Preliminary translation

Life Cycle GHG Default Values of Biomass Fuels under FIT/FIP Scheme

Biomass Sustainability Working Group

March 2024

I. Introduction

(1) About Creating Life Cycle GHG Default Values

This document describes default values that are intended to be used to identify life cycle GHGs of biomass fuels under the FIT/FIP scheme in Japan. Calculation process of the default values are also included for reference.

In calculating the default life cycle GHGs of each biomass fuel, the default values used in EU RED2 and information presented by industry associations in past Biomass Sustanability WGs are used as reference, while following the life cycle GHG calculation method under the FIT/FIP scheme described below.

Life cycle GHG calculation method under the FIT/FIP scheme

1. Covered greenhouse gases
   i. The GHG types taken into account in the calculations are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O).
   ii. The warming potential is 25 for methane (CH4) and 298 for nitrous oxide (N2O).

2. Boundary and formula
   i. Carbon stock changes including land use change, cultivation, processing, transportation, and power generation are included in the calculation. The processes and emissions activities included are specified by biomass type.
   ii. Emissions generated during one-time construction (e.g., power plants construction , fuel production facility construction) will not be included.
   iii. GHG emissions from CO2 capture and sequestration, CO2 capture and alternative use (limited to CO2 originating from biomass) can be considered as emission reductions if they can be avoided.
   iv. The "LCA Guidelines for Greenhouse Gas Reduction Effects of Renewable Energy" developed by the Ministry of Environment may be used as a reference for determining the amount of activity and setting emission factors.

(Formula) $E_{bio} = e_{stock} + e_{cultivate} + e_{processing} + e_{transportation} + e_{generation} - e_{rcc} - e_{rccr}$

$E_{elec} = E_{bio} / \eta_{el}$

where:

E_{bio} = Total GHG emissions from biomass fuel before conversion by power generation efficiency

e_{stock} = Emissions or emission reductions associated with changes in carbon stock, including land-use change

$e_{cultivate}$ = Emissions from cultivation

$e_{processing}$ = Emissions from processing

$e_{transportation}$ = Emissions from transportation

$e_{generation}$ = Emissions from power generation

e_{rccs} = Emissions reductions from CO2 capture and sequestration

e_{rccr} = Emissions reduction through CO2 recovery and alternative use (only those that recover CO2 from biomass sources)

E_{elec} = GHG emissions from biomass power generation per MJ-electricity

η_{el} = power generation efficiency of biomass power generation

3. Calculation method for each process

i) Changes in carbon stock, including land-use changes

i. For changes in carbon stock, including land-use changes, only direct land-use changes shall be accounted for at this stage. Note)

Note) In addition to direct land-use changes, such as the diversion of land use from forest to agricultural land, there are cases where carbon stock decreases due to cutting, carrying-out, and death of more wood than the amount of wood that has grown. The WG will consider such cases in accordance with the trends of future international discussions.

The direct land-use change emissions are calculated by evenly dividing the change in carbon stock in soil and vegetation from the initial date (the difference in carbon stock between the relevant year and the initial date) over 20 years, and the initial date is January 1, 2008.

ii)Cultivation (feedstock cultivation and collection)

i. GHG emissions associated with consumption of fossil fuels, electricity and heat for cultivation of feedstocks, as well as production, procurement, and use of fertilizer and chemical substances inputs and emissions from fermentation of organic matter and fertilization must be included.

ii. If CO2 generated is captured and sequestered or alternatively used (eligible only if biomass origin CO2 is captured), it may be excluded from the emissions.

iii) Processing (pre-processing and conversion)

i. For processing, the consumption of fossil fuels, electricity and heat required for processing and GHG emissions associated with the manufacture, procurement and use of chemicals must be accounted for.

ii. If the CO2 generated is recovered and sequestered or alternatively used (only those that recover CO2 from biomass sources), it may be deducted from emissions.

iv) Transportation (transportation of feedstocks and fuel)

i. GHG emissions associated with the consumption of fossil fuels, electricity and heat for transportation and storage of feedstocks and fuel must be accounted for.

ii. GHG emissions from return routes shall be taken into account. In particular, for maritime transport, the fuel consumption of the vessel shall be used, taking into account the biomass bulk density. For the time being, the ratio of empty cargo transportation shall be set at 30% of total voyage distance for cases where no specific voyage pattern is taken. In the case of round-trip transportation (round trip from the same port), the transportation of empty cargo shall be identified as the transportation distance of biomass fuel, unless it can be confirmed that the return vessel is unloaded.

v) Power generation

i. CO2 emissions from use of biomass fuels are considered to be zero.

ii. CH4, N2O emissions shall be included.

4. Allocation

i. Biomass specific boundary of processes/emission activity and products to which GHG emissions are allocated shall be specified by biomass type.

ii. Allocation of GHG emissions shall be in proportion to their energy content (determined by lower heat value) .

5. Power generation efficiency
   i. Power generation efficiency is based on power plant outlet and the heat value of fuel is based on the lower heat value standard.
   ii. In the case of a combined heat and power plant, biomass fuel life cycle GHG emissions are allocated into heat and power each with exergy base, before conversion by generation efficiency. Specifically, the following equation is followed.

(Formula) $E_{cogen\text{-}bio} = E_{bio} * [\ \eta_{el} / \{ \eta_{el} + \eta_h * (T_h - 290)/T_h \}]$

$E_{elec} = E_{cogen\text{-}bio} / \eta_{el}$

where:

$E_{cogen\text{-}bio}$ = Total GHG emissions from biomass fuels before conversion by power generation efficiency before allocation into heat and power each

E_{bio} = Total GHG emissions attributed to electricity from biomass fuels before conversion by power generation efficiency

η_{el} = Power generation efficiency in a combined heat and power plant (annual power generation at power plant outlet divided by annual heat input)

η_h = Thermal efficiency in a combined heat and power plant (annual heat supply divided by annual heat input (excluding internal consumption including processing of biomass fuel))

T_h = Absolute temperature (K) of heat supplied in a combined heat and power plant

If the excess heat is externally supplied for heating at less than 150 degrees C(423.15 K), the thermal temperature (T_h) can be set at 150 degrees C(423.15 K) in the calculation.

< Main sources information in the calculation of the default values >

In the calculation process of the default values shown in this document, the values from the following documents describing the calculation process of the EU RED2 default values are cited. [1]

- ✓ Definition of input data to assess GHG default emissions from biofuels in EU legislation, JRC (2017a)
- ✓ Solid and gaseous bioenergy pathways: input values and GHG emissions, JRC (2017b)

It should be noted that the EU RED2 default values of processing GHG emissions are 40% higher than the typical values for liquid fuels and 20% higher than the typical values for solid fuels, for purpose of conservative calculation. Therefore, in this document, the default values for liquid fuels are 40% higher and for solid fuels 20% higher than the values calculated for the processing as well.

1 Parts of the calculation process based on spreadsheets for both JRC(2017a) and JRC(2017b) can be found on https://jeodpp.jrc.ec.europa.eu/ftp/jrc-opendata/ALF-BIO/datasets/biofuels_jrc_annexv_com2016-767_v1_july17/VER2017-07-31/ and https://energy.ec.europa.eu/database-biomass_en, respectively (as of November 11, 2022). Date sources for this documents include those cited from these sources.

< Set up of default values >

The default values presented in this document represent applicable life cycle GHG emissions under the FIT/FIP scheme for biomass fuels that meet certain conditions, and do not preclude identifying more detailed conditions for individual biomass and confirming life cycle GHG emissions calculation reflecting further reductions. In addition, one of the conditions to apply the default values presented here is that there has been no direct land-use change since January 2008.

In addition, the default values provided in this document will be reviewed as necessary in the future.

(2) Application of Default Values

As confirmed in past Biomass Sustainability Working Groups, there are two ways to certify applicability of default values for life cycle GHG confirmation: by utilizing existing certification schemes and by utilizing FIT/FIP-specific verification schemes. In both methods, the following should be kept in mind when applying default values.

- The default values shown in this document are life cycle GHG defaults per biomass fuel heat value (g-CO2eq/MJ-fuel). Since the standard for life cycle GHG emissions required by the FIT/FIP system is per unit of electricity generated at power generation outlet, it is necessary to calculate the value per unit of electricity generated by dividing the default value by the generation efficiency that can be verified by the power producer. (For biomass power plants that use combined heat and power, the life cycle GHG of biomass fuel is prorated based on the electricity produced and the exergy in heat (the amount of energy that can be extracted from heat as a mechanical work) before being converted to a value per unit of electricity generated.)
- When applying the default values, it is necessary to check whether each category is applicable. For example, in the case of numerical categories such as distance, it is necessary to check whether the actual transportation distance is within the range of the default category.
- The default values in this document also provide disaggregated values by process. Such disaggregated default values can be utilized for actual calculation.

＜Definitions of categories of woody biomass for default LCGHG values＞

- The classification of woody biomass for life cycle GHG is defined as forest residues, other harvested trees, sawmill residues as shown in Table 1.
- The specific confirmation method for imported woody biomass shall be in accordance with the confirmation method established by each third-party certification scheme.

Table 1 Definition of default lifecycle GHG value categories for woody biomass

Category for default life cycle GHG value	Definition
Sawmill residues	Offcuts, sawdust, bark and other residues generated during wood processing
Forest residues	Low-quality wood generated from felling for the main purpose of producing wood for material use (including offcuts and branches), thinned wood, etc. In addition, trees damaged by pests and diseases or natural disasters, pruned branches, driftwood of dams, etc. generated by felling for purposes other than energy use(excluding waste).
Other harvested trees	Woody biomass generated from felling for the purpose of energy use

(3) Default values for newly eligible biomass fuels

At the 83rd meeting after consideration of the request of adding newly eligible biomass fuels for FT/FIP by industry groups , the Procurement Price Calculation Committee made recommendation that those that are confirmed to be inedible and by-products should be added as newly eligible biomass fuels for FT/FIP from FY2023. The following is description of newly eligible biomass fuels included in Guidelines for developing business plans (Biomass power generation) formulated in April of FY2023.

Description of newly eligible biomass fuels (*Numbered biomass species are newly eligible fuels)

- The biomass species generated by the harvesting of agricultural products currently eligible in FIT/FIP certification are palm oil as the main product and PKS, Palm trunk, (1)EFB, (2) Coconut shell, (3)Cashew nutshell, (4)Walnut shell, (5)Almond shell, (6)Pistachio shell, (7)Sunflower seed shells, (8)Corn straw pellet, (9)Bengkuang seeds, (10)Sugar cane stems & leaves, (11)Peanut shell and (12)Cashew nut shell liquid (CNSL) as the by-product.

Based on the above, we have formulated default values that can be applied to the above 12 types of newly eligible biomass fuels. Since it has been confirmed that all newly eligible biomass fuels are categorized into biomass generated by harvesting agricultural products, the results of the calculation of their default values are described in Chapter II of this document.

II. Life Cycle GHG Default Values for Biomass Arising from Harvesting Agricultural Products

1. Calculation results for default values

From the beginning of FIT scheme introduction, there have been three types of biomass generated at the harvest of agricultural products permitted under the FIT/FIP system:

- Palm oil
- PKS
- Palm trunk

For palm oil, two types of default values are set, namely Crude Palm Oil (CPO) and Palm Stearin. For each type, two pathways of default values are set, namely with and without methane recovery from wastewater in the oil extraction process.

For PKS and palm trunks, two types of transportation distance are set, namely 6,500 km and 9,000 km taking into account the distance from the main producing countries to Japan. Also, two types of ship size categories are set, namely Handysize and Supramax, considering large share of GHG emissions from maritime transport.

For palm trunk, two types of processing are assumed, namely one using fossil fuels as a heat source in the drying process and the one using biomass fuels for it. Pelletization is assumed to be conducted in the feedstock producing countries.

The calculation results of the default life cycle GHG values for each fuel are as follows.

Table 2 Life cycle GHG default values for CPO (g-CO2eq/MJ-fuel)

Process	No methane recovery	With methane recovery
Cultivation process	19.32	
Transport (FFB transport)	1.21	
Pprocessing (oil extraction)	29.81	5.21
Transport (CPO transport)	4.03	
Power generation	0	
Total	54.37	29.77

Table 3 Life cycle GHG default values for palm stearin (g-CO2eq/MJ-fuel)

Process	No methane recovery	With methane recovery
Cultivation process	19.67	
Transport (FFB transport)	1.24	
Processing (oil extraction)	30.36	5.31
Transport (CPO transport)	0.15	
Processing (refining)	1.49	
Processing (separation)	0	
Transport (Palm stearin transport)	3.92	
Power generation	0	
Total	56.83	31.78

Table 4 Life cycle GHG default values for PKS (g-CO2eq/MJ-fuel)

Process	Handysize 6,500 km transport	Supramax 6,500 km transport
Transport (domestic transport of PKS in producing countries)	0.66	
Transport (maritime transport of PKS)	7.33	4.68
Transport (domestic transport of PKS in Japan)	0.42	
Power generation	0.26	
Total	8.67	6.02

Process	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport)	10.15	6.48
(The rest of the process is omitted because it is the same as the 6,500 km transport.)		
Total	11.49	7.82

Table 5 Life cycle GHG default values for palm trunk (g-CO2eq/MJ-fuel)

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass utilization (Pelletizing: Grid power use)	
	Handysize Transport 6,500 km	Supramax Transport 6,500 km	Handysize Transport 6,500 km	Supramax Transport 6,500 km
Transport (palm trunk collection)	0.83		1.06	
processing	31.32		15.20	
Transport (domestic transport of palm trunk in producing countries)	0.55			
Transport (maritime transport)	3.11	2.01	3.11	2.01
Transport (domestic transport of palm trunk in Japan)	0.34			
Power generation	0.25			
Total	36.40	35.30	20.51	19.41

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 9,000 km	Supramax 9,000 km transport	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport)	4.30	2.78	4.30	2.78
(The rest of the process is omitted because it is the same as the 6,500 km transport.)				
Total	37.59	36.07	21.70	20.18

For the newly eligible biomass fuels from FY2023, the default values formulated this time are eight types as described in Table 6 applicable to all the 12 newly eligible fuels, considering each process and energy input. It also describes "Starting point of life cycle GHG calculation", " Processing type", and "With/Without Biomass in-house power generation".

Table 6 Newly eligible biomass fuels default values categories and conditions

	Categories	Starting point of life cycle GHG calculation	Processing type		Biomass in-house power generation	Applicable newly eligible fuels
			Drying process	Pelletization		
Solid fuel	EFB	Processing at a pellet plant*	Yes (biomass boiler/fossil fuel boiler)	Yes	No (electricity from grid)	EFB
	Nutshells (pellet)	Transport from food processing plant	No	Yes	No (electricity from grid)	Cashew nutshell Walnut shell Almond shell Pistachio shell Sunflower seed shells
	Coconuts shells	Transport from food processing plant	No	No (Only chipping is included)	No (electricity from grid)	Coconut shell
	Corn straw (pellet)	Aggregation at farm	No (Seasoning)	Yes	No (electricity from grid)	Corn straw
	Sugar cane stems & leaves (pellet)	Aggregation at farm	No (Seasoning)	Yes	Yes (power generation from Bagasse)	Sugar cane stems & leaves
	Bengkuang seeds	Transport from farm	No	No	No	Bengkuang seeds
	Cashew nut shell residues from oil extraction	Processing at extraction plant	No	No	No	Cashew nut shell residues (from oil extraction)
Liquid fuel	Cashew nut shell liquid (CNSL)	Processing at extraction plant	Pretreatment, hydrolysis, solid-liquid/oil/water separation processes are applied		No (electricity from grid)	Cashew nut shell liquid (CNSL)
					Yes (electricity from grid)	

*The default values for EFB (pellets) assumes pellet processing mill is adjacent to the oil mill.

For each newly eligible fuel, the categories of default values are as follows.

- For EFB, there are two types of heat sources in the drying process: natural gas heat sources and biomass heat sources, and two types of ship sizes, Handysize and Supramax.
- For nutshell, corn straw, sugarcane stems and leaves and Bengkuang seeds, there are two types of distance classifications assuming from the main producing countries supplying to Japan, and two types of ship sizes, Handysize and Supramax.
- For coconut shells, assuming transportation from Southeast Asia, two types of ship sizes are classified: Handysize and Supramax.
- For Cashew nut shell liquid (CNSL), two types of input power in the processing are set: grid power and biomass in-house power generation, and two categories are established with the distance assuming from the main producing countries supplying to Japan.
- For Cashew nut shell residues from oil extraction, there are two types of distance classifications assuming from the South East Asia and Africa, and two types of ship sizes, Handysize and Supramax.

The calculation results of the default life cycle GHG values for each fuel are as follows.

Table 7 Life cycle GHG default values for EFB pellets (g-CO2eq/MJ-fuel)

Process	Drying: Use of fossil fuels (Pelletizing: Use of grid power)		Drying: Use of biomass (Pelletizing: Use of grid power)	
	Handysize 9,000 km transport	Supramax 9,000 km transport	Handysize 9,000 km transport	Supramax 9,000 km transport
Processing (drying)	3.91		0.016	
Processing (cleaning, crushing, pelletizing)	16.04			
Transport (domestic transport of EFB pellets in producing countries)	0.24			
Transport (maritime transport of EFB pellet)	4.09	2.64	4.09	2.64
Transport (domestic transport of EFB pellet in Japan)	0.32			
Power generation	0.26			
Total	24.85	23.41	20.96	19.52

Table 8 Life cycle GHG default values for Nutshell pellets (g-CO2eq/MJ-fuel)

Process	Handysize 3,500 km transport	Supramax 3,500 km transport
Transport (nut shell transport)	0.38	
Processing	11.98	
Transport (domestic transport of nut shell pellets in producing countries)	0.69	
Transport (maritime transport of nut shell pellets)	1.59	1.03
Transport (domestic transport of nut shell pellets in Japan)	0.32	
Power Generation	0.26	
Total	15.23	14.67

Process	Handysize 9,000 km Transport	Supramax 9,000 km transport
Transport (maritime transport of nut shell pellets)	4.09	2.64
(The rest of the process is omitted because they are the same as 3,500 km transport)		
Total	17.72	16.28

Table 9 Life cycle GHG default values for Coconut shell (g-CO2eq/MJ-fuel)

process	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (transport of coconut shell feedstock)	0.22	
Processing	1.15	
Transport (domestic transport of coconut shells in producing countries)	0.02	
Transport (maritime transport of coconut shell)	7.90	5.05
Transport (domestic transport of coconut shells in Japan)	0.32	
Power generation	0.26	
Total	9.87	7.02

Table 10 Life cycle GHG default values for Corn straw pellets (g-CO2eq/MJ-fuel)

Process	Handysize 3,500 km transport	Supramax 3,500 km transport
Collection Process	0.97	
Transport (Corn Straw Transport)	0.23	
Processing	4.64	
Transport (domestic transport of corn straw pellets in producing countries)	0.23	
Transport (maritime transport of corn straw pellets)	1.66	1.08
Transport (domestic transport of corn straw pellets in Japan)	0.34	
Power generation	0.26	
Total	8.32	7.73

Process	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport of corn straw pellet)	4.28	2.77
(The rest of the process is omitted because they are the same as 3,500 km transport)		
Total	10.93	9.42

Table 11 Life cycle GHG default values for Sugarcane stem and leaf pellets (g-CO2eq/MJ-fuel)

Process	Handysize 10,000 km transport	Supramax 10,000 km transport
Collection process	0.97	
Transport (sugarcane stem and leaf transport)	0.23	
Processing	0.037	
Transport (domestic transport of sugarcane stem and leaf pellets in producing countries)	1.81	
Transport (maritime transport of sugarcane stem and leaf pellets)	4.75	3.07
Transport (domestic transport of sugarcane stem and leaf pellets in Japan)	0.34	
Power generation	0.26	
Total	8.39	6.71

process	Handysize 22,000 km transport	Supramax 22,000 km transport
Transport (maritime transport of sugarcane stem and leaf pellets)	10.45	6.76
(The rest of the process is omitted because they are the same as 10,000 km transport)		
Total	14.09	10.40

Table 12 Life cycle GHG default values for Bengkuang seeds (g-CO2eq/MJ-fuel)

Process	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (domestic transport of benkowan seed in producing countries)	0.57	
Transport (maritime transport of benkowan seeds)	3.05	1.97
Transport (domestic transport of benkowan seeds in Japan)	0.24	
Power Generation	0.26	
Total	4.12	3.04

process	Handysize 26,000 km transport	Supramax 26,000 km transport
Transport (maritime transport of Bengkuang seeds)	8.81	5.70
(The rest of the process is omitted because they are the same as 9,000 km transport)		
Total	9.88	6.77

Table 13 Life cycle GHG default values for Cashew nut shell liquid(CNSL) (g-CO2eq/MJ-fuel)

Process	processing: Use of grid power		processing: Use of biomass in-house power generation	
	9,000 km transport	26,000 km transport	9,000 km transport	26,000 km transport
Processing	6.11		0.05	
Transport (domestic transport of cashew nut shell liquid in producing countries)	0.74			
Transport (maritime transport of cashew nut shell liquid)	3.19	9.21	3.19	9.21
Transport (domestic transport of cashew nut shell liquid in Japan)	0.14			
Power generation	0			
Total	10.17	16.20	4.12	10.14

Table 14 Life cycle GHG default values for Cashew nut shell residues from oil extraction (g-CO2eq/MJ-fuel)

Process	9,000 km Transport		26,000 km Transport	
	Handysize	Supramax	Handysize	Supramax
Processing	0.80			
Transport (domestic transport in producing countries)	0.59			
Transport (maritime transport)	6.80	4.35	15.80	12.55
Transport (domestic transport in Japan)	0.28			
Power generation	0.26			
Total	8.73	6.28	17.74	14.49

2. Calculation process of Life cycle GHG default values for Palm oil

2-1. CPO

(1) Boundary and calculation points

<Boundary >

CPO is an unrefined oil produced by squeezing the fruits of oil palm fruit clusters. The Boundaries in CPO is assumed as shown in Figure 1.

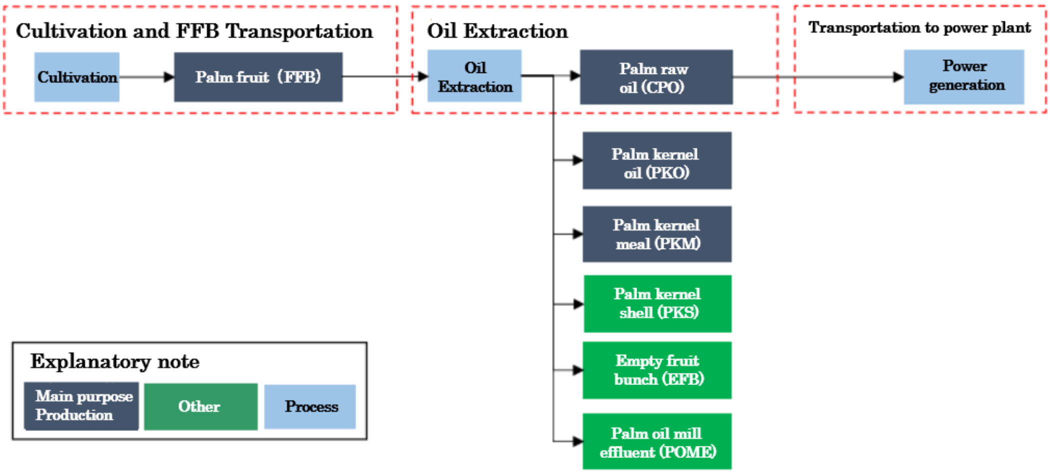

Figure 1 Boundary for life cycle GHG emissions of Palm oil (CPO)

< Allocation >

Products to which GHG emissions are allocated shall be specified by biomass type as described in "Life cycle GHG calculation method under the FIT/FIP scheme". Here they are specified by categorizing each biomass into "main purpose production" and "other". As a result of consideration, producing crude palm oil (CPO), palm kernel oil (PKO), and palm kernel meal (PKM) are specified as "main purpose production" and they are identified as products to which GHG emissions are allocated in the oil extraction process.

As for ratio of allocation, the FIT/FIP system requires that it shall be in proportion to their energy content (determined by lower heat value). For here, ratio of allocation to CPO is cited from default values calculation process of EU RED2 as in Table.15.

Table 15 Allocation ratios to CPOs used in EU RED2 default values

Table 216 LHV of palm oil

Component	Weight fraction of FFB	Source	LHV_{-vap} (MJ/kg)	Source	Moisture	Output in allocat. def. LHV_{-vap}	LHV of dry part of moist biomass (MJ/kg)
Palm oil	0.200	1	37	6	0 %	7.393	37.0
Palm kernel meal	0.029	2, 3	16.4	2	10 %	0.481	16.7
Palm kernel oil	0.024	1	37	6	0 %	0.888	37
Excess nutshells	0.074	5	**0 (*)**	4	10 %	0.000	17.3
Allocation to crude palm oil			**84 %**		**Total**	**8.762**	

Source) JRC(2017a)

(2) Calculation of emissions by process

< Cultivation >

The calculated emissions for each emission activity in the cultivation process are as follows.

Table 16 Calculation of CPO heat quantity obtained per FFB weight

Specifications		Values	Units	Source
(1)	CPO weight generation ratio to FFB (wet)	0.1998	t-CPO/t-FFB wet	JRC(2017a)
(2)	CPO heat value	37,000	MJ/t-CPO	JRC(2017a)
(3)	Resulting CPO heat per FFB (wet) weight	7,393	MJ-CPO/t-FFB wet	=(1)×(2)

Table 17 Calculation of emissions from fuel consumption by agricultural machines, etc.

Specifications		Value	Unit	Source
(1)	Diesel oil input per FFB (wet)	2.37	l-Diesel oil/t-feedstock	JRC(2017a)
(2)	Diesel oil heat value	36	MJ/l-Diesel oil	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-Diesel oil	JRC(2017a)
(4)	Emissions per FFB (wet)	8,114	g-CO2eq/t-feedstock	=(1)×(2)×(3)
(5)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-CPO/t-feedstock	Table 16
(6)	CPO allocation ratio	0.84	-	JRC(2017a)
(7)	GHG emissions from activity	0.92	g-CO2eq/MJ-fuel	=(4)/(5)×(6)

Table 18 Calculation of emissions from manufacture of input fertilizer (K2O)

Specifications		Value	Unit	Source
(1)	K2O fertilizer input per FFB (wet)	9.18	kg/t-feedstock	JRC(2017a)
(2)	K2O fertilizer production emission intensity	413	g-CO2eq/kg	COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 [2]
(3)	Emissions per FFB (wet)	3,791	g-CO2eq/t-feedstock	=(1)×(2)
(4)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-fuel/t-feedstock	Table 16
(5)	CPO allocation ratio	0.84	-	JRC(2017a)
(6)	GHG emissions from activity	0.43	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

2 Rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria

Table 19 Calculation of emissions from production of input fertilizers (nitrogen-based fertilizers)

Specifications		Value	Unit	Source
(1)	Nitrogen-based fertilizer input per FFB (wet)	5.10	kg/t-feedstock	JRC(2017a)
(2)	Nitrogen fertilizer production emission intensity	4,572	g-CO2eq/kg	JRC(2017a)
(3)	Emissions per FFB (wet)	23,317	g-CO2eq/t-feedstock	=(1)×(2)
(4)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-fuel/t-feedstock	Table 16
(5)	CPO allocation ratio	0.84	-	JRC(2017a)
(6)	GHG emissions from activity	2.65	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 20 Calculation of emissions from manufacture of input fertilizers (phosphate-based fertilizers)

Specifications		Value	Unit	Source
(1)	Phosphate fertilizer input per FFB (wet)	1.66	kg/t-feedstock	JRC(2017a)
(2)	Phosphate fertilizer production emission intensity	544	g-CO2eq/kg	COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 [3]
(3)	Emissions per FFB (wet)	903	g-CO2eq/t-feedstock	=(1)×(2)
(4)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-fuel/t-feedstock	Table 16
(5)	CPO allocation ratio	0.84	-	JRC(2017a)
(6)	GHG emissions from activity	0.10	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 21 Calculation of emissions from input fertilizer emissions (EFB compost)

Dimensions		Values	Units	Source
(1)	Methane emissions from EFB compost per weight FFB (wet)	4.10	kg-CH4/t-feedstock	Jannick Schmidt(2007)
(2)	Methane GWP	25	-	Calculation method in FIT/FIP system
(3)	Emissions per FFB (wet)	102,500	g-CO2eq/t-feedstock	=(1)×(2)×1,000
(4)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-fuel/t-feedstock	Table 16
(5)	CPO allocation ratio	0.84	-	JRC(2017a)
(6)	GHG emissions from activity	11.65	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

3 Rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria

Table 22 Calculation of emissions from manufacture of input pesticides

Specifications		Value	Unit	Source
(1)	Insecticide inputs per FFB (wet)	0.74	kg/t-feedstock	JRC(2017a)
(2)	Insecticide manufacturing emission intensity	12,011	g-CO2eq/kg	JRC(2017a)
(3)	Emissions per FFB (wet)	8,888	g-CO2eq/t-FFB	=(1)×(2)
(4)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-feedstock/t-fuel	Table 16
(5)	CPO Allocation Ratio	0.84	-	JRC(2017a)
(6)	GHG emissions from activity	1.01	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 23 Calculation of emissions of N2O leakage from nitrogen-based fertilizers from soil

Specifications		Value	Unit	Source
(1)	Nitrogen fertilizer input per FFB (wet)	5.10	kg/t-feedstock	JRC(2017a)
(2)	Emission intensity (direct emissions)	0.0097	kg-N2O/kg	Japan Greenhouse Gas Inventory Report 2022 (0.62% (kg-N 2O-N/kg-N) x 44/28)
(3)	Emission intensity (indirect emissions and atmospheric sedimentation)	0.0016	kg-N2O/kg	Derived from the default values in the 2006 IPCC Guidelines (Volatilization rate of nitrogen fertilizer 0.10[kg-NH3-N + NOX-N/kg]) x emission factor 0.010 [kg-N2O-N/kg-NH3-N+ NOX-N] x 44/28)
(4)	Emission intensity (indirect emissions and leaching)	0.0035	kg-N2O/kg	Derived from default values in the 2006 IPCC Guidelines (Percentage of leaching and outflow nitrogen 0.30 x emission factor 0.0075 [kg-N2O-N/kg-N] x 44/28)
(5)	GWP of N2O	298	-	Calculation method in FIT/FIP system
(6)	Emissions per FFB (wet)	22,493	g-CO2eq/t-feedstock	=(1)×((2)+(3)+(4))×(5)×1,000
(7)	CPO heat quantity obtained per weight of FFB (wet)	7,393	MJ-feedstock/t-fuel	Table 16
(8)	CPO Allocation Ratio	0.84	-	JRC(2017a)
(9)	GHG emissions from activity	2.56	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

< FFB transport >

The calculated emissions from FFB transport are as follows.

Table 24 Calculation of emissions from FFB transport

Specifications		Value	Unit	Source
(1)	Transport distance (farm to oil mill)	50	km	JRC(2017a)
(2)	Round-trip fuel economy (12 t truck)	2.24	MJ-Diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	213.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	213.6	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	CPO heat quantity obtained from FFB (wet)	7,393	t-feedstock /MJ-fuel	Table 16
(11)	Allocation ratio to CPO	0.84	-	JRC(2017a)
(12)	GHG emissions from process	1.21	g-CO2eq/MJ- fuel	=(1)×(9)/(10)×(11)

< Processing (oil extraction) >

The calculated emissions from oil extraction process are as follows. Following the EU default values, the processing is set at 1.4 times the calculated value.

Table 25 Calculation of emissions from oil extraction process (no methane recovery)

Specifications		Value	Unit	Source
(1)	Input power	0.000078	MJ-electric power/MJ-fuel	JRC(2017a)
(2)	Input diesel oil	0.00445	MJ-diesel oil/MJ-fuel	JRC(2017a)
(3)	Electric power emission factor (grid power)	238.7	g-CO2eq/MJ- Electric power	GREET2022 (Indonesian grid electricity GHG emission intensity)
(4)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(5)	CH4 emissions from PKS and fiber combustion	0.000700	g-CH4/MJ-fuel	JRC(2017a)
(6)	N2O emissions from PKS and fiber combustion	0.000996	g-N2O/MJ-fuel	JRC(2017a)
(7)	Methane generation from POME (no recovery)	0.9844	g-CH4/MJ-fuel	JRC(2017a)
(8)	Emission intensity from electric power	0.0186	g-CO2eq/MJ-fuel	(1)×(3)
(9)	Emission intensity from diesel oil (CO2 equivalent)	0.42	g-CO2eq/MJ-fuel	(2)×(4)
(10)	CH4 emissions from PKS and fiber combustion (CO2 equivalent)	0.0175	g-CO2eq/MJ-fuel	(5)×25
(11)	N2O emissions from PKS and fiber combustion (CO2 equivalent)	0.30	g-CO2eq/MJ-fuel	(6)×298
(12)	Methane generation from POME (no recovery) (CO2 equivalent)	24.61	g-CO2eq/MJ-fuel	(7)×25
(13)	Allocation ratio to CPO	0.84	-	JRC(2017a)
(14)	GHG emissions from the process	21.29	g-CO2eq/MJ-fuel	=((8)+(9)+(10)+(11)+(12))×(13)
(15)	GHG emissions from the process (increase (14) by 40% to ensure conservativeness)	29.81	g-CO2eq/MJ-fuel	=(14)×1.4

Table 26 Calculation of emissions from oil extraction process (with methane recovery)

Specifications		Value	Unit	Source
(1)	Input power	0.000078	MJ/MJ-fuel	JRC(2017a)
(2)	Input diesel oil	0.00445	MJ/MJ-fuel	JRC(2017a)
(3)	Electric power emission factor (grid power)	238.7	g CO2eq/MJ- Electric power	GREET2022 (Indonesian grid electricity GHG emission intensity)
(4)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(5)	CH4 emissions from PKS and fiber combustion	0.000700	g-CH4/MJ-fuel	JRC(2017a)
(6)	N2O emissions from PKS and fiber combustion	0.000996	g-N2O/MJ-fuel	JRC(2017a)
(7)	Methane generation from POME (with recovery)	0.1477	g-CH4/MJ-fuel	JRC(2017a)
(8)	Emission intensity from electric power	0.0186	g-CO2eq/MJ-fuel	=(1)×(3)
(9)	GHG emissions from diesel oil (CO2 equivalent)	0.42	g-CO2eq/MJ-fuel	=(2)×(4)
(10)	CH4 emissions from PKS and fiber combustion (CO2 equivalent)	0.02	g-CO2eq/MJ-fuel	=(5)×25
(11)	N2O emissions from PKS and fiber combustion (CO2 equivalent)	0.30	g-CO2eq/MJ-fuel	=(6)×298
(12)	Methane generation from POME (with recovery) (CO2 equivalent)	3.69	g-CO2eq/MJ-fuel	=(7)×25
(13)	Allocation ratio to CPO	0.84	-	JRC(2017a)
(14)	GHG emissions of the process	3.72	g-CO2eq/MJ-fuel	=((8)+(9)+(10)+(11)+(12))×(13)
(15)	GHG emissions from the process (increase (14) by 40% to ensure conservativeness)	5.21	g-CO2eq/MJ-fuel	=(14)×1.4

< CPO transport >

The calculated emissions from CPO transport are as follows.

Table 27 Calculation of emissions from CPO transport (in the producing country)

Dimensions		Value	Unit	Source
(1)	Transport distance (oil mill to port)	120	km	JRC(2017a)
(2)	Round-trip fuel economy	0.81	MJ-Diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	37,000	MJ-fuel/t-fuel	JRC(2017a)
(11)	GHG emissions from process	0.25	g-CO2eq/MJ-CPO	=(1)×(9)/(10)

Table 28 Calculation of emissions from CPO maritime transport

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Ama Representative Port (long distance) and Japan
(2)	Maritime transport emission intensity (chemical tanker)	0.158	g-heavy fuel oil /tkm	JRC(2017a)
(3)	Heavy fuel oil emission factor (including methane and N2O)	94.2	g-CO2eq/MJ-heavy fuel oil	JRC(2017a)
(4)	Biomass fuel heat value	37,000	MJ-fuel/t-fuel	JRC(2017a)
(5)	GHG emissions from the process	3.62	g-CO2eq/MJ-fuel	=(1)×(2)×(3)/(4)

Table 29 Calculation of emissions from CPO transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Transport distance	20	km	Document 4 of the 12th WG
(2)	Round trip fuel economy 10 t truck	3.06	MJ- Diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	290.5	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.1	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	37,000	MJ/t	JRC(2017a)
(11)	GHG emissions of the process	0.16	g-CO2eq/MJ-CPO	(1) x(9)/(10)

< Power generation>

Emissions from power generation (Methane, N2O) are zero, reflecting both the default values in EU RED2 and estimated values calculated by industry associations in document 4 of the 12th WG.

2-2. Palm stearin

(1) Boundary and calculation points

< Boundary>

Palm stearin is obtained by separating RBD palm oil. The Boundaries for life cycle GHG in palm stearin are assumed as shown in Figure 2. It is assumed that purification and separation take place in the producing country.

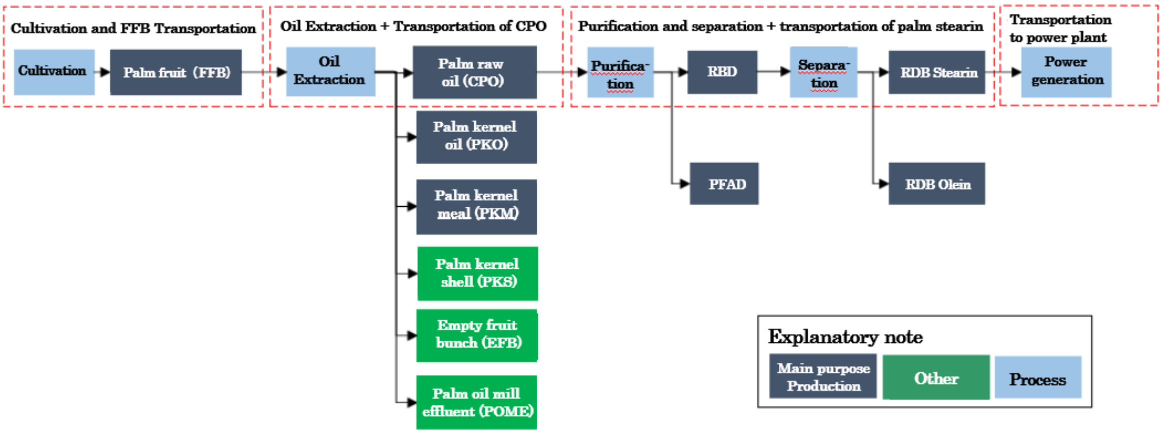

Figure 2 Boundary for life cycle GHG emissions of Palm oil (Palm Stearin)

< Allocation >

As for allocation, the products to which GHG emissions are allocated in oil extraction process are set as the same as CPO. In the refining and separation processes, products from "Main purpose production" is specified as the products to which GHG emissions are allocated as shown in Figure 2.

The allocation ratio to CPO in the oil extraction process is similarly set at 0.84. The allocation ratios in the refining and separation processes are as follows.

Table 30 Allocation ratio in refining process

	(1) Percentage of weight generated NESTE	(2) Amount of heat generated (MJt) JRC (2017a)	(3) Allocation Ratio =(1)/Σ((1)×(2))
RDB	0.9575	37000	0.9575
PFAD	0.0425	37000	0.0425

Table 31 Allocation ratio in separation process

	(1) Percentage of weight generated Document 4 of the 12th Bio WG	(2) Amount of heat generated (MJ/t) Document 4 of the 12th Bio WG	(3) Allocation Ratio =(1)/Σ((1)×(2))
Palm stearin	0.25	36,326	0.25
Palm olein	0.75	36,326	0.75

(2) Calculation of emissions by process

< Cultivation >

The calculated emissions for each emission activity in the cultivation process are as follows.

Table 32 Calculations of palm stearin calorie obtained per FFB weight

Dimensions		Values	Units	Source
(1)	Percentage of CPO weight generated per weight FFB (wet)	0.1998	t-CPO/t-FFB wet	JRC(2017a)
(2)	Ratio of RBD weight to CPO	0.9575	t-RBD/t-CPO	NESTE website [4]
(3)	Palm stearin weight percent to RBD	0.250	t-Palm Stearin/t-RBD	Document 4 of the 12th Bio WG
(4)	Palm stearin heat value	36,326	MJ/t-Palm stearin	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(5)	Amount of palm stearin obtained per weight FFB (wet)	1,737	MJ-Palm Stearin/t-FFB wet	=(1)×(2)×(3)×(4)

Table 33 Calculation of emissions from fuel consumption by agricultural equipment

Specifications		Value	Unit	Source
(1)	Diesel oil input per FFB (wet)	2.37	l-diesel oil/t-feedstock	JRC(2017a)
(2)	Diesel oil heat value	36	MJ/l- diesel oil	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017a)
(4)	Emissions per FFB (wet)	8,114	g-CO2eq/t-FFB wet	=(1)×(2)×(3)
(5)	Palm stearin heat gained per FFB (wet) weight	1,737	MJ-fuel/t-feedstock	
(6)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 エラー! 参照元が見つかりません。 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Allocation ratio to palm stearin
(7)	GHG emissions from activity	0.94	g-CO2eq/MJ-fuel	=(4)/(5)×(6)

4 https://www.neste.com/products/all-products/raw-materials/pfad-residue-palm-oil-refining#b7a200a8(2022 viewed November 10), calculated by subtracting the median PFAD generation rate of 3.5~ 5% from 100%

Table 34 Calculation of emissions from the manufacture of input fertilizer (K2O)

Dimensions		Values	Units	Source
(1)	K2O fertilizer input per FFB (wet)	9.18	kg/t-feedstock	JRC(2017a)
(2)	Emissions intensity of K2O fertilizer production emissions	413	g-CO2eq/kg	COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 [5]
(3)	Emissions per FFB (wet)	3,791	g-CO2eq/t-FFB wet	=(1)×(2)
(4)	Palm stearin heat quantity obtained per FFB (wet) weight	1,737	MJ-fuel/t feedstock	Table 16
(5)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 エラー! 参照元が見つかりません。 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(6)	GHG emissions from activity	0.44	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 35 Calculation of emissions from the production of input fertilizers (nitrogen-based fertilizers)

Specifications		Value	Unit	Source
(1)	Nitrogen-based fertilizer input per FFB (wet)	5.10	kg/t-feedstock	JRC(2017a)
(2)	Nitrogen-based fertilizer production emissions intensity	4,572	g-CO2eq/kg	JRC(2017a)
(3)	Emissions per FFB (wet)	23,317	g-CO2eq/t-feedstock	=(1)×(2)
(4)	Palm stearin heat quantity obtained per FFB (wet) weight	1,737	MJ-fuel/t-feedstock	Table 16
(5)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(6)	GHG emissions from activity	2.70	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 36 Calculation of emissions from the manufacture of input fertilizers (phosphate-based fertilizers)

Specifications		Value	Unit	Source
(1)	Phosphate fertilizer input per FFB (wet)	1.66	kg/t-feedstock	JRC(2017a)
(2)	phosphate-based fertilizer production and emissions intensity	544	g-CO2eq/kg	COMMISSION IMPLEMENTING REGULATION (EU) 2022/996 6
(3)	Emissions per FFB (wet)	903	g-CO2eq/t-feedstock	=(1)×(2)
(4)	Palm stearin heat quantity obtained per weight of FFB	1,737	MJ-fuel/t-feedstock	Table 16
(5)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(6)	GHG emissions from activity	0.10	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

5 Rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria
6 Rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria

Table 37 Calculation of emissions from input fertilizer emissions (EFB compost)

Specifications		Values	Unit	Source
(1)	EFB compost-derived methane emissions per weight FFB (wet)	4.10	kg-CH4/t-feedstock	Jannick Schmidt(2007)
(2)	Methane GWP	25	-	Calculation method in FIP/FIP system
(3)	Emissions per FFB (wet)	102,500	g-CO2eq/t-FFB wet	=(1)×(2)×1,000
(4)	Palm stearin heat gained per FFB (wet) weight	1,737	MJ-fuel/t-feedstock	Table32
(5)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(6)	GHG emissions from activity	11.86	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 38 Calculation of emissions from the manufacture of input pesticides

Specifications		Value	Unit	Source
(1)	Insecticide inputs per FFB (wet)	0.74	kg/t-feedstock	JRC(2017a)
(2)	Pesticide production emission intensity	12,011	g-CO2eq/kg	JRC(2017a)
(3)	Emissions per FFB (wet)	8,888	g-CO2eq/t-feedstock	=(1)×(2)
(4)	Palm stearin heat quantity obtained per FFB (wet) weight	1,737	MJ-fuel/t-feedstock	Table32
(5)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(6)	GHG emissions of from activity	1.03	g-CO2eq/MJ-fuel	=(3)/(4)×(5)

Table 39 Calculation of emissions of N2O leakage from nitrogen-based fertilizers from soil

Specifications		Value	Unit	Source
(1)	Nitrogen fertilizer input per FFB (wet)	5.10	kg/t-feedstock	JRC(2017a)
(2)	Emissions intensity (direct emissions)	0.0097	kg-N2O/kg	Japan Greenhouse Gas Inventory Report 2022 (0.62% [kg-N2O-N/kg-N] x 44/28)
(3)	Emissions intensity (indirect emissions and atmospheric sedimentation)	4	kg-N2O/kg	Derived from default values in the 2006 IPCC Guidelines (Volatilization rate of nitrogen fertilizer 0.10 (kg-NH3-N+ NOX-N/kg) x emission factor 0.010 (kg-N2O-N/kg-NH3-N+ NOX-N) x 44/28)
(4)	Emissions intensity (indirect emissions and leaching)	0.0035	kg-N2O/kg	Derived from default values in the 2006 IPCC Guidelines (Percentage of leaching and outflow nitrogen 0.30 x emission factor 0.0075 [kg-N2O-N/kg-N] x 44/28)
(5)	GWP for N2O	298	-	Calculation method in FIT/FIP system
(6)	Emissions per FFB (wet)	22,493	g-CO2eq/t-feedstock	=(1)×((2)+(3)+(4))×(5)×1,000
(7)	Palm stearin heat quantity obtained per FFB (wet) weight	1,737	MJ-fuel/t-feedstock	Table32
(8)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(9)	GHG emissions from activity	2.60	g-CO2eq/MJ-fuel	=(6)/(7)×(8)

< FFB transport>

The calculated emissions from FFB transport are as follows.

Table 40 Calculation of emissions from the FFB transport

Specifications		Value	Unit	Source
(1)	Transport distance (farm to oil mill)	50	km	JRC(2017a)
(2)	Round-trip fuel economy (12 t truck)	2.24	MJ- Diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	213.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	213.6	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Palm stearin heat quantity generated from FFB (wet) weight	1,737	MJ-fuel/t-feedstock	Table32
(11)	Allocation ratio to palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(12)	GHG emissions from activity	1.24	g-CO2eq/MJ-fuel	=(1)×(9)/(10)×(11)

< Processing (oil extraction) >

The calculated emissions from oil extraction process are as follows.

Table 41 Palm stearin heat value obtained per CPO heat value

	Dimensions	Values	Unit	Source
(1)	RDB heat value generated per CPO heat value	0.9575	MJ-RBD/MJ-CPO	NESTE website 7
(2)	RDB heat value	37,000	MJ/t-RBD	JRC(2017a)
(3)	Palm stearin weight generation ratio to RDB	0.250	t-Palm stearin/t-RDB	Material 4 of the 12th Bio WG
(4)	Palm stearin heat value	36,326	MJ/t-Palm Stearin	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(5)	Palm stearin heat value generated per RDB heat value	0.245	MJ-Palm stearin/MJ-RDB	=(3)×(4)/(2)
(6)	Palm stearin heat value obtained per CPO heat value	0.235	MJ-Palm Stearin/MJ-CPO	=(1)×(5)

Table 42 Calculation of emissions from oil extraction process (no methane recovery)

	Specifications	Value	Unit	Source
(1)	Input electric power	0.000078	MJ-electric power/MJ-feedstock	JRC(2017a)
(2)	Input diesel oil	0.00445	MJ-diesel oil/MJ-feedstock	JRC(2017a)
(3)	Electricity emission factor (grid power)	238.7	g-CO2eq/MJ-electric power	GHG emissions intensity of Indonesian grid power at GREET2022
(4)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(5)	CH4 emissions from PKS and fiber combustion	0.000700	g-CH4/MJ-feedstock	JRC(2017a)
(6)	N2O emissions from PKS and fiber combustion	0.000996	g-N2O/MJ-feedstock	JRC(2017a)
(7)	Methane generation from POME (no recovery)	0.9844	g-CH4/MJ-feedstock	JRC(2017a)
(8)	Emission intensity from electric power	0.0186	g-CO2eq/MJ- electric power	(1) x (3)
(9)	Emission intensity from diesel oil (not including methane and N2O from combustion)	0.42	g-CO2eq/MJ-feedstock	(2) x (4)
(10)	CH4 emissions from PKS and fiber combustion (CO2 equivalent)	0.0175	g-CO2eq/MJ-feedstock	(5) x 25
(11)	N2O emissions from PKS and fiber combustion (CO2 equivalent)	0.30	g-CO2eq/MJ-feedstock	(6) x 298
(12)	Methane generation from POME (no recovery) (CO2 equivalent)	24.61	g-CO2eq/MJ-feedstock	(7) x 25
(13)	Palm stearin heat quantity obtained per CPO heat	0.235	MJ-fuel/MJ-feedstock	Table41
(14)	Allocation ratio of palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(15)	GHG emissions from the process	21.69	g-CO2eq/MJ-fuel	=((8)+(9)+(10)+(11)+(12))/(13)×(14)
(16)	GHG emissions from the process (increase (15) by 40% to ensure conservativeness)	30.36	g-CO2eq/MJ-fuel	=(15)×1.4

7 https://www.neste.com/products/all-products/raw-materials/pfad-residue-palm-oil-refining#b7a200a8(2022 viewed November 10), calculated by subtracting the median PFAD generation rate of 3.5~ 5% from 100%

Table 43 Calculation of emissions from oil extraction process with methane recovery

Specifications		Value	Unit	Source
(1)	Input electric power	0.000078	MJ-electric power/MJ-feedstock	JRC(2017a)
(2)	Input diesel	0.00445	MJ-fuel/MJ-feedstock	JRC(2017a)
(3)	Electric power emission factor (grid power)	238.7	g-CO2eq/MJ-Electric power	GHG emission intensity of Indonesian grid power in GREET2022
(4)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017a)
(5)	CH4 emissions from PKS and fiber combustion	0.000700	g-CH4/MJ-feedstock	JRC(2017a)
(6)	N2O emissions from PKS and fiber combustion	0.000996	g-N2O/MJ-feedstock	JRC(2017a)
(7)	Methane generation from POME (with recovery)	0.1477	g-CH4/MJ-feedstock	JRC(2017a)
(8)	Emission intensity from electric power (CO2 equivalent)	0.0186	g-CO2eq/MJ-electric power	(1)×(3)
(9)	Emission intensity from diesel oil (CO2 equivalent)	0.42	g-CO2eq/MJ-feedstock	(2)×(4)
(10)	CH4 emissions from PKS and fiber combustion (CO2 equivalent)	0.0175	g-CO2eq/MJ-feedstock	(5)×25
(11)	N2O emissions from PKS and fiber combustion (CO2 equivalent)	0.30	g-CO2eq/MJ-feedstock	(6)×298
(12)	Methane generation from POME (with recovery) (CO2 equivalent)	3.69	g-CO2eq/MJ-feedstock	(7)×25
(13)	Obtained palm stearin heat value per CPO heat value	0.235	MJ-fuel/MJ-feedstock	Table41
(14)	Allocation ratio of palm stearin (from oil extraction process)	0.201	-	Calculated by multiplying Table 15 Allocation ratio to CPO, Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(15)	GHG emissions from the process	3.79	g-CO2eq/MJ-fuel	=((8)+(9)+(10)+(11)+(12))/(13)×(14)
(16)	GHG emissions from the process (increase (15) by 40% to ensure conservativeness)	5.31	g-CO2eq/MJ-fuel	=(14)×1.4

< CPO transport >

The calculated emissions from CPO transport are as follows.

Table 44 Calculation of CPO transport emissions

Specifications		Value	Unit	Source
(1)	Transport distance (oil mill to refinery)	72	km	By interview
(2)	Round-trip fuel economy	0.811	MJ- Diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	CPO heat value	37,000	MJ/t-feedstock	JRC(2017a)
(11)	Palm stearin heat obtained per CPO heat	0.235	MJ-fuel/MJ-feedstock	Table41
(12)	Allocation ratio to palm stearin (after CPO transport)	0.239	-	Calculated by multiplying Table 30 Allocation ratio to RDB, エラー! 参照元が見つかりません。 Table31 Allocation ratio to palm stearin
(13)	GHG emissions from CPO transport (in-production) process	0.15	g-CO2eq/MJ-fuel	=(1)×(2)×(3)/(10)/(11)×(12)

< Processing (refining) >

The calculated emissions from CPO purification process are as follows.

Table 45 Calculations of palm stearin heat value obtained per RBD heat value

Dimensions		Value	Unit	Source
(1)	RBD heat value	37,000	MJ/t-RBD	JRC(2017a)
(2)	Palm stearin weight generation ratio to RBD	0.25	t-Palm Stearin/t-RBD	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(3)	Palm stearin heat value	36,326	MJ/t-Palm stearin	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(4)	Palm stearin heat value generated per RBD heat value	0.245	MJ-Palm Stearin/MJ-RBD	=(2)×(3)/(1)

Table 46 Calculation of CPO refining process emissions

Specifications		Value	Unit	Source
(1)	input electric power	0.00116	MJ-electric power/MJ-feedstock	JRC(2017a)
(2)	Input phosphoric acid	0.00002	kg/MJ-feedstock	JRC(2017a)
(3)	Input acid clay (Bleaching earth)	0.00025	kg/MJ-feedstock	JRC(2017a)
(4)	Input steam (NG boiler)	0.0116	MJ-heat/MJ-feedstock	JRC(2017a)
(5)	Electric power emission factor (grid power)	238.7	g-CO2eq/MJ-Electric power	GHG emission intensity of Indonesian grid power in GREET2022
(6)	Phosphate emission factor	3,124.7	g-CO2eq/kg	JRC(2017a)
(7)	Acid clay discharge factor	199.8	g-CO2eq/kg	COMMISSION IMPLEMENTING REGULATION (EU) 2022/996[8]
(8)	Steam derived CH4 discharge factor (NG boiler)	0.0028	g-CH4/MJ-heat	JRC(2017a)
(9)	N2O emission factor from steam (NG boiler)	0.0011	g-N2O/MJ-heat	JRC(2017a)
(10)	CO2 emissions from steam	56.2	g-CO2eq/MJ-heat	JRC(2017a)
(11)	GHG emissions from electricity	0.28	g-CO2eq/MJ-feedstock	=(1)×(5)
(12)	GHG emissions from phosphoric acid	0.06	g-CO2eq/MJ-feedstock	=(2)×(6)
(13)	GHG emissions from acid clay	0.05	g-CO2eq/MJ-feedstock	=
(14)	CH4 emissions from steam	0.0008	g-CO2eq/MJ-feedstock	=(4)×(8)×25
(15)	N2O emissions from steam	0.0038	g-CO2eq/MJ-feedstock	=(4)×(9)×298
(16)	CO2 emissions from steam	0.6519	g-CO2eq/MJ-feedstock	=(4)×(10)
(17)	Palm stearin heat value obtained per RBD heat value	0.245	MJ-fuel /MJ-feedstock	Table41
(18)	Allocation ratio to palm stearin (after refining process)	0.25	-	Table 31
(19)	GHG emissions from the process	1.07	g-CO2eq/MJ-fuel	=((10)+(11)+(12)+(13)+(14)+(16))×(18)/(17)
(20)	GHG emissions from the process (increase (19) by 40% to ensure conservativeness)	1.49	g-CO2eq/MJ-fuel	=(19)×1.4

<Procesing (Separation) >

As for the separation process, based on interviews and research of literature, palm olein is thought to be separated into liquid palm olein and solid palm stearin at room temperature. Therefore no emissions are accounted. [9]

8 Rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria

9 Liquid Phase Oxygen Oxidation Reaction of Palm Stearin and Separation of Products (Toba, 1990) Journal of the Japanese Society of Petroleum Chemistry Volume 39, No. 5

< Palm stearin transport >

The calculated emissions from palm stearin transport are as follows. The heating of palm stearin during transport is not included because the exhaust heat from the transport power engine is used.

Table 47 Calculation of emissions from palm stearin transport (in the producing country)

Specifications		Values	Units	Source
(1)	Distance	35	km	Set conservatively from power plant location information
(2)	Round-trip fuel economy	0.811	MJ- Diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	36,326	MJ/t-fuel	Unit conversion from the values listed in the document 4 of the 12th WG
(11)	GHG emissions from the process	0.07	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 48 Calculation of emissions from palm stearin transport (tanker)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Ama Representative Port (long distance) and Japan
(2)	Maritime transport emissions intensity (chemical tanker)	0.158	MJ-heavy fuel oil/tkm	JRC(2017a)
(3)	Heavy fuel oil emission factor (not including methane and N2O from combustion)	94.2	g-CO2eq/MJ-heavy fuel oil	JRC(2017a)
(4)	Biomass fuel heat value	36,326	MJ-fuel/t-fuel	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(5)	GHG emissions from the process	3.69	g-CO2eq/MJ-fuel	=(1)×(2)×(3)/(4)

Table 49 Calculation of emissions from palm stearin transport (domestic transport in Japan)

Specifications		Values	Units	Source
(1)	Transport distance	20	km	Document 4 of the 12th WG
(2)	Round-trip fuel economy 10 t truck	3.06	MJ- Diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	290.5	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	291.1	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Palm stearin heat value	36,326	MJ-fuel/t-fuel	Unit conversion from the values listed in the document 4 of the 12th Bio WG
(11)	GHG emissions from the process	0.16	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

Emissions from power generation (Methane, N2O) are zero, reflecting both the default values in EU RED2 and estimated values calculated by industry associations in document 4 of the 12th WG.

3. Calculation process of Life cycle GHG default values for PKS

(1) Boundary and calculation points

< Boundary >

PKS is residue from the crushed shell surrounding the kernel of oil palm fruit, which is generated in the oil mil process. The boundaries of life cycle GHG in PKS is assumed as shown in Figure 3. It is determined that PKS is not product from "Main purpose production" of oil extraction process and only emissions from oil extraction process are included.

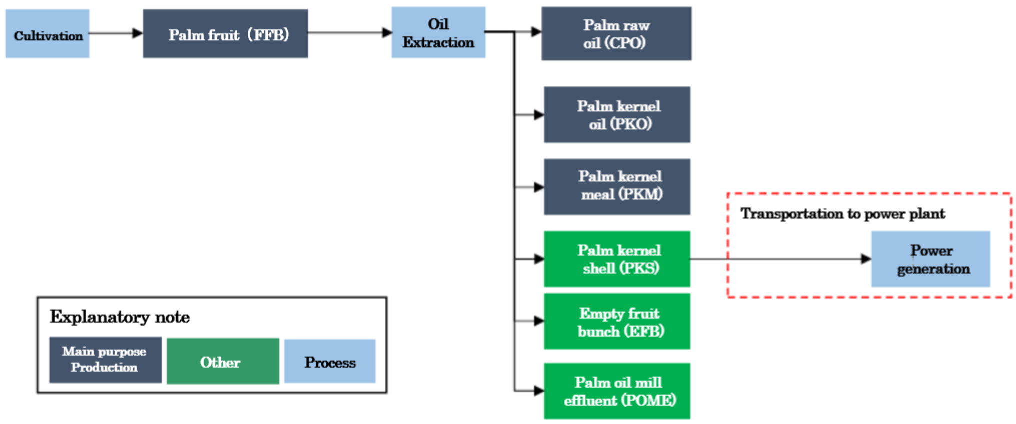

Figure 3 Boundary for life cycle GHG emissions of PKS

< Maritime Transport >

With regard to maritime transport, the 10th session of the Biomass Sustainability WG determined accounting of returning route and empty cargo transportation. Specifically, GHG emissions from return routes shall be taken into account. On the other hand, for maritime transport, the ratio of empty cargo transportation shall be set at 30% of total voyage distance for cases where no specific voyage pattern is taken. For the 9th session of the Biomass Sustainability WG recognized that no specific voyage pattern is taken for PKS, the value of the ratio of empty cargo transport is set at 30% of the total voyage distance for PKS.

(2) Calculation of emissions by process

< Transport >

The calculation results of emissions from transport of PKS in the producing country are as follows.

Table 50 Calculation of emissions from transport of PKS (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Transport distance (oil mill to port)	120	km	JRC(2017a)
(2)	Round-trip fuel economy 40t truck	0.811	MJ- Diesel oil/tkm	JRC(2017b)
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	14,020	MJ-fuel/t-fuel	Phyllis2(Net heat value (LHV))
(11)	Emissions from the process	0.66	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

For the maritime transport distance, it is set as 6500km or 9,000km assuming from Malaysia or Indonesia to representing port in Japan.

The GHG emission factor of maritime transport is cited from the emission intensity used in the EU RED2 default values development, which assumes that the ratio of empty cargo to total sea distance as 30% of total sea distance. Specifically, the emission intensity assuming a bulk density of 0.3 t/m3 in the EU RED2 default values development document (JRC(2017b)) is used. The calculation results of emissions from maritime transport for PKS are as follows.

Table 51 Calculation of emissions from maritime transport of PKS (Handysize for 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Distance	6,500	km	Approximate distance between Indonesian Representative Port (long distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density: 0.3 t/m3, Handysize)	15.8	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	14,020	MJ-fuel/t-fuel	Phyllis2(Net heat value (LHV))
(4)	GHG emissions of the process	7.33	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 52 Calculation of emissions from maritime transport of PKS (Handysize for 9,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Indonesian Representative Port (medium distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density: 0.3 t/m3, Handysize)	15.8	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	14,020	MJ/t-fuel	Phyllis2(Net heat value (LHV))
(4)	GHG emissions from the process	10.15	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 53 Calculation of emissions from maritime transport of PKS (Supramax for 6,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	6,500	km	Approximate distance between Indonesian Representative Port (medium distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.3 t/m3 or more, Handysize)	10.10	g-CO2eq/tkm	JRC(2017b)
(3)	PKS heat value	14,020	MJ/t-fuel	Phyllis2(Net heat value (LHV))
(4)	GHG emissions from the process	4.68	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 54 Calculation of emissions from maritime transport of PKS (Supramax 9,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	9,000	Km	Approximate distance between Indonesian Representative Port (long distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.3 t/m3 or more, Handysize)	10.10	g-CO2eq/tkm	JRC(2017b)
(3)	PKS heat value	14,020	MJ/t-fuel	Phyllis2(Net heat value (LHV))
(4)	GHG emissions from the process	6.48	g-CO2eq/MJ -fuel	=(1)×(2)/(3)

Table 55 Calculation of emissions of PKS transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 3 of the 12th WG
(2)	Round-trip fuel economy 10t truck	3.06	MJ- Diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	291.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	14,020	MJ/t-fuel	Phyllis2(Net heat value (LHV))
(11)	GHG emissions from the process	0.42	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

Emissions from power generation are set using the default values for agricultural residues used in the EU RED2.

Table 56 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH_4 emissions (agricultural residues)	0.002	g-CH_4/MJ-agricultural residues	JRC(2017b)
(2)	N_2O emissions (agricultural residues)	0.0007	g-N_2O/MJ-agricultural residues	JRC(2017b)
(3)	Emissions from power generation	0.26	g-CO_2eq/MJ-fuel	=(1)×25+(2)×298

4. Calculation process of Life cycle GHG default values for Palm Trunks

(1) Boundary and calculation points

<Boundary>

Palm trunk is old tree that occurs after years of the cultivation of palm fruit (FFB) from palm plantation farm. Palm trunks are collected from palm plantation and pelletized in equipment annexed to oil mill for use as biomass fuel. Therefore. emissions from transportation from the plantation farm to the pelletizing plant are included in the boundary. The boundary is as follows.

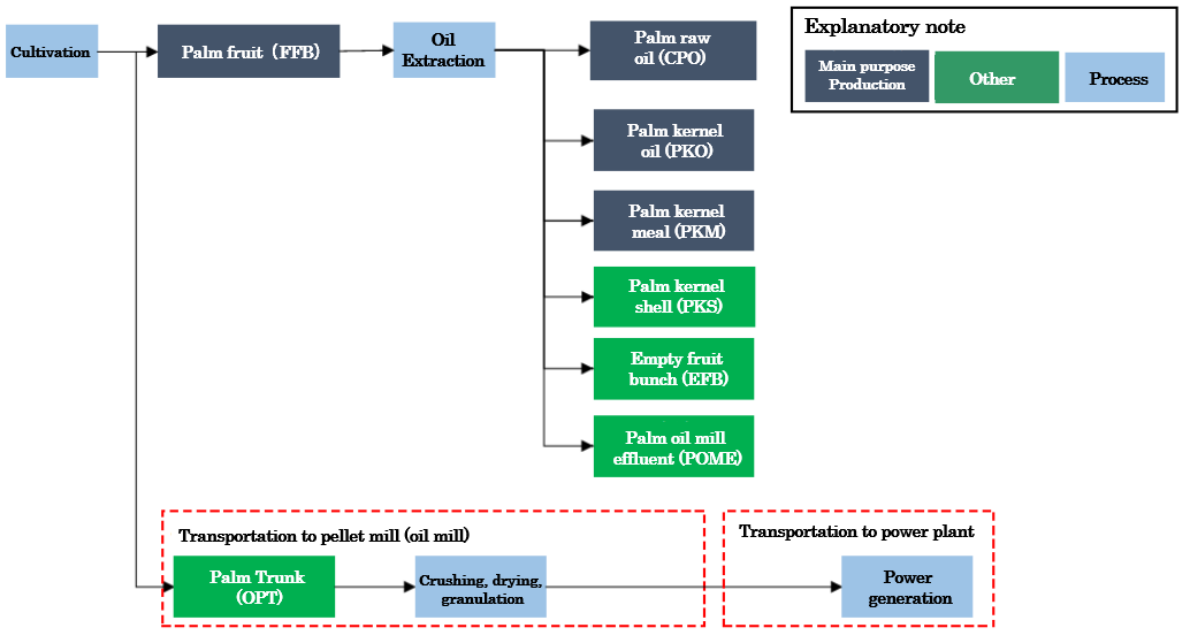

Figure 4 Boundary for life cycle GHG emissions of Palm trunk pellet

< Maritime transport >

With regard to maritime transport, the 9th session of the Biomass Sustainability WG recognized that no specific voyage pattern is taken in transporting pellets including Palm trunk. Therefore the value of the ratio of empty cargo transport is set at 30% of the total voyage distance for Palm trunk as PKS.

(2) Calculation of emissions by process

< Transport (palm trunk collection) >

The calculated emissions for transportation from the point of origin (plantation) to the oil mill are as follows.

Table 57 Calculation of emissions from palm trunk collection (when fossil fuels are used as dry heat)

Specifications		Value	Unit	Source
(1)	Distance (farm to oil mill)	50	km	JRC(2017a)
(2)	Round-trip fuel economy 12t truck	2.24	MJ-diesel oil/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	213.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	213.6	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value per weight of palm trunk	13,300	MJ-feedstock/t-feedstock	JRC(2017b) (assuming absolute dry heat value of 19,000 MJ/t with a moisture content of 30%)
(11)	Heat quantity of feedstock palm trunk required for 1 MJ of pellet (if fossil fuel is used as dry heat source)	1.035	MJ-feedstock/MJ-fuel	JRC(2017b) (Ratio of raw wood after seasoning)
(12)	GHG emissions from the process	0.83	g-CO2eq/MJ-fuel	=(1)×(9)/(10)×(11)

Table 58 Calculation of emissions from palm trunk collection (if biomass is used as dry heat source)

Specifications		Value	Unit	Source
(1)	Distance (farm to oil mill)	50	km	JRC(2017a)
(2)	Round-trip fuel economy 12t truck	2.24	MJ/tkm	JRC(2017a)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017a)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	213.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	213.6	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value per weight of palm trunk	13,300	MJ/t-feedstock	JRC(2017b) (assuming absolute dry heat value of 19,000 MJ/t with a moisture content of 30%)
(11)	Heat quantity of feedstock palm trunk required for pellet 1 MJ (if biomass is used as dry heat source)	1.32	MJ-feedstock / MJ-fuel	JRC(2017b) (Ratio of raw wood after seasoning)
(12)	GHG emissions of the process	1.06	g-CO2eq/MJ-fuel	=(1)×(9)/(10)×(11)

< Processing (if fossil fuel is used as dry heat source) >

The following are the calculated emissions from processing where fossil fuel is used as dry heat source in pelletizing a palm trunk.

Table 59 Calculation of emissions from crushing process (when fossil fuel is used as dry heat source)

Specifications		Value	Unit	Source
(1)	Diesel oil input	0.003357	MJ-Diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when using crushing machinery)	0.0000092	g-CH4/MJ-feedstock	JRC(2017b)
(4)	N2O emission intensity (when using crushing machine)	0.0000385	g-N2O/MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when using crushing machine) CO2 equivalent	0.00023	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emission intensity (when using crushing machine) CO2 equivalent	0.01147	g-CO2eq/MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of the crushing process per MJ after crushing	0.33	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Heat quantity of feedstock palm trunk required for 1 MJ of pellets (When using fossil fuels for dry heat sources)	1.01	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions from the process	0.33	g-CO2eq/MJ-fuel	=(7)/(8)
(10)	GHG emissions from the process (increased by 20% from (9) to ensure conservativeness)	0.40	g-CO2eq/MJ-fuel	=(9)×1.2

Table 60 Calculation of emissions from drying process (fossil fuel used as drying heat source)

Specifications		Value	Unit	Source
(1)	Heat quantity input (steam heat)	0.185	MJ-steam/MJ-diesel oil	JRC(2017b)
(2)	Natural gas boiler efficiency (not including methane and N2O during combustion)	0.9	MJ-steam/MJ-natural gas	JRC(2017b)
(3)	Natural gas emission factor (not including methane and N2O during combustion)	66	g-CO2eq/MJ-natural gas	JRC(2017b)
(4)	Natural gas boiler emissions intensity (not including methane and N2O during combustion)	73.3	g-CO2eq/MJ-steam	=(3)/(2)
(5)	CH4 emissions intensity from natural gas boiler combustion	0.0028	g-CH4/MJ-steam	JRC(2017b)
(6)	N2O emission intensity from combustion of natural gas boiler	0.00112	g-N2O/MJ-steam	JRC(2017b)
(7)	Natural gas boiler CH4 emissions intensity (CO2 equivalent)	0.07	g-CO2eq/MJ-steam	=(5)×25
(8)	Natural gas boiler, N2O emission intensity (CO2 equivalent)	0.33376	g-CO2eq/MJ-steam	=(6)×298
(9)	GHG emissions from the process	13.64	g-CO2eq/MJ-fuel	=(1)×((4)+(7)+(8))
(10)	GHG emissions from the process (increased by 20% from (9) to ensure conservativeness)	16.37	g-CO2eq/MJ-fuel	=(9)×1.2

Table 61 Calculation of emissions from pelletizing process

Specifications		Values	Units	Source
(1)	Input electric power	0.050	MJ-electric power/MJ-Pellet	JRC(2017b)
(2)	Electric Power Emission Factor	238.7	g-CO2eq/MJ- electric power	GREET2022 (GHG emission intensity of Indonesian grid power)
(3)	Emission intensity from electric power	11.94	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	Diesel oil input	0.0020	MJ-diesel oil/MJ-fuel	JRC(2017b)
(5)	Emission factor of diesel oil (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(6)	Emission intensity from diesel oil (excluding methane and N2O from combustion)	0.19	g-CO2eq/MJ-diesel oil	=(4)×(5)
(7)	CH4 emission intensity (entire pelletizing process)	0.0000015 3	g-CH4/MJ-fuel	JRC(2017b)
(8)	N2O emission intensity (entire pelletizing process)	0.0000064 0	g-N2O/MJ-fuel	JRC(2017b)
(9)	CH4 emissions intensity (entire pelletizing process) CO2 equivalent	0.00004	g-CO2eq/MJ-fuel	=(7)×25
(10)	N2O emissions intensity (entire pelletizing process) CO2 equivalent	0.00191	g-CO2eq/MJ-fuel	=(8)×298
(11)	GHG emissions from the process	12.13	g-CO2eq/MJ-fuel	=(3)+(6)+(9)+(10)
(12)	GHG emissions from the process (increased by 20% from (11) to ensure conservativeness)	14.55	g-CO2eq/MJ-fuel	=(11)×1.2

< Processing (biomass is used as dry heat source)) >

The following are the calculated emissions from processing where biomass fuel is used as dry heat source in pelletizing oil palm trunk. The emissions in the pelletizing process are the same as those when fossil fuel is used as drying heat source.

Table 62 Calculation of emissions from crushing (using biomass as drying heat source)

Specifications		Value	Unit	Source
(1)	Diesel oil input	0.003357	MJ-Diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ—diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when using crushing machinery)	0.0000092	g-CH4/MJ-feedstock	JRC(2017b)
(4)	N2O emission intensity (when using crushing machine)	0.0000385	g-N2O/MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when using crushing machine) CO2 equivalent	0.00023	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emission intensity (when using crushing machine) CO2 equivalent	0.01147	g-CO2eq/MJ-feedstock	=(4)×298
(7)	GHG emission intensity of crushing process per MJ after crushing	0.33	MJ/t-feedstock	=(1)×(2)+(5)+(6)
(8)	Heat quantity of feedstock palm trunk required for 1 MJ of pellets (When using biomass as drying heat source)	1.291	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	0.427	g-CO2eq/MJ-fuel	=(7)/(8)
(10)	GHG emissions from the process (increased by 20% from (9) to ensure conservativeness)	0.51	g-CO2eq/MJ-fuel	=(9)×1.2

Table 63 Calculating emissions from drying (using biomass as a drying heat source)

Specifications		Value	Unit	Source
(1)	Heat input (steam)	0.239	MJ-steam/MJ-fuel	JRC(2017b)
(2)	Woodchip boiler/CO2 emissions intensity	0	g-CO2eq/MJ-steam	Biomass-derived emissions are not accounted for
(3)	Woodchip boiler/CH4 emissions intensity	0.005751	g-CH4/MJ-steam	JRC(2017b)
(4)	Woodchip boiler/N2O emissions intensity	0.001150	g-N2O/MJ-steam	JRC(2017b)
(5)	Woodchip boiler/CH4 emissions intensity (CO2 equivalent)	0.144	g-CO2eq/MJ-steam	=(3)×25
(6)	Woodchip boiler/N2O emission intensity (CO2 equivalent)	0.343	g-CO2eq/MJ-steam	=(4)×298
(7)	GHG emissions from the process	0.12	g-CO2eq/MJ-fuel	=(1)×((2)+(5)+(6))
(8)	GHG emissions from the process (increased by 20% from (7) to ensure conservativeness)	0.14	g-CO2eq/MJ-fuel	=(7)×1.2

< Transport (pellet transport) >

The following are the results of the calculation of emissions in the transport of palm trunk pellets from the oil mill to the producing country, maritime transport and Japan.

Table 64 Calculation of emissions from Palm trunk pellet transport (in producing country)

	Specifications	Values	Units	Source
(1)	Transport distance (oil mill to port)	120	km	JRC(2017a)
(2)	Round-trip fuel economy 40t truck	0.811	MJ-fuel/tkm	JRC(2017b)
(3)	Diesel oil emission factor (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	0.55	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

As GHG emission intensity of maritime transport, the emission intensity used in the EU RED2 default value, which assumes that the ratio of empty cargo transportation is 30% of the total voyage distance, is quoted. Since there is a quality standard for wood pellets in Japan that sets a bulk density of 0.65-0.7 t/m3, the emission intensity of 0.65 t/m3 is cited. [10]

Table 65 Calculation of emissions from Palm trunk pellet maritime transport (Handysize 6,500 km transport)

	Specifications	Value	Unit	Source
(1)	Distance	6,500	km	Approximate distance between Indonesian Representative Port (medium distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	3.11	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

10 https://www.nedo.go.jp/content/100932088.pdf(2022 viewed November 10)

Table 66 Calculation of emissions from Palm trunk pellet maritime transport (Handysize 9,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Indonesian Representative Port (long distance) and Japan
(2)	Maritime transport emission intensity (Bulk density of 0.65 t/m3 or more, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	4.30	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 67 Calculation of emissions from Palm trunk pellet maritime transport (Supramax 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Distance	6,500	km	Approximate distance between Indonesian Representative Port (medium distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	2.01	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 68 Calculation of emissions from Palm trunk pellet maritime transport (Supramax 9,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Indonesian Representative Port (long distance) and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	2.78	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 69 Calculation of emissions from Palm trunk pellet transport (domestic transport in Japan)

Specifications		Values	Units	Source
(1)	Distance	20	km	Document 3 of the 12th WG
(2)	Round-trip fuel economy 10t truck	2.92	MJ- Diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	291.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	17,100	MJ/t-pellet	Ibid (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	0.34	g-CO2eq/MJ-pellet	=(1)×(9)/(10)

< Power generation>

Emissions from power generation are set using the default values for agricultural residues used in the EU RED2.

Table 70 Calculating emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (pellets)	0.00297	g-CH4/MJ pellets	JRC(2017b)
(2)	N2O emissions (pellets)	0.00059	g-N2O/MJ pellets	JRC(2017b)
(3)	Emissions from power generation	0.25	g-CO2eq/MJ pellet	(1)×25+(2)×298

5. Calculation process of Life cycle GHG default values for newly eligible biomass fuels

5-1. EFB (pellet)

(1)Boundary and calculation points

<Boundary>

EFB is the residue obtained by removing the fruit from the bunch of oil palm. The boundary of EFB (pellet) in calculating emissions is assumed as shown in Figure 5.

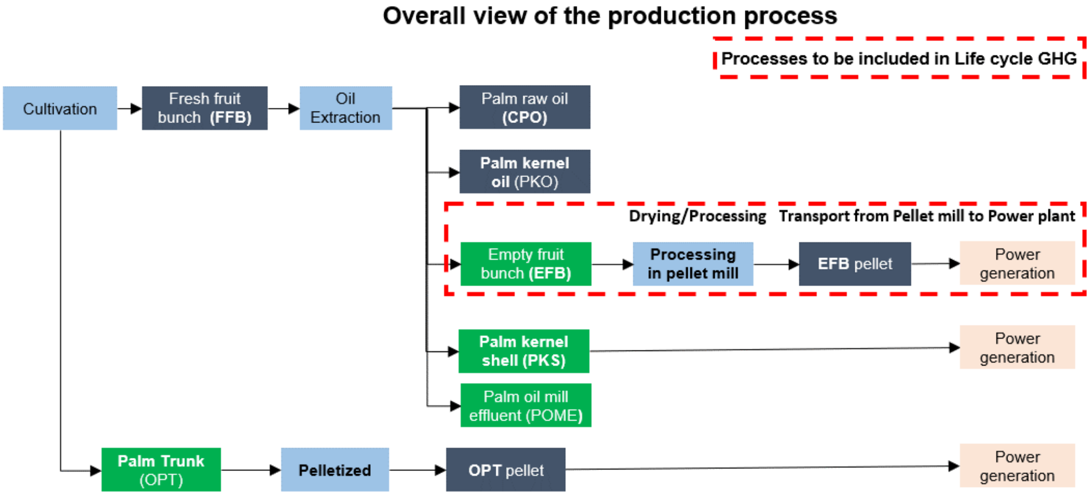

Figure 5 Boundary for life cycle GHG emissions of EFB (pellet)

(2)Calculation of emissions by process

< Drying process >

The calculation results of EFB emissions during the drying process are as follows.

Table 71 Calculation of EFB drying process emissions (natural gas heat source)

Specifications		Value	Unit	Source
(1)	Heat input (steam)	795	MJ-steam/t-fuel	Nasrin et al (2017)
(2)	Natural gas boiler efficiency (not including methane and N2O during combustion)	0.9	MJ-steam/MJ-natural Gas	JRC(2017b)
(3)	Natural gas emission factor (does not include methane or N2O during combustion)	66	g-CO2eq/MJ-natural gas	JRC(2017b)
(4)	Emission intensity of natural gas boiler (without methane and N2O during combustion)	73.3	g-CO2eq/MJ-steam	=(3)/(2)
(5)	CH4 emission intensity for natural gas boiler combustion	0.0028	g-CH4/MJ-steam	JRC(2017b)
(6)	N2O emission per unit of natural gas boiler combustion	0.00112	g-N2O/MJ-steam	JRC(2017b)
(7)	Natural gas boiler CH4 emission intensity (CO2 equivalent)	0.07	g-CO2eq/MJ-steam	=(5)×25
(8)	Natural gas boiler/N2O emission intensity (CO2 equivalent)	0.33376	g-CO2eq/MJ-steam	=(6)×298
(9)	Drying process GHG emissions per pellet weight	58,621	g-CO2eq/t-fuel	=(1)×((4)+(7)+(8))
(10)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions from the process	3.26	g-CO2eq/MJ-fuel	=(9)/(10)
(12)	GHG emissions from the process (increased by 20% to ensure conservativeness)	3.91	g-CO2eq/MJ-fuel	=(11)×1.2

Table 72 Calculation of EFB drying process emissions (biomass heat source)

Specifications		Value	Unit	Source
(1)	Steam heat input	795	MJ-steam/t-fuel	Nasrin et al (2017)
(2)	Biomass boiler efficiency	0.85	MJ-steam/MJ- Biomass	JRC(2017b)
(3)	Heat input of biomass for steam production	935	MJ- Biomass/t-fuel	=(1)/(2)
(4)	Biomass Emission Factor (Methane/N2O)	0.26	g-CO2eq/MJ- Biomass	JRC(2017b)
(5)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(6)	GHG emissions of the process	0.013	g-CO2eq/MJ-fuel	=(3)×(4)/(5)
(7)	GHG emissions from the process (increased by 20% to ensure conservativeness)	0.016	g-CO2eq/MJ-fuel	=(6)×1.2

< Processing (cleaning, crushing, pelletizing) >

The calculation results of emissions in the processing (cleaning, crushing, pelletizing) are as follows.

Table 73 Calculation of EFB emissions in the processing (cleaning, crushing, pelletizing)

Specifications		Value	Unit	Source
(1)	Input power	280	kWh/t-fuel	Based on Nasrin et al (2017)
(2)	Electric power emission factor (grid power)	0.859	kg-CO2eq/kWh	Emission factor of Indonesia from GREET2022
(3)	Amount of biomass fuel heat value	18,000	MJ/t-fuel	JRC(2017b)
(4)	GHG emissions from the process	13.37	g-CO2eq/MJ-fuel	=(1)×(2)/(3)
(5)	GHG emissions from the process (increased by 20% to ensure conservativeness)	16.04	g-CO2eq/MJ-fuel	=(4)×1.2

< Transport >

The calculation results of emissions from EFB pellets transport are as follows.

Table 74 Calculation of emissions from transport of EFB pellets (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	55	km	Document2 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy 40 t truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.24	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 75 Calculation of emissions from EFB pellet maritime transport (Handysize)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	4.09	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 76 Calculation of emissions from EFB pellet maritime transport (for Supramax)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	2.64	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 77 Calculation of emissions from EFB pellet transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Set with reference to document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Land transport GHG emission per unit	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.32	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

The calculation results of emissions from power generation with EFB pellets are as follows.

Table 78 Calculation of emissions in the power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ- Agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ- agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-2. Nutshells (pellets)

(1)Boundary and calculation points

< Boundary>

The boundary for Nutshells (pellets) is assumed as shown in Figure 6.

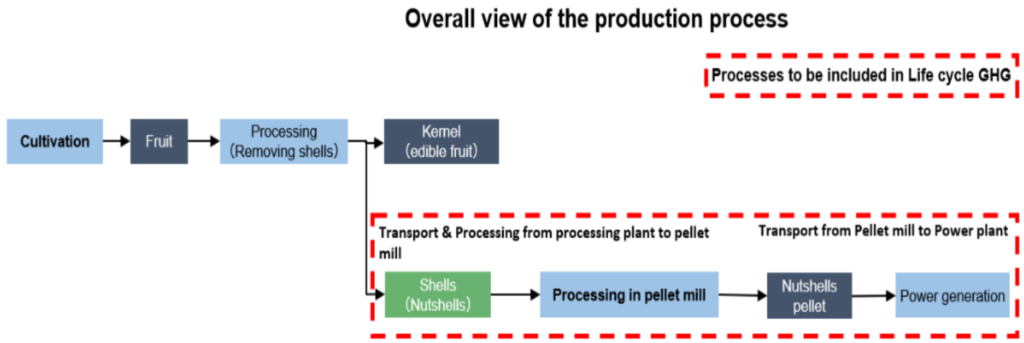

Figure 6 Boundary for life cycle GHG emissions of Nutshells (pellets)

(2)Calculation of emissions by process

< Feedstock transport >

The following table shows the results of the calculation of emissions from nut shell transport.

Table 79 Calculation of emissions from Nutshell transport (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	88	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Agricultural residue-derived pellet yield	1.01	MJ-feedstock/MJ-fuel	JRC(2017b)
(11)	Biomass Fuel Heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(12)	GHG emissions of the process	0.38	g-CO2eq/MJ-fuel	=(1)×(9)×(10)/(11)

< Processing (crushing and pelletizing) >

The calculation results of emissions from processing of nut shells (crushing and pelletizing) are as follows.

Table 80 Calculation of emissions from processing (crushing) of Nutshells

Specifications		Value	Unit	Source
(1)	Heat input	0.00336	MJ- Diesel oil/MJ-Feedstock	JRC(2017b)
(2)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- diesel	JRC(2017b)
(3)	CO2 emissions from diesel (without methane or N2O during combustion)	0.32	g-CO2eq/MJ- feedstock	JRC(2017b)
(4)	CH4 emission intensity (crushing process)	0.0000026	g-CH4/MJ- feedstock	JRC(2017b)
(5)	N2O emission intensity (crushing process)	0.0000107	g-N2O/MJ- feedstock	JRC(2017b)
(6)	CH4 emission (crushing process) CO2 equivalent	0.00006	g-CO2eq/MJ- feedstock	=(4)×25
(7)	N2O emissions (crushing process) CO2 equivalent	0.00319	g-CO2eq/MJ- feedstock	=(5)×298
(8)	Agricultural residue-derived pellet yield	1.01	MJ- Feedstocks/MJ-fuel	JRC(2017b)
(9)	GHG emissions from the process	0.33	g-CO2eq/MJ-fuel	=(3)+(6)+(7)
(10)	GHG emissions from the process (up 20% due to conservativeness)	0.39	g-CO2eq/MJ-fuel	=(9)×1.2

Table 81 Calculation of emissions from Nutshell processing (pelletizing)

Specifications		Value	Unit	Source
(1)	Electricity input	0.05	MJ-power/MJ-fuel	JRC(2017b)
(2)	Electric power emission factor (grid power)	193.17	g-CO2eq/MJ-power	Emission factor of China from GREET2022
(3)	GHG emissions of the process	9.66	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	GHG emissions from the process (up 20% due to conservativeness)	11.59	g-CO2eq/MJ-fuel	=(3)×1.2

< Transport >

The calculation results of emissions from transport of nut shell pellets are as follows.

Table 82 Calculation of emissions from Nutshell pellets transport (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	160	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)

(10)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.69	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 83 Calculation of emissions from maritime transport of Nutshell pellets (Handysize 3,500 km)

Specifications		Value	Unit	Source
(1)	Distance	3,500	km	Estimated distance between China's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Amount of biomass fuel heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	1.59	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 84 Calculation of emissions from maritime transport of Nutshell pellets (Handysize・9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between the U.S. representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	4.09	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 85 Calculation of emissions from maritime transport of Nutshell pellets (Supramax・3,500 km)

Specifications		Value	Unit	Source
(1)	Distance	3,500	km	Estimated distance between China's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	1.03	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 86 Calculation of emissions from maritime transport of Nutshell pellets (Supramax・9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between the U.S. representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel Heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	2.64	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 87 Calculation of emissions from Nutshell pellets transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Set with reference to document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ-diesel	JRC(2017b)
(4)	Unit emissions from diesel (without methane and N2O during combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.32	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

Emissions from power generation are set using the default values for agricultural residues used in the EU RED2.

Table 88 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-3. Coconut shell

(1) Boundary and calculation points.

< Boundary >

Coconut shell is made from coconut palm endocarp (a hard shell that surrounds the endosperm). The endocarp has little water ratio and low moisture content. The boundary for coconut shell is assumed as shown in Figure 7 エラー! 参照元が見つかりません。

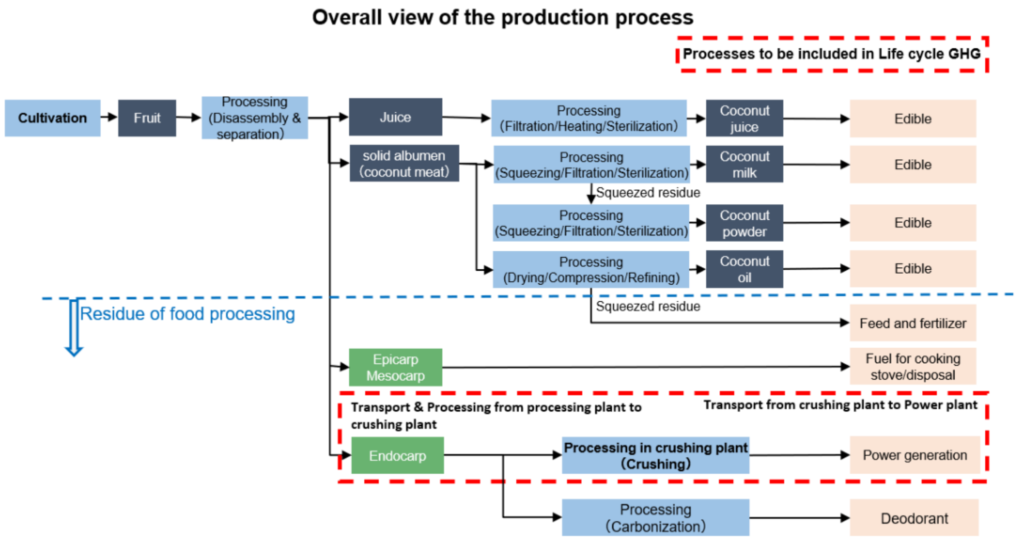

Figure 7 Boundary for life cycle GHG emissions of Coconut shell

(2)Calculation of emissions by process

< Feedstock transport >

The calculation results of emissions from transport of coconut shell feedstocks are as follows.

Table 89 Calculation of emissions from transport of Coconut shell (transport in the producing country)

	Specifications	Value	Unit	Source
(1)	Distance	50	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ/tkm	JRC(2017b)
(3)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- diesel	JRC(2017b)
(4)	Unit emissions from diesel (without methane and N2O during combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission meter for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	18,000	MJ-fuel/t- biomass fuel	JRC(2017b)
(11)	GHG emissions of the process	0.22	g-CO2eq/MJ- biomass fuel	=(1)×(9)/(10)

< Processing (crushing) >

The calculation results of emissions from processing (crushing) of coconut shell are as follows.

Table 90 Calculation of emissions from Coconut shell feedstock processing (crushing)

Specifications		Value	Unit	Source
(1)	Heat input	0.01	MJ- diesel oil/MJ-fuel	JRC(2017b)
(2)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- diesel	JRC(2017b)
(3)	Agricultural residue pretreatment process CH4 emission factor	0.000012	g-CH4/MJ-biomass fuel	JRC(2017b)
(4)	Agricultural residue pretreatment process N2O emission factor	0.000030	g-N2O/MJ- biomass fuel	JRC(2017b)
(5)	Agricultural residue pretreatment process CH4 emission factor (CO2 equivalent)	0.00031	g-CO2eq/MJ- biomass fuel	=(3)×25
(6)	Agricultural residue pretreatment process N2O emission factor (CO2 equivalent)	0.00903	g-CO2eq/MJ- biomass fuel	=(4)×298
(7)	GHG emissions from the process	0.96	g-CO2eq/MJ- biomass fuel	=(1)×(2)+(5)+(6)
(8)	GHG emissions from the process (up 20% due to conservativeness)	1.15	g-CO2eq/MJ- biomass fuel	=(7)×1.2

< Transport >

The calculation results of emissions from coconut shell transport are as follows.

Table 91 Calculation of emissions from transport of Coconut shell (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	5	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity of diesel oil (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission meter for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	18,000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.02	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 92 Calculation of emissions from maritime transport of Coconut shell (Handysize)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Japan and the representative port of Southeast Asia
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Handysize)	15.80	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	7.90	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 93 Calculation of emissions from maritime transport of Coconut shell (for Supramax)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Japan and the representative port of Southeast Asia
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Supramax)	10.10	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	18,000	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	5.05	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 94 Calculation of emissions from transport of Coconut shell (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Set with reference to document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy 10 t truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Land transport GHG emission per unit	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	18000	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.32	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

The calculation results of emissions from power generation with coconuts shell are as follows.

Table 95 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-4. Corn straw (pellets)

(1)Boundary and calculation points

< Boundary >

The boundary for Corn straw (pellet) is assumed as shown in Figure 8.

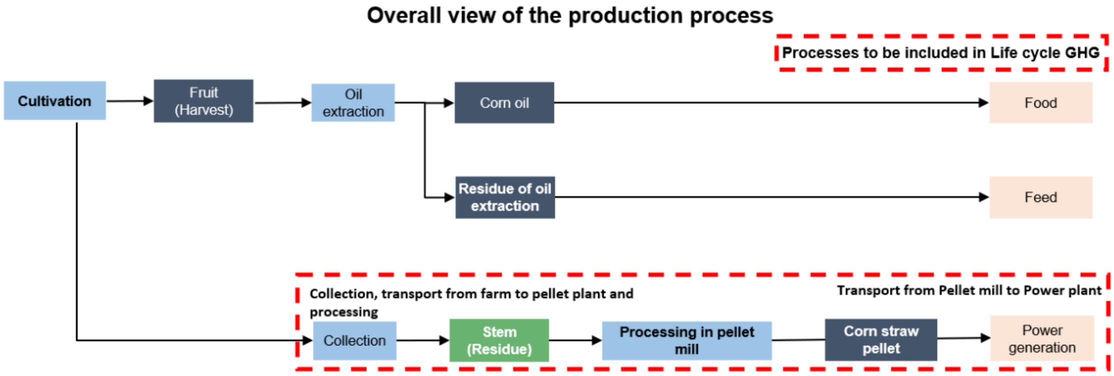

Figure 8 Boundary for life cycle GHG emissions of corn straw (pellet)

(2)Calculation of emissions by process

< Corn straw collection>

The calculation results of emissions from Corn straw collection process are as follows..

Table 96 Calculation of emissions from Corn straw collection process

Specifications		Value	Unit	Source
(1)	Heat input	0.010	MJ- Diesel oil/MJ- Bale	JRC(2017b)
(2)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- diesel	JRC(2017b)
(3)	CH4 emission intensity (when the veil is formed)	0.000012	g-CH4/MJ-bale	JRC(2017b)
(4)	N2O emission intensity (when forming the bale)	0.000030	g-N2O/MJ-bale	JRC(2017b)
(5)	CH4 emission intensity (when bale is formed) CO2 equivalent	0.00031	g-CO2eq/MJ-bale	=(3)×25
(6)	N2O emission per unit (when forming the bale) CO2 equivalent	0.00903	g-CO2eq/MJ-bale	=(4)×298
(7)	GHG emissions meter for bale formation	0.96	g-CO2eq/MJ-bale	=(1)×(2)+(5)+(6)
(8)	yield	1.01	MJ- Vail/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	0.97	g-CO2eq/MJ-fuel	=(7)×(8)

< Feedstock transport>

The calculation results of emissions from corn straw transport are as follows.

Table 97 Calculation of emissions from Corn straw transport (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	50	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	17,200	MJ-bale/t-bale	JRC(2017b)
(11)	Yield	1.01	MJ-Bale/MJ-fuel	JRC(2017b)
(12)	GHG emissions of the process	0.23	g-CO2eq/MJ-fuel	=(1)×(9)/(10)×(11)

< Processing (crushing and pelletizing) >

The calculation results of emissions from processing (crushing and pelletizing) of corn straw are as follows.

Table 98 Calculation of emissions from processing (crushing and pelletizing) of corn straw

Specifications		Value	Unit	Source
(1)	Input power	0.02	MJ-power/MJ-fuel	JRC(2017b)
(2)	Electric power emission factor (grid power)	193.2	g-CO2eq/MJ-power	Emission factor of China from GREET2022
(3)	GHG emissions of the process	3.86	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	GHG emissions from the process (increase by 20% to ensure conservativeness)	4.64	g-CO2eq/MJ-fuel	=(3)×1.2

<Corn straw pellets transport>

The calculation results of emissions from corn straw pellets transport are as follows.

Table 99 Calculation of emissions from Corn straw pellets transport（transport in the producing country）

Specifications		Value	Unit	Source
(1)	Distance	50	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission meter for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	17,200	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.23	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 100 Calculation of emissions from maritime transport of Corn straw pellet（Handysize 3,500 km)

Specifications		Value	Unit	Source
(1)	Distance	3,500	km	Estimated distance between China's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	1.66	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 101 Calculation of emissions from maritime transport of Corn straw pellet (Handysize 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between the representative port of the United States and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Amount of biomass fuel Heat value	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	4.28	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 102 Calculation of emissions from maritime transport of Corn straw pellet (Supramax 3,500 km)

Specifications		Value	Unit	Source
(1)	Distance	3,500	km	Estimated distance between China's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	1.08	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 103 Calculation of emissions from maritime transport of Corn straw pellet (Supramax 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between the U.S. representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions from the process	2.77	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 104 Calculation of emissions from Corn straw pellet transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy 10 t truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Land transport GHG emission per unit	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions from the process	0.34	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

<Power generation>

The calculation results of emissions from power generation with corn straw pellets are as follows.

Table 105 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-5. Sugarcane stems & leaves (pellets)

(1)Boundary and calculation points

< Boundary>

The boundary for stems & leaves (pellet) is assumed as shown in Figure 9.

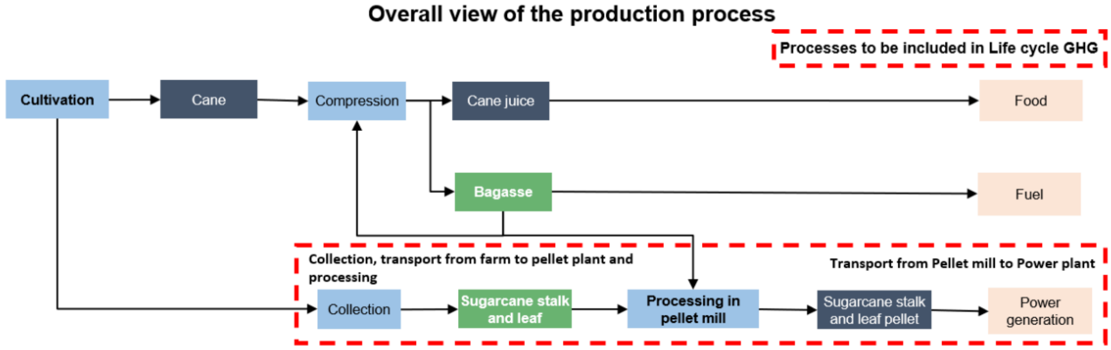

Figure 9 Boundary for life cycle GHG emissions of Sugarcane stems & leaves (pellet)

(2)Calculation of emissions by process

< Sugarcane stem and leaf collection >

The results of the calculation of emissions from Sugarcane stem and leaf collection are as follows.

Table 106 Calculation of emissions from Sugarcane stem and leaf collection process

	Specifications	Value	Unit	Source
(1)	Heat input	0.010	MJ- Diesel oil/MJ- Bale	JRC(2017b)
(2)	Diesel emission factor (methane and N2O not included in combustion)	95.1	gCO2eq/MJ- Diesel	JRC(2017b)
(3)	CH4 emission intensity (when bale is formed)	0.000012	g-CH4/MJ-bale	JRC(2017b)
(4)	N2O emission intensity (when forming the bale)	0.000030	g-N2O/MJ-bale	JRC(2017b)
(5)	CH4 emission intensity (when bale is formed) CO2 equivalent	0.00031	g-CO2eq/MJ-bale	=(3)×25
(6)	N2O emission per unit (when forming the bale) CO2 equivalent	0.00903	g-CO2eq/MJ-bale	=(4)×298
(7)	GHG emissions meter for bale formation	0.96	g-CO2eq/MJ-bale	=(1)×(2)+(5)+(6)
(8)	yield	1.01	MJ- Vail/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	0.97	g-CO2eq/MJ-fuel	=(7)×(8)

< Transport of feedstock >

The results of the calculation of emissions from transport of sugarcane stems and leaves are as follows.

Table 107 Calculation of emissions from transport of sugarcane stems and leaves (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	50	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	17,200	MJ-bale/t-bale	JRC(2017b)
(11)	Yield	1.01	MJ-Bale/MJ-fuel	JRC(2017b)
(12)	GHG emissions of the process	0.23	g-CO2eq/MJ-fuel	=(1)×(9)/(10)×(11)

< Processing (crushing and pelletizing) >

The calculation results of emissions from processing (crushing and pelletizing) of sugarcane stems and leaves are as follows.

Table 108 Calculation of emissions from sugarcane stem and leaf processing (crushing and pelletizing)

Specifications		Value	Unit	Source
(1)	Input power	0.02	MJ-power/MJ-fuel	JRC(2017b)
(2)	Electric power emission factor (bagasse power generation)	1.53	g-CO2eq/MJ-power	Emission factor of bagasse power generation from Renovacalc
(3)	GHG emissions of the process	0.03	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	GHG emissions from the process (increase by 20% to ensure conservativeness)	0.037	g-CO2eq/MJ-fuel	=(3)×1.2

< Transport >

The calculation results of emissions from transport of sugarcane stem and leaf pellet are as follows.

Table 109 Calculation of emissions from transport of sugarcane leaf pellets (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	400	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity of diesel oil (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission meter for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	17,200	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	1.81	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 110 Calculation of emissions from maritime transport of stems & leaves pellets (Handysize for 10,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	10,000	km	Estimated distance between India's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	4.75	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 111 Calculation of emissions from maritime transport of stems & leaves pellets (Handysize for 22,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	22,000	km	Estimated distance between Brazil's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	10.45	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 112 Calculation of emissions from maritime transport of stems & leaves pellets (for Supramax 10,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	10,000	km	Estimated distance between India's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel Heat value	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	3.07	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 113 Calculation of emissions from maritime transport of stems & leaves pellets (for Supramax 22,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	22,000	km	Estimated distance between Brazil's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(4)	GHG emissions of the process	6.76	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 114 Calculation of emissions from stems & leaves pellet transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Land transport GHG emission per unit	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	17,200	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.34	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

<Power generation>

The calculated emissions of sugarcane stem and leaf pellets from the power generation are as follows.

Table 115 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	Emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-6. Bengkuang seeds

(1)Boundary and calculation points .

< Boundary >

The Boundary for Bengkuang seeds is assumed as shown in Figure 10.

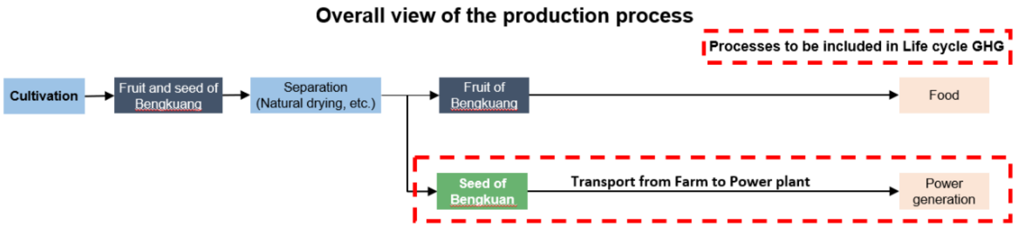

Figure 10 Boundary for life cycle GHG emissions of Bengkuang seeds

(2)Calculation of emissions by process

< Transport >

The calculation results of emissions from transport of Bengkuang seeds are as follows.

Table 116 Calculation of emissions from transport of Bengkuang seeds (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance	177	km	Document 2 of the 12th Biomass Sustainability WG
(2)	40 ton round-trip fuel economy truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Total GHG emissions of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	24,111	MJ-fuel/t-fuel	JRC(2017b)
(11)	GHG emissions of the process	0.57	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 117 Calculation of emissions from maritime transport of Bengkuang seeds (Handysize 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq /tkm	JRC(2017b)
(3)	Amount of biomass fuel Heat value	24,111	MJ-fuel/t-fuel	Document 2 of the 12th Biomass Sustainability WG
(4)	GHG emissions of the process	3.05	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 118 Calculation of emissions from maritime transport of Bengkuang seeds (Handysize 26,000 km)

Specifications		Value	Unit	Source
(1)	Distance	26,000	km	Estimated distance between Japan and the representative port of Africa (Ghana and Nigeria)
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Handysize)	8.17	g-CO2eq /tkm	JRC(2017b)
(3)	Heat value of biomass fuel	24,111	MJ-fuel/t-fuel	Document 2 of the 12th Biomass Sustainability WG
(4)	GHG emissions of the process	8.81	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 119 Calculation of emissions from maritime transport of Bengkuang seeds (Supramax 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq /tkm	JRC(2017b)
(3)	Heat value of biomass fuel	24,111	MJ-fuel/t-fuel	Document 2 of the 12th Biomass Sustainability WG
(4)	GHG emissions of the process	1.97	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 120 Calculation of emissions from maritime transport of Bengkuang seeds (Supramax 26,000 km)

Specifications		Value	Unit	Source
(1)	Distance	26,000	km	Estimated distance between Japan and the representative port of Africa (Ghana and Nigeria)
(2)	Basic unit of maritime transport emissions (Bulk density 0.65 t/m3, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Biomass fuel Heat value	24,111	MJ-fuel/t-fuel	Document 2 of the 12th Biomass Sustainability WG
(4)	GHG emissions from the process	5.70	g-CO2eq/MJ-fuel	=(1)×(2) /(3)

Table 121 Calculation of emissions from Bengkuang seeds transport (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 4 of the 12th Biomass Sustainability WG
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(4)	Unit emissions from diesel oil (without methane and N2O during combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	24,111	MJ-fuel/t-fuel	Document 2 of the 12th Biomass Sustainability WG
(11)	GHG emissions from the process	0.24	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

The calculation results of emissions from power generation with Benkowan seed are as follows.

Table 122 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

5-7. Cashew nut shell liquid(CNSL)

(1)Boundary and calculation points

< Boundary >

The boundary for Cashew nut shell liquid(CNSL) is assumed as shown in Figure 11.

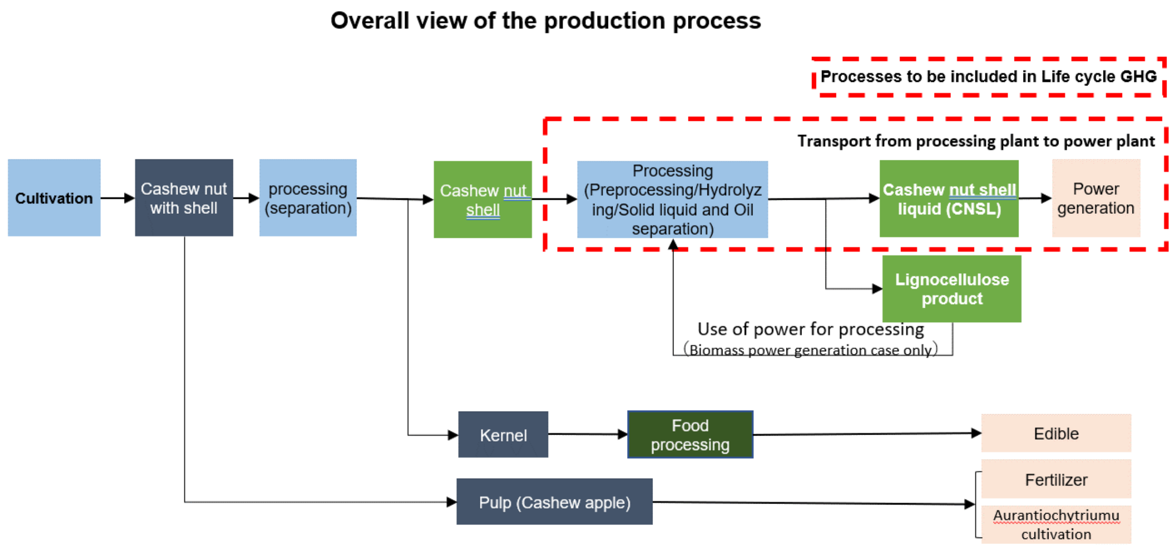

Figure 11 Boundary for life cycle GHG emissions of Cashew nut shell liquid(CNSL)

(2)Calculation of emissions by process

<Processing (pretreatment, hydrolysis, solid-liquid/oil-water separation) >

The calculation results of emissions from processing of cashew nut shell (pretreatment, hydrolysis, solid-liquid/oil-water separation) are as follows. In the case of the use of biomass for in-house power generation, all emissions from the process are to be attributed to cashew nut shell liquid (allocation ratio is 100%), as the use of feedstock generated during such processing is assumed.

Table 123 Calculation of emissions from processing (pretreatment, hydrolysis, solid-liquid/oil-water separation) (use of grid power)

Specifications		Value	Unit	Source
(1)	Input power	400	kWh/t-fuel	Information provided by industry association
(2)	Electric power emission factor (grid power)	0.859	kg-CO2eq /kWh	Emission factor of Indonesia from GREET2022
(3)	Amount of biomass fuel Heat value	42,000	MJ-fuel/t-fuel	Information provided by industry association
(4)	Allocation ratio to CNSL	0.533	-	Table 125
(5)	GHG emissions from the process	4.36	g-CO2eq/MJ-fuel	=(1)×(2)×1000/(3)×(4)
(6)	GHG emissions from the process (up 40% due to maintainability)	6.11	g-CO2eq/MJ-fuel	=(5)×1.4

Table 124 Calculation of emissions from processing (pretreatment, hydrolysis, solid-liquid/oil-water separation) (use of biomass in-house power generation)

Specifications		Value	Unit	Source
(1)	Input power	400	kWh/t-fuel	Information provided by industry association
(2)	Electric power emission factor (Agricultural Residual Generation)	0.004	kg-CO2eq /kWh	JRC (2017a) Calculated from agricultural residues
(3)	Biomass fuel Heat value	42,000	MJ-fuel/t-fuel	Information provided by industry association
(4)	Allocation ratio to CNSL	1	-	Table 125
(5)	GHG emissions from the process	0.0380	g-CO2eq/MJ-fuel	=(1)×(2)×1000/(3)×(4)
(6)	GHG emissions from the process (up 40% due to maintainability)	0.05	g-CO2eq/MJ-fuel	=(5)×1.4

Table 125 Calculation of allocation ratio (heat prorate) to CNSL

	(1)Generated Weight Ratio [11]	(2)Heat value MJ/t [12]	Allocation ratio =((1)×(2))/Σ((1)×(2))
CNSL	0.008	41,780	53.3%
Co-products in oil extraction	0.014	20,920	46.7%

< Transport >

The calculation results of emissions from transport of cashew nut shell liquid are as follows.

Table 126 Calculation of emissions from transport of CNSL (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Transport distance (from processing plant to port)	400	km	Information provided by industry association
(2)	Round-trip fuel economy 40 ton truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Emission factor of diesel oil (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (truck use)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emission intensity (when using trucks) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emission per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Land transport GHG emission per unit	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	42,000	MJ-fuel/t-fuel	Information provided by industry association
(11)	GHG emissions from activity	0.74	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

11 Refer to https://johnnycashew.com/wp-content/uploads/2023/06/Johnny-cashew-Final-Report.pdf (accessed October 24, 2023).
12 https://assets.researchsquare.com/files/rs-942065/v1/73e3bde4-8a1b-4c93-9fde-c8925281fcd3.pdf? c=1633358335, accessed October 24, https://cashewnutshellcake.com/cashew-nut-shell-cake(2023)

Table 127 Calculation of emissions from maritime transport of CNSL (for 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Chemical tankers)	0.158	MJ-heavy fuel oil/tkm	JRC(2017a)
(3)	Heavy fuel oil emission factor	94.2	g-CO2eq /MJ	JRC(2017a)
(4)	biomass fuel Heat value	42,000	MJ-fuel/t-fuel	Information provided by industry association
(5)	GHG emissions of the process	3.19	g-CO2eq/MJ-fuel	=(1)×(2)×(3)/(4)

Table 128 Calculation of emissions from maritime transport of CNSL (for 26,000 km)

Specifications		Value	Unit	Source
(1)	Distance	26,000	km	Estimated distance between Africa's representative port and Japan
(2)	Maritime transport emissions intensity (Chemical tankers)	0.158	MJ-heavy fuel oil/tkm	JRC(2017a)
(3)	Heavy fuel oil emission factor	94.2	g-CO2eq /MJ	JRC(2017a)
(4)	biomass fuel Heat value	42,000	MJ-fuel/t-fuel	Information provided by industry association
(5)	GHG emissions of the process	9.21	g-CO2eq/MJ-fuel	=(1)×(2)×(3)/(4)

Table 129 Calculation of emissions from transport of CNSL (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Information provided by industry association
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ- diesel	JRC(2017b)
(4)	Unit emissions from diesel (without methane and N2O during combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	42,000	MJ-fuel/t-fuel	Information provided by industry association
(11)	GHG emissions of the process	0.14	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

<Power generation>

Emissions of methane and N2O from the combustion of liquid fuels derived from oil crops are zero in the EU RED2 default, so emissions from power generation are set at zero.

5-8. Cashew nut shell residues from oil extraction

(1)Boundary and calculation points

<Boundary>

The boundary for the Cashew nut shell residues from oil extraction is assumed as shown in Figure 12.

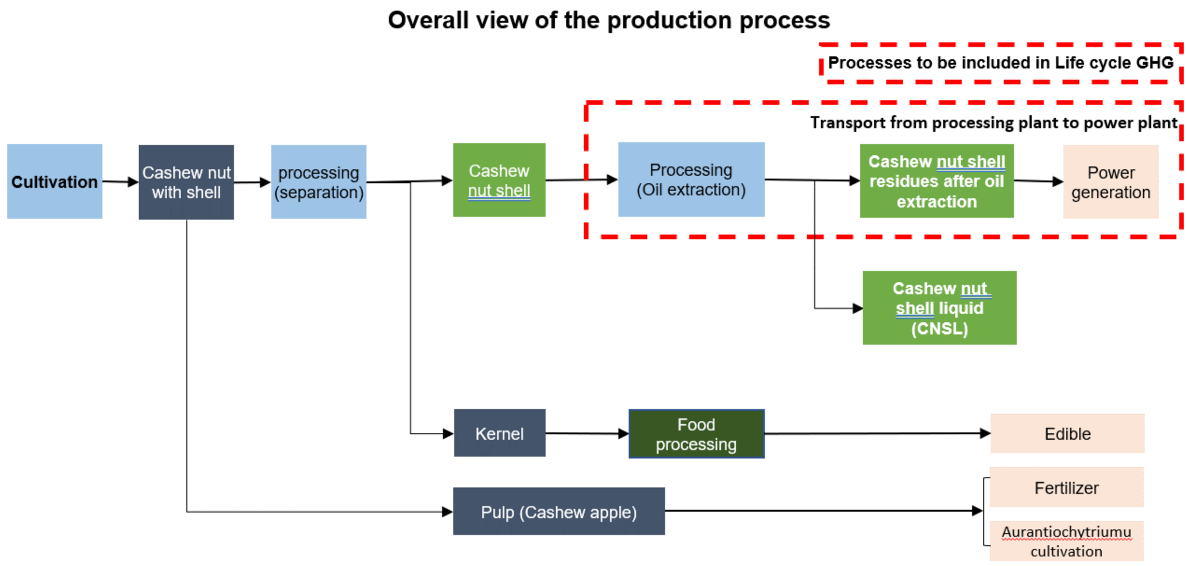

Figure 12 Boundary for life cycle GHG emissions of Cashew nut shell residues from oil extraction

(2)Calculation of emissions by process

< Processing (oil extraction) >

The calculation results of emissions from processing (oil extraction) of cashew nut shell residues from oil extraction are as follows.

Table 130 Calculation of emissions from processing (oil extraction) (use of grid power)

	Specifications	Value	Unit	Source
(1)	Input power	34.84	kWh/t-CNR	Calculated from Aina et. al (2018) [13]
(2)	Electric power emission factor (grid power)	0.859	kg-CO2eq /kWh	From GREET2022 to Indonesia Emission factor
(3)	Heat value of biomass fuel	20,920	MJ-fuel/t-fuel	Table 125
(4)	Allocation ratio to CNSL	0.467	-	Table 125
(5)	GHG emissions from the process	0.67	g-CO2eq/MJ-fuel	=(1)×(2)×1000/(3)×(4)
(6)	GHG emissions from the process (increase by 20% to ensure conservativeness)	0.80	g-CO2eq/MJ-fuel	=(5)×1.2

13 Accessed March 11, https://core.ac.uk/download/pdf/162155611.pdf(2024)

< Transport >

The calculation results of emissions from transport of cashew nut shell residues from oil extraction are as follows.

Table 131 Calculation of emissions from transport of Cashew nut shell residues from oil extraction (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Transport distance (from processing plant to port)	160	km	Information provided by industry association
(2)	Round-trip fuel economy 40 ton truck	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ	JRC(2017b)
(4)	Emission intensity by diesel use (methane and N2O not included in combustion)	77.1	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Heat value of biomass fuel	20,920	MJ-fuel/t-fuel	Table 125
(11)	GHG emissions from activity	0.74	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

Table 132 Calculation of emissions from maritime transport of Cashew nut shell residues from oil extraction (Handysize, 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Handysize)	15.80	g-CO2eq/tkm	JRC(2017a)
(3)	Heat value of biomass fuel	20,920	MJ-fuel/t-fuel	Table 125
(4)	GHG emissions from the process	6.80	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 133 Calculation of emissions from maritime transport of Cashew nut shell residues from oil extraction (Supramax, 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Estimated distance between Indonesia's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Supramax)	10.10	g-CO2eq/tkm	JRC(2017a)
(3)	Biomass fuel Heat value	20,920	MJ-fuel/t-fuel	Table 125
(4)	GHG emissions from the process	4.35	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 134 Calculation of emissions from maritime transport of Cashew nut shell residues from oil extraction

(Handysize, 26,000 km)

Specifications		Value	Unit	Source
(1)	Distance	26,000	km	Estimated distance between Africa's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Handysize)	15.80	g-CO2eq/tkm	JRC(2017a)
(3)	Heat value of biomass fuel	20,920	MJ-fuel/t-fuel	Table 125
(4)	GHG emissions from the process	15.80	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 135 Calculation of emissions from maritime transport of Cashew nut shell residues from oil extraction (Handysize, 26,000 km)

Specifications		Value	Unit	Source
(1)	Distance	26,000	km	Estimated distance between Africa's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.3 t/m3, Supramax)	10.10	g-CO2eq/tkm	JRC(2017a)
(3)	Amount of biomass fuel Heat value	20,920	MJ-fuel/t-fuel	Table 125
(4)	GHG emissions from the process	12.55	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 136 Calculation of emissions from transport of Cashew nut shell residues from oil extraction (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Information provided by industry association
(2)	Round-trip fuel economy of 10 ton truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (methane and N2O not included in combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Unit emissions from diesel oil (without methane and N2O during combustion)	291.0	g-CO2eq/tkm	JRC(2017b)
(5)	CH4 emission intensity (when using trucks)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emission intensity (when using trucks)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions per unit (for truck use) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions per unit (for truck use) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel Heat value	20,920	MJ-fuel/t-fuel	Table 125
(11)	GHG emissions from the process	0.28	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

The calculation results of the emissions from power generation of cashew nut shell residues from oil extraction are as follows.

Table 137 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (agricultural residues)	0.002	g-CH4/MJ agricultural residues	JRC(2017b)
(2)	N2O emissions (agricultural residues)	0.0007	g-N2O/MJ agricultural residues	JRC(2017b)
(3)	GHG emissions from power generation	0.26	g-CO2eq/MJ-fuel	=(1)×25+(2)×298

III. Life Cycle GHG Default Values for Imported Woody Biomass

1. Calculation results of default values

Default values for imported woody biomass is determined for each fuel of woody chips and wood pellets with categories of following three feedstock types.

- Forest residues
- Oher harvested trees
- Sawmill residues

For the maritime transport, the transportation distance is set on the assumption of the representing countries producing woody biomass imported into Japan. Specifically, there are three categories of maritime transport distance for wood chips (6,500 km, 11,600 km, and 18,000 km) and three categories for wood pellets (6,500 km, 9,000 km, and 18,000 km). Two categories are set for size of ships (Handysize and Supramax).

In addition, there are two categories for wood pellets default values for heat sources in drying process, fossil fuel and biomass fuel.

The calculation results of the default life cycle GHG values for each fuel are as follows.

Table 138 Life cycle GHG default values for imported wood chips (forest residues) (g-CO2eq/MJ-fuel)

Process	Handysize 6,500 km transport	Supramax 6,500 km transport
Transport (collection of forest residues.)	1.24	
Processing	0.40	
Transport (domestic transport of wood chips in producing countries)	1.75	
Transport (maritime transport of wood chips)	14.13	8.98
Transport (domestic transport of wood chips in Japan)	0.44	
Power generation	0.41	
Total	18.37	13.22

Process	Handysize 11,600 km transport	Supramax 11,600 km transport
Transport (maritime transport of wood chips)	25.21	16.02
(The rest of the process is omitted because it is the same as 6,500 km transport)		
Total	29.45	20.26

Process	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of wood chips)	39.13	24.86
(The rest of the process is omitted because it is the same as 6,500 km transport)		
Total	43.37	29.10

Table 139 Life cycle GHG default values for imported wood chips (Other harvested trees) (g-CO2eq/MJ-fuel)

	Handysize 6,500 km Transport	Supramax 6,500 km Transport
Cultivation	1.11	
Processing	0.40	
Transport (domestic transport of wood chips in producing countries)	1.75	
Transport (maritime transport of wood chips)	14.13	8.98
Transport (domestic transport of wood chips in Japan)	0.44	
Power generation	0.41	
Total	18.24	13.09

Process	Handysize 11,600 km transport	Supramax 11,600 km transport
Transport (maritime transport of wood chips)	25.21	16.02
(The rest of the process is omitted because it is the same as the 6,500 km transport.)		
Total	29.32	20.13

Process	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of wood chips)	39.13	24.86
(The rest of the process is omitted because it is the same as the 6,500 km transport.)		
Total	43.24	28.97

Table 140 Life cycle GHG default values for imported wood chips (Sawmill residues) (g-CO2eq/MJ-Chip)

Process	Handysize 6,500 km transport	Supramax 6,500 km transport
Processing	0	
Transport (domestic transport of wood chips in producing countries)	1.75	
Transport (maritime transport of wood chips)	14.13	8.98
Transport (domestic transport of wood chips in Japan)	0.44	
Power generation	0.41	
Total	16.73	11.58

Process	Handysize 11,600 km transport	Supramax 11,600 km transport
Transport (maritime transport of wood chips)	25.21	16.02
(The rest of the process is omitted because it is the same as 6,500 km transport)		
Total	27.81	18.62

Process	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of wood chips)	39.13	24.86
(The rest of the process is omitted because it is the same as 6,500 km transport)		
Total	41.73	27.46

Table 141 Life cycle GHG default values for imported wood pellets (Forest residues) (g-CO2eq/MJ-pellet)

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 6,500 km	Supramax Transport 6,500 km	Handysize 6,500 km transport	Supramax 6,500 km transport
Transport (collection of forest residues.)	1.18		1.51	
Transport (transport of feedstocks)	0.85		1.08	
Processing	25.78		9.66	
Transport (domestic transport of pellets in producing countries)	1.36			
Transport (maritime transport of pellets)	3.11	2.01	3.11	2.01
Transport (domestic transport of pellets in Japan)	0.34			
Power generation	0.25			
Total	32.87	31.77	17.31	16.21

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 9,000 km	Supramax Transport 9,000 km	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport of pellets)	4.30	2.78	4.30	2.78
(The rest of the process is omitted because it is the same as the 6,500 km transport)				
Total	34.06	32.54	18.50	16.98

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize 18,000 km transport	Supramax 18,000 km transport	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of pellets)	8.60	5.56	8.60	5.56
(The rest of the process is omitted because it is the same as the 6,500 km transport.)				
Total	38.36	35.32	22.80	19.76

Table 142 Life cycle GHG default values for imported wood pellets (Other harvested trees) (g-CO2eq/MJ-Pellets)

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 6,500 km	Supramax Transport 6,500 km	Handysize 6,500 km transport	Supramax 6,500 km transport
Cultivation	1.06		1.36	
Transport (transport of feedstocks)	0.85		1.08	
Processing	25.78		9.66	
Transport (domestic transport of pellets in producing countries)	1.36			
Transport (maritime transport of pellets)	3.11	2.01	3.11	2.01
Transport (domestic transport of pellets in Japan)	0.34			
Power generation	0.25			
Total	32.75	31.65	17.16	16.06

Process	Drying: fossil fuel use (pelletizing: grid power use)		Drying: biomass use (pelletizing: grid power use)	
	Handysize 9,000 km transport	Supramax 9,000 km transport	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport of pellets)	4.30	2.78	4.30	2.78
(The rest of the process is omitted because it is the same as 6,500 km transport)				
Total	33.94	32.42	18.35	16.83

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 18,000 km	Supramax 18,000 km transport	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of pellets)	8.60	5.56	8.60	5.56
(The rest of the process is omitted because it is the same as the 6,500 km transport.)				
Total	38.24	35.20	22.65	19.61

Table 143 Life cycle GHG default values for imported wood pellets (Sawmill residues) (g-CO2eq/MJ-Pellets)

Process	Drying: Fossil fuel use (Pelletizing: using grid power)		Drying: using biomass (Pelletizing: using grid power)	
	Handysize Transport 6,500 km	Supramax Transport 6,500 km	Handysize Transport 6,500 km	Supramax 6,500 km transport
Processing	14.92		5.18	
Transport (domestic transport of pellets in producing countries)	1.36			
Transport (maritime transport of pellets)	3.11	2.01	3.11	2.01
Transport (domestic transport of pellets in Japan)	0.34			
Power generation	0.25			
Total	19.98	18.88	10.24	9.14

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize Transport 9,000 km	Supramax Transport 9,000 km	Handysize 9,000 km transport	Supramax 9,000 km transport
Transport (maritime transport of pellets)	4.30	2.78	4.30	2.78
(The rest of the process is omitted because it is the same as 6,500 km transport)				
Total	21.17	19.65	11.43	9.91

Process	Drying: Fossil fuel use (Pelletizing: Grid power use)		Drying: Biomass use (Pelletizing: Grid power use)	
	Handysize 18,000 km transport	Supramax 18,000 km transport	Handysize 18,000 km transport	Supramax 18,000 km transport
Transport (maritime transport of pellets)	8.60	5.56	8.60	5.56
(The rest of the process is omitted because it is the same as the 6,500 km transport.)				
Total	25.47	22.43	15.73	12.69

2. Calculation process of Life cycle GHG default values for Wood Chips

2-1. Wood chips derived from forest residues

(1) Boundary and calculation points

< Boundary >

Boundary is shown in the red box below.

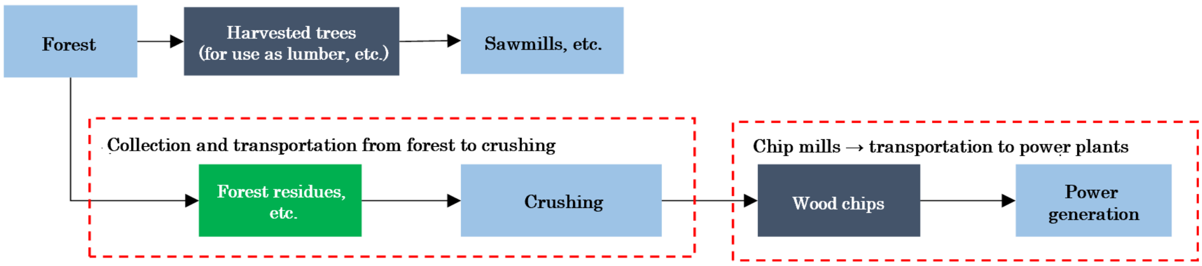

Figure 13 Boundary for life cycle GHG emissions of wood chips derived from forest residues

<Maritime transport >

With regard to maritime transport, the 9th session of the Biomass Sustainability WG recognized that specific voyage pattern is taken (dedicated vessels are used) in maritime transport of wood chips. Therefore, the distance of empty cargo transport is set as the same as that of wood chips transportation, unlike pellets for which the value of the ratio of empty cargo transport is set at 30% of the total voyage distance.

(2) Calculation of emissions by process

< Transport (collection of forest residues) >

The calculation results of emissions from transport (collection of forest residues) are as follows.

Table 144 Calculation of emissions from transport of wood chips (collection of forest residues)

Specifications		Values	Units	Source
(1)	Diesel oil input in collection of forest residues.	0.0120	MJ-diesel oil / MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor of CO_2	95.1	g-CO_2eq/MJ-diesel oil	JRC(2017b)
(3)	CH_4 emissions intensity (when agricultural machinery is used)	0.00000257	g-CH_4 /MJ-feedstock	JRC(2017b)
(4)	N_2O emissions intensity (when agricultural machinery is used)	0.00001075	g-N_2O /MJ-feedstock	JRC(2017b)
(5)	CH_4 emissions intensity (when agricultural machinery is used) CO_2 equivalent	0.00006	g-CO_2eq/MJ-feedstock	=(3)×25
(6)	N_2O emissions intensity (when agricultural machinery is used) CO_2 equivalent	0.00320	g-CO_2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of forest residue collection process per MJ of forest residue	1.14447	g-CO_2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Forest residue equivalent required for chip manufacturing	1.079	MJ- feedstock / MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.24	g-CO_2eq/MJ-fuel	=(7)×(8)

<Processing>

The calculation results of emissions from processing (crushing) are as follows.

Table 145 Calculation of emissions from processing of wood chips (crushing)

Specifications		Values	Units	Source
(1)	Diesel oil input during crushing	0.003357	MJ-diesel oil/MJ-fuel	JRC(2017b)
(2)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when using crushing machinery)	0.0000092	g-CH4/MJ-fuel	JRC(2017b)
(4)	N2O emission intensity (when using crushing machine)	0.0000385	g-N2O/MJ-fuel	JRC(2017b)
(5)	CH4 emissions intensity (when using crushing machine) CO2 equivalent	0.00023	g-CO2eq/MJ-fuel	=(3)×25
(6)	N2O emission intensity (when using crushing machine) CO2 equivalent	0.01147	g-CO2eq/MJ-fuel	=(4)×298
(7)	GHG emissions of the process	0.33	g-CO2eq/MJ-fuel	=(1)×(2)+(5)+(6)
(8)	GHG emissions from the process (increase (7) by 20% to ensure conservativeness)	0.40	g-CO2eq/MJ-fuel	=(7)×1.2

< Transport (chip transport) >

The following are the results of calculations of emissions from chip transport from wood chip factories.

Table 146 Calculations of emissions from transport of wood chips (transport in the producing country)

Specifications		Value	Unit	Source
(1)	Distance (in production)	300	km	Set based on plant locations of woody biomass suppliers
(2)	Round-trip fuel economy	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Wood chip Heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry Heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	1.75	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

For maritime transport emissions intensity, the value is originally calculated referring to values used in developing EU RED2 default values. Specifically the value assuming the ratio of empty cargo transport as 30% of total voyage distance and the bulk density as 0.22 t/m 3 used in EURED2 is converted to the values assuming the distance of empty cargo transport as the same as wood chips transportation.

Table 147 Calculations of emissions from maritime transport of wood chips (Handysize 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	6,500	km	Estimated distance between Vietnam's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.22 t/m3 or more, Handysize)	28.91	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	14.13	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 148 Calculation of emissions from maritime transport of wood chips (Handysize: 11,600 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	11,600	km	Approximate route between Australian representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.22 t/m3 or more, Handysize)	28.91	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	Same as above (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	25.21	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 149 Calculation of emissions from maritime transport of wood chips (Handysize: 18,000 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	18,000	km	Ascertaining the distance between U.S. East Coast representative ports and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.22 t/m3 or more, Handysize)	28.91	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	39.13	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 150 Calculation of emissions from maritime transport of wood chips (Supramax 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	6,500	km	Estimate between Vietnam's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.22 t/m3 or higher, Supramax)	18.37	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	8.98	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 151 Calculation of emissions from maritime transport of wood chips (Supramax 11,600 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	11,600	km	Estimated distance between Australian representative ports and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.22 t/m3 or higher, Supramax)	18.37	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	16.02	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 152 Calculation of emissions from maritime transport of wood chips (Supramax 18,000 km transport)

Specifications		Value	Unit	Source
(1)	Maritime transport distance	18,000	km	Guided service between U.S. East Coast Representative Port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.22 t/m3 or higher, Supramax)	18.37	g-CO2eq/tkm	Calculated from JRC(2017b)
(3)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	24.86	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 153 Calculating emissions from transport of wood chips (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 2 of the 12th WG
(2)	Round-trip fuel economy 10 t truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ- diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	291.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emissions intensity of land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Wood chip heat value	13,300	MJ-fuel/t-fuel	JRC(2017b) (assuming 30% moisture content for a dry heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	0.44	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

Calculation results of emissions from power generation with wood pellets are as follows.

Table 154 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (wood chips)	0.00489	g-CH4/MJ-chips	JRC(2017b)
(2)	N2O emissions (wood chips)	0.00098	g-N2O/MJ-chips	JRC(2017b)
(3)	Emissions from the Power generation	0.41	g-CO2eq/MJ-fuel	(1)×25+(2)×298

2-2. Wood chips from other harvested trees

(1) Boundary and calculation points

< Boundary >

Boundary is shown in the red box below.

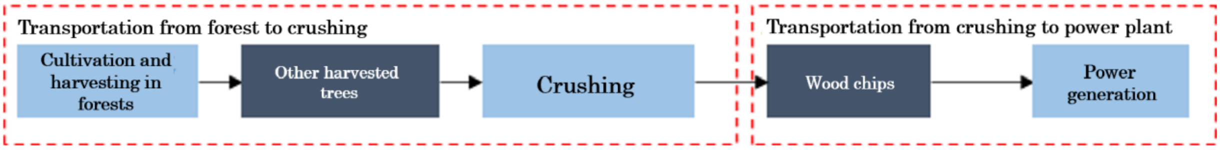

Figure 14 Boundary for life cycle GHG emissions of wood chips derived from other harvested trees

< Maritime transport >

Emissions from maritime transport are the same as wood chips derived from forest residues.

(2) Calculation of emissions by process

< Cultivation >

The calculated emissions from cultivation process are as follows.

Table 155 Calculation of emissions from cultivation process

Dimensions		Values	Units	Source
(1)	Diesel oil inputs in cultivation and logging	0.01066	MJ-diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor CO2	95.1	gCO2/MJ-diesel oil	Ibid
(3)	CH4 emissions intensity (when agricultural machinery is used)	0.00000816	g-CH4 /MJ-feedstock	JRC(2017b)
(4)	N2O emissions intensity (when agricultural machinery is used)	0.00003413	g-N2O /MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00020	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emissions intensity (when agricultural machinery is used) CO2 equivalent	0.01017	g-CO2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of cultivation process	1.02414	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Amount of other harvested trees required to make chips	1.079	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.11	g-CO2eq/MJ-fuel	=(7)×(8)

< Processing (crushing) >

Emissions from processing (crushing) are the same as wood chips derived from forest residues.

< Transport (chip transport) >

Emissions from transport (chip transport) are the same as wood chips derived from forest residues.

< Power generation>

Emissions from power generation emissions are the same as wood chips derived from forest residues.

2-3. Wood chips derived from sawmill residues

(1) Boundary and calculation points .

< Boundary >

Boundary is shown in the red box below.

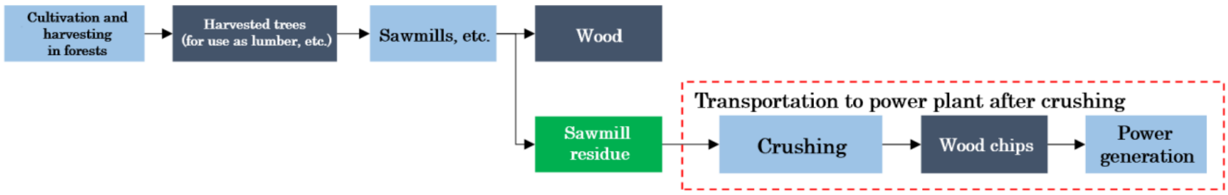

Figure 15 Boundary for life cycle GHG emissions of wood chips (sawmill residues)

< Maritime transport >

Emissions from maritime transport are the same as wood chips derived from forest residues.

(2) Calculation of emissions by process

<Processing (crushing) >

The emissions from processing (crushing) are assumed to be zero because there is no processing for wood chips derived from sawmill residues.

< Transport (wood chip transport) >

Emissions from wood chip transport are the same as wood chips derived from forest residues.

< Power generation

Emissions from power generation are the same as wood chips derived from forest residues.

3. Calculation process of Life cycle GHG default values for Wood Pellets

3-1. Wood pellets derived from forest residues.

(1) Boundary and calculation points

< Boundary>

Boundary is shown in the red box below.

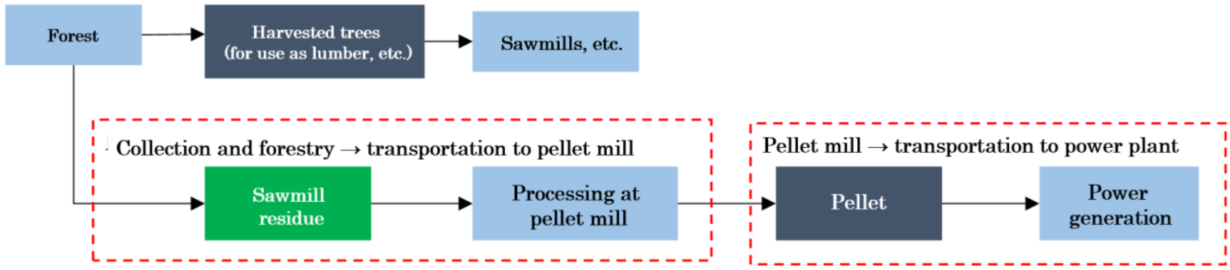

Figure 16 Boundary for life cycle GHG emissions of wood pellets derived from forest residues

< Maritime transport >

With regard to maritime transport, the 9th session of the Biomass Sustainability WG recognized that no specific voyage pattern is taken in transporting Wood pellets. Therefore, the value of the ratio of empty cargo transport is set at 30% of the total voyage distance for Wood pellets.

(2) Calculation of emissions by process

< Transport (collection of forest residue) >

The calculation results of the collection process of forest residue are as follows.

Table 156 Calculation of emissions from collection of forest residue (when fossil fuels are used as dry heat sources)

Specifications		Value	Unit	Source
(1)	Diesel oil input in collection of forest residues.	0.0120	MJ-diesel oil/MJ-forest residues, etc. (before seasoning)	JRC(2017b)
(2)	Diesel oil emission factor CO2	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when agricultural machinery is used)	0.00000257	g-CH4 /MJ-feedstock	JRC(2017b)
(4)	N2O emissions intensity (when agricultural machinery is used)	0.00001075	g-N2O /MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00006	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00320	g-CO2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of forest residue collection process per MJ of forest residue	1.14447	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Equivalent amount of forest residue required for pellet production (before seasoning)	1.035	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.18	g-CO2eq/MJ-fuel	=(7)×(8)

Table 157 Calculation of emissions from forest residue collection (when biomass is used as a dry heat source)

Specifications		Value	Unit	Source
(1)	Diesel oil input in collection of forest residues.	0.012	MJ-diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor CO2	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when agricultural machinery is used)	0.00000257	g-CH4 /MJ-feedstock	JRC(2017b)
(4)	N2O emissions intensity (when agricultural machinery is used)	0.00001075	g-N2O /MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00006	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00320	g-CO2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of forest residue collection process per MJ of forest residue	1.14447	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Equivalent amount of forest residue required for pellet production (before seasoning)	1.323	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.51	g-CO2eq/MJ-fuel	=(7)×(8)

< Transport (pre-processing transport) >

The calculation results of the transport (pre-processing transport) are as follows.

Table 158 Calculation of emissions from transport of wood chips (pre-processing transport) (when fossil fuels are used as dry heat sources)

Specifications		Value	Unit	Source
(1)	Distance	100	km	JRC(2017b)
(2)	Round-trip fuel economy	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel oil emission factor (including CH4 and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Heat value of forest residue	9,500	MJ-feedstock/t-feedstock	Ibid (assuming a moisture content of 50% for a dry heat value of 19,000 MJ/t)
(10)	GHG emission intensity for land transport	0.817	g-CO2eq/MJ-feedstock	=(1)×(4)+(7)+(8)/(9)
(11)	Equivalent amount of forest residue required for pellet production (Before seasoning)	1.035	MJ- feedstock/MJ-fuel	JRC(2017b)
(12)	GHG emissions of the process	0.85	g-CO2eq/MJ-fuel	=(10)×(11)

Table 159 Calculation of emissions from transport of wood chips (pre-processing transport) (when biomass is used as a dry heat source)

Specifications		Value	Unit	Source
(1)	Distance	100	km	JRC(2017b)
(2)	Round-trip fuel economy	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel fuel emission factor (including CH4 and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017b)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017b)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	Heat value of forest residue	9,500	MJ-feedstock/t-feedstock	JRC（2017b）(Assuming a moisture content of 50% for a dry heat value of 19,000 MJ/t)
(10)	GHG emission intensity for land transport	0.817	g-CO2eq/MJ-feedstock	=(1)×(4)+(7)+(8)/(9)
(11)	Equivalent amount of forest residue required for pellet production (before seasoning)	1.323	MJ-feedstock/MJ-fuel	JRC(2017b)
(12)	GHG emissions of the process	1.08	g-CO2eq/MJ-fuel	=(10)×(11)

< Processing (if fossil fuel is used as dry heat source) >

The following are the calculated emissions from processing when fossil fuel is used as dry heat source for pelletizing.

Table 160 Calculation of emissions from crushing process of wood pellets (fossil fuel is used as dry heat source)

Specifications		Value	Unit	Source
(1)	Diesel fuel input in crushing process	0.003357	MJ-diesel oil oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor (including CH4 and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when using crushing machinery)	0.0000092	g-CH4/MJ-feedstock	JRC(2017b)
(4)	N2O emission intensity (when using crushing machine)	0.0000385	g-N2O/MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when using crushing machine) CO2 equivalent	0.00023	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emission intensity (when using crushing machine) CO2 equivalent	0.01147	g-CO2eq/MJ-feedstock	=(4)×298
(7)	CO2 equivalent emissions from crushing process per MJ after crushing	0.33	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Equivalent amount of forest residue, required for pellet production (after seasoning)	1.010	MJ-feedstock/MJ-fuel	Derived from JRC(2017b) calculated data
(9)	GHG emissions of the process	0.33	MJ/MJ-fuel	=(7)×(8)
(10)	GHG emissions from the process (increase (9) by 20% to ensure conservativeness)	0.40	g-CO2eq/MJ-fuel	=(9)×1.2

Table 161 Calculation of emissions from drying process of wood pellets (using fossil fuels as a drying heat source)

Specifications		Value	Unit	Source
(1)	Natural gas input for boilers	0.185	MJ-steam/ MJ-fuel	JRC(2017b)
(2)	Natural gas boiler efficiency	0.9	MJ-steam/ MJ-natural gas	JRC(2017b)
(3)	Natural gas emission factor (not including methane and N2O during combustion)	66	g-CO2eq/MJ-natural gas	JRC(2017b)
(4)	Natural gas boiler emissions intensity (not including methane and N2O during combustion)	73.3	g-CO2eq/MJ-steam	=(3)/(2)
(5)	CH4 emissions intensity from natural gas boiler combustion	0.00280	g-CH4/MJ-steam	JRC(2017b)
(6)	N2O emission intensity from combustion of natural gas boiler	0.00112	g-N2O/MJ-steam	JRC(2017b)
(7)	Natural gas boiler CH4 emissions intensity (CO2 equivalent)	0.070	g-CO2eq/MJ-steam	=(5)×25
(8)	Natural gas boiler, N2O emission intensity (CO2 equivalent)	0.33376	g-CO2eq/MJ-steam	=(6)×298
(9)	GHG emissions of the process	13.64	g-CO2eq/MJ-fuel	=(1)×((4)+(7)+(8))
(10)	GHG emissions from the process (increased by 20% from (9) to ensure conservativeness)	16.37	g-CO2eq/MJ-fuel	=(9)×1.2

Table 162 Calculation of emissions from pelletizing process of wood pellets (using fossil fuels as a dry heat source)

Specifications		Value	Unit	Source
(1)	Input power	0.050	MJ-power / MJ-fuel	JRC(2017b)
(2)	Electric power emission factor (grid power)	148.1	g-CO2eq/MJ-power	GHG Emissions Intensity for U.S. Florida Grid power in GREET2022
(3)	Electricity-derived emissions intensity	7.32	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	Diesel oil input	0.0020	MJ-diesel oil/MJ-fuel	JRC(2017b)
(5)	Emission factor of diesel oil (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(6)	Emission intensity from diesel oil (excluding methane and N2O from combustion)	0.19	g-CO2eq/MJ-diesel oil	=(4)×(5)
(7)	CH4 emissions intensity (entire pelletizing process)	0.00000153	g-CH4/MJ-fuel	JRC(2017b)
(8)	N2O emissions intensity (entire pelletizing process)	0.00000640	g-N2O/MJ-fuel	JRC(2017b)
(9)	CH4 emissions intensity (entire pelletizing process) CO2 equivalent	0.00004	g-CO2eq/MJ-fuel	=(7)×25
(10)	N2O emissions intensity (entire pelletizing process) CO2 equivalent	0.00191	g-CO2eq/MJ-fuel	=(8)×298
(11)	GHG Emissions from the Process	7.51	g-CO2eq/MJ-fuel	=(3) + (6)+(9)+(10)
(12)	GHG emissions from the process (increase (11) by 20% to ensure conservativeness)	9.01	g-CO2eq/MJ-fuel	=(11)×1.2

< Processing (if biomass is used as drying heat source) >

The calculation results of the emissions from processing when biomass is used as drying heat source for pelletizing are as follows. The emissions from pelletizing process are the same as when fossil fuels are used as drying heat source.

Table 163 Calculation of emissions from crushing process of wood pellets (using biomass as drying heat source)

Specifications		Value	Unit	Source
(1)	Diesel oil input for the crushing process	0.003357	MJ-diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor (including CH4 and N2O)	95.1	g-CO2eq/MJ- Diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when using crushing machinery)	0.0000092	g-CH4/MJ-feedstock	JRC(2017b)
(4)	N2O emission intensity (when using crushing machine)	0.0000385	g-N2O/MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when using crushing machine) CO2 equivalent	0.00023	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emission intensity (when using crushing machine) CO2 equivalent	0.01147	g-CO2eq/MJ-feedstock	=(4)×298
(7)	CO2 equivalent emissions from crushing process per MJ after crushing	0.33	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Equivalent amount of forest residue required for pellet production (after seasoning)	1.291	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	0.43	MJ-feedstock/MJ-fuel	=(7)×(8)
(10)	GHG emissions from the process (increase (9) by 20% to ensure conservativeness)	0.51	g-CO2eq/MJ-fuel	=(9)×1.2

Table 164 Calculating emissions from drying process of wood pellets (using biomass as a drying heat source)

Specifications		Value	Unit	Source
(1)	Biomass input for boilers	0.239	MJ-heat/MJ-fuel	JRC(2017b)
(2)	Woodchip boiler/CO2 emissions intensity	0	g-CO2eq/MJ-steam	Biomass-derived emissions are not accounted for
(3)	Woodchip boiler/CH4 emissions intensity	0.005751	g-CH4/MJ-steam	JRC(2017b)
(4)	Woodchip boiler/N2O emissions intensity	0.001150	g-N2O/MJ-steam	JRC(2017b)
(5)	Woodchip boiler/CH4 emissions intensity (CO2 equivalent)	0.144	g-CO2eq/MJ-steam	=(3)×25
(6)	Woodchip boiler/N2O emission intensity (CO2 equivalent)	0.343	g-CO2eq/MJ-steam	=(4)×298
(7)	GHG emissions of the process	0.12	g-CO2eq/MJ-fuel	=(1)×((2)+(5)+(6))
(8)	GHG emissions from the process (increase (7) by 20% to ensure conservativeness)	0.14	g-CO2eq/MJ-fuel	=(7)×1.2

< Transport (pellet transport) >

The calculated emissions from transport (pellet transport) are as follows.

Table 165 Calculations of emissions from transport of wood pellets (production domestic transport)

Specifications		Value	Unit	Source
(1)	Distance	300	km	Set with reference to plant locations of woody biomass suppliers
(2)	Round-trip fuel economy	0.811	MJ-diesel oil/tkm	JRC(2017b)
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	77.1	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	77.7	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Biomass fuel heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	1.36	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

As GHG emission intensity of maritime transport, the emission intensity used in the EU RED2 default value, which assumes that the ratio of empty cargo transportation is 30% of the total voyage distance, is quoted. As quality standards for wood pellets in Japan include a bulk density of 0.65-0.7 t/m3, emission intensity of 0.65 t/m3 is cited. [14]

Table 166 Calculation of emissions from maritime transport of wood pellets (Handysize 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Distance	6,500	km	Estimate between Vietnam's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	3.11	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

14 https://www.nedo.go.jp/content/100932088.pdf(2022 viewed November 10)

Table 167 Calculation of emissions from maritime transport of wood pellets (Handysize 9,000 km)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Approximate distance between Canada West Coast Representative Port and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet heat value	17,100	MJ-fuel/t-fuel	Same as above (assuming 10% moisture content for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	4.30	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 168 Calculation of emissions from maritime transport of wood pellets (Handysize 18,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	18,000	km	Guided service between U.S. East Coast Representative Port and Japan
(2)	Maritime transport emissions intensity (Bulk density of 0.65 t/m3 or more, Handysize)	8.17	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet Heat value	17,100	MJ-fuel/t-fuel	Same as above (assuming a moisture content of 10% for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	8.60	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 169 Calculation of emissions from maritime transport of wood pellets (Supramax 6,500 km transport)

Specifications		Value	Unit	Source
(1)	Distance	6,500	km	Estimated distance between Vietnam's representative port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3 or higher, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet Heat value	17,100	MJ-fuel/t-fuel	Ibid (assuming 10% moisture content for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	2.01	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 170 Calculation of emissions from maritime transport of wood pellets (Supramax 9,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	9,000	km	Guided service between Canada West Coast Representative Port and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3 or higher, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet Heat value	17,100	MJ-fuel/t-fuel	Same as above (assuming a moisture content of 10% for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	2.78	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 171 Calculation of emissions from maritime transport of wood pellets (Supramax 18,000 km transport)

Specifications		Value	Unit	Source
(1)	Distance	18,000	km	Understanding the distance between the East Coast Representative Port of the United States and Japan
(2)	Maritime transport emissions intensity (Bulk density 0.65 t/m3 or higher, Supramax)	5.28	g-CO2eq/tkm	JRC(2017b)
(3)	Wood pellet Heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry Heat value of 19,000 MJ/t)
(4)	GHG emissions from the process	5.56	g-CO2eq/MJ-fuel	=(1)×(2)/(3)

Table 172 Calculation of emissions from transport of wood pellets (domestic transport in Japan)

Specifications		Value	Unit	Source
(1)	Distance	20	km	Document 3 of the 12th WG
(2)	Round-trip fuel economy 10 t truck	3.06	MJ-diesel oil/tkm	Table.179
(3)	Diesel oil emission factor (including methane and N2O)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(4)	Emission intensity from diesel oil (not including methane and N2O from combustion)	291.0	g-CO2eq/tkm	=(2)×(3)
(5)	CH4 emissions intensity (when trucks are used)	0.0034	g-CH4/tkm	JRC(2017a)
(6)	N2O emissions intensity (when trucks are used)	0.0015	g-N2O/tkm	JRC(2017a)
(7)	CH4 emissions intensity (when trucks are used) CO2 equivalent	0.085	g-CO2eq/tkm	=(5)×25
(8)	N2O emissions intensity (when trucks are used) CO2 equivalent	0.447	g-CO2eq/tkm	=(6)×298
(9)	GHG emission intensity for land transport	291.5	g-CO2eq/tkm	=(4)+(7)+(8)
(10)	Pellet Heat value	17,100	MJ-fuel/t-fuel	JRC(2017b) (assuming 10% moisture content for a dry Heat value of 19,000 MJ/t)
(11)	GHG emissions from the process	0.34	g-CO2eq/MJ-fuel	=(1)×(9)/(10)

< Power generation>

Emissions from power generation are calculated using the defaults for wood pellets used in the EU RED2 defaults.

Table 173 Calculation of emissions from power generation

Specifications		Value	Unit	Source
(1)	CH4 emissions (pellets)	0.00297	g-CH4/MJ pellet	JRC(2017b)
(2)	N2O emissions (pellet)	0.00059	g-N2O/MJ pellet	JRC(2017b)
(3)	Emissions from the power generation	0.25	g-CO2eq/MJ-fuel	(1)×25+(2)×298

3-2. Pellets from other harvested trees

(1) Boundary

<Boundary >

Boundary is shown in the red box below.

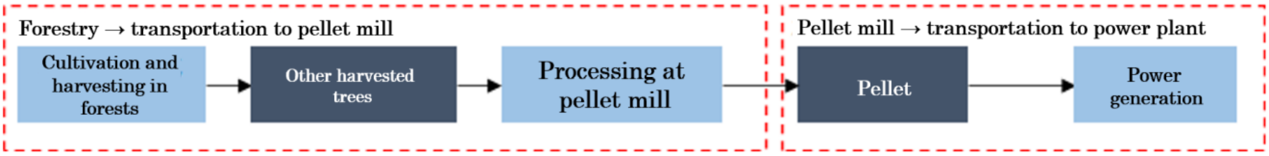

Figure 17 Boundary for life cycle GHG emissions of wood pellets from Other harvested trees

< Maritime transport >

Emissions from maritime transport are the same as pellets derived from forest residues.

(2) Calculation of emissions by process

<Cultivation >

The calculation results of cultivation are as follows.

Table 174 Calculation of emissions from cultivation (when fossil fuels are used as dry heat sources)

	Specifications	Value	Unit	Source
(1)	Input diesel oil for cultivation	0.01066	MJ- diesel oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor CO2	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when agricultural machinery is used)	0.00000816	g-CH4 /MJ-feedstock	JRC(2017b)
(4)	N2O emissions intensity (when agricultural machinery is used)	0.00003413	g-N2O /MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00020	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emissions intensity (when agricultural machinery is used) CO2 equivalent	0.01017	g-CO2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of cultivation process per MJ of other harvested trees	1.02414	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Amount of other harvested trees required for pellet production (before seasoning)	1.035	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.06	g-CO2eq/MJ-fuel	=(7)×(8)

Table 175 Calculation of emissions from cultivation (when using biomass as a drying heat source)

Specifications		Value	Unit	Source
(1)	Input-diesel oil in cultivation	0.01066	MJ-diesel oil oil/MJ-feedstock	JRC(2017b)
(2)	Diesel oil emission factor CO2	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(3)	CH4 emissions intensity (when agricultural machinery is used)	0.00000816	g-CH4 /MJ-feedstock	JRC(2017b)
(4)	N2O emissions intensity (when agricultural machinery is used)	0.00003413	g-N2O /MJ-feedstock	JRC(2017b)
(5)	CH4 emissions intensity (when agricultural machinery is used) CO2 equivalent	0.00020	g-CO2eq/MJ-feedstock	=(3)×25
(6)	N2O emissions intensity (when agricultural machinery is used) CO2 equivalent	0.01017	g-CO2eq /MJ-feedstock	=(4)×298
(7)	GHG emissions intensity of cultivation process per MJ of other harvested trees	1.02414	g-CO2eq/MJ-feedstock	=(1)×(2)+(5)+(6)
(8)	Amount of other harvested trees required for pellet production (before seasoning)	1.323	MJ-feedstock/MJ-fuel	JRC(2017b)
(9)	GHG emissions of the process	1.36	g-CO2eq/MJ-fuel	=(7)×(8)

< Transport (pre-processing transport) >

Emissions from transport (pre-processing transport) are the same as pellets from forest residues.

<Processing>

Emissions from processing are the same as pellets from forest residues.

< Transport (pellet transport) >

Emissions from transport (pellet transport) are the same as pellets from forest residues.

< Power generation>

Emissions from power generation are the same as pellets from forest residues.

3-3. Pellets from sawmill residues

(1) Boundary and calculation points

<Boundary>

Boundary is shown in the red box below.

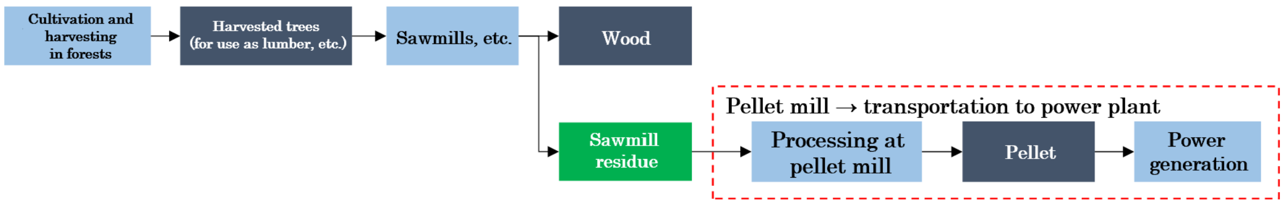

Figure 18 Boundary for life cycle GHG emissions of wood pellets (derived from sawmill residue)

< Maritime transport >

Emissions from maritime transport are the same as pellets derived from forest residues.

(2) Calculation of emissions by process

<Processing (fossil fuel is used as dry heat source) >

The following are the calculated emissions from processing when fossil fuel is used as dry heat source for pelletizing. In line with the EU RED2 default. Crushing process is not included.

Table 176 Calculation of emissions from processing of wood pellets (drying) (when fossil fuel is used as the drying heat source)

Specifications		Value	Unit	Source
(1)	Natural gas input for boilers	0.111	MJ-heat/MJ-fuel	JRC(2017b)
(2)	Natural gas boiler efficiency	0.9	MJ-steam/MJ-natural gas	JRC(2017b)
(3)	Natural gas emission factor (including CH4 and N2O)	66	g-CO2eq/MJ-natural gas	JRC(2017b)
(4)	Natural gas boiler emissions intensity (not including methane and N2O during combustion)	73.3	g-CO2eq/MJ-steam	=(3)/(2)
(5)	CH4 emissions intensity from natural gas boiler combustion	0.0028	g-CH4/MJ-steam	JRC(2017b)
(6)	N2O emission intensity from combustion of natural gas boiler	0.00112	g-N2O/MJ-steam	JRC(2017b)
(7)	Natural gas boiler CH4 emissions intensity (CO2 equivalent)	0.07	g-CO2eq/MJ-steam	=(5)×25
(8)	Natural gas boiler, N2O emission intensity (CO2 equivalent)	0.33376	g-CO2eq/MJ-steam	=(6)×298
(9)	Drying process GHG emissions	8.18	MJ/MJ-fuel	=(1)×((4)+(7)+(8))
(10)	GHG emissions from the process (increase (11) by 20% to ensure conservativeness)	9.82	g-CO2eq/MJ-fuel	=(9)×1.2

Table 177 Calculation of emissions from processing of wood pellets (pelletizing) (using fossil fuels as drying heat sources)

Specifications		Value	Unit	Source
(1)	Input power	0.028	MJ-power/MJ-pellet	JRC(2017b)
(2)	Electric power emission factor (grid power)	146.3	g-CO2eq/MJ-power	GHG Emissions Intensity for U.S. Florida Grid power in GREET2022
(3)	Electricity-derived emissions intensity	4.10	g-CO2eq/MJ-fuel	=(1)×(2)
(4)	Diesel oil input	0.0016	MJ-diesel oil/MJ-fuel	JRC(2017b)
(5)	Emission factor of diesel oil (not including methane and N2O from combustion)	95.1	g-CO2eq/MJ-diesel oil	JRC(2017b)
(6)	Emission intensity from diesel oil (excluding methane and N2O from combustion)	0.19	g-CO2eq/MJ-diesel oil	=(4)×(5)
(7)	CH4 emission intensity (entire pelletizing process)	0.00000153	g-CH4/MJ-fuel	JRC(2017b)
(8)	N2O emission intensity (entire pelletizing process)	0.00000640	g-N2O/MJ-fuel	JRC(2017b)
(9)	CH4 emissions intensity (entire pelletizing process) CO2 equivalent	0.00004	g-CO2eq/MJ-fuel	=(7)×25
(10)	N2O emissions intensity (entire pelletizing process) CO2 equivalent	0.00191	g-CO2eq/MJ-fuel	=(8)×298
(11)	GHG emissions from pelletizing process	4.25	g-CO2eq/MJ-fuel	=(3)+(6)+(9)+(10)
(12)	GHG emissions from the process (increase (11) by 20% to ensure conservativeness)	5.10	g-CO2eq/MJ-fuel	=(11)×1.2

< Processing (if biomass is used as a drying heat source) >

The calculation results of the emissions from processing when biomass is used as a drying heat source for pelletizing are as follows. The emissions from pelletizing process are the same as when fossil fuels are used as a drying heat source.

Table 178 Calculation of emissions from processing of wood pellets (drying) (using biomass as a drying heat source)

Specifications		Value	Unit	Source
(1)	Biomass input for boilers	0.143	MJ-heatp/MJ-fuel	JRC(2017b)
(2)	Woodchip boiler/CO2 emissions intensity	0	g-CO2eq/MJ-steam	Biomass-derived emissions are not accounted for
(3)	Woodchip boiler/CH4 emissions intensity	0.005751	g-CH4/MJ-steam	JRC(2017b)
(4)	Woodchip boiler/N2O emissions intensity	0.001150	g-N2O/MJ-steam	JRC(2017b)
(5)	Woodchip boiler/CH4 emissions intensity (CO2 equivalent)	0.144	g-CO2eq/MJ-steam	=(3)×25
(6)	Woodchip boiler/N2O emission intensity (CO2 equivalent)	0.343	g-CO2eq/MJ-steam	=(4)×298
(7)	Drying process GHG emissions	0.07	g-CO2eq/MJ-fuel	=(1)×((2)+(5)+(6))
(8)	GHG emissions from the process (increase (7) by 20% to ensure conservativeness)	0.08	g-CO2eq/MJ-fuel	=(7)×1.2

< Transport (pellet transport) >

Emissions from transport (pellet transport) are the same as pellets from forest residues.

< Power generation>

Emissions from power generation are the same as pellets from forest residues.

(Ref.) Fuel Economy of vehicles in Japan

Fuel economy of vehicles in Japan cited in previous tables is calculated as follows.

Table 179 Round-trip economy used to calculate the specified value for domestic woody biomass

Truck Size (Maximum loading capacity)	(1)Maximum loading capacity (ton)	(2)Loading rate	(3)Outbound fuel consumption l-diesel oil	(4)Loading rate when assuming empty load	(5)Loading fuel consumption assuming empty load l-diesel oil/tkm	(6)Return fuel consumption	(7)Round-trip fuel economy MJ-diesel oil /tkm
	–	JRC (2017b)	Calculated from(1)(2) in accordance with the notification of Energy Conservation Act[15]	Joint guidelines on methods for calculating carbon dioxide emissions in the logistics sector. (Ver. 3.2) 16	Calculated from(1)(4) in accordance with the notification of Energy Conservation Act	＝(5)× ((1)×(4)) ÷ ((1)×(2))	＝ ((3)＋(6)) ×Diesel oil Heat value (lower Heat value 36 MJ/l)
Over 4 tons	4	0.675	0.091	0.1	0.429	0.064	5.56
Over 10 tons	10	0.675	0.05	0.1	0.236	0.035	3.06
Over 20 tons	20	0.675	0.0318	0.1	0.15	0.022	1.94

15 https://www.enecho.meti.go.jp/category/saving_and_new/saving/enterprise/transport/institution/ninushi_santeikokuji.pdf

16 https://www.enecho.meti.go.jp/category/saving_and_new/saving/ninushi/pdf/guidelinev3.2.pdf