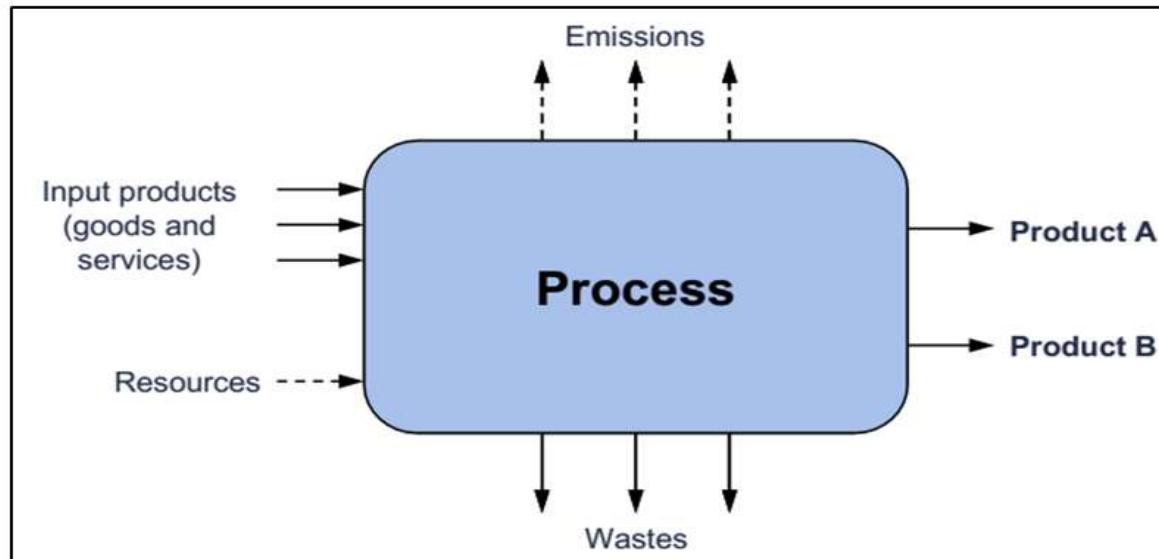


Structure d l'Inventaire du Cycle de Vie (ICV)

Example of LCI

Process inventory



Input flows:

Definitions

- Energy:** Various energy sources used by the process.
- Chemicals:** Any material with a definite chemical composition.
- Raw materials:** Unprocessed material, basic material that is used to produce goods, finished products, energy, or intermediate materials.
- Products:** Products used during the process.

Examples

- oil, natural gas, biomass, ...
EtOH, citric acid, NiCO₃, sodium silicate, ...
crude oil, cotton, coal, raw biomass, iron ore,...
vehicles for transport, PVC pipe, inverter, ...

Output flows:

Definitions

- Product:** The aim of the process.
- Emissions:** Emissions to air, to water, to soil.
- Wastes:** All elements generated by the product excepted emissions and products.

Examples

- 1 kg of final product; 1 kWh energy produced; ...
CO₂, NO_x, CH₄, COD, Suspended solids, heat,...
hard coal ash, inert material, plastic, ...

Inventaire des émissions et extractions

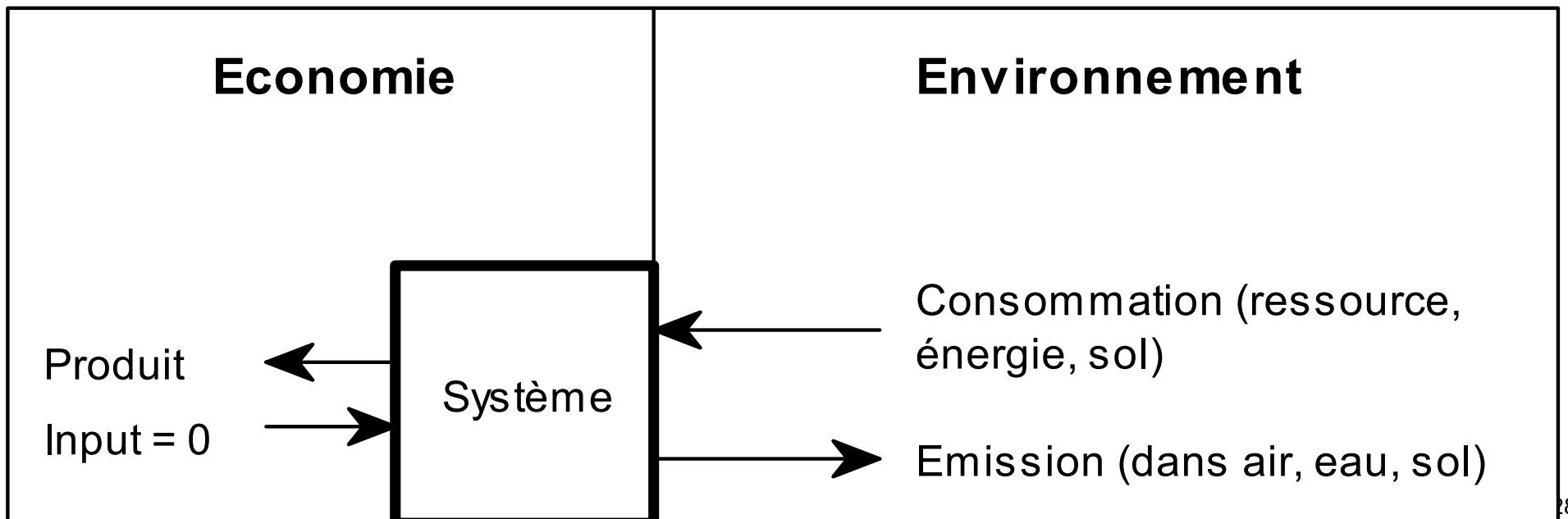
Il s'agit à présent de **quantifier les différents flux entrant et sortant du système**

Inventaire environnemental des flux

Principe général

L'inventaire des flux environnementaux est par définition la description quantitative des flux de matière, énergie, polluants qui traversent les limites du système.

Calculés à partir des modules de base,
à l'aide de facteurs d'émissions (bases de données).



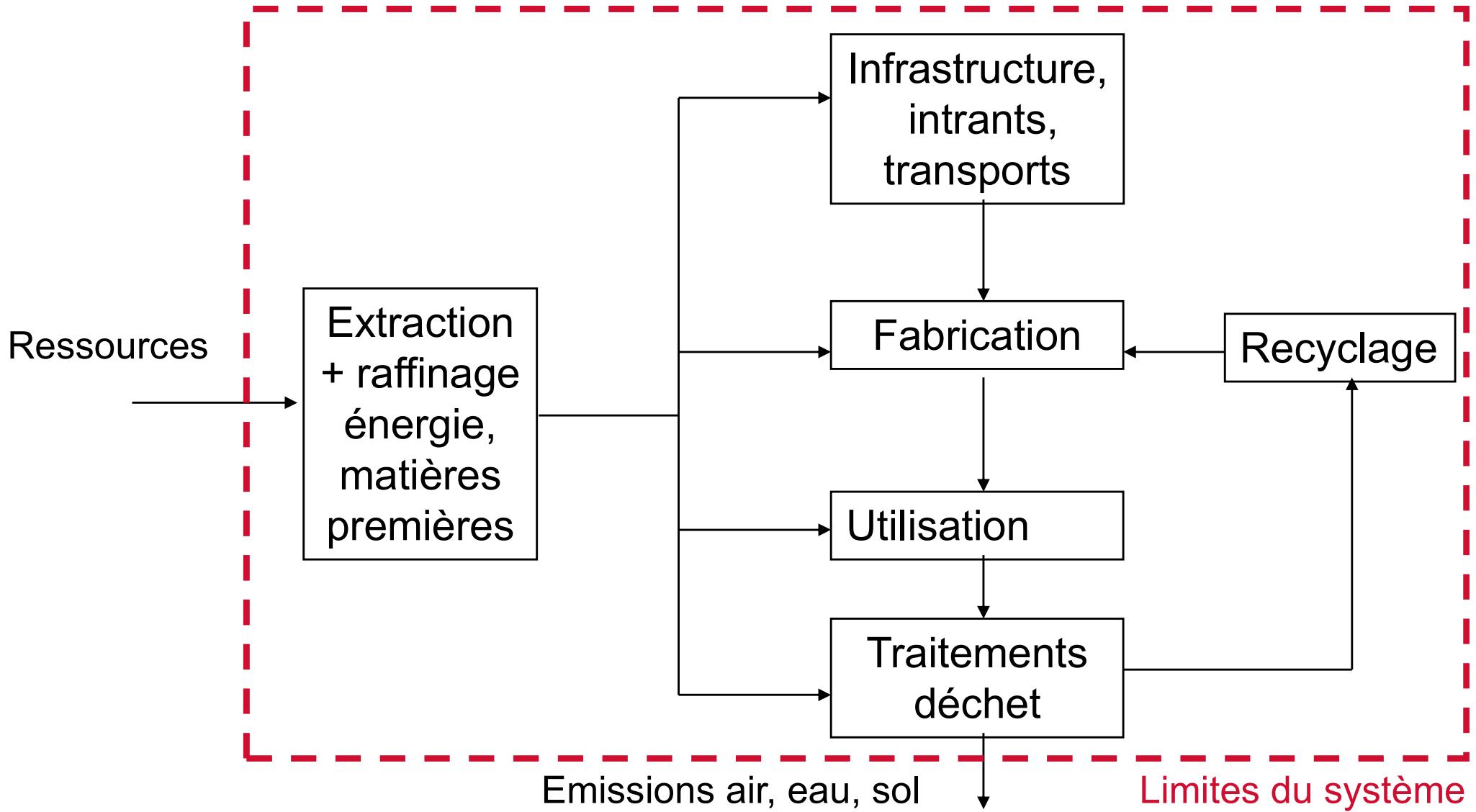
Flux de produits entrant et sortant **-> les flux intermédiaires**

Pour une unité de fonctionnelle, on quantifiera les flux de produits entrants et sortant du système

Flux de produits entrant: ensemble des flux matériels (matière première transformée, réactifs ...) ou immatériels (transport, procédé, énergie ...) utilisé pour réaliser l'UF

Flux de produits sortants: Ensemble des flux matériels (déchets solides, liquides ...) sortant du système à la suite de la réalisation de l'UF

Arbre des procédés et principales étapes



Le traitement des déchets fait partie du système de production !



Flux élémentaires

Pour une unité de fonctionnelle, on quantifiera les flux élémentaires entrants et sortant du système

Flux élémentaires entrant: ensemble des consommations de ressources brutes extraites pour réaliser l'UF

Flux élémentaires sortants: ensemble des émissions brutes dans l'air, l'eau ou le sol sortant du système à la suite de la réalisation de l'UF

Bases de données d'Analyse du Cycle de Vie

Principaux formats de bases de données

- Ecoinvent (Ecospold)
- ELCD (ELCD-editor)
- Global Life Cycle Assessment Database (UNEP-SETAC Life Cycle Initiative) for Life Cycle Data format & exchange

Ecoinvent

Informations quantitatives (intrants/sortants de processus) et informations qualitatives (validité technologique, temporelle et géographique)

Thèmes :

- **L'approvisionnement en énergie**
- **Les matériaux et processus de construction**
- **Les produits chimiques**
- **Les détergents**
- **Les papiers graphiques**
- **Les services de traitement des déchets**
- **Les produits et processus agricoles**

etc

Ecoinvent – Données quantitatives

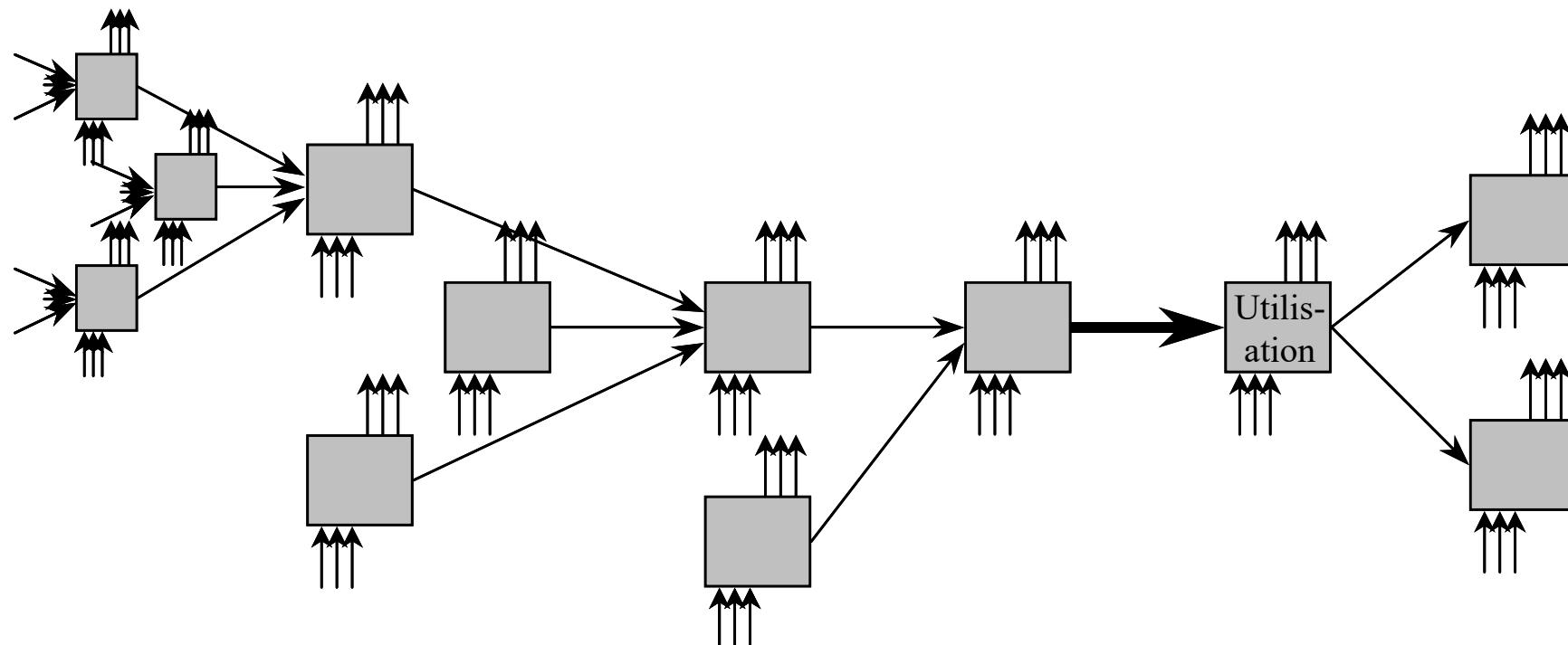
Flow data				steel, converter, low-alloyed, at plant, RER, [kg]			
Exchanges				steel, converter, low-alloyed, at plant, RER, [kg]			
From Nature				steel, converter, low-alloyed, at plant, RER, [kg]			
Number	Name	Location	Infra	Mean value	Unit	Uncertainty type	SD95%
resource/in water							
3905	Water, unspecified natural origin		no	0.0027	m3	lognormal	1.11
From Technosphere				steel, converter, low-alloyed, at plant, RER, [kg]			
Number	Name	Location	Infra	Mean value	Unit	Uncertainty type	SD95%
chemicals/inorganics							
301	oxygen, liquid, at plant	RER	no	0.0714	kg	lognormal	1.11
construction materials/additives							
474	quicklime, in pieces, loose, at plant	CH	no	0.0425	kg	lognormal	1.11
construction materials/others							
523	dolomite, at plant	RER	no	0.00275	kg	lognormal	1.11
electricity/production mix							
664	electricity, medium voltage, production UCTE, at grid	UCTE	no	0.0219	kwh	lognormal	1.11
hard coal/fuels							
832	hard coal coke, at plant	RER	no	0.00025	MJ	lognormal	1.11
metals/extraction							
1065	blast oxygen furnace converter	RER	yes	1.33E-11	unit	lognormal	3.23
1095	ferrochromium, high-carbon, 68% Cr, at plant	GLO	no	0.0147	kg	lognormal	1.07

Ecoinvent – Métadonnées

Meta information	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
Process information	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
Reference function	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
name	electricity, medium voltage, production UCTE, at grid
localName	Strom, Mittelspannung, Produktion UCTE, ab Netz
infrastructureProcess	no
unit	kWh
category	electricity
subCategory	supply mix
localCategory	Elektrizität
localSubCategory	Versorgungsmix
amount	1
includedProcesses	cradle to busbar emissions, including construction, operation and dismantling of power plants
infrastructureIncluded	yes
datasetRelatesToProduct	yes
Geography	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
location	UCTE
Technology	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
text	average power plant technologies
Time period	electricity, medium voltage, production UCTE, at grid, UCTE, [kWh]
dataValidForEntirePeriod	yes
startYear	1990
endYear	1995

Ecoinvent – Calcul des données

Problématique : arbre des procédés sans fin



-> approche matricielle

Ecoinvent – Calcul des données

Modèle = technosphère (système économique)
+ **écosphère (système écologique)**

$$\mathbf{A} = \begin{pmatrix} a_{11} & \dots & a_{1m} \\ \dots & \dots & \dots \\ a_{m1} & \dots & a_{mm} \end{pmatrix} \quad \mathbf{B} = \begin{pmatrix} b_{11} & \dots & b_{1m} \\ \dots & \dots & \dots \\ b_{n1} & \dots & b_{nm} \end{pmatrix}$$

a_{ij} = flux intermédiaire d'intrant provenant du processus économique i nécessaire au processus j

b_{kj} = flux élémentaire de substance k extraite de l'environnement ou émise dans l'environnement par processus j

Ecoinvent – Calcul des données

$$\mathbf{b} = \mathbf{E} \cdot \mathbf{p} = \mathbf{B} (\mathbf{I} - \mathbf{A})^{-1} \mathbf{p}$$

\mathbf{p} : inventaire de production, demande

\mathbf{E} : matrice des facteurs d'émissions et d'extraction consolidée (S dans ecoinvent):

\mathbf{A} : matrice technologique: ce dont on a besoin pour fabriquer un produit donné

$$(\mathbf{I}-\mathbf{A})^{-1}=1+\mathbf{A}+\mathbf{A}^2+\mathbf{A}^3+\dots \quad 1+x+x^2+x^3+\dots=1/(1-x)$$

\mathbf{B} : inventaire des émis. et extract. directes

Format de données d'inventaire

- ISO 14 048: Format des bases de données d'inventaire
 - Format Ecospold
 - Format Ecoeditor
 - Format ILCD-editor

Contrôle des données d'inventaire par revue d'expert:

- Pas couvert par ISO
- Expert accrédités par l'UE



Qualité des données

Critères de définition de la qualité des données

- Fiabilité des données, qui dépend de la méthode de mesure et des procédures de vérification ;
- Représentativité des données, qui dépend du nombre d'entreprises considérées sur une période de temps suffisante ;
- Corrélations géographiques, temporelles et technologiques, à savoir si les données utilisées couvrent le lieu, la période et la technologie du procédé étudié.
- Deux approches différentes : Pedigree matrix (Ecoinvent), Data Quality Ratio (ILCD).



Pedigree matrix

Méthode retenue par ecoinvent pour calculer le niveau de qualité des données (Weidema 1999)

- Approche empirique semi-quantitative
 - Six paramètres définis selon 5 score
 - Calcul statistique de la variance de la données
- Limites:
- Pas nécessairement représentatif de la variance statistique.
 - Pas de calcul = pas de variance

Critères d'évaluation de la pédigree matrix

Indicator score	1	2	3	4	5 (default)
Reliability	Verified ³ data based on measurements ⁴	Verified data partly based on assumptions <i>or</i> non-verified data based on measurements	Non-verified data partly based on qualified estimates	Qualified estimate (e.g. by industrial expert)	Non-qualified estimate
Completeness	Representative data from all sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from >50% of the sites relevant for the market considered, over an adequate period to even out normal fluctuations	Representative data from only some sites (<<50%) relevant for the market considered <i>or</i> >50% of sites but from shorter periods	Representative data from only one site relevant for the market considered <i>or</i> some sites but from shorter periods	Representativeness unknown or data from a small number of sites <i>and</i> from shorter periods
Temporal correlation	Less than 3 years of difference to the time period of the dataset	Less than 6 years of difference to the time period of the dataset	Less than 10 years of difference to the time period of the dataset	Less than 15 years of difference to the time period of the dataset	Age of data unknown or more than 15 years of difference to the time period of the dataset
Geographical correlation	Data from area under study	Average data from larger area in which the area under study is included	Data from area with similar production conditions	Data from area with slightly similar production conditions	Data from unknown <i>or</i> distinctly different area (North America instead of Middle East, OECD-Europe instead of Russia)
Further technological correlation	Data from enterprises, processes and materials under study	Data from processes and materials under study (i.e. identical technology) but from different enterprises	Data from processes and materials under study but from different technology	Data on related processes or materials	Data on related processes on laboratory scale <i>or</i> from different technology

Facteurs d'incertitude par défaut

Indicator score	1	2	3	4	5
Reliability	1.00	1.05	1.10	1.20	1.50
Completeness	1.00	1.02	1.05	1.10	1.20
Temporal correlation	1.00	1.03	1.10	1.20	1.50
Geographical correlation	1.00	1.01	1.02	–	1.10
Further technological correlation	1.00	–	1.20	1.50	2.00
Sample size	1.00	1.02	1.05	1.10	1.20

Ces facteurs ont été développés par Weidema (1996) et sont appliqués à la matrice qualité pour ecoinvent V1 et V2

Facteurs d'incertitude empiriques

Indicator score	1	2	3	4	5
Reliability	1	1,54*	1,61	1,69	(n.a.)
Completeness	1	1,03	1,04	1,08	(n.a.)
Temporal correlation	1	1,03	1,10	1,19	1,29
Geographical correlation	1	1,04	1,08	1,11	(n.a.)
Further technological correlation	1	1,18	1,65	2,08	2,80

Développés par Green delta (2013) et utilisés pour ecoinvent v3

Calcul selon la pedigree matrix

Variance (intervalle de confiance de 95%) :

$$SD_{95} = \exp^{\sqrt{\ln(U_1)^2 + \ln(U_2)^2 + \ln(U_3)^2 + \ln(U_4)^2 + \ln(U_5)^2 + \ln(U_6)^2 + \ln(U_b)^2}}$$

U_1 incertitude sur la fiabilité,

U_2 incertitude sur l'exhaustivité,

U_3 incertitude sur la corrélation temporelle,

U_4 incertitude sur la corrélation géographique,

U_5 incertitude sur la corrélation technologique,

U_6 incertitude sur la taille de l'échantillon,

U_b incertitude de base.

Incertitude de base

Input / output group	c	p	a
Demand of:			
Thermal energy, electricity, semi-finished products, working material, waste treatment services	1.05	1.05	1.05
Transport services (tkm)	2.00	2.00	2.00
Infrastructure	3.00	3.00	3.00
Resources:			
Primary energy carriers, metals, salts	1.05	1.05	1.05
Land use, occupation	1.50	1.50	1.50
Land use, transformation	2.00	2.00	2.00
Pollutants emitted to air:			
CO ₂	1.05	1.05	
SO ₂	1.05		
NMVOC total	1.50		
NO _x , N ₂ O	1.50		1.40
CH ₄ , NH ₃	1.50		1.20
Individual hydrocarbons	1.50	2.00	

Extrait du tableau des incertitudes de bases d'ecoinvent.

c: processus de combustion, p: émissions des processus industriels, a: émissions agricoles

Cas d'étude pour une pièce automobile

Pour un processus nécessitant une quantité d'aluminium, avec données sur la quantité d'aluminium suivantes :

- vérifiées et basées sur des mesures (fiabilité = 1),
- représentatives d'un petit nombre d'entreprises et pour la période temporelle adéquate (exhaustivité = 2),
- obtenues moins de 3 ans avant l'étude (corrélation temporelle = 1),
- zone géographique ayant des conditions similaires aux conditions de l'étude de cas (corrélation géographique = 4),
- correspondant au type d'aluminium voulu (corrélation technologique = 1)
- à partir d'un échantillon de taille inconnue (taille de l'échantillon = 5)
- incertitude de base (matériaux, Frischnecht 2003) = 1,05

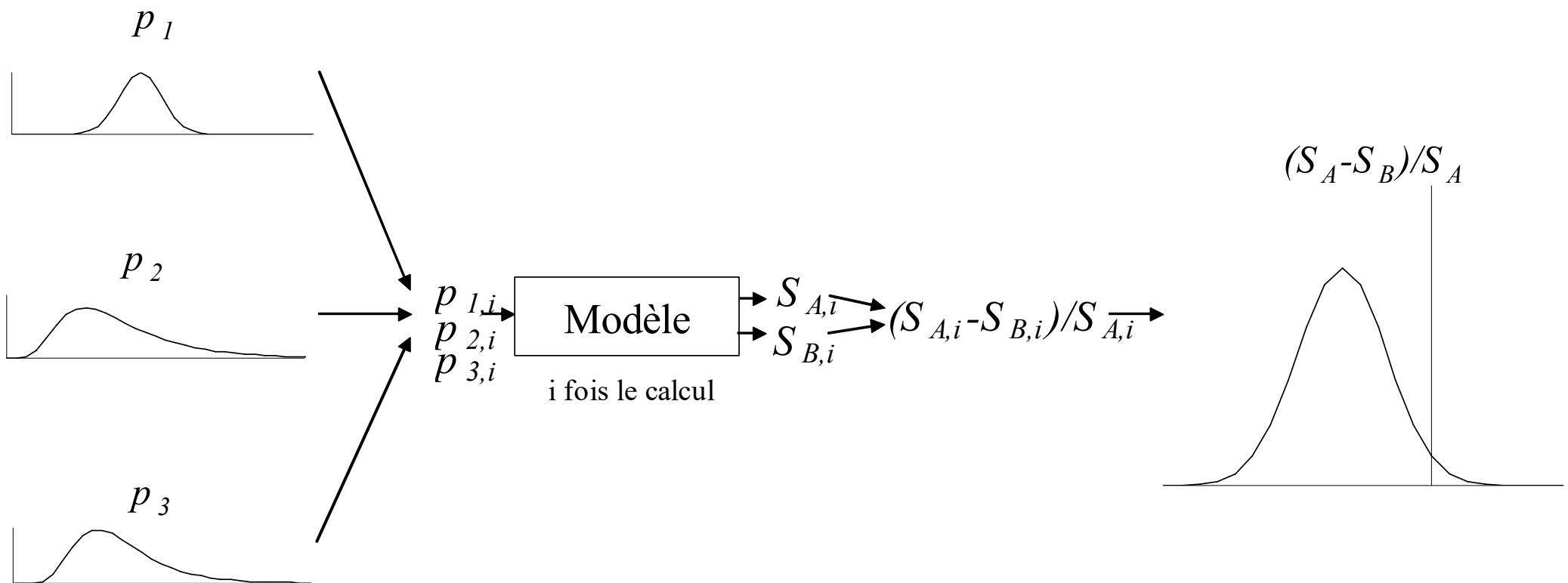
Selon facteurs d'incertitudes par défaut :

$$SD_{95} = \exp^{\sqrt{\ln(1,00)^2 + \ln(1,02)^2 + \ln(1,00)^2 + \ln(1,02)^2 + \ln(1,00)^2 + \ln(1,20)^2 + \ln(1,05)^2}} = 1,21$$

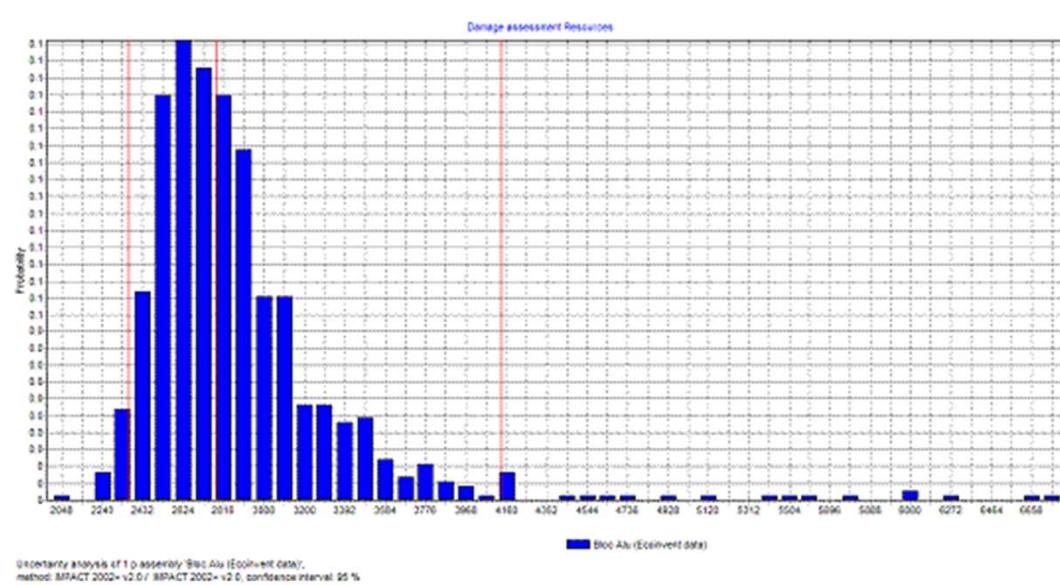
SD₉₅ (sans dimension) ne dépend pas de la quantité d'aluminium requise.

Incertitudes

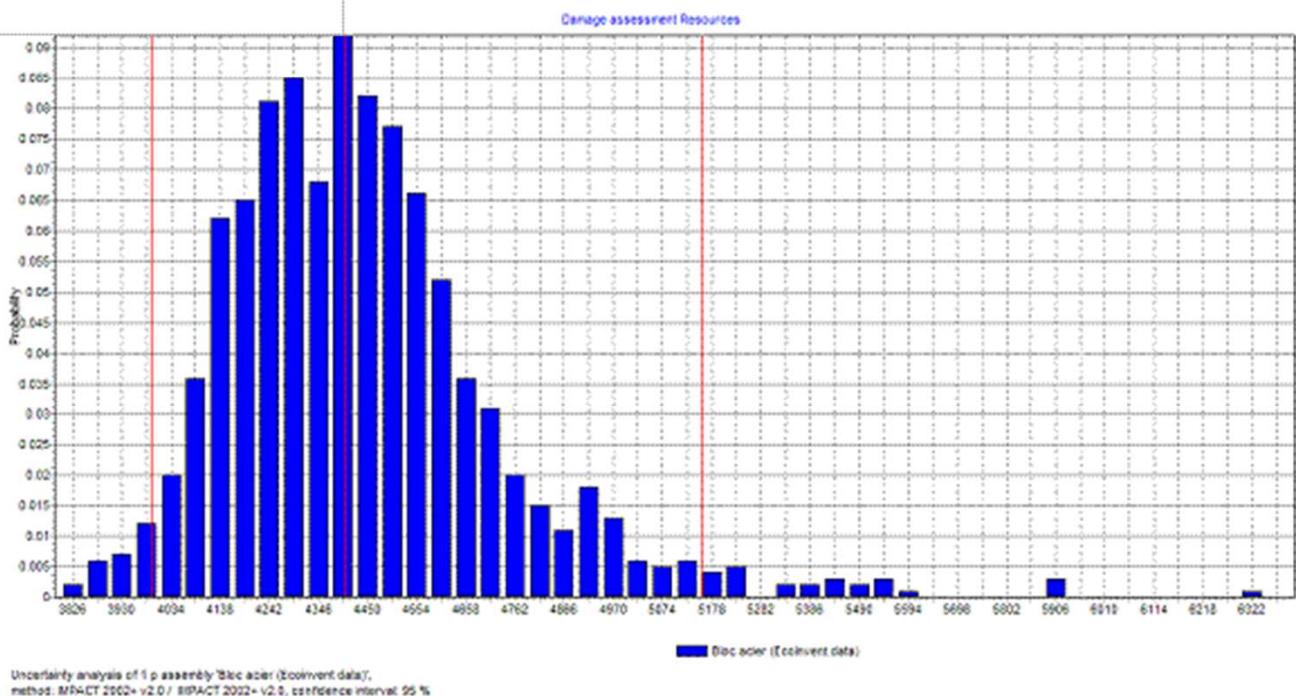
Significativité de la différence entre deux scénarios : analyse de Monte Carlo



Exemple évaluation incertitudes bloc avant

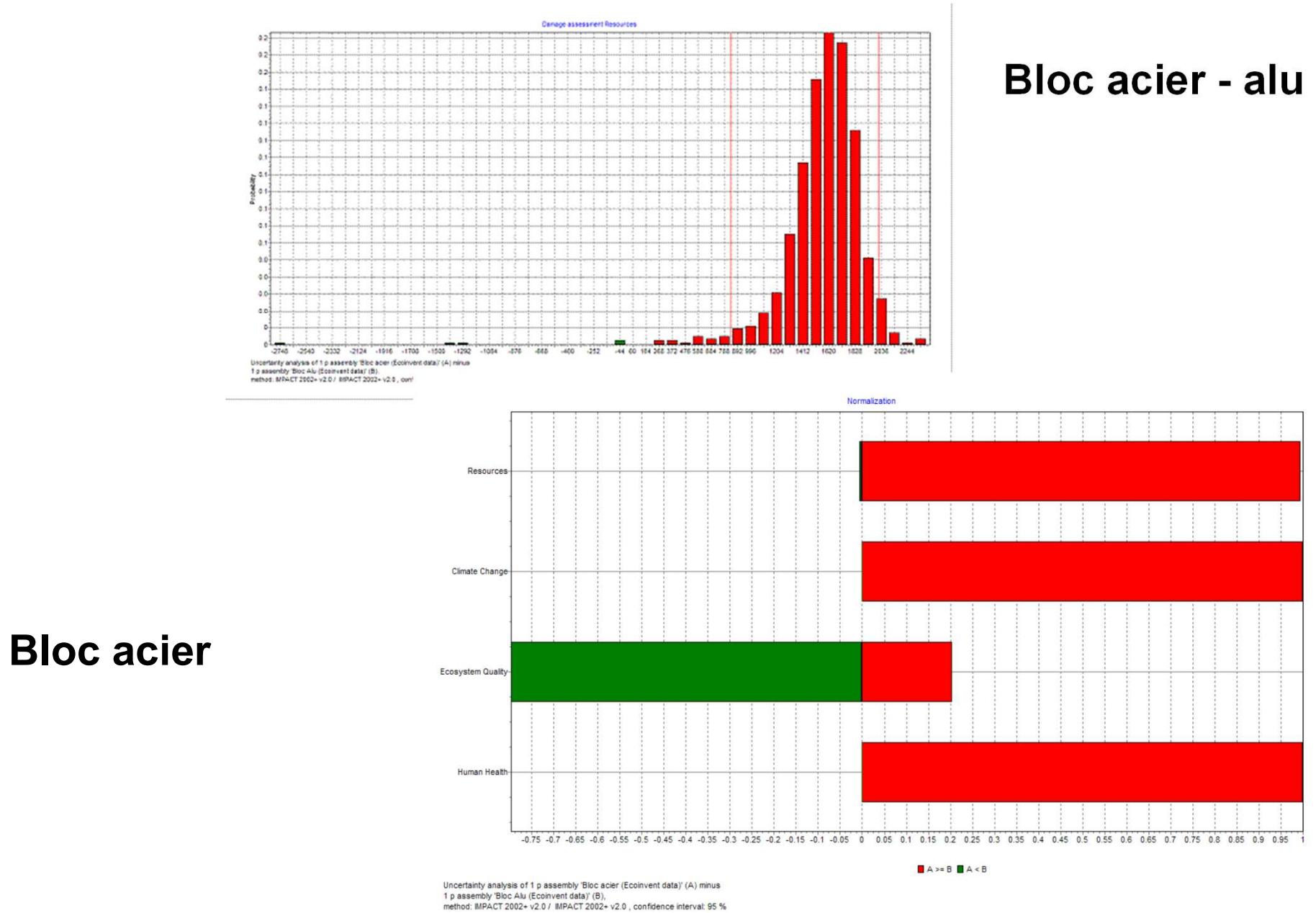


Bloc alu



Bloc acier

Exemple évaluation incertitudes bloc avant



DQR (Data Quality Rating)



Méthode retenue par l'ILCD pour calculer le niveau de qualité des données (PEF-OEF, Commission Européenne 2013)

- Système de présélection des données
 - Tous les inventaires peuvent être évalués
 - Six paramètres sont qualifiés selon le contexte industriel et validés dans le cadre d'une revue d'expert
 - Calcul d'un indice de qualité (DQR)
- Limite:
 - Pas de calcul d'incertitude

Exigence de qualité des données selon le PEF



Minimum requirements	Completeness Methodological appropriateness and consistency ⁶⁸
Data quality criteria (scored)	Technological Representativeness ⁶⁹ (TeR) Geographical Representativeness ⁷⁰ (GeR) Time-related Representativeness ⁷¹ (TiR) Precision ⁷² (P)
Documentation	Compliant with the ILCD format and with additional requirements on the metadata information available in the Guide for EF compliant datasets ⁷³
Nomenclature	Compliant with the ILCD nomenclature structure (use of EF reference elementary flows for IT compatible inventories; see detailed requirements in Section 4.3)
Review	Review by ‘Qualified reviewer’ Separate review report

Quality rating

Quality level	Quality rating	
Very good	1	Measured/calculated <u>and</u> verified
Good	2	Measured/calculated/literature and plausibility checked by reviewer
Fair	3	Measured/calculated/literature and plausibility not checked by reviewer OR Qualified estimate based on calculations plausibility checked by reviewer
Poor	4	Qualified estimate based on calculations, plausibility not checked by reviewer
Very poor	5	Rough estimate with known deficits



Data Quality Rating (DQR)

$$DQR = \frac{TeR+GeR+TiR+P}{4}$$

- DQR: Data Quality Rating of the dataset
- TeR: Technological Representativeness
- GR: Geographical Representativeness
- TiR: Time-related Representativeness
- P: Precision/uncertainty;

Qualité générale des DQR

Overall DQR	Overall data quality level
DQR \leq 1.5	‘Excellent quality‘
$1.5 < \text{DQR} \leq 2.0$	‘Very good quality‘
$2.0 < \text{DQR} \leq 3.0$	‘Good quality‘
$3 < \text{DQR} \leq 4.0$	‘Fair quality‘
DQR > 4	‘Poor quality‘

La «Data Need Matrix» (DNM)



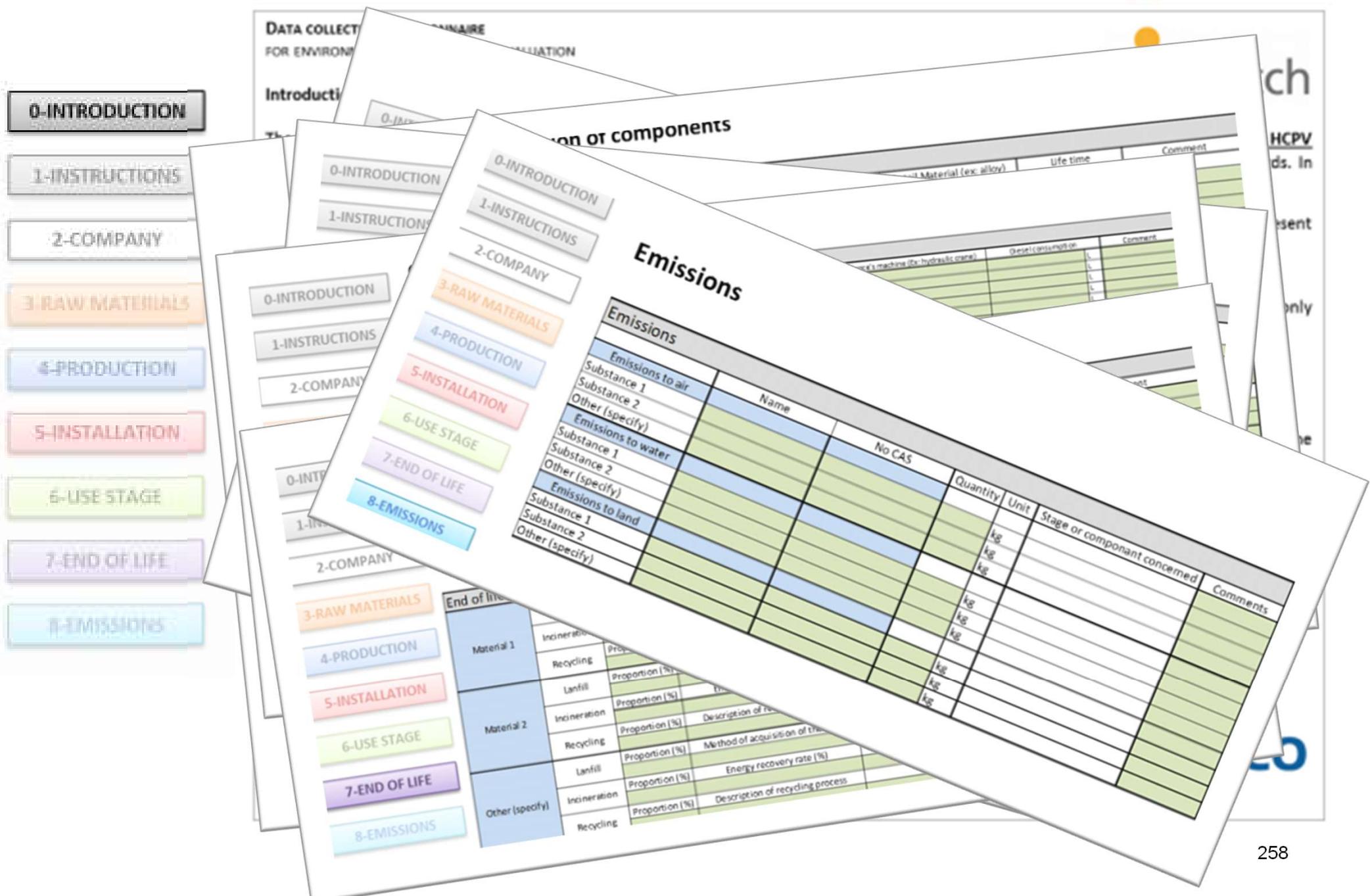
Situation 1: the process is run by the company conducting the PEF study.

Situation 2: the process is not run by the company conducting the PEF study, but this company has access to (company-) specific information.

Situation 3: the process is not run by the company conducting the PEF study and this company does not have access to (company-) specific information.

		Data requirements
Situation 1: process run by the company	Option 1	Provide company-specific data (both activity data and direct emissions) and create a company-specific dataset ($DQR \leq 1.5$). Calculate DQR of the dataset following the rules in Section 4.6.5.2.
Situation 2: process <u>not</u> run by the company but with access to company-specific information	Option 1	Provide company-specific data and create a company-specific dataset ($DQR \leq 1.5$). Calculate DQR of the dataset following the rules in Section 4.6.5.2.
	Option 2	Use an EF compliant secondary dataset and apply company-specific activity data for transport (distance), and substitute the sub-processes used for electricity mix and transport with supply-chain specific EF compliant datasets ($DQR \leq 3.0$). Recalculate DQR of the dataset used (see Section 4.6.5.6).
Situation 3: process <u>not</u> run by the company and without access to company-specific information	Option 1	Use an EF compliant secondary dataset in aggregated form ($DQR \leq 3.0$). Recalculate DQR of the dataset if the process is most-relevant (see Section 4.6.5.7).

Summary of previous presentation: *Data collection questionnaire*

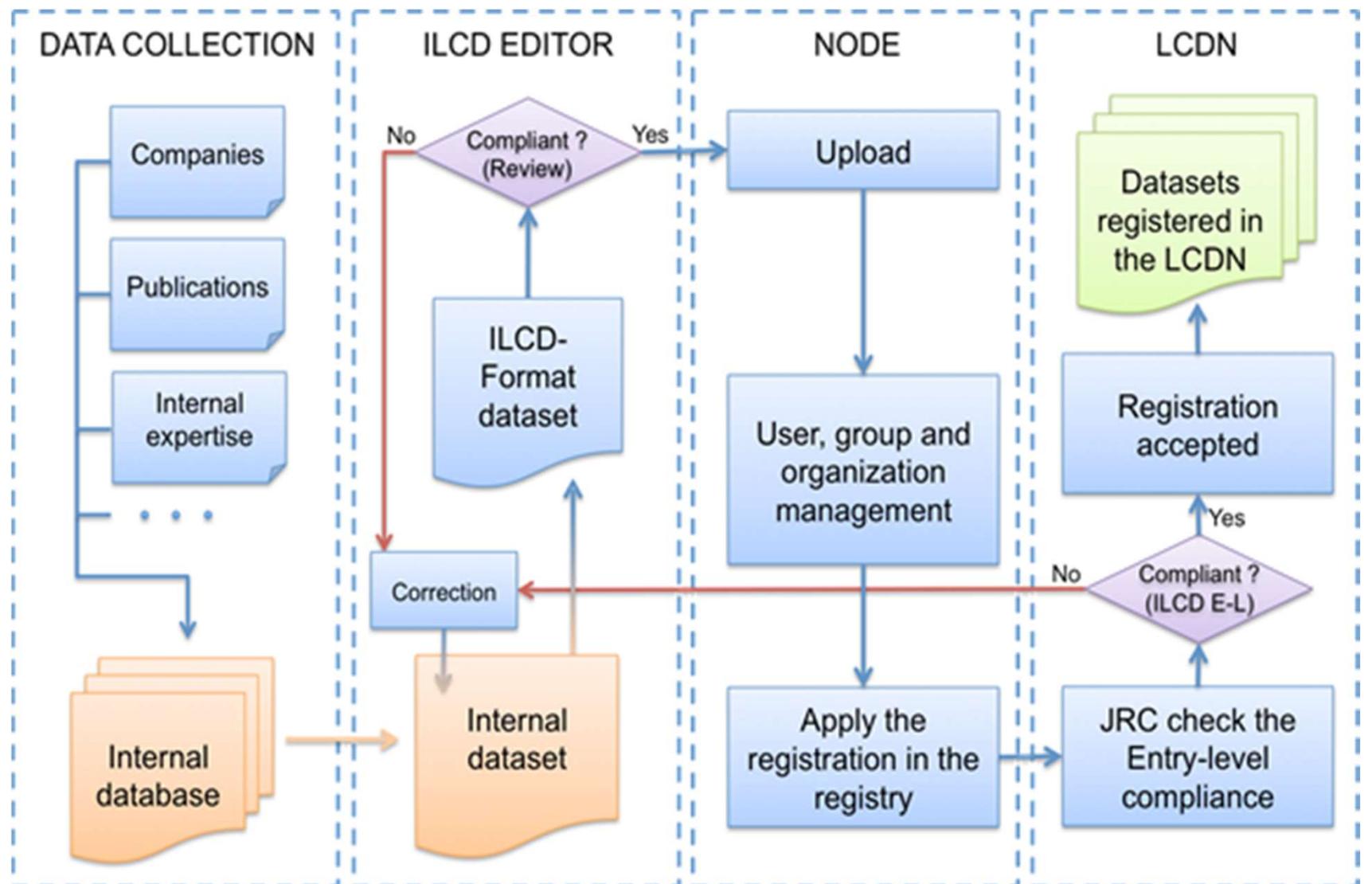


ILCD - Data Format

Name of the process	
Title of dataset: Water repellent finishing - treatment and validation Administered information: Inputs and Outputs	
<p>Key Data Set Information</p> <p>Location: GLO Geographical representativeness description: The geographical representativeness of the dataset covers the application of the water repellent finishing in the world. Reference year: 1998 Name: Base name: Treatment, standards, results, sites and location types Technical purpose of product or process: Clothing - Furnishing Classification: Class name / Hierarchy level: Systems / Textiles, furnitures and other interiors General comment on data set: The data set is a partly terminated system; the end-of-life of textile waste and the electricity needs to be added. Use advice for data set: The data set is a partly terminated system; the end-of-life of textile waste and the electricity needs to be added. Copyright? Yes Owner of data set (contact details): CIECO</p>	
<p>Quantitative reference</p> <p>Reference flows: Water repellent fabric - 1.0 kg (Mass) Time representativeness: Time representative: 2016 Technological representativeness: The finishing process refers to the application of a water repellent finish to a fabric by dipping the fabric in a solution by padding technique, considering a wet picking rate of 60%. The dipping bath is composed by water and chemicals. The active ingredients chemicals is a mixture of anionic surfactants and an inorganic water repellent agent. The fabric is obtained by passing between two rolls and then dried by hot air. This step of polymerisation uses electrical and thermal energy.</p>	
<p>Process information</p> <p>Key data set information</p> <p>Quantitative reference</p> <ul style="list-style-type: none"> - Time representativeness - Technological representativeness <pre> graph TD Electricity[Electricity] --> Finishing[Finishing of the fabric] Water[Water] --> Finishing FuelHeat[Fuel, heat] --> Finishing Chemicals[Chemicals] --> Finishing Finishing --> WasteManagement[Waste water management] Finishing --> UseEndLife[Use and end of life of the fabric] subgraph SystemBoundary [System boundaries] Production[Production of the fabric] Production --- Finishing end </pre>	
<p>Modelling and validation</p> <p>LCI method and allocation</p> <p>Data sources, treatment and representativeness</p> <p>Data cut off and completeness principles: Coverage of at least 90% of mass and energy of the input and output. Data selection and combination principles: Statistical approach used for process location</p> <p>Deviations from data selection and combination principles / explanations: None</p> <p>Data treatment and extrapolation principles: Water repellent finishing is modelled according to general data.</p> <p>Deviations from data treatment and extrapolation principles: None</p>	

<p>Data source(s) used for this data set (Source ID(s), ID(s))</p> <p>Location: v2.2 Multi-use de finition data (Industrie textile) US Patent 5112419-A US Patent 4262624-A Technical document from company, their US Patent 7035001-B2 EPTD Tadla 2003 Network of companies</p>																																																																																											
<p>Percentage of supply or production covered: 99 %</p>																																																																																											
<p>Completeness</p> <p>Completeness product model: All relevant flows quantified</p>																																																																																											
<p>Validation</p> <p>Review: Independent internal review Scope of review: Method(s) of review Method(s) of review: CIECO (Partly terminated system, Cradle-to-gate, LCA) Documentation: Documentation</p>																																																																																											
<p>Modelling and validation:</p> <ul style="list-style-type: none"> - Completeness - Validation - Compliance declarations 																																																																																											
<p>Data quality indicators</p> <p>Name: Name Overall quality: Very good Methodological appropriateness and consistency: Good Precision: Good Completeness: Good Geographical representativeness: Good Time representativeness: Fair Technological representativeness: Very good</p>																																																																																											
<p>Review details</p> <p>The dataset is of adequate data quality in view of the intended user as well as stated geographical and technology coverage. The LCI method applied is in compliance with ISO 14040 and ISO 14044 requirements. The documentation includes all relevant information in view of data quality and scope of application of the dataset.</p>																																																																																											
<p>Review details and instructions (contact details)</p> <p>Reviewer: Bartosz Piszael Complete review report (source data set): LCI review report of water repellent finishing (Global)</p>																																																																																											
<p>Compliance declarations</p> <table border="1"> <thead> <tr> <th>Compliance</th> <th>Compliance system name (source data set)</th> <th>Approval of overall compliance</th> <th>Nomenclature compliance/Nomenclature compliance</th> <th>Methodological compliance/Methological compliance</th> <th>Review compliance/Review compliance</th> <th>Documentation compliance/Documentation compliance</th> </tr> </thead> <tbody> <tr> <td>Compliance</td> <td>Product Environmental Footprint</td> <td>Approved</td> <td>None</td> <td>None</td> <td>None</td> <td>None</td> </tr> </tbody> </table>		Compliance	Compliance system name (source data set)	Approval of overall compliance	Nomenclature compliance/Nomenclature compliance	Methodological compliance/Methological compliance	Review compliance/Review compliance	Documentation compliance/Documentation compliance	Compliance	Product Environmental Footprint	Approved	None	None	None	None																																																																												
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Compliance	Product Environmental Footprint	Approved	None	None	None	None																																																																																					
<p>Administrative information</p> <p>Comments on your data set:</p> <p>Commissioner of data set (contact data set): Jerome Palet Intended applications: Product Environmental Footprint</p>																																																																																											
<p>Data set generator / modeller</p> <p>Data set generator / modeller (name): CIECO generator / modeller (contact details): Paul Laatitia Data set generator / modeller (time frame last saved): 2014-02-27T14:31:15+01:00 Data set format(s) (source data set): ILCI format Content of original data set frame (source data set): Enviroplus v2.2 Date of approval of data set: Not applicable Procedure for updating data set: Not applicable Publication and ownership</p>																																																																																											
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LCDN – ILCD editor & Node





Points importants concernant la fiabilité des Inventaires du cycle de vie

- Détail des flux de produits entrant et sortant
- Transparence des hypothèses
- Transparence dans la définition du périmètre et des règles d'allocation
- Niveau élevé de revue d'expert et de communication au public

Dans tous les cas il s'agit de trouver le meilleur compromis entre la confidentialité et la transparence