An Eco-profile and Environmental Product Declaration of the European Chlor-Alkali Industry

Chlorine (The chlor-alkali process)
Euro Chlor
September 2013 - Synthesis

Introduction

This Environmental Product Declaration (EPD) is based upon life cycle inventory (LCI) data from Euro Chlor's member companies. It has been prepared according to the rules of PlasticsEurope's LCI Methodology **"Eco-profiles and Environmental Declarations"** (version 2.0, April 2011). EPDs provide environmental performance data, but no information on the economic and social aspects, which would be necessary for a complete sustainability assessment. Further, they do not imply a value judgment between environmental criteria.
This EPD describes the production of chlorine by chlor-alkali electrolysis from cradle to gate (from production of salt/brine to liquid chlorine, sodium hydroxide, and hypochlorite at plant).
Please keep in mind that comparisons cannot be made on the level of the chemicals alone: it is necessary to consider the full life cycle of an application in order to compare the performance of different materials and the effects of relevant life cycle parameters. This EPD is intended to be used by member companies, to support product-orientated environmental management; by users of chemicals from the chlor-alkali industry, as a building block of life cycle assessment (LCA) studies of individual products; and by other interested parties, as a source of life cycle information.

Meta Data

Data Owner	Euro Chlor
LCA Practitioner	IFEU Heidelberg GmbH
Programme Owner	PlasticsEurope aisbl
Programme Manager, Reviewer	DEKRA Consulting GmbH
Number of plants included in data collection	50
Representativeness	68 % of European (EU27 + EFTA) chlorine production capacity (based on installed nameplate capacity; Source: Euro Chlor)
Reference year	2011
Year of data collection and calculation	Collection: 2012 Calculation: 2013
Expected temporal validity	31.12.2016
Cut-offs	None
Data Quality	Overall good quality
Allocation method	Stoichiometric allocation for Salt, mass allocation for all other input and emissions. Sensitivity analysis for other allocation methods was performed.

Description of the Product and the Production Process

This Eco-profile and EPD represents the European average industrial production of chlorine, sodium hydroxide, hydrogen, and sodium hypochlorite by chlor-alkali electrolysis from cradle to gate.

Production Process

Salt (NaCl) recovered from various sources (rock salt, solar salt, solution-mined brine, vacuum salt) is dissolved in water and the resulting brine is purified and fed to the electrolysis unit where the brine is electrochemically decomposed into chlorine, hydrogen, and sodium hydroxide. Three different electrolysis techniques are applied: mercury, diaphragm, and membrane cell technology. Sodium hypochlorite is produced by feeding chlorine to a dilute sodium hydroxide solution. Upstream processes like salt production, electricity, and steam production are included in the model as well as transportation of feedstock and waste treatment.

Data Sources and Allocation

The model of the electrolysis unit including brine preparation and processing of the products is based on confidential process and emission data obtained directly from chlorine producers. On-site production of electricity and steam was partially modelled using primary data from chlorine producers; data gaps in on-site energy production were closed using European average data of power plants and steam boilers. Data from several European salt producers (primary data) as well as literature data was used for modelling sodium chloride production. Country specific electricity mixes were used for grid electricity supply.
Allocation by mass was generally applied, except for salt input, which was allocated by stoichiometry to products containing sodium and/or chlorine. As different partitioning

approaches are possible, sensitivities were calculated for several allocation approaches.

Use Phase and End-of-Life Management

The use phase and end-of-life processes of the investigated products are outside the system boundaries of this cradle-to-gate system: since the objects of this study are substances, which are widely applied in various production processes, even a qualitative discussion of these aspects was deemed inappropriate. However, the disposal of waste from production processes is considered within the system boundaries of this Eco-profile.

Environmental Performance

The tables below show the environmental performance indicators associated with the production of 1 kg of each chlor-alkali electrolysis product and of 1 kg of sodium chloride (average mix of salt types; based on information from the participating chlorine production sites).

Input Parameters

Indicator	Unit	Chlorine (Cl_2)	Sodium Hydroxide (NaOH)	Hydrogen (H_2)	Sodium Hypochlorite (NaOCl)	Sodium chloride[2] (NaCl)
Non-renewable energy resources[1]						
• Fuel energy	MJ	15.4	14.8	14.1	16.7	1.1
• Feedstock energy	MJ	0.0	0.0	0.0	0.0	0.0
Renewable energy resources[1]						
• Fuel energy	MJ	4.5	3.3	1.7	22.9	2.6
• Feedstock energy	MJ	0.0	0.0	0.0	0.0	0.0
Abiotic Depletion Potential						
• Elements	kg Sb eq	1.9E-05	1.1E-05	2.1E-07	1.3E-05	1.6E-05
• Fossil fuels	MJ	10.5	10.0	9.6	12.0	0.8
Water use (only of chlor-alkali electrolysis)						
• for process	kg	1.7	1.6	1.6	1.4	- [3]
• for cooling	kg	28.7	28.9	27.5	15.4	- [3]

[1] Calculated as upper heating value (UHV)
[2] Average salt mix used as input to the participating chlorine production sites
[3] not calculated as sodium chloride is no product of chlor-alkali electrolysis

Output Parameters

Indicator	Unit	Chlorine (Cl_2)	Sodium Hydroxide (NaOH)	Hydrogen (H_2)	Sodium Hypochlorite (NaOCl)	Sodium chloride[2] (NaCl)
Global Warming Potential (GWP)	kg CO_2 eq	0.90	0.86	1.14	0.93	0.06
Ozone Depletion Potential (ODP)	g CFC-11 eq	1.1E-03	1.1E-03	1.1E-03	1.2E-03	4.0E-05
Acidification Potential (AP)	g SO_2 eq	3.46	2.70	1.96	3.16	0.96
Photochemical Ozone Creation Potential (POCP)	g Ethene eq	0.09	0.08	0.07	0.10	0.01
Eutrophication Potential (EP)	g PO_4 eq	0.34	0.32	0.30	0.29	0.02
Dust/particulate matter[1]	g PM10 eq	2.00	1.77	1.62	2.23	0.12
Total particulate matter[1]	g	2.14	1.91	1.76	2.33	0.12
Waste (only from chlor-alkali electrolysis)						
• Hazardous	kg	2.3E-03	2.4E-03	2.3E-03	3.8E-03	- [3]
• Non-hazardous	kg	7.0E-03	7.2E-03	1.3E-02	1.0E-03	-[3]

[1] Including secondary PM10
[2] Average salt mix used as input to the participating chlorine production sites
[3] not calculated as sodium chloride is no product of chlor-alkali electrolysis

Additional Environmental and Health Information

Chlorine dissolves when mixed with water. It can also escape from water and enter air under certain conditions. Most direct releases of chlorine to the environment are to air and to surface water.

Effects of chlorine on human health depend on the amount of chlorine that is present, and the length and frequency of exposure.

Chlorine enters the body breathed in with contaminated air or when consumed with contaminated food or water. It does not remain in the body, due to its reactivity.

Additional Technical Information

Electrolysis of an aqueous sodium chloride solution co-produces chlorine, sodium hydroxide solution, and hydrogen in a fixed ratio. Chlorine is used largely for the production of chlorinated hydrocarbons, especially for polyvinyl chloride (PVC) and polymer precursors (isocyanates, oxygenates).

Sodium hydroxide solution is a strong chemical base as is mostly used in the manufacture of pulp and paper, textiles, soaps and detergents, and for water disinfection.

Hydrogen from electrolysis is mostly used on site as a chemical, to fuel steam boilers or generators or it is sold to a distributor.

A small share of the produced chlorine gas is directed into diluted sodium hydroxide solution to produce sodium hypochlorite solution. Sodium hypochlorite solutions are used instead of chlorine for bleaching, disinfection, bio-fouling control, and odour control.

Additional Economic Information

The growth in European chlor-alkali industry output in 2011 was eventually weaker than expected because of increased business uncertainty and reduction in inventories. Caustic soda stocks position was low and relatively static. Chlorinated solvents market went down in 2011, after a recovery in 2010.

With 9,939k tonnes, the 2011 European chlorine production was just 0.6% below the 2010 level, and the 2011 average capacity utilisation rate stood at 78.7% compared to 79.0% in the previous year.

Germany, Belgium/The Netherlands and France remained the top three regions accounting together for nearly 70% of the total European chlorine production in 2011 (Germany: 43.8%; Belgium/The Netherlands: 15.0%; France: 11,0%).

Information

For copies of this EPD, for the underlying LCI data (Eco-profile); and for additional information, please refer to http://www.eurochlor.org/.

Data Owner

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DEKRA Consulting GmbH
This Environmental Product Declaration has been reviewed by DEKRA Consulting GmbH. It was approved according to the Product Category Rules PCR version 2.0 (2011-04) and ISO 14025:2006.
Registration number: PlasticsEurope 2013-001 validation expires on 31 December 2016 (date of next revalidation review).

Programme Owner

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References

- PlasticsEurope: Eco-profiles and environmental declarations – LCI methodology and PCR for uncompounded polymer resins and reactive polymer precursor (version 2.0, April 2011).
- Euro Chlor: Chlorine Industry Review 2011-2012

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