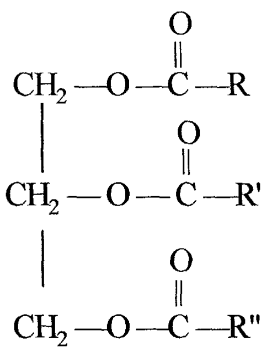
Date: 09/06/2017

Environmental Fact Sheet (#34)

Refined Palm Kernel Oil (RPKO)

renewable precursor

Substance Identification			
IUPAC Name	Refined palm kernel oil	**CAS Number**	8023-79-8
Other Names			
Molecular Formula	UVCB	Structural formula: 	

Physical/Chemical Properties [1] (see also fact sheet 33)	
Molecular Weight	No data available
Physical state	No data available
Appearance	No data available
Odour	No data available
Density	No data available
Melting Points	No data available
Boiling point	No data available
Flash Point	No data available
Vapour Pressure	No data available
Water Solubility	No data available
Flammability	No data available
Explosive Properties	No data available
Surface Tension	No data available
Octanol/water Partition coefficient (Kow)	No data available
Product and Process Description	The process for producing refined palm kernel oil is the same till crude palm kernel oil (further detail in the Eco-profile of Crude palm kernel oil (CPKO)). After obtaining the crude palm kernel oil, the refinery process of palm kernel oil consist on purify oils. There are different methods for refining CPKO. In this study was modelled the physical refining method. The refining process consists of: 1) Degumming step: phosphoric acid is added to the CPKO to ensure that the phosphatides and gums are aggregated for easier removal by the bleaching earth [5]. 2) Bleaching step: removing undesired coloured particles and trace metals. Within the bleaching process the oil is in contact with active substances (bleaching earth) which absorb the undesired particles. Sometimes filter aid is added to the bleaching earth, this helps building up a filter structure

	and avoiding the filter to get clogged [4]. 3) De-acidification and deodorization step: steam is injected into the deodorizers during the stripping of FFA (free fatty acids) and other undesirable volatiles from the oil Palm fatty acid distillate (PFAD) is obtained as a by-product, s a condensate of the volatile compounds carried over from the deodorizer by the stripping steam [5].
Application	Refined palm kernel oil is used for human consumption or for use in technical applications such as soaps and candles manufacture, food industry, oleo-chemical industry [6]. The PFAD, as palm fatty acid distillate, is commonly used in producing soap, animal feed, plastics and other intermediate products for the oleo-chemical industry [7].

Life Cycle Assessment

General Introduction

These Environmental Fact Sheets are a product of the *ERASM Surfactant Life Cycle & Ecofootprinting (SLE)* project. The objective of this project was to create representative, global, attributional, industry average datasets for oil palm-based precursors in the production of several particular surfactants.

The Fact Sheets are based upon life cycle assessment (LCA) and have been prepared in accordance with the ISO standard [ISO 14040: 2006 and ISO 14044: 2006]. In addition, the project follows the ILCD (2010) handbook. This Fact Sheet describes the cradle-to-gate production for refined palm kernel Oil (RPKO). RPKO is an oleo chemical precursor for the production of surfactants.

Further information on the ERASM SLE project and the source of these datasets can be found in [2].

The full LCI can be accessed via www.erasm.org or via http://lcdn.thinkstep.com/Node/

Goal and Scope of ERASM SLE Project [2]

The main goal was to develop the LCI datasets for the production of refined palm kernel oil (RPKO) for further use in LCA studies.

Temporal Coverage	Data collected for the production are based on literature research covering one production year technology. Due to lack of data, a consistent usage of data with one reference year or reference time was not possible. Some parameters used do not change over time. All used values have been published 2007 or after. Time dependent inputs, like yield are averaged over several years to be able to exclude peaks or years with poor harvests. Background data dates back to the reference year 2011. The datasets are considered to be valid until substantial technological changes in the production chain occur. The temporal representativeness for RPKO was considered 'good'
Geographical Coverage	Data for palm kernel oil came from the two most important global suppliers of palm kernel oil, Indonesia and Malaysia, covering approximately 83% of the global production. In the background system some processes are modeled for different geographical system boundaries (mostly Germany and the US). The geographical representativeness for RPKO was considered 'fair'.
Technological Coverage	The production technology was based on different literature sources. Partly processes with better data availability were chosen to be used as representative technology rather than creating averages of different technologies. I.e. for palm kernel oil mills only the technology of mechanical extraction was applied and the location of the palm kernel oil mill was set to be close to the sea and not located next to the palm oil mill. In the palm kernel oil refinery only physical processing was considered. As the palm oil industry is rapidly expanding and evolving, full technological representativeness cannot be guaranteed. All relevant technologies were considered and technology modelled to best knowledge. The technological representativeness for RPKO was considered 'good'. Figure 1 provides a schematic overview of the production process of RPKO.
Declared Unit	In ERASM SLE project the declared unit (functional unit) and the reference flow of the product is one

<table>
<tr><td></td><td colspan="2">thousand kilogram (1000 kg). This was the reference unit also used in [3].
Functional Unit: 1 tonne 'Refined Palm Kernel Oil', at the refinery gate.</td></tr>
<tr><td>Cradle-to Gate System Boundaries</td><td colspan="2"><table>
<tr><th>Included</th><th>Excluded</th></tr>
<tr><td>Palm Oil Plantation</td><td>Palm oil nursery</td></tr>
<tr><td>Direct Land use change effects</td><td>Equipment</td></tr>
<tr><td>Unit processes (including material and energy inputs) of the palm oil mill</td><td>Transport to Europe</td></tr>
<tr><td>Unit processes (including material and energy inputs) of the palm kernel oil mill</td><td></td></tr>
<tr><td>Unit processes (including material and energy inputs) of the Refinery</td><td></td></tr>
<tr><td>Transport from the field to the palm oil mill</td><td></td></tr>
<tr><td>Transport from the palm oil mill to the palm kernel oil mill</td><td></td></tr>
<tr><td>Transport from the palm kernel oil mill to the refinery</td><td></td></tr>
</table></td></tr>
<tr><td>Assumptions and Limitations</td><td colspan="2">The major assumptions made on land use change cultivation, processing usage of co-products, emissions from land use change and cultivation on peatland. Exclusion of primary data collection as it would not be feasible to assess primary data of the entire global production of palm kernel oil products. There is a lack of information, so several flows are only estimated (i.e. amount waste water or the exact composition of POME). The literature sources used could not display all technologies and production pathways.
Model agrarian systems are considered but may strongly vary within one region. A mix of Malaysian and Indonesian palm kernel oil is used to describe a global average of these products (For Indonesia there are big data gaps so that the same process conditions as for Malaysia are assumed).</td></tr>
<tr><td>Cut-off Criteria</td><td colspan="2">The LCI study included all the flows which had more than 2% of the cumulative mass inputs and greater than 2 % of the cumulative energy of the respective gate-to-gate model inventory, providing its environmental relevance is not a concern.
Material flows which leave the system (emissions) and whose environmental impact is greater than 2% of the whole impact of an impact category that has considered in the assessment have been covered. The sum of the neglected material flows must not exceed 5% of mass, energy or environmental relevance of the system inventory.</td></tr>
<tr><td rowspan="2">Calculation Rules</td><td>Allocation</td><td>Mass allocation was applied for palm kernel oil between the product crude palm kernel oil and the co-product palm kernel cake.</td></tr>
<tr><td>Aggregated data</td><td>From literature research.</td></tr>
<tr><th colspan="3">Life Cycle Inventory and Impact Assessment [2]</th></tr>
<tr><td colspan="3">Based on the LCI data an environmental impact assessment was performed for the indicators Primary Energy Demand (PED), Global Warming Potential (GWP), Eutrophication Potential (EP) and Acidification Potential (AP). Other impacts may be calculated from the full LCI dataset. Table 1 shows the environmental impact results per 1 t of RPKO

<u>Primary Energy Demand</u> (PED):): An analysis of the inventory data showed that the PED come from electricity which is required in the palm oil mill, palm kernel oil mill and in the refinery process (degumming, bleaching and de-acidification and deodorization stage).
<u>Global Warming Potential</u> (GWP): An analysis of the inventory data showed that the main contribution comes from cultivation on peat land. The second biggest contributor of carbon dioxide emissions are the ones which occur due to land use change. Cultivation and processing contributes most methane emissions. Methane emissions occur to approximately 82-84% in the palm oil mill and originate from the POME treatment. Other methane emissions occur on the plantation. Nitrous oxide emissions occur almost entirely on the plantation
<u>Air emissions related to Acidification (AP) and Eutrophication Potential (EP)</u>: An analysis of the inventory data showed that ammonia, nitrogen oxides, and sulphur dioxide emissions from LUC originate from the incineration of vegetation of the above ground biomass and of shells and fibres at the palm oil mill.
Besides ammonia emissions occur during cultivation and POME treatment. Hydrogen sulphide is emitted during the provision of electricity which is required in the palm oil mill and palm kernel oil mill. Nitrogen monoxides are emitted during the transport</td></tr>
</table>

of intermediate products and in the plantation (originate from agricultural processes). Nitrogen oxide emissions occur during the provision of electricity, the combustion of shells in the palm oil mill and use of tractors on the field.
Emissions to fresh water related to Acidification (AP) and Eutrophication Potential (EP): An analysis of the inventory data showed that the main emissions (Nitrogen and phosphate) to the fresh water occur during the cultivation of palm oil.

Sensitivity Analysis: Different sensitivity analysis were carried out. The analyses showed that depending on the allocation method, yield, fertilizer use, and land use change, the results are affected. In the case of economic allocation, the choice of allocation is significant and strongly affecting overall results.

Table 1. Global warming potential, acidification potential and eutrophication potential related to emissions to air and fresh water, and primary energy demand per 1 tonne of RPKO

LCI result	Unit	Amount		
		Cultivation and processing	Land Use Change	Cultivation on peatland
Air emissions related to Global Warming Potential				
Carbon uptake, biotic	kg	-5.06E+03	-	-
Carbon dioxide, fossil	kg	3.57E+02	1.05E+03	2.75E+03
Carbon dioxide, biotic	kg	2.51E+03	-	-
Methane	kg	3.54E+01	-	-
Nitrous oxide (laughing gas)	kg	2.31E-01	-	7.85E-01
Air emissions related to Acidification and Eutrophication Potential				
Ammonia	kg	1.08E+00	7.31E-01	-
Hydrogen sulfide	kg	2.24E-01	-	-
Nitrogen monoxide	kg	3.23E-01	-	-
Nitrogen oxides	kg	5.02E+00	1.77E+00	-
Sulphur dioxide	kg	1.64E+00	8.43E-01	-
Emissions to fresh water related to Eutrophication Potential				
Nitrogen organic bound	kg	4.95E-01	-	-
Phosphate	kg	1.19E-01	-	-
Total GWP (according to [IPCC 2007])	kg	-7.63E+02	1.05E+03	2.99E+03
EP	kg	1.32E+00	-	2.12E-01
AP	kg	6.84E+00	-	-
Primary energy demand				
Primary energy demand from renewable materials (net calorific value)	MJ		4.95E+04	
Primary energy demand from fossil materi-als (net calorific value)	MJ		5.78E+03	
Primary energy demand from fossil and renewable materials (net calorific value)	MJ		5.52E+04	

References for the ERASM SLE Project

Data Owner and Commissioner of the study	ERASM (Environment & Health Risk Assessment and Management). A research partnership of the Detergents and Surfactants Industries in Europe (www.erasm.org)
LCA Practitioner	thinkstep AG (www.thinkstep.com)
Reviewers	Prof. Walter Kloepffer, LCA Consult Mrs. Charlotte Petiot and Dr. Yannick Leguern, BiolS by Deloitte Jannick Schmidt (2.0 LCA Consultants)
References	[1] Daniel Swern (1979). Bailey's Industrial oil fat products, volume 1, 1979. [2] Schowanek. D *et al*. (2017). New and Updated Life Cycle Inventories for Surfactants used in European Detergents: Summary of the ERASM Surfactant Life Cycle and Ecofootprinting Project. Int J. LCA, in press. [3] CEFIC-Franklin (1994). Resource and environmental profile analysis of petrochemical and oleo chemical surfactants produced in Europe. Phase II Final Report, Franklin Associates. [4] Schmidt, J. (2007). Life Cycle Assessment of Rapeseed Oil and Palm Oil. Ph.D. thesis, Part 3: Life Cycle Inventory of Rapeseed Oil and Palm Oil. [5] Tan *et al.* (2010). Life Cycle Assessment of Refined Palm Oil Production and Fractionation (Part 4). Journal of Oil Palm Research Vol. 22 December 2010 p. 913-926. [6] Pacidunia (2013) (http://www.pacidunia.com/palmoil/palmoiluses.html). [7] Wicke *et al*. (2008). Different Palm Oil Production Systems for Energy Purposes and their Greenhouse Gas Implications. Biomass & Bioenergy, 32, 1322-1337.

Figure 1. Production process of Refined Palm Kernel Oil [4][5]