**	**10**

28 This group of materials includes agricultural residues with a low bulk density and it comprises materials such as straw bales, oat hulls, rice husks and sugar cane bagasse bales (not exhaustive list).

29 The group of agricultural residues with higher bulk density includes materials such as corn cobs, nut shells, soybean hulls, palm kernel shells (not exhaustive list).

	500 to 10000 km	**10**	**12**
	Above 10000 km	**14**	**16**
Bagasse briquettes	500 to 10 000 km	**5**	**6**
	Above 10 000 km	**9**	**10**
Palm Kernel Meal	Above 10000 km	**54**	**61**
Palm Kernel Meal (no CH4 emissions from oil mill)	Above 10000 km	**37**	**40**

Typical and default values - biogas for electricity

Biogas production system	Technological option		Typical value GHG emissions (g CO2eq/MJ)	Default value GHG emissions (g CO2eq/MJ)
Biogas for electricity from wet manure	Case 1	Open digestate[30]	-28	3
		Close digestate[31]	-88	-84
	Case 2	Open digestate	-23	10
		Close digestate	-84	-78
	Case 3	Open digestate	-28	9
		Close digestate	-94	-89
Biogas for electricity from maize whole plant	Case 1	Open digestate	38	47
		Close digestate	24	28
	Case 2	Open digestate	43	54
		Close digestate	29	35
	Case 3	Open digestate	47	59
		Close digestate	32	38
Biogas for electricity from biowaste	Case 1	Open digestate	31	44
		Close digestate	9	13
	Case 2	Open digestate	37	52
		Close digestate	15	21
	Case 3	Open digestate	41	57
		Close digestate	16	22

Typical and default values for biomethane

[30] Open storage of digestate accounts for additional emissions of methane which change with the weather, the substrate and the digestion efficiency. In these calculations the amounts are taken to be equal to 0.05 MJCH4 / MJbiogas for manure, 0.035 MJCH4 / MJbiogas for maize and 0.01 MJCH4 / MJbiogas for biowaste.

[31] Close storage means that the digestate resulting from the digestion process is stored in a gas tight tank and the additional biogas released during storage is considered to be recovered for production of additional electricity or biomethane.

Biomethane production system	**Technological option**	**Typical greenhouse gas emissions** (g CO2eq/MJ)	**Default greenhouse gas emissions** (g CO2eq/MJ)
Biomethane from wet manure	Open digestate, no off-gas combustion[32]	-20	22
	Open digestate, off-gas combustion[33]	-35	1
	Close digestate, no off-gas combustion	-88	-79
	Close digestate, off-gas combustion	-103	-100
Biomethane from maize whole plant	Open digestate , no off-gas combustion	58	73
	Open digestate, off-gas combustion	43	52
	Close digestate, no off-gas combustion	41	51
	Close digestate, off-gas combustion	26	30
Biomethane from biowaste	Open digestate , no off-gas combustion	51	71
	Open digestate, off-gas combustion	36	50
	Close digestate, no off-gas combustion	25	35
	Close digestate, off-gas combustion	10	14

Typical and default values - biogas for electricity - mixtures of manure and maize: GHG emissions with shares given on a fresh mass basis

[32] This category includes the following categories of technologies for biogas upgrade to biomethane: Pressure Swing Absorption (PSA), Pressure Water Scrubbing (PWS), Membranes, Cryogenic, and Organic Physical Scrubbing (OPS). It includes an emission of 0.03 MJCH4/MJbiomethane for the emission of methane in the off-gases.

[33] This category includes the following categories of technologies for biogas upgrade to biomethane: Pressure Water Scrubbing (PWS) when water is recycled, Pressure Swing Absorption (PSA), Chemical Scrubbing, Organic Physical Scrubbing (OPS), Membranes and Cryogenic upgrading. No methane emissions are considered for this category (the methane in the off gas is combusted, if any).

Biogas production system		Technological options	Typical greenhouse gas emissions (g CO2eq/MJ)	Default greenhouse gas emissions (g CO2eq/MJ)
Manure – Maize 80% - 20%	Case 1	Open digestate	17	33
		Close digestate	-12	-9
	Case 2	Open digestate	22	40
		Close digestate	-7	-2
	Case 3	Open digestate	23	43
		Close digestate	-9	-4
Manure – Maize 70% - 30%	Case 1	Open digestate	24	37
		Close digestate	0	3
	Case 2	Open digestate	29	45
		Close digestate	4	10
	Case 3	Open digestate	31	48
		Close digestate	4	10
Manure – Maize 60% - 40%	Case 1	Open digestate	28	40
		Close digestate	7	11
	Case 2	Open digestate	33	47
		Close digestate	12	18
	Case 3	Open digestate	36	52
		Close digestate	12	18

Comments

Case 1 refers to pathways in which power and heat required in the process are supplied by the CHP engine itself.

Case 2 refers to pathways in which the electricity required in the process is taken from the grid and the process heat is supplied by the CHP engine itself. In some Member States, operators are not allowed to claim the gross production for subsidies and Case 1 is the more likely configuration.

Case 3 refers to pathways in which the electricity required in the process is taken from the grid and the process heat is supplied by a biogas boiler. This case applies to some installations in which the CHP engine is not on-site and biogas is sold (but not upgraded to biomethane).

Typical and default values – biomethane - mixtures of manure and maize: GHG emissions with shares given on a fresh mass basis

Biomethane production system	**Technological options**	**Typical** (g CO2eq/MJ)	**Default** (g CO2eq/MJ)
Manure – Maize 80% - 20 %	Open digestate, no-off gas combustion	32	57
	Open digestate, off gas combustion	17	36
	Close digestate, no-off gas combustion	-1	9
	Close digestate, off gas combustion	-16	-12
Manure – Maize 70% - 30 %	Open digestate, no off-gas combustion	41	62
	Open digestate, off gas combustion	26	41
	Close digestate, no off-gas combustion	13	22
	Close digestate, off-gas combustion	-2	1
Manure – Maize 60% - 40 %	Open digestate, no off-gas combustion	46	66
	Open digestate, off gas combustion	31	45
	Close digestate, no off-gas combustion	22	31
	Close digestate, off-gas combustion	7	10

In case of biomethane used as Compressed Biomethane as a transport fuel, a value of 3.3 gCO2eq./MJ biomethane needs to be added to the typical values and a value of 4.6 gCO2eq./MJ biomethane to the Default values.

↓ 2009/28/EC

~~ANNEX VI~~

~~Minimum requirements for the harmonised template for national renewable energy action plans~~

~~1. Expected final energy consumption:~~

~~Gross final energy consumption in electricity, transport and heating and cooling for 2020 taking into account the effects of energy efficiency policy measures.~~

~~2. National sectoral 2020 targets and estimated shares of energy from renewable sources in electricity, heating and cooling and transport:~~

~~(a) target share of energy from renewable sources in electricity in 2020;~~

~~(b) estimated trajectory for the share of energy from renewable sources in electricity;~~

~~(c) target share of energy from renewable sources in heating and cooling in 2020;~~

~~(d) estimated trajectory for the share of energy from renewable sources in heating and cooling;~~

~~(e) estimated trajectory for the share of energy from renewable sources in transport;~~

~~(f) national indicative trajectory as referred to in Article 3(2) and part B of Annex I.~~

~~3. Measures for achieving the targets:~~

~~(a) overview of all policies and measures concerning the promotion of the use of energy from renewable sources;~~

~~(b) specific measures to fulfil the requirements of Articles 13, 14 and 16, including the need to extend or reinforce existing infrastructure to facilitate the integration of the quantities of energy from renewable sources needed to achieve the 2020 national target, measures to accelerate the authorisation procedures, measures to reduce non-technological barriers and measures concerning Articles 17 to 21;~~

~~(c) support schemes for the promotion of the use of energy from renewable sources in electricity applied by the Member State or a group of Member States;~~

~~(d) support schemes for the promotion of the use of energy from renewable sources in heating and cooling applied by the Member State or a group of Member States;~~

~~(e) support schemes for the promotion of the use of energy from renewable sources in transport applied by the Member State or a group of Member States;~~

~~(f) specific measures on the promotion of the use of energy from biomass, especially for new biomass mobilisation taking into account:~~

~~(i) biomass availability: both domestic potential and imports;~~

~~(ii) measures to increase biomass availability, taking into account other biomass users (agriculture and forest-based sectors);~~

~~(g) planned use of statistical transfers between Member States and planned participation in joint projects with other Member States and third countries:~~

~~(i) the estimated excess production of energy from renewable sources compared to the indicative trajectory which could be transferred to other Member States;~~

~~(ii) the estimated potential for joint projects;~~

~~(iii) the estimated demand for energy from renewable sources to be satisfied by means other than domestic production.~~

~~4. Assessments:~~

~~(a) the total contribution expected of each renewable energy technology to meet the mandatory 2020 targets and the indicative trajectory for the shares of energy from renewable sources in electricity, heating and cooling and transport;~~

~~(b) the total contribution expected of the energy efficiency and energy saving measures to meet the mandatory 2020 targets and the indicative trajectory for the shares of energy from renewable sources in electricity, heating and cooling and transport.~~

↓ 2009/28/EC (adapted)

ANNEX VII

Accounting of energy from heat pumps

The amount of aerothermal, geothermal or hydrothermal energy captured by heat pumps to be considered energy from renewable sources for the purposes of this Directive, E_{RES}, shall be calculated in accordance with the following formula:

$E_{RES} = Q_{usable} * (1 – 1/SPF)$

where

– Q_{usable} = the estimated total usable heat delivered by heat pumps fulfilling the criteria referred to in Article 7 ~~5~~(4), implemented as follows: Only heat pumps for which $SPF > 1,15 * 1/\eta$ shall be taken into account,

– SPF = the estimated average seasonal performance factor for those heat pumps,

– η is the ratio between total gross production of electricity and the primary energy consumption for electricity production and shall be calculated as an EU average based on Eurostat data.

~~By 1 January 2013, the Commission shall establish guidelines on how Member States are to estimate the values of Q_{usable} and SPF for the different heat pump technologies and applications, taking into consideration differences in climatic conditions, especially very cold climates.~~

↓ 2009/28/EC

↓ 2015/1513 Art. 2.13 and Annex II.2
⇨ new

ANNEX VIII

PART A. PROVISIONAL ESTIMATED INDIRECT LAND-USE CHANGE EMISSIONS FROM BIOFUEL AND BIOLIQUID FEEDSTOCKS (gCO_{2eq}/MJ) ⇨ [34] ⇦

Feedstock group	Mean ⇨ [35] ⇦	Interpercentile range derived from the sensitivity analysis ⇨ [36] ⇦
Cereals and other starch-rich crops	12	8 to 16
Sugars	13	4 to 17
Oil crops	55	33 to 66

PART B. BIOFUELS AND BIOLIQUIDS FOR WHICH THE ESTIMATED INDIRECT LAND-USE CHANGE EMISSIONS ARE CONSIDERED TO BE ZERO

Biofuels and bioliquids produced from the following feedstock categories will be considered to have estimated indirect land-use change emissions of zero:

(1) feedstocks which are not listed under part A of this Annex.

(2) feedstocks, the production of which has led to direct land-use change, i.e. a change from one of the following IPCC land cover categories: forest land, grassland, wetlands, settlements, or other land, to cropland or perennial cropland ⇨ [37] ⇦ . In such a case a direct land-use change emission value (e_l) should have been calculated in accordance with point 7 of part C of Annex V.

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34 (+) The mean values reported here represent a weighted average of the individually modelled feedstock values. The magnitude of the values in the Annex is sensitive to the range of assumptions (such as treatment of co-products, yield developments, carbon stocks and displacement of other commodities) used in the economic models developed for their estimation. Although it is therefore not possible to fully characterise the uncertainty range associated with such estimates, a sensitivity analysis conducted on the results based on a random variation of key parameters, a so-called Monte Carlo analysis, was conducted.

35 The mean values included here represent a weighted average of the individually modelled feedstock values.

36 The range included here reflects 90 % of the results using the fifth and ninety-fifth percentile values resulting from the analysis. The fifth percentile suggests a value below which 5 % of the observations were found (i.e. 5 % of total data used showed results below 8, 4, and 33 gCO_{2eq}/MJ). The ninety-fifth percentile suggests a value below which 95 % of the observations were found (i.e. 5 % of total data used showed results above 16, 17, and 66 gCO_{2eq}/MJ).

37 (++) Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.

↓ 2015/1513 Art. 2.13 and Annex II.3 (adapted)
⇨ new

ANNEX IX

Part A. Feedstocks ⇨ for the production of advanced biofuels ⇦ ~~and fuels, the contribution of which towards the target referred to in the first subparagraph of Article 3(4) shall be considered to be twice their energy content~~:

(a) Algae if cultivated on land in ponds or photobioreactors.

(b) Biomass fraction of mixed municipal waste, but not separated household waste subject to recycling targets under point (a) of Article 11(2) of Directive 2008/98/EC.

(c) Bio-waste as defined in Article 3(4) of Directive 2008/98/EC from private households subject to separate collection as defined in Article 3(11) of that Directive.

(d) Biomass fraction of industrial waste not fit for use in the food or feed chain, including material from retail and wholesale and the agro-food and fish and aquaculture industry, and excluding feedstocks listed in part B of this Annex.

(e) Straw.

(f) Animal manure and sewage sludge.

(g) Palm oil mill effluent and empty palm fruit bunches.

(h) ⌦ Tall oil and ⌫ ~~T~~tall oil pitch.

(i) Crude glycerine.

(j) Bagasse.

(k) Grape marcs and wine lees.

(l) Nut shells.

(m) Husks.

(n) Cobs cleaned of kernels of corn.

(o) Biomass fraction of wastes and residues from forestry and forest-based industries, i.e. bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin ~~and tall oil~~.

(p) Other non-food cellulosic material as defined in point (s) of the second paragraph of Article 2.

(q) Other ligno-cellulosic material as defined in point (r) of the second paragraph of Article 2 except saw logs and veneer logs.

(r) Renewable liquid and gaseous transport fuels of non-biological origin.

(s) Carbon capture and utilisation for transport purposes, if the energy source is renewable in accordance with point (a) of the second paragraph of Article 2.

(t) Bacteria, if the energy source is renewable in accordance with point (a) of the second paragraph of Article 2.

Part B. Feedstocks ⇨ for the production of biofuels ⇦ , the contribution of which towards the ⇨ minimum share established in Article 25(1) is limited ⇦ target referred to in the first subparagraph of Article 3(4) shall be considered to be twice their energy content:

(a) Used cooking oil.

(b) Animal fats classified as categories 1 and 2 in accordance with Regulation (EC) No 1069/2009 of the European Parliament and of the Council [38]

⇩ new

(c) Molasses that are produced as a by-product from of refining sugarcane or sugar beets provided that the best industry standards for the extraction of sugar has been respected.

🡻 2015/1513 Art. 2.13 and Annex II.3

[38] ⇨ ⇦ Regulation (EC) No 1069/2009 of the European Parliament and of the Council of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal by-products Regulation) (OJ L 300, 14.11.2009, p. 1).

⇩ new

ANNEX X

Part A: Maximum contribution from liquid biofuels produced from food or feed crops to the EU renewable energy target as referred to in Article 7 paragraph 1

Calendar year	Maximum share
2021	7.0%
2022	6.7%
2023	6.4%
2024	6.1%
2025	5.8%
2026	5.4%
2027	5.0%
2028	4.6%
2029	4.2%
2030	3.8%

Part B: Minimum shares of energy from advanced biofuels and biogas produced from feedstock listed in Annex IX, renewable transport fuels of non-biological origin, waste-based fossil fuels and renewable electricity, as referred to in Article 25(1)

Calendar year	Minimum share
2021	1.5 %
2022	1.85 %
2023	2.2 %
2024	2.55 %
2025	2.9 %
2026	3.6 %
2027	4.4 %

2028	5.2 %
2029	6.0 %
2030	6.8 %

Part C: Minimum shares of energy from advanced biofuels and biogas produced from feedstock listed in Part A of Annex IX as referred to in Article 25(1)

Calendar year	Minimum share
2021	0.5 %
2022	0.7%
2023	0.9 %
2024	1.1 %
2025	1.3 %
2026	1.75 %
2027	2.2 %
2028	2.65 %
2029	3.1 %
2030	3.6 %

↑

ANNEX XI

Part A

Repealed Directive with list of the successive amendments thereto (referred to in Article 34)

Directive 2009/28/EC of the European Parliament and of the Council (OJ L 140, 5.6.2009, p. 16)	
Council Directive 2013/18/EU (OJ L 158, 10.6.2013, p. 230)	
Directive (EU) 2015/1513 (OJ L 239, 15.9.2015, p. 1)	Only Article 2

Part B

Time-limits for transposition into national law

(referred to in Article 34)

Directive	**Time-limit for transposition**
2009/28/EC	25 June 2009
2013/18/EU	1 July 2013
(EU) 2015/1513	10 September 2017

ANNEX XII

Correlation table

Directive 2009/28/EC	This Directive
Article 1	Article 1
Article 2, first subparagraph	Article 2, first subparagraph
Article 2, second subparagraph, introductory wording	Article 2, second subparagraph, introductory wording
Article 2, second subparagraph, point a	Article 2, second subparagraph, point a
Article 2, second subparagraph, points b, c and d	—
—	Article 2, second subparagraph, point b
Article 2, second subparagraph, points e, f, g, h, i, j, k, l, m, n, o, p, q, r, and s	Article 2, second subparagraph, points c, d, e, f ,g h , i ,j, k, l, m ,n, o, p and q
Article 2, second subparagraph, point t	—
—	Article 2, second subparagraph, point r
Article 2, second subparagraph, points u, v and w	Article 2, second subparagraph, points s, t and u
—	Article 2, second subparagraph, points x, y, z, aa, bb, cc, dd, ee, ff, gg, hh, ii, jj, kk, ll, mm, nn, oo, pp, qq, rr, ss, tt and uu
Article 3	—
—	Article 3
Article 4	—
—	Article 4
—	Article 5
—	Article 6
Article 5, paragraph 1, subparagraphs 1, 2 and 3	Article 7, paragraph 1, subparagraphs 1, 2 and 3
—	Article 7, paragraph 1, subparagraph 4

Article 5, paragraph 2	—
Article 5, paragraphs 3 and 4	Article 7, paragraphs 2 and 3
—	Article 7, paragraphs 4 and 5
Article 5, paragraphs 5 and 6	Article 7, paragraphs 6 and 7
Article 6	Article 8
Article 7	Article 9
Article 8	Article 10
Article 9	Article 11
Article 10	Article 12
Article 11	Article 13
Article 12	Article 14
Article 13, paragraph 1, subparagraph 1	Article 15, paragraph 1, subparagraph 1
Article 13, paragraph 1, subparagraph 2	Article 15, paragraph 1, subparagraph 2
Article 13, paragraph 1, subparagraph 2, points a and b	—
Article 13, paragraph 1, subparagraph 2, points c, d ,e and f	Article 15, paragraph 1, subparagraph 2, points a, b, c and d
Article 13, paragraph 2	Article 15, paragraph 2
—	Article 15, paragraphs 3
Article 13, paragraphs 3, 4 and 5	Article 15, paragraphs 4, 5 and 6
Article 13, paragraph 6, first subparagraph	Article 15, paragraph 7, first subparagraph
Article 13, paragraph 6, subparagraphs 2,3,4 and 5	—
—	Article 15, paragraphs 8 and 9
—	Article 16
—	Article 17
Article 14	Article 18

Article 15, paragraphs 1 and 2	Article 19, paragraphs 1 and 2
Article 15, paragraph 3	—
—	Article 19, paragraphs 3 and 4
Article 15, paragraphs 4 and 5	Article 19, paragraphs 5 and 6
Article 15, paragraph 6, first subparagraph, point a	Article 19, paragraph 7, first subparagraph, point a
Article 15, paragraph 6, first subparagraph, point b (i)	Article 19, paragraph 7, first subparagraph, point b (i)
—	Article 19, paragraph 7, first subparagraph, point b (ii)
Article 15, paragraph 6, first subparagraph, point b (ii)	Article 19, paragraph 7, first subparagraph, point b (iii)
—	Article 19, paragraph 7, second subparagraph
Article 15, paragraph 7	Article 19, paragraph 8
Article 15, paragraph 8	—
Article 15, paragraphs 9 and 10	Article 19, paragraphs 9 and 10
—	Article 19, paragraph 11
Article 15, paragraphs 11 and 12	Article 19, paragraphs 12 and 13
	Article 19, paragraph 14
Article 16, paragraphs 1, 2, 3, 4, 5, 6, 7 and 8	—
Article 16, paragraphs 9, 10 and 11	Article 20, paragraphs 1, 2 and 3
—	Article 21
—	Article 22
—	Article 23
—	Article 24
—	Article 25
Article 17, paragraph 1, first and second subparagraphs	Article 26, paragraph 1, first, second and fourth subparagraphs

—	Article 26, paragraph 1, third subparagraph
Article 17, paragraph 2	Article 26, paragraph 7
Article 17, paragraph 3, first subparagraph	Article 26, paragraph 2, first subparagraph
Article 17, paragraph 3, first subparagraph	Article 26, paragraph 2, first subparagraph
—	Article 26, paragraph 2, second subparagraph
Article 17, paragraph 4, first subparagraph	Article 26, paragraph 3, first subparagraph
Article 17, paragraph 4, first subparagraph, points a and b	Article 26, paragraph 3, first subparagraph, points a and b
Article 17, paragraph 4, first subparagraph, point c	—
Article 17, paragraph 4, second subparagraph,	Article 26, paragraph 3, second subparagraph
Article 17, paragraph 5	Article 26, paragraph 4
Article 17, paragraphs 6 and 7	—
Article 17, paragraph 8	Article 26, paragraph 9
Article 17, paragraph 9	—
—	Article 26, paragraphs 5, 6 and 8
Article 18, paragraph 1, first subparagraph	Article 27, paragraph 1, first subparagraph
Article 18, paragraph 1, first subparagraph, point a, b and c	Article 27, paragraph 1, first subparagraph, points a, c and d
—	Article 27, paragraph 1, first subparagraph, points b
Article 18, paragraph 2	—
—	Article 27, paragraph 2
Article 18, paragraph 3, first subparagraph	Article 27, paragraph 3, first subparagraph
Article 18, paragraph 3, second and third subparagraphs	—
Article 18, paragraph 3, fourth and fifth subparagraphs	Article 27, paragraph 3, second and third subparagraphs

Article 18, paragraph 4, first subparagraph	—
Article 18, paragraph 4, second and third subparagraphs	Article 27, paragraph 4, first and second subparagraphs
Article 18, paragraph 4, fourth subparagraph	—
Article 18, paragraph 5	Article 27, paragraph 5
Article 18, paragraph 6, first and second subparagraphs	Article 27, paragraph 6, first and second subparagraphs
Article 18, paragraph 6, third subparagraph	—
Article 18, paragraph 6, fourth subparagraph	Article 27, paragraph 6, third subparagraph
—	Article 27, paragraph 6, fourth subparagraph
Article 18, paragraph 6, fifth subparagraph	Article 27, paragraph 6, fifth subparagraph
Article 18, paragraph 7, first subparagraph	Article 27, paragraph 7, first subparagraph
—	Article 27, paragraph 7, second and third subparagraph
Article 18, paragraphs 8 and 9	—
Article 19, paragraph 1, first subparagraph	Article 28, paragraph 1, first subparagraph
Article 19, paragraph 1, first subparagraph, point a, b and c	Article 28, paragraph 1, first subparagraph, point a, b and c
—	Article 28 paragraph 1, first subparagraph, point d
Article 19, paragraph 2, 3 and 4	Article 28, paragraph 2, 3 and 4
Article 19, paragraph 5	—
Article 19, paragraph 7, first subparagraph	Article 28, paragraph 5, first subparagraph
Article 19, paragraph 7, first subparagraph, first, second third and fourth indents	—
Article 19, paragraph 7, second subparagraph	Article 28, paragraph 5, second subparagraph
Article 19, paragraph 7, third subparagraph, introductory words	Article 28, paragraph 5, third subparagraph, introductory words
Article 19, paragraph 7, third subparagraph,	Article 28, paragraph 5, third subparagraph,

point a	point a
Article 19, paragraph 7, third subparagraph, point b	—
Article 19, paragraph 8	—
Article 20	Article 29
Article 22	—
Article 23, paragraphs 1 and 2	Article 30, paragraphs 1 and 2
Article 23, paragraphs 3, 4, 5, 6, 7 and 8	—
Article 23, paragraph 9	Article 30, paragraph 3
Article 23, paragraph 10	Article 30, paragraph 4
Article 24	—
Article 25, paragraph 1	Article 31, paragraph 1
Article 25, paragraph 2	—
Article 25, paragraph 3	Article 31, paragraph 2
Article 25 a, paragraphs 1, 2, 3, 4 and 5	Article 32, paragraphs 1, 2, 3, 5 and 6
—	Article 32, paragraph 4
Article 26	—
Article 27	Article 33
—	Article 34
Article 28	Article 35
Article 29	Article 36
Annex I	Annex I
Annex II	Annex II
Annex III	Annex III
Annex IV	Annex IV
Annex V	Annex V

Annex VI	—
—	Annex VI
Annex VII	Annex VII
Annex VIII	Annex VIII
Annex IX	Annex IX
—	Annex X
—	Annex XI
—	Annex XII