PEFCR DRAFT of contracted supply service for school meals

Version 1.1 - November 2018

Authors: ENEA SSPT-USER-RISE

CAMST

TABLE OF CONTENTS

1. Introduction

This document provides technical guidance on how to conduct an LCA study of contracted supply service for school meals according to the PEF (Product Environmental Footprint) methodology for the evaluation of the product environmental footprint, as defined in the Commission Recommendation 2013/179/EU and, when applicable, in the Product Environmental Footprint Category Rules Guidance, Version 6.3, May 2018.

The document, developed as a part of the LIFE EFFIGE project, addresses only the Italian market and has been prepared by ENEA in collaboration with CAMST. Its content is a contribution to the sector studies, but it is not binding on other ongoing or future initiatives.

2. General information about the PEFCR

This PEFCR is valid for products in scope sold/consumed in Italy.

The applicability to the European Union context needs to be tested.

This PEFCR has been prepared in conformance with the following documents:

- PEFCR "Guidance version 6.3"
- Product Environmental Footprint (PEF) Guide; Annex II to the Recommendation 2013/179/EU, 9 April 2013. Published in the official journal of the European Union Volume 56, 4 May 2013.

3. PEFCR scope

The scope of this PECR is the “contracted school food service”, defined as the catering service offered to children who attend nursery school, kindergarten, primary school, first-level secondary school and to teachers and operators working in the school. It must be guaranteed to all users and all through the school year.

Food services for other school levels not explicitly mentioned are not included.

3.1 Product classification

The CPA code for the products included in this PEFCR is:

56.29.1 Contract food services

3.2 Representative product

"Collective catering" is the service of large-scale preparation and delivery of complete meals for a community (company canteens, schools, hospitals, prisons, etc.). The customer can be private or public, with a predominance of the latter at school and health services. In Italy the value of the turnover of school catering accounts for about one third of the entire value of collective catering and contracted school food service represents approximately 70% of the school meals served.

The representative product has been defined as “the contracted supply service for a school meal for the following levels: nursery school, kindergarten, primary school, first-level secondary school”.

The representative product is a virtual product defined starting from the case study of CAMST, which is significant in terms of technology and organization of the supply chain in Italy.

Two types of production processes are considered: meal preparation at school kitchens (68% of the total meals) and preparation in central kitchens (32%). Three types of kitchen are considered in the screening study: high performance central kitchens (12%), medium performance central kitchens (20%), and school kitchens (68%).

Two scenarios of food serving are included: disposable tableware and reusable tableware.

3.3 Functional unit and reference flow

The function of the system is to meet the nutritional needs of a user at school in agreement with the scientific criteria established in the following documents:

- Linee Guida per una Sana Alimentazione Italiana, Istituto Nazionale di Ricerca per gli Alimenti e la Nutrizione – Rev. 1997 and rev. 2003
- Livelli di Assunzione Raccomandati di Energia e Nutrienti per la Popolazione Italiana- LARN, Società Italiana di Nutrizione Umana – Rev. 1996 and rev. 2014

The functional unit (FU) is the supply of a daily meal at school for one average user and 200 days, i.e. 200 meals/year, which is approximately the yearly number of meals consumed at school by an Italian schoolchild.

In line with the recommendations by the Italian Ministry of Health for school catering[1], meals served at school should account for 35% (lunch) and 8-10% (snacks) of the daily caloric intake. In particular, lunch should contain 15% protein, 30% fat and 55% carbohydrate and should provide the following energy amounts, in relation to different school levels:

- kindergarten: 440 – 640 kcal;
- primary school: 520 – 810 kcal;
- first-level secondary school: 700 – 830 kcal.

Since the recommended daily caloric intake can vary in relation to gender, age and levels of physical activity within the same school level, the energy amounts are provided as ranges.

In addition, it is recommended that the menus are designed to have a rotation of minimum 4-5 weeks.

Table 1 defines the key aspects used to define the FU.

Table 1 Key aspects of the FU

What?	To provide school meals
How much?	One daily meal
How well?	In agreement with the recommendations of the Italian Ministry of Health for school catering and with the GPP minimum environmental criteria
How long?	For one year (considering 200 school days)

The reference flow is the amount of product needed to fulfil the defined function and shall be measured in "number of meals". All quantitative input and output data collected in the study shall be calculated in relation to this reference flow.

The reference flow is defined as 200 average meals. The average meal is defined on the basis of the list of food bought in one year to provide the service and the number of meals provided.

[1] Ministero della Salute "Linee di indirizzo nazionale per la ristorazione scolastica" Conferenza Unificata Provvedimento 29 aprile 2010 Intesa, ai sensi dell'art.8, comma 6, della legge 5 giugno 2003, n.131, G.U. n. 134 del 11-6-2010.

3.4 System boundaries

Figure 1 shows the flow diagram of the entire process.

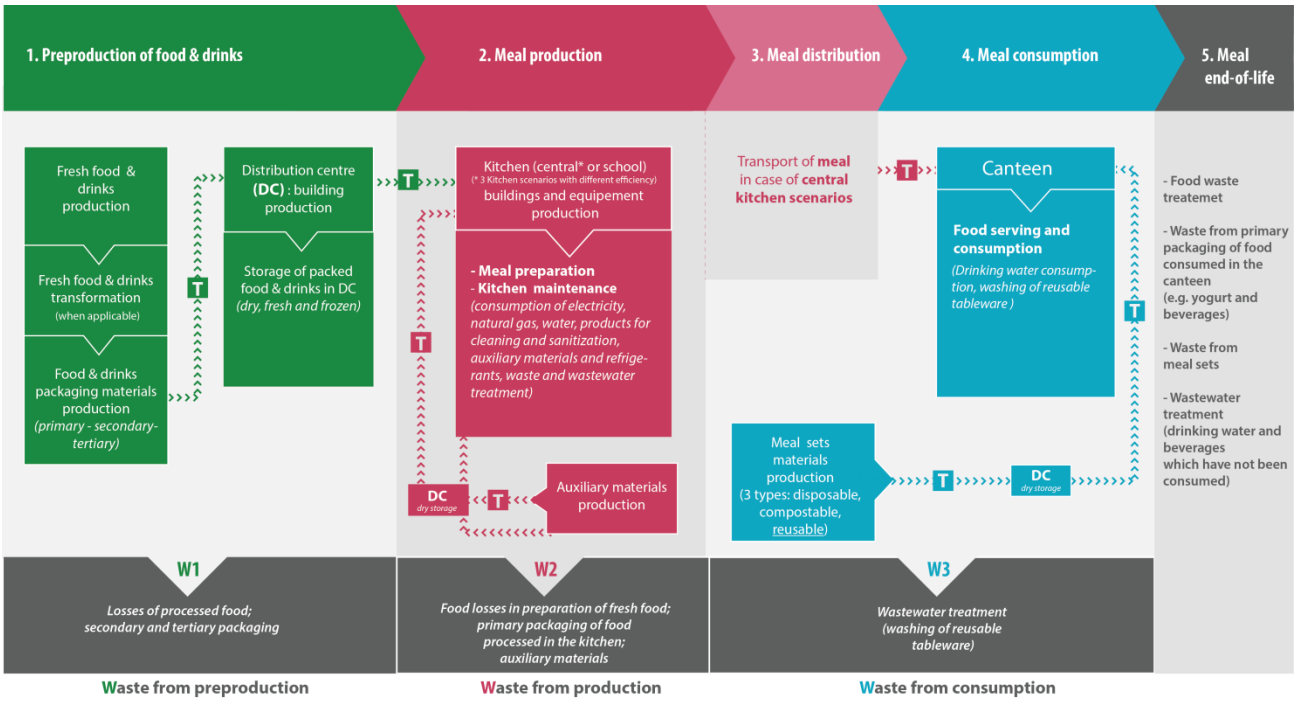

Figure 1 Flow diagram of the entire process

Table 2 describes the activities related to the life cycle stages of the product.

In addition, the production of buildings and equipment is included in the following stages:

- pre-production: building of distribution centre;
- production: building of kitchens and equipment.

Table 2 Life cycle stages[2]

Life cycle stage	*Short description of the processes included*
Preproduction (see section 6.1 Preproduction)	- Production of packed food and transport to a Distribution Centres (DC) - Storage in DC, which may be run by the same company which provides the meal service. Not all materials needed for the meal service come from the company's DC, but also direct purchase may occur - Distribution of packed food to the kitchens (central kitchens or school kitchens) - Waste and emissions which occurs at this stage
Production (see section 6.2 Production)	- Supply of auxiliary materials to the kitchens (production, transport to DC, storage, distribution to kitchens) - Meal preparation (electricity, water, gas, refrigerants consumption) - Cleaning and sanitization of spaces and equipment - Waste and emissions which occurs at this stage
Distribution (see section 6.3 Distribution)	- Distribution from kitchens to school canteens (when applicable)
Use (see section 6.4 Use)	- Serving of food, including the supply of meal sets (production, transport to DC, storage, distribution to kitchens, washing of reusable tableware) - Drinking water supply - Waste and emissions which occurs at this stage
End-of-Life (see section 6.5 End-of-Life)	- Treatment of food and non-food (e.g. meal sets) waste - Wastewater treatment (drinking water and beverages which have not been consumed)

3.5 EF impact assessment

Currently the PEF impact categories are not implemented in the LCA software. Until the completion of the process of integration and control by software developers, the ILCD 2011 Midpoint (version 1.0.9, May 2016) released by the European Commission, will be used.

[2] The decision about processes that may be excluded on the basis of the cut-off rule will be taken when results of the supporting studies will be available.

This LCIA method includes 16 midpoint impact categories[3]:

1 - Climate change: Global Warming Potential calculating the radiative forcing over a time horizon of 100 years. | IPCC 2007.

2 - Ozone depletion: Ozone Depletion Potential (ODP) calculating the destructive effects on the stratospheric ozone layer over a time horizon of 100 years. | World Meteorological Organization (WMO) 1999.

3 - Human toxicity, cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works. | USEtox (recommended + interim).

4 - Human toxicity, non-cancer effects: Comparative Toxic Unit for humans (CTUh) expressing the estimated increase in morbidity in the total human population per unit mass of a chemical emitted (cases per kilogramme). Specific groups of chemicals requires further works. | USEtox (recommended + interim).

5 - Particulate matter: Quantification of the impact of premature death or disability that particulates/respiratory inorganics have on the population, in comparison to PM2.5. It includes the assessment of primary (PM10 and PM2.5) and secondary PM (incl. creation of secondary PM due to SOx, NOx and NH3 emissions) and CO. | Rabl and Spadaro 2004.

6 - Ionizing radiation HH (human health): Quantification of the impact of ionizing radiation on the population, in comparison to Uranium 235. | Frischknecht et al. 2000.

7 - Ionizing radiation E (ecosystems) [note: this method is classified as interim; see reference for explanation]: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a radionucleide emitted (PAF m^3 year/kg). Fate of radionucleide based on USEtox consensus model (multimedia model). Relevant for freshwater ecosystems. | Garnier-Laplace et al. 2008.

8 - Photochemical ozone formation: Expression of the potential contribution to photochemical ozone formation. Only for Europe. It includes spatial differentiation | van Zelm et al. 2008.

9 - Acidification: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area in terrestrial and main freshwater ecosystems, to which acidifying substances deposit. European-country dependent. | Seppälä et al. 2006 and Posch et al. 2008.

10 - Terrestrial eutrophication: Accumulated Exceedance (AE) characterizing the change in critical load exceedance of the sensitive area, to which eutrophying substances deposit. European-country dependent. | Seppälä et al. 2006 and Posch et al. 2008.

11 - Freshwater eutrophication: Expression of the degree to which the emitted nutrients reaches the freshwater end compartment (phosphorus considered as limiting factor in freshwater). European validity. Averaged characterization factors from country dependent characterization factors. | ReCiPe version 1.05.

[3] SimaPro software documentation.

12 - Marine eutrophication: Expression of the degree to which the emitted nutrients reaches the marine end compartment (nitrogen considered as limiting factor in marine water). European validity. Averaged characterization factors from country dependent characterization factors. | ReCiPe version 1.05.

13 - Freshwater ecotoxicity: Comparative Toxic Unit for ecosystems (CTUe) expressing an estimate of the potentially affected fraction of species (PAF) integrated over time and volume per unit mass of a chemical emitted (PAF m^3 year/kg). Specific groups of chemicals requires further works. | USEtox (recommended + interim).

14 - Land use: Soil Organic Matter (SOM) based on changes in SOM, measured in (kg C/m^2/a). Biodiversity impacts not covered by the data set. | Mila i Canals et al. 2007.

15 - Water resource depletion: Freshwater scarcity: Scarcity-adjusted amount of water used. | Swiss Ecoscarcity 2006.

16 - Mineral, fossil and renewable resource depletion: Scarcity of mineral resource with the scarcity calculated as 'Reserve base'. It refers to identified resources that meets specified minimum physical and chemical criteria related to current mining practice. The reserve base may encompass those parts of the resources that have a reasonable potential for becoming economically available within planning horizons beyond those that assume proven technology and current economics. | van Oers et al. 2002.

3.6 Limitations

The following limitations are particularly relevant to the school meal service sector and must be reported by the PEF applicant when relevant:

- Huge lack of primary data concerning equipment, infrastructure, primary production, etc. requires large use of proxies to model the system. This will affect the quality of the PEF results.
- Use of inconsistent data for food supply (i.e. primary vs secondary) may lead to misinterpretation of the PEF results. As a consequence, the current PEFCR may support comparative assertions (i.e. comparative claims) among meal services only under the following conditions:
    - Primary data for food supply are used for all compared products,
    - Secondary data for production of food and auxiliary materials are used for all compared products, excepting when suppliers have a PEF study compliant with European PEFCRs. In this case primary data shall be used.
- The technological system described is typical of an Italian situation and its constraints. For example in Italy cook&chill is not accepted in Public Procurement of school meals service. The extension to a European situation requires testing.

4. Most relevant impact categories, life cycle stages, processes and elementary flows

The most relevant impact categories should be identified as all impact categories that cumulatively contribute to at least 80% of the total environmental impact (excluding toxicity related impact categories). However, due to the high uncertainty related to the ILCD normalisation factors, the normalised results of the screening study were used only as a starting point in the selection of the most relevant impact categories. Society interests in specific environmental impact categories were used as additional justifications.

The most relevant impact categories are the following:

- Water resource depletion (28%)
- Terrestrial eutrophication (15%)
- Mineral, fossil and renewable resource depletion (12%)
- Acidification (11%)
- Ionizing radiation HH (9%)
- Marine eutrophication (8%)
- Climate change (7%).

The percentages have been calculated on the total weighted results excluding the toxicity categories. Ionising radiation shall be excluded from the analysis.

The most relevant life cycle phases are Preproduction (contribution equal to 75% of the total weighted results) and Production (21%).

Table 3 shows the most relevant processes for the product group in scope of this PEFCR.

Table 3 List of the most relevant processes

Process	***Contribution to the total category***
CLIMATE CHANGE	
Food production (including primary packaging)	44% *with Meat, fish and eggs accounting for 27% and Dairy for 8%*
Food (including primary packaging) transport to Distribution Centre	12%
Electricity consumption in Kitchen	11%
Heat consumption (natural gas) in Kitchen	8%

Kitchen Equipment	7%
Total	82%
WATER RESOURCE DEPLETION	
Food production (including primary packaging)	94% *with Condiments accounting for 44% , Meat, fish and eggs for 27% and Fruit for 13%*
TERRESTRIAL EUTROPHICATION	
Food production (including primary packaging)	86% *with Meat, fish and eggs accounting for 61% and Dairy for 17%*
MINERAL, FOSSIL AND RENEWABLE RESOURCE DEPLETION	
Kitchen Equipment	35%
Food (including primary packaging) transport to Distribution Centre	20%
Food production (including primary packaging)	14%
Food (including primary packaging) transport to Kitchen	11%
Total	80%
ACIDIFICATION	
Food production (including primary packaging)	79% *with Meat, fish and eggs accounting for 54% and Dairy for 15%*
Electricity consumption in Kitchen	7%
MARINE EUTROPHICATION	
Food production (including primary packaging)	87% *with Meat, fish and eggs accounting for 60%, Dairy for 13% and Bakery and flour products for 4%*

5. Life cycle inventory

5.1 List of mandatory company-specific data

5.1.1 Packed Food supply

The applicant shall provide a list of the food products supplied to the kitchens in one year to provide the service and their weight (kg) or volume (litre).

Each food shall be classified according to the following list:

I. Vegetables and Legumes
II. Fruits
III. Meat, fish and eggs
IV. Dairy
V. Cereals
VI. Bakery and flour products
VII. Condiments
VIII. Beverages.

Data about food packaging shall be included. If primary data are not available, default data are provided in section 6.1.2 Food Packaging.

5.1.2 Kitchens operations

The following data shall be collected referred to one year and to the service provided:

- Electricity consumption: voltage and amount
- Fuel consumption for cooking and heating: type and amount
- Water consumption: type and amount.

5.2 List of processes expected to be run by the company

The following processes are expected to be run by the company applying the PEFCR:

- Storage in Distribution Centre
- Transport from Distribution Centre to kitchens
- Kitchen buildings and equipment
- Auxiliary materials supply to kitchens
- Transport from kitchens to school canteens
- Supply of meal sets.

For these data, directions on how to manage data gaps are given in section 6. Life cycle stages.

5.2.1 Storage in Distribution centre

If the company runs the process, the following data shall be collected:

- Size of the Building and Parking Area
- Electricity consumption of the Offices Area
- Electricity consumption of the Chilled Store
- Electricity consumption of the Frozen Store
- Electricity consumption of the Dry Store
- Fuel consumption
- Refrigerant consumption and leakages
- Water consumption
- Amount of goods leaving the frozen store per year
- Amount of goods leaving the chilled store per year
- Amount of goods leaving the dry store per year
- Waste.

5.2.2 Transport from Distribution Centre to kitchens

Data about the distance between Distribution Centre and kitchens and type of transport means shall be collected.

5.2.3 Kitchens buildings and equipment

The applicant shall provide a list of the kitchen equipment and the size of the building and parking area. Refrigerating gas content in cooled cells, life time of the plants and consumption of refrigerant in one year shall also be provided.

5.2.4 Auxiliary materials supply

The applicant shall provide a list of the auxiliary materials supplied to the kitchens in one year to provide the service and their weight/volume, e.g. detergents, clothing, disposable aluminium trays, thermal containers, paper rolls.

5.2.5 Transport from kitchens to school canteens

Data about the distance between kitchens and school canteens and type of transport means shall be collected.

As an alternative, data about fuel consumption and type of transport means shall be collected.

5.2.6 Supply of tableware

Data about the meal sets (e.g. dishes, cutlery, glasses, table mats, napkins) used to serve and consume the meals shall be collected. This shall include:

- amount and materials for the meal sets

- transportation of the meal sets from supplier to distribution centre, then to the kitchen and then to the canteen.

In case the meal set is reusable, data shall be collected about the lifetime of the meal set as well as its washing (water, detergent and electricity consumption).

5.3 Data gaps

Section 6. Life cycle stages includes directions about how to deal with data gaps and gives default data to be used to cover the gaps.

5.4 Data quality requirements

The data quality of each dataset and the total EF study shall be calculated and reported. The calculation of the DQR shall be based on the following formula with four criteria:

$$DQR = \frac{\overline{Te_R}+\overline{G_R}+\overline{Ti_R}+\bar{P}}{4} \qquad [Equation\ 1]$$

where TeR is the Technological-Representativeness, GR is the Geographical-Representativeness, TiR is the Time-Representativeness, and P is the Precision/uncertainty. The representativeness (technological, geographical and time-related) characterises to what degree the processes and products selected are depicting the system analysed, while the precision indicates the way the data is derived and related level of uncertainty.

Tables and criteria to be used for the semi-quantitative assessment of each criterion are reported in the PEFCR "Guidance version 6.3*".*

5.5 Data needs matrix (DNM)

All processes required to model the product and outside the list of mandatory company-specific (listed in section 5.1 List of mandatory company-specific data5.1 List of mandatory company-specific data*) shall be evaluated using the Data Needs Matrix (see* Table 4*). The DNM shall be used by the PEFCR applicant to evaluate which data is needed and shall be used within the modelling of its PEF, depending on the level of influence the applicant (company) has on the specific process. The following three cases are found in the DNM and are explained below:*

1. ***Situation 1****: the process is run by the company applying the PEFCR*
2. ***Situation 2****: the process is not run by the company applying the PEFCR but the company has access to (company-)specific information.*
3. ***Situation 3****: the process is not run by the company applying the PEFCR and this company does not have access to (company-)specific information.*

The detailed description of the three situations is given in the PEFCR "Guidance version 6.3".

Table 4 Data Needs Matrix (DNM)[4]

		Most relevant process	Other process
Situation 1: process run by the company applying the PEFCR	**Option 1**	Provide company-specific data (as requested in the PEFCR) and create a company specific dataset partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + total).	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR ≤3.0). Use the default DQR values.
Situation 2: process not run by the company applying the PEFCR but with access to (company-)specific information	**Option 1**	Provide company-specific data (as requested in the PEFCR) and create a company specific dataset partially disaggregated at least at level 1 (DQR ≤1.6). Calculate the DQR values (for each criteria + total)	
	Option 2	Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets (DQR ≤3.0).* Re-evaluate the DQR criteria within the product specific context.	
	Option 3		Use company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific PEF compliant datasets (DQR ≤4.0). Use the default DQR values.
Situation 3: process not run by the company applying the PEFCR and without access to (company)-specific information	**Option 1**	Use default secondary dataset, in aggregated form (DQR ≤3.0). Re-evaluate the DQR criteria within the product specific context.	
	Option 2		Use default secondary dataset in PEFCR, in aggregated form (DQR ≤4.0) Use the default DQR values.

*Disaggregated datasets shall be used.

[4] The options described in the DNM are not listed in order of preference.

5.6 Which datasets to use?

The secondary datasets to be used by the applicant are those listed in this PEFCR.

Whenever a dataset needed to calculate the PEF-profile is not among those listed in this PEFCR, then the applicant shall choose between the following options (in hierarchical order)[5]*:*

- *Use an EF-compliant dataset available on one of the following nodes:*
    - *http://eplca.jrc.ec.europa.eu/EF-node*
    - *http://lcdn.blonkconsultants.nl*
    - *http://ecoinvent.lca-data.com*
    - *http://lcdn-cepe.org*
    - *https://lcdn.quantis-software.com/PEF/*
    - *http://lcdn.thinkstep.com/Node*
- *Use an EF-compliant dataset available in a free or commercial source;*
- *Use another EF-compliant dataset considered to be a good proxy. In such case this information shall be included in the "limitation" section of the PEF report.*
- *Use an ILCD-entry level-compliant dataset. In such case this information shall be included in the "data gap" section of the PEF report.*

5.7 Allocation rules

In the Distribution Centre if primary data are available, data of consumption of energy, water, refrigerants shall be allocated with respect to the total mass of materials leaving the store from each storage area (chilled, frozen and dry) in one year. If secondary data are used, see section 6.1.4 Storage in Distribution Centre.

In the kitchens, consumption (electricity, gas, water, auxiliary materials, detergents and refrigerants), solid waste, wastewater and emissions data shall be allocated on the basis of the number of provided meals.

The number of meals estimated to be produced during the equipment and building lifetime shall be considered to calculate the fraction to be allocated to the functional unit.

For meals distribution, fuel consumption data shall be allocated on the basis of the number of transported meals, when the vehicles are solely used for school meals transportation, or on the basis of the load share

[5] The use of EF compliant datasets, instead of those listed in this PEFCR, is mandatory if one of the following conditions occur: 1) the EF compliant datasets are included in the Database integrated into the software of LCA; or 2) checked and validated procedures exist for the import of EF compliant datasets into the structure required by the software; or 3) the EF compliant impact assessment method is available in the LCA software and a PEFCR exists and benchmarks have been set; or 4) the EF compliant impact assessment method is available in the LCA software and the PEF of a supplier exists with the EF compliant environmental profile (characterized results).

dedicated to school meals transportation and the number of transported meals, when vehicles are used to transport goods other than the school meals.

5.8 Modelling of wastes and recycled content

The waste of products used during the production, distribution, retail, the use stage or after use shall be included in the overall modelling of the life cycle of the organisation. Overall, this should be modelled and reported at the life cycle stage where the waste occurs. This section gives guidelines on how to model the End-of-Life of products as well as the recycled content.

If primary data are not available, default values of the parameters used in the Circular Footprint Formula (CFF) below are provided in Annex A of this PEFCR.

The Circular Footprint Formula is used to model the End-of-Life of products as well as the recycled content and is a combination of "material + energy + disposal", i.e.:

Material $(1 - R_1)E_V + R_1 \times \left(AE_{recycled} + (1 - A)E_V \times \frac{Q_{Sin}}{Q_p}\right) + (1 - A)R_2 \times \left(E_{recyclingEoL} - E_V^* \times \frac{Q_{Sout}}{Q_P}\right)$

Energy $(1 - B)R_3 \times (E_{ER} - LHV \times X_{ER,heat} \times E_{SE,heat} - LHV \times X_{ER,elec} \times E_{SE,elec})$

Disposal $(1 - R_2 - R_3) \times E_D$

With the following parameters:

A: *allocation factor of burdens and credits between supplier and user of recycled materials.*

B: *allocation factor of energy recovery processes: it applies both to burdens and credits. It shall be set to zero for all PEF studies.*

Qs_{in}: *quality of the ingoing secondary material, i.e. the quality of the recycled material at the point of substitution.*

Qs_{out}: *quality of the outgoing secondary material, i.e. the quality of the recyclable material at the point of substitution.*

Q_p: *quality of the primary material, i.e. quality of the virgin material.*

R_1: *it is the proportion of material in the input to the production that has been recycled from a previous system.*

R_2: *it is the proportion of the material in the product that will be recycled (or reused) in a subsequent system. R2 shall therefore take into account the inefficiencies in the collection and recycling (or reuse) processes. R2 shall be measured at the output of the recycling plant.*

R_3: *it is the proportion of the material in the product that is used for energy recovery at EoL.*

$E_{recycled}$ (E_{rec}): *specific emissions and resources consumed (per functional unit) arising from the recycling process of the recycled (reused) material, including collection, sorting and transportation process.*

$E_{recyclingEoL}$ (E_{recEoL}): *specific emissions and resources consumed (per functional unit) arising from the recycling process at EoL, including collection, sorting and transportation process.*

E_v: *specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material.*

E^*_v: *specific emissions and resources consumed (per functional unit) arising from the acquisition and pre-processing of virgin material assumed to be substituted by recyclable materials.*

EER: *specific emissions and resources consumed (per functional unit) arising from the energy recovery process (e.g. incineration with energy recovery, landfill with energy recovery, …).*

$E_{SE,heat}$ and $E_{SE,elec}$: *specific emissions and resources consumed (per functional unit) that would have arisen from the specific substituted energy source, heat and electricity respectively.*

ED: *specific emissions and resources consumed (per functional unit) arising from disposal of waste material at the EoL of the analysed product, without energy recovery.*

$X_{ER,heat}$ and $X_{ER,elec}$: *the efficiency of the energy recovery process for both heat and electricity.*

LHV: *Lower Heating Value of the material in the product that is used for energy recovery.*

6. Life cycle stages

6.1 Preproduction

Activities from material acquisition to entrance gate of kitchens are included in this stage, in particular: the production (primary production and processing) of food and beverages to provide the school meal service, their packaging, the transport to a Distribution Centre, the storage, and the distribution to the kitchens (central kitchens or school kitchens).

6.1.1 Food and drinks production inventory

Tables 5-12 give information about the food production datasets according the following list:

I. Vegetables and Legumes
II. Fruits
III. Meat, fish and eggs
IV. Dairy
V. Cereals
VI. Bakery and flour products
VII. Condiments
VIII. Beverages.

Fruit, vegetables and legumes have been classified into botanic families and for each of them a proxy dataset has been identified. In some cases more than one dataset is associated with the same family in order to better represent differences of specific food products within the same class. Primary data on weight or volume of food are mandatory**.** Food shall be classified as specified in the following tables where proxy datasets identified are mandatory.

Agri-footprint is the main reference database; when food processes were not available in Agri-footprint, the Ecoinvent 3 – Allocation, Cut Off by classification database has been used.

Table 5 Classification of vegetables and legumes and datasets to be used

I. VEGETABLES AND LEGUMES		
Family	**Proxy DATASET**	**Database**
Lily (*Liliaceae*)	Onion at farm/FR Mass	Agri-footprint mass allocation
Gourd (*Cucurbitaceae*)	Zucchini {GLO}| market for | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification
Chenodopiaceae, aromatic plants and herbs, and Minestrone (vegetable soup)	Spinach, at farm/BE Mass	Agri-footprint mass allocation
Legumes (*Fabaceae* or *Leguminosae*)	Pea, at farm/IT Mass	Agri-footprint mass allocation

I. VEGETABLES AND LEGUMES		
Family	**Proxy DATASET**	**Database**
Dry legumes (*Fabaceae* or *Leguminosae*)	Beans, dry, at farm/NL Mass	Agri-footprint mass allocation
Umbellifers (*Apiaceae* or *Umbelliferae*)	Carrot, at farm/BE Mass	Agri-footprint mass allocation
Mustards (*Brassicaceae* or *Cruciferae*)	Broccoli, at farm/FR Mass	Agri-footprint mass allocation
Fresh tomato (*Solanaceae*)	Tomato, fresh grade {ES}| tomato production, fresh grade, in unheated greenhouse | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification
Tomato for puree (*Solanaceae*)[6]	Tomato, processing grade {IT}| tomato production, processing grade, open field | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification
Potato (*Solanaceae*)	Potato, at farm/IT Mass	Agri-footprint mass allocation
Others Nightshades (*Solanaceae*)	Aubergine {GLO}| production | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification

Table 6 Classification of fruits and datasets to be used

II. FRUITS		
Classification	**Proxy DATASET**	**Database**
Fruit trees (autumn/winter)	Apple {IT}| apple production | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification
Fruit trees (spring/summer)	Peach {ES}| peach production | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification
Berry	Strawberry {ES}| strawberry production, open field, macro tunnel | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification
Tropical fruits and fruit salad	Banana {GLO}| production | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification
Citrus fruits	Orange, fresh grade {ES}| orange production, fresh grade | Cut-off	Ecoinvent 3 – Allocation, Cut Off by classification
Gooseberry family *(Actinidiaceae)*	Grape {GLO}| production | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification

[6] For 1 Kg of tomato puree, 1.5 Kg of tomato are needed

II. FRUITS		
Classification	**Proxy DATASET**	**Database**
Chinese gooseberry family *(Actinidiaceae)*	Kiwi {GLO}| production | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification
Gourd (*Cucurbitaceae*)	Cucumber {GLO}| production | APOS, U	Ecoinvent 3 – Allocation, Cut Off by classification
Fruit Jam[7]	Strawberry {ES}| strawberry production, open field, macro tunnel | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification
	Sugar, from sugar beet, from sugar production, at plant/IT Mass	Agri-footprint mass allocation

Table 7 Classification of Meat, Fish and Eggs and datasets to be used

III. MEAT, FISH, AND EGGS			
Classification	**Proxy DATASET**	**Database**	**Amount for 1 Kg**
Beef and veal, cured Meat	Beef meat, fresh, from beef cattle, at slaughterhouse, PEF compliant/IE Economic/Mass	Agri-footprint mass-allocation	1Kg (losses included in dataset)
Poultry	Chicken meat, fresh, at slaughterhouse/NL Mass	Agri-footprint mass-allocation	1Kg (losses included in dataset)
Sheep	Sheep for slaughtering, live weight {GLO}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1.67 Kg
Pork	Pig meat, fresh, at slaughterhouse/NL Mass	Agri-footprint mass-allocation	1Kg (losses included in dataset)
Fish	Landed fish, from fishery, at plant/CL Mass	Agri-footprint mass-allocation	2 Kg
Eggs	Consumption eggs, laying hens >17 weeks, at farm/NL Mass	Agri-footprint mass-allocation	0.0616 pieces

[7] For 1 kg of fruit jam 1.25 kg of strawberry and 0.35 kg of sugar shall be considered

Table 8 Classification of Dairy Products and datasets to be used

IV. DAIRY		
Classification	**Proxy DATASET**	**Database**
Cheese, butter, cream	Cheese, from cheese production, at plant/NL Mass	Agri-footprint mass-allocation
Milk, yogurt, other dairy products	Raw milk, at dairy farm, PEF compliant/NL IDF/Mass	Agri-footprint mass-allocation

Table 9 Classification of Cereals and datasets to be used

V. CEREALS		
Classification	**Proxy DATASET**	**Database**
Rice and all types of cereals	Rice, at farm/CN Mass	Agri-footprint mass-allocation
Flour	Wheat flour, from dry milling, at plant/IT Mass	Agri-footprint mass-allocation

Table 10 Classification of Bakery and flour products and datasets to be used

VI. BAKERY AND FLOUR PRODUCTS			
Classification	**Proxy DATASET**	**Database**	**Amount for 1 kg of product**
Dry pasta (1 kg)[8]	Wheat flour, from dry milling, at plant/IT Mass	Agri-footprint mass-allocation	1.07 kg
	Tap water {Europe without Switzerland}| market for | Cut-off, U	Ecoinvent 3 – Allocation, Cut Off by classification	1.4 kg
	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	0.2 kWh
	Heat, from steam, in chemical industry {RER}| market for heat, from steam, in chemical industry | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1.9 MJ
Bread (1 kg) and all kind of salted baked snacks and products (e.g. pizza, crackers)[9]	Wheat flour, from dry milling, at plant/IT Mass	Agri-footprint mass-allocation	0.7 kg
	Tap water {Europe without Switzerland}| market for | Cut-off, U	Ecoinvent 3 – Allocation, Cut Off by classification	1.9 kg
	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	0.02 kWh
	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1 MJ

[8] Data source: Screening report - Dry pasta v20151106

[9] Data source: Data set "Brad, rye, conventional, fresh", from LCA Food DK Database

VI. BAKERY AND FLOUR PRODUCTS			
Classification	**Proxy DATASET**	**Database**	**Amount for 1 kg of product**
Cakes (1 kg) and all kind of sweet baked snacks/products	Wheat flour, from dry milling, at plant/IT Mass	Agri-footprint mass-allocation	0.4 kg
	Raw milk, at dairy farm, PEF compliant/NL IDF/Mass	Agri-footprint mass-allocation	0.3 kg
	Sugar, from sugar beet, from sugar production, at plant/IT Mass	Agri-footprint mass-allocation	0.2 kg
	Consumption eggs, laying hens >17 weeks, at farm/NL Mass	Agri-footprint mass-allocation	3 pcs
	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	0.02 kWh
	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1 MJ

Table 11 Classification of Condiments and datasets to be used

VII. CONDIMENTS		
Classification	**Proxy DATASET**	**Database**
Olive oil and all other types of condiments (sauce, salad dressing, mustard)	Medium benchmark value *(Oil density= 0.92 . Packaging and EoW are included in the dataset)*	PEFCR olive oil[10]
Sugar, honey, all products used as sweeteners	Sugar, from sugar beet, from sugar production, at plant/IT Mass	Agri-footprint mass-allocation
Salt	Sodium chloride, powder {RER}| production | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification

[10] Annex III, Table III-1. The Benchmark and classes of environmental performance. The results of 'Ionising Radiation, human health effect model' shall not been included due to inconsistencies.

Table 12 Classification of Beverages and datasets to be used

VIII. BEVERAGES			
Classification	**Proxy DATASET**	**Database**	**Amount for 1 kg**
Bottled Water[11]	Tap water {Europe without Switzerland}| market for | Cut-off, U	Ecoinvent 3 – Allocation, Cut Off by classification	1 kg
Juice (1 kg) and all types of drinks	Orange, fresh grade {ES}| orange production, fresh grade | Cut-off	Ecoinvent 3 – Allocation, Cut Off by classification	2.29 kg
	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	32.1 Wh
	Heat, from steam, in chemical industry {RER}| market for heat, from steam, in chemical industry | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1.05 kg
Dry/grinded/soluble preparations for drinks (e.g. tea, coffee)	Tea, dried {LK}| tea production, dried | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1 kg

In addition to the previous food list, in case of frozen and canned processed food the following relevant aspects shall be considered:

- input of food needed to obtain the final amount of processed food
- energy for processing (freezing and thermal treatment)
- input of water in case of canned products

Input of food needed to obtain the final amount of processed food

Producing 1 kg of processed food needs higher amount of fresh food (ex. Table 13). Table B.1 in Annex B shall be used to calculate the amount of food in input.

Table 13 Example of input of food to obtain the final amount of processed food

Product	Final product weight	Losses (%)	Weight in input
Frozen spinach	1 kg	26 %	1.35 kg

[11] Note: Packaging shall be included in agreement with Table 6.1.11 Primary Packaging data

Energy for processing (freezing and thermal treatment)

In the Food and beverage sector, transformation processes are very numerous and different in terms of function and technology.

If primary data are not available, the following main processes and related datasets (see Table 14 and Table 15) shall be considered:

- Thermal treatment for canned products
- Freezing process

Table 14 Datasets and default data for food thermal treatment

THERMAL TREATMENT (PASTEURIZATION)			
Classification	**Proxy DATASET**	**Database**	**Quantity for 1 kg**
Electricity for pasteurizing	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	5.5 Wh
Electricity for cooling	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	26.6 Wh
Steam	Heat, from steam, in chemical industry {RER}| market for heat, from steam, in chemical industry | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	1.05 kg

Table 15 Datasets and default data for food freezing

FREEZING				
Classification	**Proxy DATASET**	**Database**	**Quantity for 1 kg**	**Note**
Electricity for freezing	Electricity, medium voltage {IT}| market for | Cut-off, S	Ecoinvent 3 – Allocation, Cut Off by classification	180 Wh	Average data elaborated in agreement with "Reference Document on Best Available Techniques in the Food, Drink and Milk Industries" (EC, 2006)

Input of water in case of canned products

In some canned food an input of water for conservation is commonly added. If primary data are not available, a content of water equal to 40% of the total weight of canned product shall be considered (ex. Table 16).

Table 16 Example of canned peas

Product	Final product weight	Water content (25% of total weight)	Peas content
Canned peas	400 g	160 g	240 g

6.1.2 Food Packaging

Food production shall include packaging divided into the following three categories:

- Primary Packaging is the packaging in direct contact with the product and is sometimes referred to as consumer or retail packaging. The main purpose of primary packaging is to protect and/or preserve, contain and inform the consumer.
- Secondary Packaging is used for branding display and logistical purposes.
- Tertiary Packaging facilitates the protection, handling and transportation of a series of sales units in order to group everything into unit loads during transit.

If primary data are not available, data from Table 17, Table 18 and Table 19 shall be used.

For each type of packaging, the type of food and the amount of packaging material in input for 1 kg of food to be packed is provided. Packaging model include packaging material production, packaging process are not included.

Table 17 Primary packaging data

Type of packaging	Type of food	Dataset (Ecoinvent 3)	Quantity (g per kg of food)
Plastic (PP) box	Fruit and vegetables	Polypropylene, granulate {RER}| production | Cut-off, S	50
Plastic (PET) tray	Meat, fish and cheese	Polyethylene terephthalate, granulate, amorphous {Europe without Switzerland}| polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | Cut-off, S	70
Plastic (PET) tray	Eggs	Polyethylene terephthalate, granulate, amorphous {Europe without Switzerland}| polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | Cut-off, S	100
Plastic (PET) Bottle	Bottled water	Polyethylene terephthalate, granulate, amorphous {Europe without Switzerland}| polyethylene terephthalate, granulate, amorphous, recycled to generic market for amorphous PET granulate | Cut-off, S	24
Liquid packaging board	Milk + juice + all type of drinks	Liquid packaging board {GLO}| production | Cut-off, S	60
Plastic bag (LDPE)	Frozen food	Polyethylene, low density, granulate {GLO}| market for | Cut-off, S	22

Type of packaging	Type of food	Dataset (Ecoinvent 3)	Quantity (g per kg of food)
Plastic bag (LDPE)	Tomato puree	Polyethylene, low density, granulate {GLO}| market for | Cut-off, S	40
Plastic (PP) Jar	Jam + ice cream + other dairy products	Polypropylene, granulate {GLO}| market for | Cut-off, S	55
Plastic (PS) /Aluminium Jar	Yogurt	Polystyrene, general purpose {GLO}| market for | Cut-off, S	40
		Aluminium, primary, ingot {RoW}| market for | Cut-off, S	2
Steel can	Canned food	Stainless steel ***	120
Plastic (PP) bag	All food not included in the previous list (e.g. bakery & flour product, condiments, fruits and vegetables ready to be consumed)	Polypropylene, granulate {GLO}| market for | Cut-off, S	50
BOTTLE FOR OLIVE OIL	Olive oil + all other type of condiments	ALREADY INCLUDED IN DATASET (including its waste treatment)	-

*** To properly apply the Circular Footprint Formula to stainless steel the following procedure has been used:

- a primary stainless steel dataset has been modelled based on the Ecoinvent dataset Steel, chromium steel 18/8 {GLO}| market for | Cut-off, U by keeping only converter production (Steel, chromium steel 18/8 {RER}| steel production, converter, chromium steel 18/8 | Cut-off, U and Steel, chromium steel 18/8 {RoW}| steel production, converter, chromium steel 18/8 | Cut-off, U) and using the same proportion as in the original dataset to split in between European (RER) and extra European (RoW) production, respectively 15% and 85%, and the same transports;
- a secondary stainless steel dataset has been modelled based on the same Ecoinvent dataset Steel, chromium steel 18/8 {GLO}| market for | Cut-off, U by keeping only electric production (Steel, chromium steel 18/8 {RER}| steel production, electric, chromium steel 18/8 | Cut-off, U and Steel, chromium steel 18/8 {RoW}| steel production, electric, chromium steel 18/8 | Cut-off, U) and using the same proportion as in the original dataset to split in between European (RER) and extra European (RoW) production, respectively 26% and 74%, and the same transports;

- finally, a stainless steel dataset has been modelled by mixing 89,2% of primary stainless steel and 10,8% of secondary stainless steel.

Table 18 Secondary packaging data

Type of packaging	Type of food	Dataset	Quantity (g of packaging for 1 kg of food)
Cardboard Box	All food and beverages	Corrugated board box {GLO}| market for corrugated board box | Cut-off, S	25 g

Table 19 Tertiary packaging data

Type of packaging	Type of food	Dataset	Quantity (g of packaging for 1 kg of food)
Pallet	All food and beverages	EUR-flat pallet {RER}| production | Cut-off, S	7 g
Plastic film needed to wrap the pallet	All food and beverages	Packaging film, low density polyethylene {RER}| production | Cut-off, S	0.34 g

6.1.3 Transport of packed food to the Distribution Centre

Transport of Packed food includes primary, secondary and tertiary packaging. If primary data about type of transport and distance are not available, the following distances shall be considered:

- For products made in Italy: 600 km by truck (16-32 t, EURO 4)
- For products made in Europe: 1500 km by truck (16-32 t, EURO 4)
- For products made outside Europe: 15000 km by ship (freight, sea, transoceanic ship with reefer, cooling) +1500 km by truck.

When the origin is unknown, Europe will be the default choice.

To select the type of transport, the total **packed food** shall be grouped as follows:

- Total Dry food & beverage (kg)
- Total Fresh food & beverage (kg)
- Total Frozen food & beverage (kg)

For each group of packed food the datasets of Table 20 shall be used.

Table 20 Ecoinvent 3 Datasets for transport to Distribution Centre

Category	Transport
Dry food and beverages	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S
Fresh food and beverages	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, cooling {GLO}| market for | Cut-off, S
Frozen food and beverages	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, freezing {GLO}| market for | Cut-off, S
All food and beverages by ship	Transport, freight, sea, transoceanic tanker {GLO}| market for | Cut-off, S

6.1.4 Storage in Distribution Centre

The following data shall be used to calculate impacts of the process "storage in Distribution Centre", when the company does not run the process:

- Infrastructure and building: a distribution centre is a 30,000 m^2 building, 10 m high, and with a 30,000 m^2 parking. Life of the building is 80 years.
- Energy consumption: the electricity consumption for storage and services areas shall be 30 kWh/m^2·year. For chilled and frozen storage areas 40 kWh/m^3·year shall be added. Chilled and frozen storage areas shall be 30% of the total area. Area of services shall be 5%, Area of offices shall be 1500 m^2 (5% of the total area).Electricity consumption for offices shall be 180 kWh/m2[12]. Consumption and burning of 10 Nm^3 natural gas/m^2·year, calculated only for offices area, shall be included.
- Refrigerant gases consumption and leakages for DCs that contains cooling systems: gas content in fridges and freezers is 0.031 kg R404A per m^3 of refrigerated cells and 0.010 kg per m^3 for air conditioning (offices). A 10% annual leakage is considered (Palandre, 2003). For the portion of refrigerant gases remaining in the equipment at End-of-Life, 5% is emitted at end-of-life and the remaining fraction is treated as hazardous waste. Life of the refrigerating plants has been assumed 30 years.
- Water consumption: 0.5 m^3/m^2 per year. The production of this amount of tap water as well as its treatment in wastewater treatment plant shall be considered.
- Allocation of the DC space-time per product: The distribution centre impact per product is calculated using an allocation based on the total storage capacity of the distribution centre. The total area of storage is 90% of the distribution centre. The average distribution centre can store 72,000 m^3 for ambient storage and 36,000 m^3 for chilled or frozen storage (assuming 50% of the area of storage and 8 m high) Storage during 52 weeks, i.e., 5,616,000 m^3-weeks/year. The total storage capacity shall be allocated with the following storage volumes and times:
    - For ambient products: 4 times the product volume * stored 4 weeks
    - For chilled products: 3 times the product volume * stored 1 week

[12] The Guide Energy use in offices, March 2003 has been developed in the framework of the UK Government's Energy Efficiency Best Practice programme

- For frozen products: 2 times the product volume * stored 4 weeks

If the volume of product is unknown, but mass is known, a density of 0.4 t/m^3 shall be assumed.

Inventory data and default datasets (Ecoinvent 3 – Allocation, Cut Off) are shown in Table 21, Table 22 and Table 23.

Table 21 Storage of 1 kg of dry product

Input	Amount	Unit
Tap water {Europe without Switzerland}| market for	0.11	kg
Building, multi-storey {GLO}| market for	2.7E-05	m^3
Refrigerant R134a {GLO}| market for	4.36E-05	g
Road, company, internal {CH}| construction	1.2E-04	m^2a
Electricity, medium voltage {IT}| market for	8.2E-03	kWh
Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas	1.03E-03	kWh
Air emissions	**Amount**	**Unit**
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1.33E-06	g
Ethane, pentafluoro-, HFC-125	1.47E-05	g
Ethane, 1,1,1-trifluoro-, HFC-143a	1.73E-05	g
Waste treatment	**Amount**	**Unit**
Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9 l/year	0.11	L
Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration	1.04E-05	g

Table 22 Storage of 1 kg of chilled products

Input	Amount	Unit
Tap water {Europe without Switzerland}| market for	0.02	kg
Building, multi-storey {GLO}| market for	5.0-06	m^3
Refrigerant R134a {GLO}| market for	1.48E-03	g
Road, company, internal {CH}| construction	1.2E-04	m^2a
Electricity, medium voltage {IT}| market for	15.9-03	kWh
Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas	0.19E-03	kWh
Air emissions	**Amount**	**Unit**
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	4.51E-05	g
Ethane, pentafluoro-, HFC-125	4..96E-04	g
Ethane, 1,1,1-trifluoro-, HFC-143a	5.86E-04	g
Waste treatment	**Amount**	**Unit**
Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9 l/year	0.02	L
Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration	3.51E-04	g

Table 23 Storage of 1 kg of frozen products

Input	Amount	Unit
Tap water {Europe without Switzerland}| market for	0.05	kg
Building, multi-storey {GLO}| market for	1.3-05	m^3
Refrigerant R134a {GLO}| market for	3.95E-03	g
Road, company, internal {CH}| construction	1.2E-04	m^2a
Electricity, medium voltage {IT}| market for	42-03	kWh
Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas	0.51E-03	kWh
Air emissions	**Amount**	**Unit**
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	1.2E-04	g
Ethane, pentafluoro-, HFC-125	1.32E-03	g
Ethane, 1,1,1-trifluoro-, HFC-143a	1.56E-03	g
Waste treatment	**Amount**	**Unit**
Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9 l/year	0.05	L
Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration	9.37E-4	g

6.1.5 Waste at Distribution Centre

Waste shall include the secondary (cardboard boxes) and tertiary packaging (pallets) used to transport food with their primary packaging to kitchens (see section 6.1.2 Food Packaging).

To model the End-of-Life of these packaging materials according to the CFF, see the following rows in Annex A:

- Food packaging waste treatment – Cardboard
- Food packaging waste treatment – Wood
- Food packaging waste treatment – LDPE.

6.1.6 Transport of packed food from Distribution Centre to kitchens

If primary data about type of transport and distances are not available the average distance shall be 400 km, with the following assumptions:

- 30% of the transport shall be by truck (16-32 t, EURO 4)
- 30% of the transport shall be by truck (7.5-16 t, EURO 4)
- 40% of the transport shall be by truck (3.5-7.5 t, EURO 4).

To select the type of transport, the total **packed food** shall be grouped as follow :

- Total Dry food & beverage (kg)
- Total Fresh food & beverage (kg)
- Total Frozen food & beverage (kg).

For each group the datasets of Table 24 shall be used.

Table 24 Datasets for transport to kitchens

TRANSPORT OF PACKED FOOD TO THE KITCHEN		
Type of food	**Type of transport**	**Dataset (Ecoinvent 3)**
Dry food and beverage	Truck 16-32 t, EURO 4	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S
	Truck 3.5-7.5 t, EURO 4	Transport, freight, lorry 3.5-7.5 metric ton, EURO4 {GLO}| market for | Cut-off, S
	Truck 7.5-16 t, EURO 4	Transport, freight, lorry 7.5-16 metric ton, EURO4 {GLO}| market for | Cut-off, S
Fresh food and beverage	Truck 3.5-7.5 t, EURO 4	Transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO4, R134a refrigerant, cooling {GLO}| market for | Cut-off, S
	Truck 16-32 t, EURO 4 and Truck 7.5-16 t, EURO 4	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, cooling {GLO}| market for | Cut-off, S
Frozen food and beverage	Truck 3.5-7.5 t, EURO 4	Transport, freight, lorry with refrigeration machine, 3.5-7.5 ton, EURO3, R134a refrigerant, freezing {GLO}| market for | Cut-off, S
	Truck 16-32 t, EURO 4 and Truck 7.5-16 t, EURO 4	Transport, freight, lorry with refrigeration machine, 7.5-16 ton, EURO4, R134a refrigerant, freezing {GLO}| market for | Cut-off, S

6.2 Production

This stage includes the following elements:

- auxiliary materials,
- water, electricity, natural gas and refrigerant gas,
- kitchen infrastructure,
- kitchen equipment,
- emissions, waste and wastewater.

In the reference context, i.e. Italy, school meals for a contracted food service are prepared in kitchens with different characteristics. In relation to their dimensions and the presence/absence of air-conditioning and ventilation systems and the related level of comfort provided to operators, three classes can be identified:

- High Performance Central Kitchens, which are big production sites (about 1600 m^2 with an additional loading/unloading area of about the same size) dedicated to the preparation of meals, for schools only or for different types of final users (e.g. hospitals), equipped with systems providing a highly comfortable working space in terms of temperature, humidity, and air quality, from where the prepared meals are delivered to different canteens;
- Medium Performance Central Kitchens, which are big production sites (about 1600 m^2 with an additional loading/unloading area of about the same size) dedicated to the preparation of meals, for schools only or for different types of final users (e.g. hospitals), equipped with systems providing an averagely comfortable working space in terms of temperature, humidity, and air quality, from where the prepared meals are delivered to different canteens;
- School Kitchens, which are smaller spaces (about 100 m^2 with no dedicated loading/unloading area) usually integrated in a school building, with no or limited air-conditioning and ventilation systems, where meals for schools but also for other type of users (e.g. public servants) are prepared; meals can be served in an adjacent room (canteen) or they can be transported, usually to canteens of nearby schools.

In the Production stage, when data are affected by the kitchen type, e.g. electricity, water, gas, refrigerant, detergents consumption, the provided default data are a weighted mean of data of the three types, considering that 68% are School Kitchens, 20% are Medium Performance Central Kitchens and 12% are High Performance Central Kitchens.

6.2.1 Auxiliary materials

The supply of all consumable auxiliary materials needed in the kitchen for meal preparation shall be considered, e.g. detergents, clothing, disposable aluminium trays, thermal containers, paper rolls.

For each product, material production, product transportation from supplier to distribution centre, dry storage at the distribution centre, and transportation to the kitchen shall be considered.

If primary data on auxiliary materials are not available, data of Table 25 shall be used.

Table 25 Production – AUXILIARY MATERIALS calculated in relation to the functional unit

Name of the process	Default amount	Unit of measurement	Default dataset (Ecoinvent 3)
Ethoxylated alcohol in detergents	130	g	Ethoxylated alcohol (AE>20) {RoW}| ethoxylated alcohol (AE>20) production, palm oil | Cut-off, S
NaCl in detergents	10.3	g	Sodium chloride, powder {GLO}| market for | Cut-off, S
Fatty alcohols in detergents	20.6	g	Dodecanol {GLO}| market for dodecanol | Cut-off, S
Sodium hydroxide in detergents	275	g	Sodium hydroxide, without water, in 50% solution state {GLO}| market for | Cut-off, S
Bleach in detergents	58.2	g	Sodium hypochlorite, without water, in 15% solution state {GLO}| market for | Cut-off, S

Name of the process	Default amount	Unit of measurement	Default dataset (Ecoinvent 3)
Isopropanol in detergents	11.7	g	Isopropanol {GLO}| market for | Cut-off, S
Ethanol in detergents	20.8	g	Ethanol, without water, in 95% solution state, from fermentation {GLO}| market for | Cut-off, S
Soap in detergents	4.24	g	Soap {GLO}| market for | Cut-off, S
Glycerine in detergents	6.12	g	Glycerine {GLO}| market for | Cut-off, S
Citric acid in detergents	64.9	g	Citric acid {GLO}| market for | Cut-off, S
Non-ionic surfactant in detergents	51.8	g	Non-ionic surfactant {GLO}| market for non-ionic surfactant | Cut-off, S
Ethylenediamine in detergents	24.0	g	Ethylenediamine {GLO}| market for | Cut-off, S
Phosphoric acid in detergents	8.50	g	Phosphoric acid, industrial grade, without water, in 85% solution state {GLO}| market for | Cut-off, S
Lactic acid in detergents	0.535	g	Lactic acid {GLO}| market for | Cut-off, S
Propylene glycol in detergents	11.5	g	Propylene glycol, liquid {GLO}| market for | Cut-off, S
Water in detergents	2.65	kg	Tap water {Europe without Switzerland}| market for | Cut-off, S
Paper for auxiliary materials	0.49	kg	Tissue paper {RER}| production | Cut-off, S
PP for auxiliary materials	1.24	kg	Polypropylene, granulate {RER}| production | Cut-off, S
PS for auxiliary materials	0.01	kg	Polystyrene, general purpose {RER}| production | Cut-off, S
Textile for auxiliary materials	0.01	kg	Textile, woven cotton {GLO}| market for | Cut-off, S
LDPE for auxiliary materials	0.97	kg	Polyethylene, linear low density, granulate {RER}| production | Cut-off, S
Aluminium for auxiliary materials	0.13	kg	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Transport of auxiliary materials from supplier to DC	9.29	tkm	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S
Dry storage of auxiliary materials in DC	6.19	kg	Dry storage (see Table 21 for modelling details).
Transport of auxiliary materials from DC to kitchen	0.991	tkm	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S
	0.743		Transport, freight, lorry 3.5-7.5 metric ton, EURO4 {GLO}| market for | Cut-off, S
	0.743		Transport, freight, lorry 7.5-16 metric ton, EURO4 {GLO}| market for | Cut-off, S

6.2.2 Water, electricity, natural gas consumption

Data of consumption of water (e.g. for cooking and cleaning), electricity (e.g. for lighting, air conditioning and cooking), and natural gas (e.g. for cooking and heating) shall be collected in relation to the number of meals produced during the considered period. Ecoinvent 3 datasets to be used for background data are given in Table 26.

Table 26 Production – WATER, ELECTRICITY, NATURAL GAS DEFAULT DATASETS

Name of the process	Unit of measurement	Default dataset (Ecoinvent 3)
Electricity consumption - Medium voltage	kWh	Electricity, low voltage {IT}| market for | Cut-off, S
Electricity consumption - Low voltage	kWh	Electricity, medium voltage {IT}| market for | Cut-off, S
Natural gas consumption	Smc	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S
Water consumption	L	Tap water {Europe without Switzerland}| market for | Cut-off, S

6.2.3 Infrastructure

The life cycle of the kitchen building and of the external loading/unloading area, if present, shall be accounted for. This shall include the materials used for construction and repair/maintenance.

If primary data are not available, the default data of Table 27, where the infrastructure lifetime has been estimated at 80 years, shall be used.

Table 27 Production – INFRASTRUCTURE calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Kitchen building	m^3	0.0178	Building, multi-storey {GLO}| market for | Cut-off, S
External loading/unloading area	m^2a	0.0635	Road, company, internal {CH}| construction | Cut-off, S

6.2.4 Equipment

The materials used for the kitchen equipment shall be considered and shall include, for instance, furniture (e.g. tables, shelves, lockers), appliances (e.g. ovens, fridges, washing machines, scales), reusable tools and containers (e.g. trays, chopping boards, casseroles).

The number of meals produced during the equipment lifetime shall be considered to calculate the share of the equipment to be allocated to the functional unit.

Table 28 provides default data, calculated estimating the lifetime of the equipment at 15 years, to be used for equipment if primary data are not available.

Table 28 Production – EQUIPMENT main materials calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Equipment - Steel	kg	0.606	Stainless steel (see Table 17)
Plastic part of Equipment	kg	0.0897	Polypropylene, granulate {GLO}| market for | Cut-off, S

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Equipment - Aluminium	kg	0.131	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Equipment - Electronic Components	kg	0.0262	Electronic component, active, unspecified {GLO}| market for | Cut-off, S
Equipment - Printed Wiring Board	kg	0.000875	Printed wiring board, surface mounted, unspecified, Pb free {GLO}| production | Cut-off, S
Refrigerant gas consumption (incl. refills)	g	0.858	Refrigerant R134a {GLO}| market for | Cut-off, S

6.2.5 Refrigerant consumption

Consumption of refrigerant gas (used for refrigerated storage, including losses in air during the life cycle and the corresponding refills) shall also be included.

Table 29 gives default data, calculated estimating the lifetime of the equipment at 15 years, to be used for refrigerant gas consumption if primary data are not available.

Table 29 Default data for refrigerant consumption calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Refrigerant gas consumption (inc. refills)	g	0.858	Refrigerant R134a {GLO}| market for | Cut-off, S

6.2.6 Emissions, waste and wastewater

Emissions to air related to leakages of the refrigeration system, emissions to air and hazardous waste due to the residual refrigerant gas disposal, solid waste (e.g. organic waste from food scraps, food packaging waste, solid waste generated by auxiliary materials and equipment disposal) and wastewater generated during meal preparation shall be considered.

Emissions and hazardous waste generated by the refrigerant gas shall be modelled according to directions provided in section 6.1.4 Storage in Distribution Centre.

To model the End-of-Life of this waste according to the CFF, see Annex A and check the correct rows for each material.

Waste which occurs at this stage includes:

- food waste (see Annex B for calculation of food waste at kitchen; for food waste treatment see datasets and CFF coefficients of Annex A)
- primary packaging of food processed in the kitchen (e.g. pasta packaging)
- solid waste generated by auxiliary materials disposal
- solid waste generated by equipment disposal.

If primary data are not available the default data of Table 30 shall be used.

Table 30 Production – EMISSIONS, WASTE AND WASTEWATER calculated in relation to the functional unit

Name of the process/flow	Unit of measurement	Default amount	Default dataset/flow (Ecoinvent 3)
Emission to air from refrigerant gas	g	0.0268	Ethane, 1,1,1,2-tetrafluoro-, HFC-134a
	g	0.295	Ethane, pentafluoro-, HFC-125
	g	0.348	Ethane, 1,1,1-trifluoro-, HFC-143a
Hazardous waste treatment for Refrigerant gas	g	0.188	Hazardous waste, for incineration {Europe without Switzerland}| treatment of hazardous waste, hazardous waste incineration | Cut-off, S
Wastewater treatment	L	3,619	Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9l/year | Cut-off, S

6.3 Distribution

When the kitchen where meals are prepared is not adjacent to the canteen where the meals are served and consumed, the transportation in between the kitchen and the canteen shall be considered.

If primary data are not available the data of Table 31 shall be used.

Table 31 Distribution calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Meals Distribution	tkm	0.276	Transport, freight, light commercial vehicle {Europe without Switzerland}| processing | Cut-off, S

6.4 Use

This stage includes the serving and consumption of school meals.

The amount of tap water served with the meal, if applicable, shall be collected.

Data about the meal sets (e.g. dishes, cutlery, glasses, table mats, napkins) used to serve and consume the meals shall be collected. This shall include:

- production of materials needed for the meal sets;
- transportation of the meal sets from supplier to distribution centre, then to the kitchen and then to the canteen;
- dry storage in the distribution centre.

In case the meal set is reusable, its washing shall be considered and data related also to, e.g., water and wastewater treatment, detergent, electricity consumption shall be collected.

In this PEFCR, the meal sets are assumed to be the product packaging and their disposal is therefore considered in the End-of-Life stage.

If primary data are not available, default data are provided in Table 32. The following assumptions have been considered: 66% of the meal sets are disposable and not compostable, 17% of them are disposable and compostable, and 17% of them are reusable. A total distance from the supplier of meal sets to the canteen has been assumed equal to 1900 km. Reusable meal sets are considered to last for 200 uses, i.e. one reusable meal set for functional unit.

Table 32 Use calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
Drinking Water	kg	35	Tap water {Europe without Switzerland}| market for | Cut-off, S
Melamine Resin for Meal Sets	kg	0.0568	Melamine {GLO}| market for | Cut-off, S
Paper and Cellulose for Meal Sets	kg	1.56	Tissue paper {RER}| production | Cut-off, S
PC (Polycarbonate) for Meal Sets	kg	0.00910	Polycarbonate {RER}| production | Cut-off, S
Stainless Steel for Meal Sets	kg	0.0231	Stainless steel (see Table 17)
PLA for Meal Sets	kg	1.79	Polylactide, granulate {GLO}| production | Cut-off, S
PS for Meal Sets	kg	4.40	Polystyrene, general purpose {RER}| production | Cut-off, S
Meal Sets Transportation	tkm	11.8	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S
		1.25	Transport, freight, lorry 16-32 metric ton, EURO4 {GLO}| market for | Cut-off, S

Name of the process	Unit of measurement	Default amount	Default dataset (Ecoinvent 3)
		0.941	Transport, freight, lorry 3.5-7.5 metric ton, EURO4 {GLO}| market for | Cut-off, S
		0.941	Transport, freight, lorry 7.5-16 metric ton, EURO4 {GLO}| market for | Cut-off, S
Meal Sets Dry Storage in Distribution Centre	kg	7.84	Dry storage (see Table 21 for modelling details)
Water for Washing Meal Sets	L	51	Tap water {Europe without Switzerland}| market for | Cut-off, S
Detergent for Washing Meal Sets	g	34	Soap {GLO}| market for | Cut-off, S
Electricity for Washing Meal Sets	kWh	4.08	Electricity, low voltage {IT}| market for | Cut-off, S
Wastewater Treatment	L	51	Wastewater, average {Europe without Switzerland}| treatment of wastewater, average, capacity 1E9l/year | Cut-off, S

6.5 End-of-Life

The End-of-Life stage is a life cycle stage that in general includes the waste of the product in scope, such as food waste, primary packaging, or the product left at its end of use.

Data related to solid waste produced after serving and consuming the meals shall be accounted in the End-of-Life stage. This shall include food served but not consumed, waste generated by food packaging disposed in canteens (e.g. yogurt pots, bags for packed bread, plastic bottles for water, juice cartons) and waste generated by the disposal of meal sets. Water and beverages which are served but not consumed shall be considered to be treated as wastewater.

If no primary data are available about the amount of food, tap water, and beverages not consumed, 22.5% of the served quantity shall be assumed.

If the secondary data provided in the Use stage have been used for meals sets, related waste shall be quantified in agreement with data of Table 33.

For each waste treatment see datasets and CFF coefficients of Annex A.

Table 33 Solid waste originated by meal sets calculated in relation to the functional unit

Name of the process	Unit of measurement	Default amount
Melamine resin waste treatment	kg	0.0568
Paper waste treatment	kg	1.56
PC waste treatment	kg	0.00910
Steel waste from meal sets treatment	kg	0.0231
Compostable material (PLA) waste treatment	kg	1.79
PS waste from meal sets waste treatment	kg	4.40

7. PEF results

The characterised results of the screening study are reported in Table 34, referred to the supply of a daily meal at school for one average user and 200 days.

Table 34 Characterised results of the screening study calculated in relation to the functional unit

Impact Category	Unit	Total
Climate change	kg CO2 eq	4.68E+02
Ozone depletion	kg CFC-11 eq	3.76E-05
Human toxicity, non-cancer effects	CTUh	5.42E-04
Human toxicity, cancer effects	CTUh	2.26E-05
Particulate matter	kg PM2.5 eq	2.54E-01
Ionizing radiation HH	kBq U235 eq	2.18E+01
Ionizing radiation E (interim)	CTUe	9.29E-05
Photochemical ozone formation	kg NMVOC eq	1.33E+00
Acidification	molc H+ eq	6.24E+00
Terrestrial eutrophication	molc N eq	2.46E+01
Freshwater eutrophication	kg P eq	1.89E-01
Marine eutrophication	kg N eq	2.32E+00
Freshwater ecotoxicity	CTUe	1.270E+04
Land use	kg C deficit	2.73E+03
Water resource depletion	m^3 water eq	1.92E+01
Mineral, fossil and renewable resource depletion	kg Sb eq	2.40E-02

Annex A – CFF parameters

CFF Material

	A	R1	R2	Qsin/Qp	Qsout/Qp	Ev	Erecycled	ErecyclingEoL	Ev*
Food waste treatment	0.5	0	0.5	0	0.016	See Tables of section 6.1	-	Biowaste {RoW}| treatment of biowaste, industrial composting | Cut-off, S	Urea, as N {RER}| production | Cut-off, S
Food packaging waste treatment - PP	0.5	0	0	0.9	0.9	Polypropylene, granulate {GLO}| market for | Cut-off, S	-	-	-
Food packaging waste treatment - PET	0.5	0	0.31	0.9	0.9	Polyethylene terephthalate, granulate, bottle grade {RER}| production | Cut-off, S	-	Polyethylene terephthalate, granulate, amorphous, recycled {Europe without Switzerland}| market for polyethylene terephthalate, granulate, amorphous, recycled | Cut-off, S	Polyethylene terephthalate, granulate, amorphous {GLO}| market for | Cut-off, S
Food packaging waste treatment - LDPE	0.5	0	0	0.75	0.75	Polyethylene, low density, granulate {GLO}| market for | Cut-off, S	-	-	-
Food packaging waste treatment - PS	0.5	0	0.28	0.9	0.9	Polystyrene, general purpose {GLO}| market for | Cut-off, S	-	Polystyrene scrap, post-consumer {GLO}| market for | Cut-off, S	Polystyrene, general purpose {GLO}| market for | Cut-off, S

	A	R1	R2	Qsin/Qp	Qsout/Qp	Ev	Erecycled	ErecyclingEoL	Ev*
Food packaging waste treatment - Steel	0.2	0	0.73	1	1	Primary stainless steel	-	Iron scrap, sorted, pressed {GLO}| market for | Cut-off, S	Pig iron {GLO}| market for | Cut-off, S
Food packaging waste treatment - Liquid beverage carton - Paper	0.2	0	0.43	1	1	Liquid packaging board {GLO}| production | Cut-off, S	-	Waste paper, sorted {GLO}| market for | Cut-off, S	Sulfate pulp {GLO}| market for | Cut-off, S
Food packaging waste treatment - Liquid beverage carton - Aluminium	0.2	0	0.43	1	1		-	Aluminium scrap, post-consumer, prepared for melting {GLO}| market for | Cut-off, S	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Food packaging waste treatment - Liquid beverage carton - PE	0.5	0	0	0.75	0.75		-	-	-
Food packaging waste treatment - Cardboard	0.2	0	0.62	1	1	Corrugated board box {GLO}| market for corrugated board box | Cut-off, S	-	Waste paper, sorted {GLO}| market for | Cut-off, S	Sulfate pulp {GLO}| market for | Cut-off, S

	A	R1	R2	Qsin/Qp	Qsout/Qp	Ev	Erecycled	ErecyclingEoL	Ev*
Food packaging waste treatment - Aluminium	0.2	0	0.72	1	1	Aluminium, primary, ingot {RoW}| market for | Cut-off	-	Aluminium scrap, post-consumer, prepared for melting {GLO}| market for | Cut-off, S	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Food packaging waste treatment - Wood	0.8	0	0.39	1	1	EUR-flat pallet {RER}| production | Cut-off	-	Wood chipping, industrial residual wood, stationary electric chipper {RER}| processing | Cut-off, S	Residual wood, dry {GLO}| market for | Cut-off, S
Auxiliary material waste treatment - Textile	0.8	0	0	-	-	Textile, woven cotton {GLO}| market for | Cut-off	-	-	-
Auxiliary material waste treatment - Paper	0.2	0	0	1	1	Tissue paper {RER}| production | Cut-off	-	Waste paper, sorted {GLO}| market for | Cut-off, S	Sulfate pulp {GLO}| market for | Cut-off, S
Auxiliary material waste treatment - PP	0.5	0	0	0.9	0.9	Polypropylene, granulate {GLO}| market for | Cut-off	-	-	-
Auxiliary material waste treatment - PS	0.5	0	0	-	-	Polystyrene, general purpose {GLO}| market for | Cut-off	-	-	-
Auxiliary material waste treatment - Aluminium	0.2	0	0.72	1	1	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market |Cut-off	-	Aluminium scrap, post-consumer, prepared for melting {GLO}| market for | Cut-off, S	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Equipment waste treatment - Steel	0.2	0.54	0.9	1	1	Primary stainless steel	Secondary stainless steel	Iron scrap, sorted, pressed {GLO}| market for | Cut-off, S	Pig iron {GLO}| market for | Cut-off, S

	A	R1	R2	Qsin/Qp	Qsout/Qp	Ev	Erecycled	ErecyclingEoL	Ev*
Equipment waste treatment - PP	0.5	0	0	0.9	0.9	Polypropylene, granulate {GLO}| market for | Cut-off, S	-	-	-
Equipment waste treatment - Aluminium	0.2	0	0.9	1	1	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S	-	Aluminium scrap, post-consumer, prepared for melting {GLO}| market for | Cut-off, S	Aluminium, wrought alloy {GLO}| aluminium ingot, primary, to market | Cut-off, S
Equipment waste treatment - Electronic Components	-	0	0	-	-	Electronic component, active, unspecified {GLO}| market for | Cut-off, U	-	-	-
Equipment waste treatment - Printed Wiring Board	-	0	0	-	-	Printed wiring board, surface mounted, unspecified, Pb free {GLO}| market for | Cut-off, U	-	-	-
Melamine resin waste treatment	0.5	0	0	-	-	Melamine {GLO}| market for | Cut-off, S	-	-	-
PC waste treatment	0.5	0	0	-	-	Polycarbonate {RER}| production | Cut-off, S	-	-	-
Compostable material (PLA) waste treatment	0.5	0	0.5	0	0.016	Polylactide, granulate {GLO}| production | Cut-off, S	-	Biowaste {RoW}| treatment of biowaste, industrial composting | Cut-off, S	Urea, as N {RER}| production | Cut-off, S
Meal set waste treatment - Tissue paper	0.2	0	0	1	1	Tissue paper {RER}| production | Cut-off, S	-	Waste paper, sorted {GLO}| market for | Cut-off, S	Sulfate pulp {GLO}| market for | Cut-off, S

CFF Energy

	B	R3	LHV (MJ/kg)	Xer,heat	Xer,elec	Eer	Ese,heat	Ese,elec
Food waste treatment	0	0.175	9	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off,	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PP waste treatment	0	0.35	46	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PET waste treatment	0	0.242	46	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PE from food packaging waste treatment	0	0.35	46	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PS from food packaging waste treatment	0	0.252	42	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Steel from food packaging waste treatment	0	0.095	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Paper from liquid beverage carton waste treatment	0	0.2	17	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Aluminium from liquid beverage carton waste treatment	0	0.2	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S

	B	R3	LHV (MJ/kg)	Xer,heat	Xer,elec	Eer	Ese,heat	Ese,elec
PE from liquid beverage carton waste treatment	0	0.35	46	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Cardboard waste treatment	0	0.133	17	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Aluminium from food packaging waste treatment	0	0.098	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Wood waste treatment	0	0.21	17	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Textile waste treatment	0	0.35	21	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Paper waste treatment	0	0.35	17	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PS from auxiliary materials waste treatment	0	0.35	42	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Aluminium from auxiliary material waste treatment	0	0.35	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Steel from equipment waste treatment	0	0.098	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S

	B	R3	LHV (MJ/kg)	Xer,heat	Xer,elec	Eer	Ese,heat	Ese,elec
Aluminium from equipment waste treatment	0	0.035	0	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Electronic Components from equipment waste treatment	0	0.35	28	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Printed Wiring Board from equipment waste treatment	0	0.035	28	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Melamine resin waste treatment	0	0.35	16	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
PC waste treatment	0	0.35	43	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S
Compostable material (PLA) waste treatment	0	0.35	9	0%	0%	Municipal solid waste {IT}| treatment of, incineration | Cut-off	Heat, central or small-scale, natural gas {Europe without Switzerland}| market for heat, central or small-scale, natural gas | Cut-off, S	Electricity, medium voltage {IT}| market for | Cut-off, S

CFF Disposal

	(1-R2-R3)	Ed
Food waste treatment	0.325	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PP waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PET waste treatment	0.4485	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PE from food packaging waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PS from food packaging waste treatment	0.468	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Steel from food packaging waste treatment	0.1755	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Paper from liquid beverage carton waste treatment	0.3705	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Aluminium from liquid beverage carton waste treatment	0.3705	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PE from liquid beverage carton waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Cardboard waste treatment	0.247	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Aluminium from food packaging waste treatment	0.182	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Wood waste treatment	0.3965	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Textile waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Paper waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PS from auxiliary materials waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Aluminium from auxiliary material waste treatment	0.182	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Steel from equipment waste treatment	0.065	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Aluminium from equipment waste treatment	0.065	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Electronic Components from equipment waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Printed Wiring Board from equipment waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Melamine resin waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
PC waste treatment	0.65	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S
Compostable material (PLA) waste treatment	0.15	Municipal solid waste {RoW}| treatment of, sanitary landfill | Cut-off, S

Annex B – Food losses

Tables B.1 and B.2 shall be used to calculate the amount of fresh food needed for processed food in the Preproduction stage and food preparation in the kitchens (Production stage).

Preproduction: food losses of fresh vegetables shall be considered to produce final products .For fruit the percentage of losses shall be equal to zero. Tables B.1 shall be used to calculate the total amount of vegetables and legumes in input to transformation processes. Losses of all other food families in Preproduction are already included in the selected dataset.

Production: further losses occur in Production during the preparation of vegetables, meat, fish and eggs. Tables B.1 and B.2 shall be used to calculate the total amount of food losses in the kitchen.

Food losses after meals consumption (Use stage) shall be equal to 22.5% for each type of food category and their disposal shall be accounted for in the End-of-Life stage.

Table B.1

I. VEGETABLES AND LEGUMES		
Family	**Proxy DATASET**	**Losses (%)**
Lily (*Liliaceae*)	Onion at farm/FR Mass	11%
Gourd (Cucurbitaceae)	Zucchini {GLO}| market for | APOS, U	5%
Chenodopiaceae, aromatic plants and herbs, and Minestrone (vegetable soup)	Spinach, at farm/BE Mass	26%
Legumes (Fabaceae or Leguminosae)	Pea, at farm/IT Mass	Already included in dataset
Dry legumes (Fabaceae or Leguminosae)	Beans, dry, at farm/NL Mass	Already included in dataset
Umbellifers (Apiaceae or Umbelliferae)	Carrot, at farm/BE Mass	18%
Mustards (*Brassicaceae* or *Cruciferae*)	Broccoli, at farm/FR Mass	39%
Fresh tomato (*Solanaceae*)	Tomato, fresh grade {ES}| tomato production, fresh grade, in unheated greenhouse | Cut-off, S	9%
Potato (*Solanaceae*)	Potato, at farm/IT Mass	19%
Others Nightshades (*Solanaceae*)	Aubergine {GLO}| production | APOS, U	19%

Table B.2

III. MEAT, FISH AND EGGS		
Classification	**Proxy DATASET**	**Losses (%)**
Beef	Beef meat, fresh, from beef cattle, at slaughterhouse, PEF compliant/IE Economic/Mass	9%
Cured meat + others	Beef meat, fresh, from beef cattle, at slaughterhouse, PEF compliant/IE Economic/Mass	4%
Poultry	Chicken meat, fresh, at slaughterhouse/NL Mass	2%
Sheep	Sheep for slaughtering, live weight {GLO}| market for | Cut-off, S	2%

III. MEAT, FISH AND EGGS		
Pork	Pig meat, fresh, at slaughterhouse/NL Mass	9%
Fish	Landed fish, from fishery, at plant/CL Mass	Already included in dataset provided in Table 7
Eggs	Consumption eggs, laying hens >17 weeks, at farm/NL Mass	10%