

Life Cycle Environmental Impacts and Costs of Beer Production and Consumption in the UK

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Supplementary information: Data quality assessment

S1 Methodology

Data quality assessment has been carried out following the CCaLC methodology (CCaLC, 2014) as an indication of the level of confidence in the results. This methodology considers the following criteria for the LCA and LCC data (see Table S1):

- age;
- geographical origin;
- source;
- completeness; and
- reproducibility, reliability and consistency.

Depending on the above, the quality of data is defined as:

- high;
- medium; or
- low.

Table S2 shows how the criteria in Table S1 can be aggregated to arrive at an overall Data Quality Indicator (DQI) - high, medium or low. For these purposes, each data quality criterion is assigned a weight of importance on a scale of 1-10. For example, as shown in Table S2, "Age of data" has the weight of 2, being twice as important as the geographical origin of data. Each data quality indicator is assigned (an arbitrary) maximum score for each criterion: e.g. the 'high' quality has a score of 3, 'medium' has 2 and 'low' has a score of 1 (see Table S2). Applying the weights of importance for each criterion and its maximum score for the respective quality indicators, the maximum score for each quality indicator is:

- 10 for low;
- 20 for medium; and
- 30 for high.

The following score ranges are adopted to indicate the quality of data:

- low: score in the range of 1-10;
- medium: score in the range of 11-20; and
- high: score range of 21-30.

It should be noted that the overall data quality will depend on both the quality of the particular datasets used as well as on the confidence on the quantity/amount of environmental burdens or costs for each part of the system.

The approach used for calculating DQI for a sub-system is shown in Table S3. Note that the quantity/amount is considered more important here than the quality of the dataset.

Once the data quality indicators have been calculated for each part of the system, a weighted approach is then applied for assessing the overall data quality of the whole system based on the percentage contribution of each life cycle stage to the life cycle impacts or costs. The overall data quality for the whole system is, therefore, calculated as:

$$DQ_{CF} = \sum_{n=1}^N I_n \left(\sum_{m=1}^M DQS_m \right) \quad (S1)$$

where:

DQ_{CF} - overall data quality of the system

I_n – percentage contribution of each life cycle stage to the total impacts or costs (%)

DQS_m – data quality (1, 2 or 3) for sub-system m .

The following ranges have been adopted for the overall data quality of the whole system:

- low data quality: $DQ_{CF} = 100 - 166$;
- medium data quality: $DQ_{CF} = 167 - 233$; and
- high overall data quality: $DQ_{CF} = 234 - 300$.

The above approach has been followed for both the LCA and LCC data quality analyses.

Table S1 Matrix of data quality indicators (CCaLC, 2014)

Data quality criteria	Data quality indicators		
	High	Medium	Low
Age of data	< 5 years	5 – 10 years	> 10 years
Geographical origin of data	Specific	Partly specific	Generic/average
Source of data	Measured and/or modelled based on specific data (e.g. company data or from suppliers)	Modelled using generic data from LCA databases; some data derived using expert knowledge	Mainly sourced from literature and/or estimated and/or derived using expert knowledge
Completeness of data	All inputs and outputs considered	Majority of relevant inputs and outputs considered	Some relevant inputs and outputs considered or known
Reproducibility, reliability and consistency of data	Completely reproducible/reliable/consistent	Partly reproducible/reliable/consistent	Not reproducible/reliable/not known

Table S2 Aggregating individual data quality indicators to arrive at an overall DQI for each process (CCaLC, 2014)

Data quality criteria	Weighting for each criterion on a scale of 1 – 10 ^a	High quality Max score for each criterion: 3	Medium quality Max score for each criterion: 2	Low quality Max score for each criterion: 1	Example data quality assessment
Age	2	3	2	1	1 (Low)
Geographical origin	1	3	2	1	3 (High)
Source	3	3	2	1	2 (Medium)
Completeness	2	3	2	1	3 (High)
Reproducibility/reliability/consistency	2	3	2	1	1 (Low)
Maximum score		30 (max score) Overall score for High in the range: 21 – 30	20 (max score) Overall score for Medium in the range: 11 – 20	10 (max score) Overall score for Low in the range: 1 – 10	19 (overall score) Data quality indicator: Medium

^aThe sum of all weights is 10.

Table S3 Aggregating the data quality indicators to arrive at an overall DQI for each sub-system or life cycle stage

DQI for LCI/LCC dataset	DQI for the amount entered by the user	Data quality of each sub-system of life cycle stage
High	High	High (3)
Medium	High	Medium (2)
Low	High	Medium (2)
High	Medium	Medium (2)
Medium	Medium	Medium (2)
Low	Medium	Low (1)
High	Low	Medium (2)
Medium	Low	Low (1)
Low	Low	Low (1)

S2 Data quality assessment for LCA

Table S4 Beer in glass bottle

Raw materials																		
		Data quality for amount							LCI data quality									
		2	1	3	2	2			2	1	3	2	2					
Raw materials	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Water	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Diatomaceous earth	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Sulphuric acid (63% in water)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Barley	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Water (barley product)	Ecoinvent (2010)	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																		
High (3)																		
Packaging																		
		Data quality for amount							LCI data quality									
		2	1	3	2	2			2	1	3	2	2					
Primary packaging type	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Bottle glass, green	Manufacturer	3	2	3	3	3	29	High	CCaLC (2010)	3	3	3	3	3	30	High	High	3
Steel	Manufacturer	3	2	3	3	3	29	High	CCaLC (2010)	3	3	3	3	3	30	High	High	3
Paperboard	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																		
High (3)																		
Manufacturing																		
		Data quality for amount							LCI data quality									
		2	1	3	2	2			2	1	3	2	2					
Electricity	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Electricity (UK grid, medium voltage)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	3	3	3	3	30	High	High	3
Subsystem DQA																		
High (3)																		
Waste management																		
		Data quality for amount							LCI data quality									
		2	1	3	2	2			2	1	3	2	2					
Waste	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Wastewater (to wastewater treatment plant)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Paperboard (to landfill)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	2	2	3	3	3	27	High	High	3
Glass (to landfill)	Manufacturer	3	2	3	3	3	29	High	ELCD/PE (2010)	3	2	3	3	3	29	High	High	3
Steel (to landfill)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																		
High (3)																		
Transport																		
		Data quality for distance							LCI data quality									
		2	1	3	2	2			2	1	3	2	2					
Material	Source of data for distance	Age	Geography	Source	Completeness	Reproducibility	DQA for distance	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Barley malt (40 t truck)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Primary packaging (3 t truck)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Packaged product to brewery	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																		
High (3)																		
DQA for system																		
42(3) + 45(3) + 8(3) + 3(3) + 2(3) = 300 (High)																		
Life cycle stage (subsystem) contribution to total environmental impacts																		
Key	Life cycle	Contribution																
Raw materials	42%	42%																
Packaging	45%	45%																
Manufacturing	8%	8%																
Waste management	3%	3%																
Transport	2%	2%																
Total	100%	100%																

Table S5 Aluminium can system

Raw materials																		
Data quality for amount										LCI data quality								
		2	1	3	2	2				2	1	3	2	2				
Raw materials	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Water	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Diatomaceous earth	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Sulphuric acid (63% aq)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Barley	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Water (barley product)	Ecoinvent (2010)	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																	High (3)	
Packaging																		
Data quality for amount										LCI data quality								
		2	1	3	2	2				2	1	3	2	2				
Primary packaging type	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Aluminium can	Literature	3	3	2	3	3	27	High	CCaLC (2010)	3	3	3	3	3	30	High	High	3
Subsystem DQA																	High (3)	
Manufacturing																		
Data quality for amount										LCI data quality								
		2	1	3	2	2				2	1	3	2	2				
Electricity	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Electricity (UK grid, national average)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	3	3	3	3	30	High	High	3
Subsystem DQA																	High (3)	
Waste management																		
Data quality for amount										LCI data quality								
		2	1	3	2	2				2	1	3	2	2				
Waste	Source of data for amount	Age	Geography	Source	Completeness	Reproducibility	DQA for amount	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Wastewater (to wastewater treatment plant)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Aluminium (to landfill)	Literature	3	2	2	3	3	26	High	PE (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																	High (3)	
Transport																		
Data quality for distance										LCI data quality								
		2	1	3	2	2				2	1	3	2	2				
Material	Source of data for distance	Age	Geography	Source	Completeness	Reproducibility	DQA for distance	Qualitative	Source of LCI data	Age	Geography	Source	Completeness	Reproducibility	DQA for LCI data	Qualitative	Process DQA	
Barley malt (40 t truck)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Primary packaging (30 t truck)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Packaged product to distribution centre	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3
Subsystem DQA																	High (3)	
DQA for system																		
55(3) + 33(3) + 9(3) + 2(3) + 1(3) = 300 (High)					Life cycle stage (subsystem) contribution to total environmental impacts													
Key		Life cycle stage		Contribution														
Subsystem		Raw materials		55%														
Weighting factor		Packaging		33%														
Data quality for process		Manufacturing		9%														
Data quality for subsystem		Waste management		2%														
Data quality for system		Transport		1%														
		Total		100%														

Table S6 Steel can system

Raw materials																			
Data quality for amount										LCI data quality									
		2	1	3	2	2				2	1	3	2	2					
Raw materials	Source of data for	Age	Geography	Source	Completer	Reproduci	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproduci	DQA for LC	Qualitative	Process DQA		
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Water	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Diatomaceous earth	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Sulphuric acid (63% i)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Barley	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
Water (barley product)	Ecoinvent (2010)	3	2	3	3	3	29	High	Ecoinvent (2010)	3	2	3	3	3	29	High	High	3	
																		Subsystem DQA	High (3)
Packaging																			
Data quality for amount										LCI data quality									
		2	1	3	2	2				2	1	3	2	2					
Primary packaging type	Source of data for	Age	Geography	Source	Completer	Reproduci	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproduci	DQA for LC	Qualitative	Process DQA		
Steel can	Literature	3	3	3	3	3	30	High	CCaLC (2010)	3	3	3	3	3	30	High	High	3	
																		Subsystem DQA	High (3)
Manufacturing																			
Data quality for amount										LCI data quality									
		2	1	3	2	2				2	1	3	2	2					
Electricity	Source of data for	Age	Geography	Source	Completer	Reproduci	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproduci	DQA for LC	Qualitative	Process DQA		
Electricity (UK grid, m)	Manufacturer	3	2	3	3	3	29	High	Ecoinvent (2010)	3	3	3	3	3	30	High	High	3	
																		Subsystem DQA	High (3)
Waste management																			
Data quality for amount										LCI data quality									
		2	1	3	2	2				2	1	3	2	2					
Waste	Source of data for	Age	Geography	Source	Completer	Reproduci	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproduci	DQA for LC	Qualitative	Process DQA		
Wastewater (to waste)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3	
Steel (to landfill)	Literature	3	2	2	3	3	26	High	PE (2010)	3	2	3	3	3	29	High	High	3	
																		Subsystem DQA	High (3)
Transport																			
Data quality for distance										LCI data quality									
		2	1	3	2	2				2	1	3	2	2					
Material	Source of data for	Age	Geography	Source	Completer	Reproduci	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproduci	DQA for LC	Qualitative	Process DQA		
Barley malt (40 t truck)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3	
Primary packaging (3)	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3	
Packaged product to	Manufacturer	3	2	3	3	3	29	High	PE (2010)	3	2	3	3	3	29	High	High	3	
																		Subsystem DQA	High (3)
DQA for system																			
60(3) + 21(3) + 15(3) + 3(3) + 1(3) = 300 (High)																			
										Life cycle stage (subsystem) contribution to total environmental impacts									
Key		Life cycle		Contribution															
Subsystem		Raw mate		60%															
Weighting factor		Packaging		21%															
Data quality for process		Manufactu		15%															
Data quality for subsystem		Waste ma		3%															
Data quality for system		Transport		1%															
		Total		100%															

S3 Data quality assessment for LCC

Table S7 Beer in glass bottles

Raw materials																		
Data quality for amount									LCC data quality									
		2	1	3	2	2			2	1	3	2	2					
Raw materials	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LC	Qualitative	Process DQA	
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	OECD (2007)	2	1	1	1	1	12	Medium	Medium 2	
Water	Manufacturer	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2	
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	ICChemE (2002)	3	1	1	1	1	14	Medium	Medium 2	
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2	
Sulphuric acid (63% i	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2	
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Confidential (2009)	3	1	1	1	1	14	Medium	Medium 2	
Barley	Manufacturer	3	2	3	3	3	29	High	Indexmundi (2011)	3	1	1	1	1	14	Medium	Medium 2	
Water (barley product	Ecoinvent (2010)	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2	
																	2	
																	Subsystem DQA	Medium (2)
Packaging																		
Data quality for amount									LCC data quality									
		2	1	3	2	2			2	1	3	2	2					
Primary packaging ty	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LC	Qualitative	Process DQA	
Bottle glass, green	Manufacturer	3	2	3	3	3	29	High	Aliexpress (2010)/WRAP	3	1	1	1	1	14	Medium	Medium 2	
Steel	Manufacturer	3	2	3	3	3	29	High	LME (2011)	3	1	1	1	1	14	Medium	Medium 2	
Paperboard	Manufacturer	3	2	3	3	3	29	High	WRAP (2011)	3	3	1	1	1	16	Medium	Medium 2	
																	2	
																	Subsystem DQA	Medium (2)
Manufacturing																		
Data quality for amount									LCC data quality									
		2	1	3	2	2			2	1	3	2	2					
Electricity	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LC	Qualitative	Process DQA	
Electricity (UK grid, m	Manufacturer	3	2	3	3	3	29	High	Electricityprices.org.uk	3	3	1	1	1	16	Medium	Medium 2	
																	2	
																	Subsystem DQA	Medium (2)
Waste management																		
Data quality for amount									LCC data quality									
		2	1	3	2	2			2	1	3	2	2					
Waste	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LC	Qualitative	Process DQA	
Wastewater (to waste	Manufacturer	3	2	3	3	3	29	High	Scottish Water (201)	3	3	1	1	1	16	Medium	Medium 2	
Paperboard (to landfill	Manufacturer	3	2	3	3	3	29	High	WRAP (2010)	3	3	1	1	1	16	Medium	Medium 2	
Glass (to landfill)	Manufacturer	3	2	3	3	3	29	High	WRAP (2010)	3	3	1	1	1	16	Medium	Medium 2	
Steel (to landfill)	Manufacturer	3	2	3	3	3	29	High	WRAP (2010)	3	3	1	1	1	16	Medium	Medium 2	
																	2	
																	Subsystem DQA	Medium (2)

Note: Transport costs are assumed to be included in the material costs therefore Transport has not been considered as a separate life cycle stage in the LCC analysis.

DQA for system

$$55(2) + 26(2) + 14(2) + 5(2) = 200 \text{ (Medium)}$$

Key	
Subsystem	
Weighting factor	
Data quality for process	
Data quality for subsystem	
Data quality for system	

Life cycle stage (subsystem) contribution to total environmental impacts

Life cycle	Contribution
Raw mate	55%
Packaging	26%
Manufactu	14%
Waste ma	5%
Total	100%

Table S8 Beer in aluminium cans

Raw materials																	
		Data quality for amount							LCC data quality								
		2	1	3	2	2			2	1	3	2	2				
Raw materials	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	OECD (2007)	2	1	1	1	1	12	Medium	Medium 2
Water	Manufacturer	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	IChemE (2002)	3	1	1	1	1	14	Medium	Medium 2
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2
Sulphuric acid (63% in water)	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Confidential (2009)	3	1	1	1	1	14	Medium	Medium 2
Barley	Manufacturer	3	2	3	3	3	29	High	Indexmundi (2011)	3	1	1	1	1	14	Medium	Medium 2
Water (barley product)	Ecoinvent (2010)	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Packaging																	
		Data quality for amount							LCC data quality								
		2	1	3	2	2			2	1	3	2	2				
Primary packaging type	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Aluminium can	CCaLC (2010)	3	3	2	3	3	27	High	LME (2011)/Letsrecycle	3	1	1	1	1	14	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Manufacturing																	
		Data quality for amount							LCC data quality								
		2	1	3	2	2			2	1	3	2	2				
Electricity	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Electricity (UK grid, medium voltage)	Manufacturer	3	2	3	3	3	29	High	Electricityprices.org.uk	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Waste management																	
		Data quality for amount							LCC data quality								
		2	1	3	2	2			2	1	3	2	2				
Waste	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Wastewater (to wastewater treatment plant)	Manufacturer	3	2	3	3	3	29	High	Scottish Water (201)	3	3	1	1	1	16	Medium	Medium 2
Aluminium (to landfill)	Literature	3	2	2	3	3	26	High	WRAP (2010)	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	

Note: Transport costs are assumed to be included in the material costs therefore Transport has not been considered as a separate life cycle stage in the LCC analysis.

DQA for system
 $72(2) + 8(2) + 20(2) + 1(2) = 202$ (Medium)

Key		Life cycle stage (subsystem) contribution to total environmental impacts	
		Life cycle	Contribution
Subsystem		Raw materials	72%
Weighting factor		Packaging	8%
Data quality for process		Manufacturing	20%
Data quality for subsystem		Waste management	1%
Data quality for system		Total	100%

Table S9 Beer in steel cans

Raw materials																	
Data quality for amount										LCC data quality							
		2	1	3	2	2				2	1	3	2	2			
Raw materials	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Light fuel oil	Manufacturer	3	2	3	3	3	29	High	OECD (2007)	2	1	1	1	1	12	Medium	Medium 2
Water	Manufacturer	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2
Sodium hydroxide (50%)	Manufacturer	3	2	3	3	3	29	High	IChemE (2002)	3	1	1	1	1	14	Medium	Medium 2
Phosphoric acid (75%)	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2
Sulphuric acid (63% in solution)	Manufacturer	3	2	3	3	3	29	High	ICIS (2010)	3	1	1	1	1	14	Medium	Medium 2
Carbon dioxide, liquid	Manufacturer	3	2	3	3	3	29	High	Confidential (2009)	3	1	1	1	1	14	Medium	Medium 2
Barley	Manufacturer	3	2	3	3	3	29	High	Indexmundi (2011)	3	1	1	1	1	14	Medium	Medium 2
Water (barley product)	Ecoinvent (2010)	3	2	3	3	3	29	High	United Utilities (2010)	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Packaging																	
Data quality for amount										LCC data quality							
		2	1	3	2	2				2	1	3	2	2			
Primary packaging type	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Steel can	CCaLC (2010)	3	3	3	3	3	30	High	LME (2011)/Letsrecycle	3	1	1	1	1	14	Medium	Medium 2
Aluminium (can ends)	CCaLC (2010)	3	3	3	3	3	30	High	LME (2011)/Letsrecycle	3	1	1	1	1	14	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Manufacturing																	
Data quality for amount										LCC data quality							
		2	1	3	2	2				2	1	3	2	2			
Electricity	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Electricity (UK grid, medium voltage)	Manufacturer	3	2	3	3	3	29	High	Electricityprices.org.uk	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	
Waste management																	
Data quality for amount										LCC data quality							
		2	1	3	2	2				2	1	3	2	2			
Waste	Source of data for	Age	Geography	Source	Completer	Reproducit	DQA for ar	Qualitative	Source of LCI data	Age	Geography	Source	Completer	Reproducit	DQA for LCI	Qualitative	Process DQA
Wastewater (to wastewater treatment plant)	Manufacturer	3	2	3	3	3	29	High	Scottish Water (2011)	3	3	1	1	1	16	Medium	Medium 2
Steel (to landfill)	Literature	3	2	2	3	3	26	High	WRAP (2010)	3	3	1	1	1	16	Medium	Medium 2
Subsystem DQA																	
2 Medium (2)																	

Note: Transport costs are assumed to be included in the material costs therefore Transport has not been considered as a separate life cycle stage in the LCC analysis.

DQA for system
 $68(2) + 13(2) + 18(2) + 1(2) = 200$ (Medium)

Life cycle stage (subsystem) contribution to total environmental impacts

Key	Life cycle	Contribution
Subsystem	Raw materials	68%
Weighting factor	Packaging	13%
Data quality for process	Manufacturing	18%
Data quality for subsystem	Waste management	1%
Data quality for system	Total	100%