



# Guidelines for calculating food supply GHG emissions with the ACGE calculator

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Author: Jan Broeze, Wageningen Food & Biobased Research.

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#### DISCLAIMER:

The developer of this tool checked correctness through comparison with other calculations. However, since the secondary offered in this tool are based on averages the results cannot be expected to exactly predict the GHG emissions and food losses in a specific practical situation.

For further information and recommendations please contact jan.broeze@wur.nl

#### 1 Introduction

The Agro-Chain Greenhouse gas Emissions (ACGE) calculator is a tool for estimating total greenhouse gas emissions associated to a food product. It addresses the most common stages of 'linear' agro-food chains (chains for fresh and simple processed products: canned, frozen, packaged and other minimal processed forms). It combines a calculation framework with a datasets containing crops GHG emission factors and Food Loss factors along the chain. Combined with user-definition parameters for the product-chain considered it generates an estimate for GHG emissions associated to a product when bought by a consumer. The default data that the calculator derives from the dataset may be overruled by the user if more specific data are available; this would make the calculations more case specific.

## 2 Calculator details

The method can be used at relatively little effort. Based on a chain flow diagram (that includes region of production, transport modalities and distances, duration of refrigered and frozen storage, packaging material use and energy use) a spread-sheet can be filled, resulting in estimate of total impact per unit product bought by the consumer.

Chain stage	Factors included	Sources for default data	User-defined		
			parameters and potential adjustments		
Agricultural production	Crop GHG emission factor	(Porter et al. 2016): Crop emission factor, aggregated to crop categories for 7 global regions, extended with outcomes of a few published LCA results.	(Default) GHG emission factor may be adjusted		
Post-harvest handling and storage	Refrigerated storage energy use Other energy use	Refrigerated storage energy use: derived from (Evans et al. 2014) with estimated filling degree. "Other energy use": default 0.	Duration of refrigerated storage. Other energy use per kg product (fuel-based and electric)		
Collection transport	Fuel use, well-to-wheels (impacts related to vehicles and infrastructure construction and maintenance are neglected, EcotransIT 2018)	<ul> <li>Values in line with Ecolnvent 3 and ecotransit.org (visited December 2018). The following vehicles are included: <ul> <li>delivery van (average filling degree)</li> <li>delivery van (full load capacity used)</li> <li>lorries (small, medium, large, very large)</li> <li>cargo train (electric, diesel)</li> <li>cargo ships (inland, sea ship, sea ship containers)</li> <li>air cargo (continental, intercontinental)</li> </ul> </li> </ul>	Distance Modality		
Primary processing and packaging	Packaging materials Refrigerated storage energy Other energy use	Packaging materials:	Packaging material use per kg product. Processing energy use per kg product		

Table 1. Scope, impacts included and sources for default data.

(International) Transport (optionally multi- modal)	Fuel use	see above	see above
(Secondary) processing, repackaging, cross-docking	See Primary processing	See above	see above
Distribution transport	Fuel use	Values in line with Ecolnvent 3 and IMO (IMO 2015).	see above
Retail outlet	Energy use, specifically refrigeration	Refrigerated storage in retail shelfs: energy use data derived from literature study.	Duration of refrigerated storage (display cabinet)
All stages along the post-harvest chain	Percentage of FLW per chain stage	Values from (Porter et al. 2016).	(Default) FLW percentages may be adjusted
All stages along the post-harvest chain	GHG emissions due to waste management process (varying from landfilling to bio- fermentation)	Values from EPA (EPA 2016).	

Either default data can be used (only chain configuration parameters must be inserted then) or the analyis can be made more specific (through replacing some generic data (Table 1) by primary data or more specific data from literature).

More background information can be found in Broeze et al. (2019).

#### 3 Calculator setup

The calculator is implemented in Excel, with a set of work sheets:

- Model (this is the actual calculator user-interface);
- DataEurope (contains crop GHG emission factors and Loss factors, averages for Europe);
- DataNAmOce (contains crop GHG emission factors and Loss factors, averages for North-America and Oceania);
- DataIndusAsia (contains crop GHG emission factors and Loss factors, averages for Industrialized Asia);
- DataNAWCA (contains crop GHG emission factors and Loss factors, averages for North Africa, West and Central Asia);
- DataSSA (contains crop GHG emission factors and Loss factors, averages for Sub-Sahara Africa);
- DataSSEAsia (contains crop GHG emission factors and Loss factors, averages for South and South-East Asia);
- DataLatAm (contains crop GHG emission factors and Loss factors, averages for Latin America);
- TransportModalities (contains emission factors for transportation modalities);
- ResiduesManagmOptions (contains emissions factors for residues management options).

Definition of the geographic areas can be found in the supplementary material by Porter et al. (2016)

The data sheets for crops are open for editing; when available the user may add a crop with more specific data to enrich his working set.

Also the last two datasheets are user-amendable, for instance for correcting the data to countryspecific best-known values or by adding alternative technology options.

## 4 Instructions for use of the calculator

#### 4.1 Selecting geographic location and crop

Since GHG emission factors and loss factors largely differ amongst global regions, the first step must be choice a region of production, a region of consumption and a crop.

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op 🔻 : 🗙 🗸 $f_{\rm x}$ Vegetable	es: fresh					
A	B C		D	E	F	G H
Agro Chain Greenhouse gases Em	issions (ACGE) calc	ulator	RESEARCH /	Change,	_	
Jan Broeze, Wageningen Food & Biobased Research	h, version 13 December 2019		CGIAR Food Se	ture and		UNIVERSITY & RESEAR
CASE: vegetables case in Sub-Sah	ara Afri <mark>ca</mark>	Seve	al impact estimates are ba	sed on GER data and Eco	Invent database	
Geographical region (production)	Sub-Sahara	n Africa	confirm regions			
Geographical region (consumption)	Europe		Committeelions			
Crop	Vegetables:					
	Roots and Tubers: fresh Roots and Tubers: proce					
GLOBAL RESULT	Cassava Oil palm		OTAL IMPACT PER KG CRO	P 0.60	0.435 CC	D2 IMPACT cum. (
CHAIN PRODUCT EFFICIENCY (KG SOLE	O/KG Oil crops	DT. GHG EN	IISS PER KG SOLD IN RETAI	L 1.03	0.749 per 0	chain stage kg pe
	Pulses Fruits: fresh			Energy use (MJ)	CO2-equiv.	per kg end product
	Fruits: processed	¥		(primary equivalent)	emissions (kg)	
Agricultural production	Initial unit	1.00 kg crop				
CO2 impact	Reset		kg harvested crop		0.400	
Energy use			p (primary energy equivale	n 0.00		
Losses	Reset	0%				
Losses waste management	(left out of the a	inalysis)			0.000	
						0.40 0
Postharvest handling and storage	product in	1.00 kg				
Average number of hours at ambient con	ditions	0 hours				
Ambient temperature		20 C				
Average number of days in refrig. storage	<i>د</i>	0 days	1	0.00	0.000	
Other energy use Losses	Reset	18%	oduct (primary energy eq.)	0.00	0.000	
Losses Losses waste management	(left out of the a	11.10X207.		Г	0.000	
Losses waste management	lien our or the a	indiysis)		L	0.000	
Collection transport						
Transport distance		100 km				
Transport modality	Truck, r	nedium		0.36	0.022	
Refrigeration in transport?		0		0.00	0.000	
						0.113 (
Primary processing and packaging	product in	0.82 kg				
Losses	Reset	25%		-		
Losses waste management	(left out of the a	and the second se			0.000	
Packaging steel			aging per kg product	0.00	0.000	
Packaging aluminium		0 kg aluminiun	board per kg product	0.00	0.000	
Packaging paper and board     Model DataEurope DataNAr	mOce DataIndusAsia	DataNAWCA DataSSA		[ • ]	0.000	

After selection of the Geographical region of production and Geographical region of consumption, the user must press the button "confirm regions" to let the tool select the correct data.

# 4.2 Inserting chain configuration data and optionally overrule default parameter values

Based on the selection of geographic regions and crop, the tool automatically inserts default crop GHG emission factor and loss percentages in the post-harvest chain (differentiated to 'Postharvest handling and storage', 'Primary processing and packaging', 'Processing/repackaging/distribution' and 'Retail' stages). Since losses in transport mostly become apparent in the handling afterwards, the losses in transport are not separately listed.

The user may override the default crop GHG emission factor and loss factors by inserting a new values in the concerning fields. This 'overruling' destroys the link to the default values. However this link can be repaired by clicking the 'Reset' button next to the field.

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le Home Insert Page Layout Formi	ulas Data	Review View [	Developer Q Tell me what y	ou want to do				
B 🔻 : 🗙 🗸 $f_{\rm x}$ Processir	g/repackaging	/distribution						
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Agro Chain Greenhouse gases En	-			la municipality				ENINGEN
Jan Broeze, Wageningen Food & Biobased Researd	•	•		Climate C Agricultu CGIAR Food Seco	hange, O			TY & RESEARC
CASE: vegetables case in Sub-Sał			Coursellingent		ed on GER data and	Contract database		
Geographical region (production)	Idra Africa	Sub-Saharan Africa		estimates are bas	ea on GER aata ana	Econvent databas	2	
Geographical region (production) Geographical region (consumption)		Europe	confir	m regions				
Crop		Vegetables: fresh	-					
Сгор		vegetables. Itesti	]					
GLOBAL RESULT				ACT PER KG CROP	0.		-	
CHAIN PRODUCT EFFICIENCY (KG SOLI	D/KG CROP)	0.58	TOT. GHG EMISS PER KO	SOLD IN RETAIL	1.		9 per chain stage	
					Energy use (N			product
					(primary equivaler	nt) emissions (kg	5)	
Postharvest handling and storage	product in	1.00	kg					
Average number of hours at ambient cor	ditions		hours					
Ambient temperature		20						
Average number of days in refrig. storage	2	0	days		0.0	00.00	0	
Other energy use	_		MJ per kg product (prim	ary energy eq.)	0.0		-	
Losses	Reset	18%						
Losses waste management	(loft	out of the analysis)	1			0.00	0	
			-					
Collection transport								
Transport distance		100	km				- 10	
Transport modality		Truck, medium			0.	36 0.02	2	
Refrigeration in transport?		0			0.	0.00	0	
			-				0.113	0.
Primary processing and packaging	product in	0.82						
Losses	Reset	25%					-	
Losses waste management	(left	out of the analysis)	-		-	0.00		
Packaging steel			kg steel packaging per k	E parte de la companya de la company	0.0			
Packaging aluminium			kg aluminium per kg pro		0.0			
Packaging paper and board			kg paper and board per		0.0			
Packaging plastics			kg plastics per kg produ	ct	0.1	550 ST		
Packaging glass			kg glass per kg product		0.0	00.00	0	
Reusable transportation means (pellets,	crates, etc.)		kg tarra per kg product				3	
Processing and packaging electricity use			MJ per kg product (prim	그는 것이 같은 것이 같은 것이 같은 것이 같이 같이 같이 같이 같이 같이 같이 않는 것이 같이				
Processing and packaging fuels use	1.41		MJ per kg product (prim	ary energy equiv.	0.1	0.00	U	
Average number of hours at ambient cor Model DataEurope DataNA		IndusAsia DataNAV	hours VCA DataSSA DataSSE	Aria (D) 1	21			
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Next, the user can further specify the product, amongst others (see also Table 1):

- durage of refrigerated storage in different stages of the chain;
- packaging material use (in 'Primary processing and packaging' and 'Processing / repackaging / distribution')
- transportation distances and modalities (including size of the vehicles)
- losses waste management options (default: left out of the analysis).

The white cells are user-editable.

#### 4.3 Results

The results are summarized in cells E8:F9.

Cells E8 and E9 summarize total enery use associated to the product, per kg crop and per kg sold in retail respectively.

Cells F8 and F9 summarize total GHG emissions induced by the production chain, per kg crop and per kg sold in retail respectively. F9 is considered the essential result of a calculation.

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3	CASE: vegetab	les case in Sub	-Sahara Africa	ı						
4		gion (production)		Sub-Saharan Africa	confirm regions					
5		gion (consumption	)	Europe						
6	Crop			Vegetables: fresh						
7								•		
8	GLOBAL RESU				TOTAL IMPACT PER KG CRC					
9	CHAIN PRODUC	T EFFICIENCY (KG	SOLD/KG CROP)	0.58	TOTALS PER KG SOLD IN RETA		0.749			
10	-					Energy use (MJ)		CO2 IMPACT	cum. CO	
11 12	-					(primary equivalent)	emissions (kg)	per chain stage per kg end p	kg per k vroduct	8
	Agricultural produ	uction	Initial unit	1.00	kg crop			per kg end p	nouuci	
	Crop CO2 emissio		Re	-	kg CO2eq per kg harvested crop		0.400			
15				·				0.40	0.4	O
16	Postharvest hand	ling and storage	product in	1.00	kg			•		
17	Average number of	of hours at ambien	nt conditions	-	hours					
	Ambient tempera			20						
	9 Average number of days in refrig. storage		orage		days	0.00				
	20 Other energy use				MJ per kg product (primary energy eq.)	0.00	0.000			
	Losses	agamant	Reset	18% out of the analysis)			0.000			
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