# LAVOISIER

# Conversion Documentation

Specific for ILCD to EcoSpold 2
format conversion pathway

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## Lavoisier purpose

The conversion application Lavoisier was first created to bridge the Brazilian research community and the National Life Cycle Inventory Database (SICV Brasil). Still, it is rapidly evolving to be a suite of format conversions between Life Cycle Inventory (LCI) formats. The main issue at Lavoisier's start was that while SICV Brasil was built upon the ILCD format, the research done in the country was mainly ecoinvent-oriented, resulting in EcoSpold 2 format inventories. In this context, to populate SICV Brasil and have a more comprehensive repository of LCI datasets for the country, the Lavoisier was proposed to solve the linking problem between database and research.

Lavoisier is an open-source python library and web application that handles the following conversions: EcoSpold 2 to ILCD. Its primary goals are to be reliable (minimum loss of data and functionality), transparent (detailed documentation), accessible (for use by all practitioners and data hosts), and format-related (bound to the specificities of the formats it is converting) as a tool for LCI conversion.

Lavoisier is being developed by the Laboratory of Sustainable Life Cycle Assessment (GYRO) of the Federal Technological University - Paraná (UTFPR) in partnership with the Brazilian Institute of Information in Science and Technology (IBICT).

# Summary

# Lavoisier EcoSpold 2 to ILCD conversion

## 1.    Basic File Structures

EcoSpold 2 and ILCD are two different formats to store the same type of data, the life cycle assessment inventory. Both are compliant with ISO 14048 requisites, but their approach to information storage yields different data structures and proposes a conversion challenge.

Both formats are based on the eXtensible Markup Language (XML), which can hierarchically store text data. Aside from that, their overall structure of files is remarkably different, as shown in Figure 1.
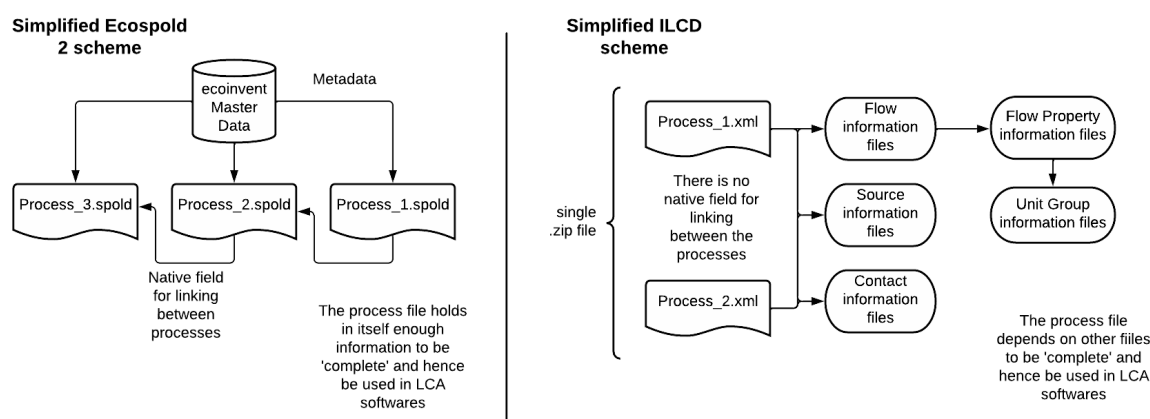


Figure 1: EcoSpold 2 (left) and ILCD (right) file scheme

The EcoSpold 2 file structure features a standalone process dataset containing all the LCA required information about the process. Although it is complete for LCA practice, it has additional metadata bound to the ecoinvent Master Data and can hold information about its linkage with other datasets employing unique identifications. As for the ILCD, its structure is composed of several files that represent a distinct part of the process dataset. The final process dataset is a compressed zip file containing all the information (and XML files) relative to the process and its connections. Although it is possible to have several process datasets inside the same ILCD zip file sharing other datasets, they are not linked in a way that could be considered a database.

Because they rely on ISO 14048 guidance for inventory data storage, both follow four main data structures inside their process XML files:

- Dataset description structure (dataSetInformation in ILCD and activityDescription in EcoSpold 2): Holds general information about the dataset such as name and identification, and information about technological applicability, geography, and validity. It can have additional fields depending on the format.
- Modeling and validation structure: Holds information about the data modeling behind the inventory, its logic, sampling methods, approaches, and extrapolations. Aside from that, it has validation data, such as reviews done and a measure of the process representativeness.
- Administrative information: As the name suggests, it holds administrative information such as restrictions of access, copyright, and of the persons or entities that are related to the data research, upload to an LCI database, and ownership.
- Flow information (exchange in ILCD and flowData in EcoSpold 2): Holds the quantitative characterization of the flows (amount and uncertainty) and general information such as unit, name, and identification. For EcoSpold 2, the field supports production volume and property specification.

More information about the formats is in each format's description material. These are used as a basis for conversion explanations.

- EcoSpold 2: https://ecoinvent.org/the-ecoinvent-database/data-formats/ecospold2/

- ILCD
  https://eplca.jrc.ec.europa.eu/LCDN/developerILCDDataFormat.xhtml

## 2. Conversion specifics

Although their primary structures are about the same, both represent the data inside in different ways. For this reason, Lavoisier's development required a more in-depth study of the formats. This in-depth study led to the specification of five different types of field conversion (specified in the field-by-field conversion section):

- Direct: The conversion is done by copying the ILCD field and pasting it into the corresponding EcoSpold 2 field.
- Indirect: The conversion is done by copying the ILCD information, modifying it to an equivalent for EcoSpold 2, and pasting it into the corresponding EcoSpold 2 field. Here we considered the fields in which information is not placed under an EcoSpold 2 field but used as support information in other conversions as well.
- Incomplete: The ILCD field had no corresponding field in EcoSpold 2, so the information was allocated as text in the nearest (most related) comment field. Additionally, when a field is converted for only a portion of its appearances, it was considered in this category as well. A loss of functionality usually accompanies this conversion.
- Complex (structural): A structure of data in ILCD is converted to the corresponding structure in EcoSpold 2. This distinction is necessary as a set of fields can behave as one unique structure. An additional field-by-field separation using the other categories is made for further comparisons.
- Not converted: The ILCD field was not converted due to limitations of EcoSpold 2 fields or because its data was inherent to the ILCD format.

For further performance analysis and comparison, all fields were classified as

- Essential data: Fields with data mandatory for LCA practice. Their lack of conversion induces a loss of data.
- Essential metadata: Fields with metadata mandatory for LCA practice. Their lack of conversion induces a loss of data. Essential dataset descriptors such as name, classification, and main comments are considered here.
- Other metadata: Fields with additional information about the dataset. Their lack of conversion reduces the completeness of the dataset but to a lower degree than essential information.
- Not used: Additional ILCD specific structures not yet actively used in the datasets.

## 3. Field-by-Field conversion

Before diving into the field conversion specifics, a few words are given about this section structure. As a field-by-field approach would not consider the complex conversions in a didactic way, the following section was separated into its description and the description of other types of conversion. In that way, both conversions are well separated and explained without duplication.

This section follows the ILCD fields throughout the conversions and is organized following their hierarchy whenever possible.

Glossary:
- @: stands for an XML attribute
- {m}: field is mandatory in ILCD
- {r}: field is required in ILCD
- {o}: field is optional in ILCD
- UUID stands for Unique Identifier and is a fixed-format string-based identifier

### 3.1.  Complex (structural) conversions

#### 3.1.1.  Allocation

For ILCD, the allocation information is stored into the flow as the fraction (percentage) of the flow considered for each allocation (there can be more than one) and for each reference product and by-product present in them. This structure allows for different allocations inside the same dataset and a direct allocation value for each flow.

There are two main sources of allocation information in EcoSpold 2: (i) the field masterAllocationPropertyId and (ii) the field specificAllocationPropertyId. To understand their importance and how their conversion is done, one should understand what a property is inside EcoSpold 2. The property expands the characterization of a given flow by specifying additional quantitative features, such as density for a wood flow in kilograms or net energy for a diesel flow in kilograms. Each property carries a UUID bound to their names and can be used in different flows at the same process dataset. Allocation is done by searching for the masterAllocationPropertyId in the dataset allocatable flows or indications of the specificAllocationPropertyId.

For this conversion, each allocation in ILCD's allocations field is mapped to an EcoSpold 2 property called 'allocation for n' with 'n' being the internal ID of the product or co-product that flow is being allocated. (ILCD1ToECS2FlowConversion.__init__ and Property.allocation_init). No field of either master or specific allocation property is populated in the EcoSpold 2 file, as there is no information on which is the preferred allocation in ILCD. The unit is always assumed to be dimensionless.

The ILCD fields included in that conversion are:

- ../exchanges/exchange/allocations/allocation/@internalReferenceToCoProduct {o}
  - Type of conversion: Complex (indirect). The field is used as support information.

- ○ Importance: Essential data. Allocation data is essential for LCI.
  - ○ EcoSpold 2 correspondent fields: for each allocatable flow
    - ■ exchange/property/@propertyId
    - ■ exchange/property/name

- ../exchanges/exchange/allocations/allocation/@allocatedFraction {o}
  - ○ Type of conversion: Complex (indirect). The field is used as support information.
  - ○ Importance: Essential data. Allocation data is essential for LCI.
  - ○ EcoSpold 2 correspondent fields: for each allocatable flow
    - ■ exchange/property/@amount

### 3.1.2.   Classification

The ILCD classification is different for processes, flows sources, contacts, flow properties and unit groups. Although functional, the ILCD classification does not have good correspondence with classifications used in EcoSpold 2, as they are way more disaggregated. Additionally, EcoSpold 2 classifications must be the ones permitted in the master data (ISIC, EcoSpold 1 Categories, CPC and By-Product Classification), which hinders the conversion of them from ILCD to EcoSpold 2. For these reasons, the ILCD classification is not converted to EcoSpold 2.

The ILCD fields included in that conversion are:

- ../processInformation/dataSetInformation/classificationInformation/classification/@name {r}
  - ○ Type of conversion: Complex (not converted).
  - ○ Importance: Essential metadata. The classification is used to organize and make data hierarchical.

- ../processInformation/dataSetInformation/classificationInformation/classification/@classes {r}
  - Type of conversion: Complex (not converted).
  - Importance: Other metadata. Link to classification file.

- ../processInformation/dataSetInformation/classificationInformation/classification/class/@level {r}
  - Type of conversion: Complex (not converted).
  - Importance: Other metadata. Indicates the level of the class in the classification system.

- ../processInformation/dataSetInformation/classificationInformation/classification/class/@classId {r}
  - Type of conversion: Complex (not converted).
  - Importance: Essential metadata. The classification identifier.

### 3.1.3.  General comment sections

ILCD comment fields are plain text fields without a specific internal structure of subelements. On the other hand, general comments in EcoSpold 2 are fields composed of a structure of other subelements. The EcoSpold 2 general comment subfields are:

- text: holds the actual text of the field
- imageURL: holds image information using an URL
- variable: holds a text that can be changed in child process datasets. This text is used inside the text subfield and is substituted when the dataset is used in the software.

All ILCD plain text fields are either placed within the 'text' tag of the most contextually appropriate comment section in EcoSpold 2 or converted directly into plain text fields, where supported by the format. In cases where the 'text' tag is used, Lavoisier generates an indexed structure that allows for assigning levels of importance to each comment. As EcoSpold 2 does not have specific language tags for

comments, the language attribute in ILCD is not converted in any of the fields.

The ILCD fields included in that conversion are:

- ../processInformation/dataSetInformation/generalComment {o}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/activity/generalComment/text

- ../processInformation/time/timeRepresentativenessDescription {r}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the validity of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/timePeriod/comment

- ../processInformation/mathematicalRelations/variableParameter/comment {o}
  - Type of conversion: Complex (incomplete). EcoSpold 2 does not have a comment field for variables that were not parameters.
  - Importance: Essential metadata. General description of the parameters.
  - EcoSpold 2 correspondent fields: (for some cases)
    - parameter/comment

- ../processInformation/geography/locationOfOperationSupplyOrProduction/descriptionOfRestrictions {o}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the geography of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/geography/comment

- ../processInformation/geography/subLocationOfOperationSupply
OrProduction/descriptionOfRestrictions {o}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the geography of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/geography/comment

- ../processInformation/technology/technologyDescriptionAndIncludedProcesses {r}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the technology of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/technology/comment

- ../processInformation/technology/technologicalApplicability {r}
  - Type of conversion: Complex (direct).
  - Importance: Essential metadata. General description of the technology of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/technology/comment

- ../processInformation/mathematicalRelations/modelDescription {o}
  - Type of conversion: Complex (incomplete).
  - Importance: Other metadata. General description of the modelling of the process.
  - EcoSpold 2 correspondent fields:
    - activityDescription/activity/generalComment/text

- ../modellingAndValidation/LCIMethodAndAllocation/deviationsFromLCIMethodPrinciple {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Deviations from methodology.

- - EcoSpold 2 correspondent fields:
      - modellingAndValidation/representativeness/extrapolat ions

- ../modellingAndValidation/LCIMethodAndAllocation/deviationsFr omLCIMethodApproaches {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Deviations from methodology.
  - EcoSpold 2 correspondent fields:
      - activityDescription/activity/allocationComment/text

- ../modellingAndValidation/LCIMethodAndAllocation/modellingC onstants {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Methodology.
  - EcoSpold 2 correspondent fields:
      - modellingAndValidation/representativeness/sampling Procedure

- ../modellingAndValidation/LCIMethodAndAllocation/deviationsFr omModellingConstants {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Deviations from methodology.
  - EcoSpold 2 correspondent fields:
      - modellingAndValidation/representativeness/extrapolat ions

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat iveness/dataCutOffAndCompletenessPrinciples {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Methodology.
  - EcoSpold 2 correspondent fields:
      - modellingAndValidation/representativeness/sampling Procedure

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/deviationsFromCutOffAndCompletenessPrinciples {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Deviations from methodology.
  - EcoSpold 2 correspondent fields:
    - modellingAndValidation/representativeness/extrapolations

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/dataSelectionAndCombinationPrinciples {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Methodology.
  - EcoSpold 2 correspondent fields:
    - modellingAndValidation/representativeness/samplingProcedure

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/deviationsFromSelectionAndCombinationPrinciples {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Deviations from methodology.
  - EcoSpold 2 correspondent fields:
    - modellingAndValidation/representativeness/extrapolations

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/dataTreatmentAndExtrapolationsPrinciples {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata. Methodology.
  - EcoSpold 2 correspondent fields:
    - modellingAndValidation/representativeness/extrapolations

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat
  iveness/deviationsFromTreatmentAndExtrapolationPrinciples {r}
    - Type of conversion: Complex (direct).
    - Importance: Other metadata. Deviations from methodology.
    - EcoSpold 2 correspondent fields:
        - modellingAndValidation/representativeness/extrapolat
          ions

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat
  iveness/samplingProcedure {o}
    - Type of conversion: Complex (direct).
    - Importance: Other metadata. Methodology.
    - EcoSpold 2 correspondent fields:
        - modellingAndValidation/representativeness/sampling
          Procedure

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat
  iveness/uncertaintyAdjustments {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata. Methodology.
    - EcoSpold 2 correspondent fields:
        - modellingAndValidation/representativeness/sampling
          Procedure

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat
  iveness/useAdviceForDataSet {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata. Methodology.
    - EcoSpold 2 correspondent fields:
        - modellingAndValidation/representativeness/sampling
          Procedure

- ../modellingAndValidation/validation/review/reviewDetails {r}
    - Type of conversion: Complex (direct).

- ○ Importance: Essential metadata. Have details of each review.
- ○ EcoSpold 2 correspondent fields:
  - ■ review/details/text

- ● ../modellingAndValidation/validation/review/otherReviewDetails {o}
  - ○ Type of conversion: Complex (direct).
  - ○ Importance: Essential metadata. Have details of each review.
  - ○ EcoSpold 2 correspondent fields:
    - ■ review/otherDetails

### 3.1.4. Access Restrictions

A specific conversion was done for access restriction data since this information is stored in different places. The conversion followed the steps:

1. If there was information on the field 'licenseType', the field was converted as:
   a. Free of charge for all users and uses: '0' (public),
   b. Free of charge for some user types or use types: '1' (Licensees),
   c. Free of charge for members only: '1' (Licensees),
   d. License fee: '1' (Licensees),
   e. Other: '1' (Licensees)
2. If the field 'licenceType' didn't have any data and the field 'referenceToEntitiesWithExclusiveAccess' had data, the field was set to '3' (Restricted)
3. The field 'accessRestriction' from ILCD was assessed if there were information regarding restrictions placed by Lavoisier while doing a conversion from EcoSpold 2 to ILCD

The fields impacted in this conversion were:

- ../administrativeInformation/publicationAndOwnership/licenceType {r}
    - Type of conversion: Complex (indirect).
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:
        - administrativeInformation/dataGeneratorAndPublication/accessRestrictedTo

- ../administrativeInformation/publicationAndOwnership/accessRestrictions {r}
    - Type of conversion: Complex (indirect).
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:
        - administrativeInformation/dataGeneratorAndPublication/accessRestrictedTo

- ../administrativeInformation/referenceToEntitiesWithExclusiveAccess {@refObjectId and shortDescription} and [sourceDataSet].../@uri {o}
    - Type of conversion: Complex (indirect).
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:
        - administrativeInformation/dataGeneratorAndPublication/accessRestrictedTo
        - administrativeInformation/dataGeneratorAndPublication/@companyId
        - administrativeInformation/dataGeneratorAndPublication/@companyCode

### 3.1.5.  Completeness and Compliance

The fields related to completeness and compliance did not have a good correspondence with any structure inside the EcoSpold 2 format. This happened as ILCD is a format structured to receive additional information validating the dataset and EcoSpold 2 does not have this purpose. Placing this information inside general comment sections

would override their text capacity and spam text inside comment sections not ready to receive that information, even as a generic entry. Due to that, these fields were not converted. All fields were considered as other metadata as they are additional information for ILCD.

The ILCD fields impacted by this were:

- ../modellingAndValidation/completeness/referenceToSupportedImpactAssessmentMethods {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/completeness/referenceToSupportedImpactAssessmentMethods {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/completeness/completenessElementaryFlows/@type {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/completeness/completenessElementaryFlows/@value {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/completeness/completenessOtherProblemField {o}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/referenceToComplianceSystem {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/approvalOfOverallCompliance {o}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/nomenclatureCompliance {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/methodologicalCompliance {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/reviewCompliance {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/documentationCompliance {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

- ../modellingAndValidation/complianceDeclarations/compliance/qualityCompliance {r}
    - Type of conversion: Not converted
    - Importance: Other metadata

### 3.1.6. Sources and Contacts

Sources and contacts are one of the core metadata information inside an LCI dataset. While the sources behave like references in a bibliographical sense, with information about publications or

documents related to the data, the contacts characterize important actors for the development, ownership, and other aspects of the data.

Although they carry different information, their structure follows similar paths within each format but differs significantly structurally. ILCD treats sources and contacts as separated datasets that connect to others based on specific reference structures. These structures hold the UUID information and some basic metadata descriptors about the source or contact in a way software can easily identify it (as the XML name is the UUID) within the source or contact folder. The main ILCD fields for this conversion are:

- Source:
    - referenceTo…/shortDescription
    - [sourceDataSet].../dataSetInformation/sourceCitation
    - [sourceDataSet].../dataSetInformation/shortName
    - [sourceDataSet].../dataSetInformation/referenceToDigitalFile/@uri
- Contact:
    - referenceTo…/shortDescription
    - [contactDataSet].../dataSetInformation/name
    - [contactDataSet].../dataSetInformation/email

Fields in the reference structures such as @refObjectId, @type, @version, @uri were used as references to find the correct file, but only the @refObjectId was converted as information to EcoSpold 2. Therefore, they were always considered as other metadata with an indirect conversion, except for @refObjectId which had a direct conversion. The field subReference, specific to sourceDataSets, was not converted as it rarely appeared in the use cases and its information was found in the sourceDataSet itself. It was considered as other metadata as well.

For EcoSpold 2, sources and contacts are given by a collection of fields that can hold enough information about them without relying on additional ecoinvent metadata. For the sources, the fields are as follows

- Source Id: UUID of the source, which can be crossed with ecoinvent Master Data for additional information (Lavoisier only uses the file data).
- Source Year: Year of the source publication.
- Source First Author: Main author of the publication.
- Source Page Numbers: (only one case) Page numbers of the publication.

For the contacts, the fields are as follows

- Person/Company Id: UUID linked to that person/company in the ecoinvent Master Data (Lavoisier only uses the file data).
- Person/Company Name: Name of the person/company code
- Person/Company Email: Email of the person. Companies don't have this value
- Person is an active author: (only one case) boolean with information if the author is still an active researcher

The conversion between both formats occurs in a direct form even with such differences. The fact is that the information rarely changes regarding both the structures, so the fields are roughly the same but in different places. For Lavoisier, the following steps are usually used:

- The information of a source or contact in ILCD is collected whenever a reference structure is identified. This calls the Reference conversion class with the information from the reference itself
- The Reference class initializes and returns itself
- The Reference object method 'get_source' is called to gather information from the contact or source dataset
- Both the initialization and the 'get_source' methods fill the information required on the EcoSpold 2 fields

Some specific steps can be taken for specific cases, such as the source page numbers and if the contact is an active author which are taken out, when possible, from the citation.

If an ILCD source file has a referenceToDigitalFile and is identified as being converted using Lavoisier, it has the referenceToDigitalFile converted back to an imageUrl or dataSetIcon field. Otherwise, regular ILCD datasets don't have this field converted.

Although some fields were successfully converted, a significant number of sources and contacts didn't have a proper field in EcoSpold 2 as the latter does not include a generic source or contact field.

The ILCD fields included in that conversion are:

- ../dataSetInformation/referenceToExternalDocumentation/{@refObjectId and shortDescription} and [sourceDataSet].../@uri {o}
    - Type of conversion: Complex (incomplete). Only files identified as converted using Lavoisier enters this conversion as imageUrl and dataSetIcon information is placed there
    - Importance: Other metadata. Source information
    - EcoSpold 2 correspondent fields:
        - ../activity/generalComment/imageUrl
        - ../activity/dataSetIcon

- ../technology/referenceToTechnologyPictogramme/{@refObjectId and shortDescription} and [sourceDataSet].../@uri {o}
    - Type of conversion: Complex (indirect)
    - Importance: Other metadata. Source information
    - EcoSpold 2 correspondent fields:
        - ../activity/generalComment/imageUrl

- ../technology/referenceToTechnologyFlowDiagrammOrPicture/{@refObjectId and shortDescription} and [sourceDataSet].../@uri {o}
    - Type of conversion: Complex (indirect)
    - Importance: Other metadata. Source information
    - EcoSpold 2 correspondent fields:
        - ../activity/generalComment/imageUrl

- ../LCIMethodAndAllocation/referenceToLCAMethodDetails/{@ref ObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {o}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../dataSourcesTreatmentAndRepresentativeness/referenceToData HandlingPrinciples/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {o}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../dataSourcesTreatmentAndRepresentativeness/referenceToData Source/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {r}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../validation/review/referenceToNameOfReviewerAndInstitution/{ @refObjectId and shortDescription} and [contactDataSet].../{name and email} {r}
    - Type of conversion: Complex (direct)
    - Importance: Other metadata. Contact information
    - EcoSpold 2 correspondent fields:
        - ../review/@reviewerId
        - ../review/@reviewerName
        - ../review/@reviewerEmail

- ../validation/review/referenceToCompleteReviewReport/{@refObj ectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {r}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../commissionerAndGoal/referenceToCommissioner/{@refObjectId and shortDescription} and [contactDataSet].../{name and email} {r}
  - Type of conversion: Complex (not converted)
  - Importance: Other metadata. Contact information

- ../validation/review/referenceToPersonOrEntityGeneratingTheDataSet/{@refObjectId and shortDescription} and [contactDataSet].../{name and email} {r}
  - Type of conversion: Complex (direct)
  - Importance: Other metadata. Contact information
  - EcoSpold 2 correspondent fields:
    - ../dataGeneratorAndPublication/@personId
    - ../dataGeneratorAndPublication/@personName
    - ../dataGeneratorAndPublication/@personEmail

- ../dataEntryBy/referenceToDataSetFormat/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {r}
  - Type of conversion: Complex (not converted)
  - Importance: Other metadata. Source information

- ../dataEntryBy/referenceToConvertedOriginalDataSetFrom/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {o}
  - Type of conversion: Complex (not converted)
  - Importance: Other metadata. Source information

- ../dataEntryBy/referenceToPersonOrEntityEnteringTheData/{@refObjectId and shortDescription} and [contactDataSet].../{name and email} {r}
  - Type of conversion: Complex (direct)
  - Importance: Other metadata. Contact information
  - EcoSpold 2 correspondent fields:
    - ../dataEntryBy/@personId
    - ../dataEntryBy/@personName

- ../dataEntryBy/@personEmail

- ../dataEntryBy/referenceToDataSetUseApproval/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {r}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../publicationAndOwnership/referenceToUnchangedRepublication /{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {o}
    - Type of conversion: Complex (indirect)
    - Importance: Other metadata. Source information
    - EcoSpold 2 correspondent fields:
        - administrativeInformation/dataGeneratorAndPublication/@publishedSourceId
        - administrativeInformation/dataGeneratorAndPublication/@publishedSourceFirstAuthor
        - administrativeInformation/dataGeneratorAndPublication/@publishedSourceYear
        - administrativeInformation/dataGeneratorAndPublication/@pageNumbers

- ../publicationAndOwnership/referenceToRegistrationAuthority/{@refObjectId and shortDescription} and [contactDataSet].../{name and email} {o}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Contact information

- ../publicationAndOwnership/referenceToOwnershipOfDataSet/{@refObjectId and shortDescription} and [sourceDataSet].../{sourceCitation and shortName} {r}
    - Type of conversion: Complex (not converted)
    - Importance: Other metadata. Source information

- ../exchange/referencesToDataSource/referenceToDataSource/{@refObjectId and shortDescription} and [contactDataSet].../{name and email} {o}
  - Type of conversion: Complex (incomplete). Only one of the sources for a specific flow is converted as there is space for only one entry.
  - Importance: Other metadata. Contact information
  - EcoSpold 2 correspondent fields:
    - exchange/@sourceId
    - exchange/@sourceFirstAuthor
    - exchange/@sourceYear
    - exchange/@pageNumbers

### 3.1.7.    References to other datasets

Aside from source and contact datasets, the ILCD format includes several other dataset types that can be referenced within a processDataSet. In this section, we address all such references excluding referenceToFlowDataSet, which will be covered separately in the sections dedicated to flows.

Unlike ILCD, EcoSpold 2 does not support linking across multiple sections of the same dataset - except, arguably,  for connecting provider processes to their respective flows. As a result, whenever a reference to a non-flow dataset was present in an ILCD processDataSet, there was no corresponding structure in EcoSpold 2 to represent that information. Consequently, such references could not be converted.

The ILCD fields affected were:

- ../dataSetInformation/complementingProcesses/referenceToComplementingProcess {o}
  - Type of conversion: Complex (not converted).
  - Importance: Essential metadata. Carries information about complementing processes that, together, would construct the total process dataset.
  - Obs: Each process dataset is still being converted as a single inventory by Lavoisier

- ../dataSetInformation/identifierOfSubDataSet {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata. Carries name information about complementing processes that, together, would construct the total process dataset.
    - EcoSpold 2 correspondent fields:
        - ../activity/generalComment/text

- ../technology/referenceToIncludedProcesses {r}
    - Type of conversion: Complex (not converted).
    - Importance: Other metadata. Similar to complementing processes, but refers to other datasets which the process being converted is a combination of, so no additional information is necessary from others to form the process.

- ../administrativeInformation/publicationAndOwnership/reference ToPrecedingDataSetVersion {o}
    - Type of conversion: Complex (not converted).
    - Importance: Other metadata. Last version of dataset.

### 3.1.8. Variables and formulas

In LCI, it is common that the inventories have calculations and parametrization done to get to the final result. This mathematical information is conserved under both formats and is bound to the values of certain flows to preserve the underlying relations that lead to a certain value.

In ILCD, the only structures that can link to a variable parameter are the flows (exchanges), even though other structures have similar fields such as name, amount, uncertainty and comments.

As in other cases, although the same functionality is archived, the structure is different among the formats. The ILCD structure has a distinct space for all the mathematical relations and variable distinction, the mathematicalRelations field under the process dataset. Any entrance to this field can be referenced directly by the flow, and this

reference is used to calculate the flow amount (resultingValue; see details on the uncertainty section).

EcoSpold 2 uses two sets of fields that can result in a mathematical variable. The first set of fields can be used by the following quantity entity inside EcoSpold 2: flow, properties, and product volumes, and is characterized by the fields:

- Mathematical Relation: The formula used to calculate the amount of the quantity entity. It can reference other variables established in the process dataset.
- Boolean isCalculatedAmount: Certifies if the amount is calculated by a formula.
- Variable Name: Name of the variable that carries the amount of the quantity entity. It can be used in other quantity entities' formulas to calculate their amount.

To facilitate the understanding of this first set of fields, one can think of them as extensions of the quantity structure for calculations done inside the dataset. These fields hold information about how the amount is calculated using other variables (the formula) and how a given quantity entity's amount (and uncertainty) is referenced by other formulas that calculate the value of other quantity entities throughout the dataset.

This first set of fields enables the use of values of a flow, property of production volume in calculating other flows, properties, or production volumes' values. Although a great start, this feature has to be complemented by the second set of fields, the parameter structure, to enable the specification of parameters or values that are not an amount of flow, property, or production volume but are still used in the calculations inside the dataset. This parameter structure reassembles other quantity structures as it defines name, unit, comment, uncertainty, identification, amount, and the first set of fields for variables (it can have a formula and a variable name to be referenced by other calculations).

The conversion of ILCD variables to EcoSpold 2 is generally straightforward. Since ILCD variables are only linked to flows, those

associated with flows are mapped to flowData fields in EcoSpold 2 (exceptions below). All other variables are converted into parameters. In some cases, additional information from Lavoisier allows the recovery and reconstruction of data related to other quantity fields, beyond what is available directly from flows in EcoSpold 2.

However, the conversion of flow-related variables requires special handling when the meanValue field of the associated ILCD flow is not equal to 1. In such cases, the ILCD variable does not represent the actual flow value (as it does in EcoSpold 2), but rather serves as a multiplier of the flow's meanValue, producing the resultingValue - the actual quantity of the flow.

To address this, the ILCD variable is split into two parts during conversion:

- The original ILCD variable is retained as a parameter, preserving its use in formulas.
- A second variable is created for inclusion in flowData, defined as the product of the original variable and the flow's meanValue.

If the original ILCD variable does not have a formula, one is generated using the parameter name. This ensures compatibility with other formulas in the dataset, while the flowData entry accurately reflects the ILCD model where resultingValue = meanValue × variableValue.

A specific correction is done in formulas, as ecoinvent's EcoEditor only accepts formulas with letters in the first space. All variableParameters are considered dimensionless for the unit as information about their unit is not available (even for the flow variables, the unit can be the flow one or not considering the resultingValue logic).

The affected fields in ILCD are:

- ../mathematicalRelations/variableParameter/@name {o}
  - Type of conversion: Complex (direct).
  - Importance: Essential data. Name used in equations.
  - EcoSpold 2 correspondent fields:

- ../flowData/…exchange/@variableName
- ../parameter/@variableName
- ../parameter/name

- ../mathematicalRelations/variableParameter/formula {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Equations.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/@mathematicalRelation
    - ../flowData/…exchange/@isCalculatedAmount
    - ../parameter/@mathematicalRelation
    - ../parameter/@isCalculatedAmount

- ../mathematicalRelations/variableParameter/meanValue {o}
  - Type of conversion: Complex (direct).
  - Importance: Essential data. Mean value of equation. It is not converted for flows as flows already have this value in their structure
  - EcoSpold 2 correspondent fields:
    - ../parameter/@amount

- ../exchange/referenceToVariable {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Reference to a variable used in flow calculations. Used indirectly to identify the variable.

### 3.1.9. Flow Properties and Units

The definition of properties and units is essential for any quantitative value in LCI datasets. As such, both formats have different ways of structuring this information inside their datasets.

In ILCD, flow properties and units are tightly constructed as a unit is only a derivation of a specific flow property. ILCD have separate datasets for both, being the flowPropertyDataSet and the unitGroupDataSet. The flowPropertyDataSet is called from a flowDataSet for each property of that flow, including its main property

(which is equivalent to a unit, ex: flow property = mass and unit = kg). It is important to stress that flow property and unit group datasets are listed and cannot be created.

EcoSpold 2, on the other hand, has unit and property information splitted. Units are covered in each quantitative field as unitName and unitId, which limits the possible units for the ones actually in their master data. For properties, each flow can have multiple properties and each is a quantitative field (has amount, unit, uncertainty and comment).

For the conversion, each flowDataSet is opened and, for each flow property, an instance of the Property class is initiated. If the variable has the same internal ID as the value in the flowDataSet's 'referenceToReferenceFlowProperty', it is considered as a unit and proceeds to be converted as such. This process is overridden (specifically for when the internal ID matches) for elementary flows as the unit actually comes from the mapping file used in the conversion.

For the unit, the id of the flow property is used to convert, through a mapping list, the flow property to a unit name and id for EcoSpold 2.

For other properties, a series of steps is used for conversion:

- The properties undergo an initialization process. In it, the class is initiated with the basic values from the property (name, id) and is checked for correspondence in a mapping list from flow property id to equivalent property information from ecoinvent;
- If the property has ecoinvent information, this information is used to fill ecoinvent's structure. The amount and its uncertainty are gathered and unit name and id are passed to ecoinvent's structure. The comment is passed to the ecoinvent structure;
- If the option to convert properties directly from master data is active, Lavoisier uses the master data information to directly assess and fill the properties for EcoSpold 2, effectively avoiding the rest of the property conversion;
- The convertible properties pass through a series of modifications based on their values and of their flows. First, properties are parsed for a water content property, from which other ecoinvent

properties can be derived (such as wet mass, dry mass). Their amount and uncertainty are adjusted accordingly. Second, other content properties are converted to ecoinvent units of kg/kg and kg/m3 and specific equivalent property ids are used. If the flow does not have a unit of kg or m3, the property can be corrected by the dry mass if this property is available (with units of kg/kg). For all, the fields name, @propertyId, @amount are filled;

- Additional allocation properties are assessed and added to the flow in EcoSpold 2.

With this conversion, all properties and units are assessed for flows (including units from properties themselves).

The ILCD fields affected by this are:

- ../exchange/referenceToFlowDataSet/{@refObjectId and shortDescription} and [flowDataSet].../flowProperties/flowProperty/{referenceToFlowProperty} {r}
    - Type of conversion: Complex (indirect)
    - Importance: Essential data. Unit and property information
    - EcoSpold 2 correspondent fields:
        - ../exchange/unitName
        - ../exchange/@unitId
        - ../exchange/property/name
        - ../exchange/property/unitName
        - ../exchange/property/@unitId
        - ../exchange/property/@amount
        - ../exchange/property/@parameterId
        - ../exchange/property/comment
        - ../exchange/property/uncertainty

### 3.1.10. Uncertainty

In ILCD, the uncertainty structure is characterized by a mean value (for flows, it is the resulting value), an uncertainty type and three parameterization fields: maximum value, minimum value and standard deviation for 95% confidence interval. This structure appears (in the

processDataSet as an inventory without LCIA results) for flows and variable parameters. The use of this parameterization for all the distributions summarizes the information, but differs from the structure used in the EcoSpold 2.

The calculation structure for ILCD amounts is mounted as a complement to the Amount class. In that way, every amount can have uncertainty information initialized for further calculations without much boilerplate. Additionally, any conversion of the amount is stored as a factor to be used to adjust the uncertainty parameters after.

The EcoSpold 2 structure yields one specific parameterization for each distribution (beta, gamma, binomial, normal, lognormal, uniform, triangular and undefined). All ILCD possible distributions are inside the EcoSpold 2 possible distributions. Additionally, EcoSpold 2 has a specific field for Pedigree matrix coefficients and the variance with the Pedigree matrix accounted for. For all distributions, the EcoSpold 2 parameterization was derived from the ILCD fields and the variance and the variance with the pedigree matrix were considered equal for consistency with software. If additional Lavoisier information indicates that the ILCD process is converted from EcoSpold 2, the information from the Pedigree matrix is recovered and used to calculate the variance and the variance with the Pedigree matrix.

The conversion to EcoSpold 2 is specific for each uncertainty type.

### 3.1.10.1.   Lognormal

One of the staple distributions in LCA, the lognormal is widely used by ecoinvent association, especially regarding the Pedigree Matrix uncertainty attribution.

For the ILCD format, the distribution is characterized by the relative standard deviation for 95% range (for lognormal, it can be approximated as the square of its geometric standard deviation), the mean (median for lognormal), minimum and maximum values (considering 95% interpercentile range and calculated using the relative standard deviation).

Inside EcoSpold 2, the lognormal is parametrized by its median (or geometric mean; field meanValue) and the underlying normal distribution mean (mu), variance (variance), and variance with the Pedigree matrix (varianceWithPedigreeUncertainty) accounted.

The EcoSpold 2 parameters were calculated as:

$$\mu = ln(mean) \qquad (1)$$

$$meanValue = mean \qquad (2)$$

$$variance = ln(\sqrt{\sigma_{95ln}})^2 \qquad (3)$$

$$variance\_with\_pedigree = ln(\sqrt{\sigma_{95ln}})^2 \qquad (4)$$

### 3.1.10.2.  Normal

For the ILCD format, the distribution is characterized by the relative standard deviation for 95% range (for normals, it can be approximated as two times the standard deviation), the mean (median for lognormal), minimum and maximum values (considering 95% interpercentile range and calculated using the relative standard deviation).

Inside EcoSpold 2, the normal distribution is parametrized by its mean (field meanValue), the variance relative to the mean (variance), and the variance relative to the mean with the Pedigree matrix (varianceWithPedigreeUncertainty) accounted.

For this uncertainty type, the conversion factors that the amount (mean) passed throughout the conversion are stored (f) and used in the calculations. This way, the variance is corrected as well for the same conversion that the amount passed through.

The EcoSpold 2 parameters were calculated as:

$$meanValue = mean \qquad (5)$$

$$variance = (\frac{\sigma_{95ln} * f}{2})^2 \qquad (6)$$

$$variance\_with\_pedigree = (\frac{\sigma_{95ln} * f}{2})^2 \qquad (7)$$

### 3.1.10.3.  Triangular and uniform

Inside EcoSpold 2, the triangular distribution is parametrized by its mode (field mostLikelyValue), maximum and minimum values. Similarly, the uniform distribution is parametrized by its minimum and maximum values. Both distributions are parametrized in a similar manner in ILCD, so their conversion is direct.

For this uncertainty type, the conversion factors that the amount (mean) passed throughout the conversion are stored (f) and used in the calculations. This way, the variance is corrected as well for the same conversion that the amount passed through.

The EcoSpold 2 parameters were calculated as (mostLikelyValue is only for triangular):

$$minValue = minimumValue * f \qquad (8)$$

$$mostLikelyValue = mean \qquad (9)$$

$$minValue = maximumValue * f \qquad (10)$$

The ILCD fields covered in this conversion are:

- ../mathematicalRelations/variableParameter/uncertaintyDistributionType {o}
    - Type of conversion: Complex (indirect).
    - Importance: Essential data. Uncertainty.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/uncertainty
        - ../parameter/uncertainty

- ../mathematicalRelations/variableParameter/minimumValue {o}
    - Type of conversion: Complex (indirect).
    - Importance: Essential data. Uncertainty.

- - EcoSpold 2 correspondent fields:
      - ../flowData/…exchange/uncertainty
      - ../parameter/uncertainty

- ../mathematicalRelations/variableParameter/maximumValue {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Uncertainty.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/uncertainty
    - ../parameter/uncertainty

- ../mathematicalRelations/variableParameter/relativeStandardDeviation95In {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Uncertainty.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/uncertainty
    - ../parameter/uncertainty

- ../exchange/uncertaintyDistributionType {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Uncertainty.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/uncertainty
    - ../parameter/uncertainty

- ../exchange/minimumValue {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Uncertainty.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/uncertainty
    - ../parameter/uncertainty

- ../exchange/maximumValue {o}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Uncertainty.

- ○ EcoSpold 2 correspondent fields:
  - ../flowData/…exchange/uncertainty
  - ../parameter/uncertainty

- ../exchange/relativeStandardDeviation95In {o}
  - ○ Type of conversion: Complex (indirect).
  - ○ Importance: Essential data. Uncertainty.
  - ○ EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/uncertainty
    - ../parameter/uncertainty

### 3.1.11.   Flow

This section covers the conversion of other fields from the flows that were not assessed previously. In Lavoisier, ILCD flows are processed by the FlowConversion class. The FlowConversion class is initialized with all the 'exchange' information from ILCD, which is extracted as parameters.

After the flow class initialization, the flow conversion continues with opening the flowDataSet using the referenceToFlowDataSet information. In this step, the type of the flow is identified and the structures of either intermediate or elementary flow are gathered to be filled. Additionally, flow name, CAS, formula and property information are gathered. Flow property information is covered in the Flow Property and Units section.

In this step, flow conversion is different for elementary or intermediate flows. For elementary, conversion is done by using the mapping of elementary flows from ILCD to EcoSpold 2 from GLADs GitHub. This is done as both elementary flow lists cannot be extended freely and need to be converted from a specific id in ILCD to a specific id in EcoSpold 2. If no matching is found on the mapping, the conversion of the elementary flow is canceled and a log is made to indicate failure on the conversion.

For elementary flows, information from the mapping table is used to fill the fields in EcoSpold 2. This information includes the id, name, CAS, synonyms, formula, compartment and subcompartment,

uncertainty (explained better in the Uncertainty section), unit and properties (explained better in the section Flow Properties and Units). The conversion factor, when existent, is used to adjust the amount and uncertainty of the flow.

For intermediate flows, information from the flowDataSet and processDataSet are used to fill the fields. In this step, id, name, CAS, synonyms, uncertainty (explained better in the Uncertainty section), unit and properties (explained better in the section Flow Properties and Units).

Flow classifications are not converted to EcoSpold 2 for the same reason explained in the Classification section.

Finally, all convertible flows pass through a final round of conversions. In this step the amounts and comments are filled and the reference flow logic begins. In this, information about the type, the direction and if the flow is a reference flow (the @dataSetInternalId of the flow matches the referenceToReferenceFlow field) are used to assign the input- or outputGroup fields. For it, the following rules apply:

- If it is the reference flow: outputGroup = 0
- If direction is input and type is 'Elementary flow': inputGroup = 4
- If direction is input and type is not 'Elementary flow': inputGroup = 5
- If direction is output and type is 'Elementary flow': outputGroup = 4
- If direction is output and type is 'Waste flow': outputGroup = 3
- If direction is output and type is not 'Elementary flow' and not 'Waste flow': outputGroup = 2

Final logic for variables, properties and sources are done and the flow is converted. It is worth mentioning that the only information from the ILCD field quantitativeReference converted is the referenceToReferenceFlow. Location information is converted indirectly to EcoSpold 2 as there are no fields for this information at a flow level. Additional information such as functionType, dataSourceType and

dataDerivationTypeStatus are converted indirectly to the flow comment field.

The ILCD fields that passes through this conversion are:

- ../quantitativeReference/referenceToReferenceFlow {r}
    - Type of conversion: Complex (indirect).
    - Importance: Essential data. Indicates the reference flow.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/outputGroup

- ../exchange/@dataSetInternalID {r}
    - Type of conversion: Complex (indirect).
    - Importance: Essential data. Identifies the flow internally, helping to find the reference flows.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/outputGroup

- ../exchange/@dataSetInternalID {r}
    - Type of conversion: Complex (indirect).
    - Importance: Essential data. Identifies the flow internally, helping to find the reference flows.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/outputGroup

- ../exchange/location {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Essential data. Geographical information of the flow.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/comment

- ../exchange/functionType {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../flowData/…exchange/comment

- ../exchange/exchangeDirection {r}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Indicates if the flow is input or output
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/inputGroup
    - ../flowData/…exchange/outputGroup

- ../exchange/meanAmount {r}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Mean amount of the flow (before variable parameter correction). Used in the calculations.

- ../exchange/resultingAmount {r}
  - Type of conversion: Complex (indirect).
  - Importance: Essential data. Final amount of the flow (after variable parameter correction).
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/@amount

- ../exchange/dataSourceType {o}
  - Type of conversion: Complex (incomplete).
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/comment

- ../exchange/dataDerivationTypeStatus {o}
  - Type of conversion: Complex (incomplete).
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../flowData/…exchange/comment

- ../exchange/dataDerivationTypeStatus {o}
  - Type of conversion: Complex (incomplete).

- ○ Importance: Other metadata.
- ○ EcoSpold 2 correspondent fields:
    - ■ ../flowData/…exchange/comment

- ● ../exchange/generalComment {o}
    - ○ Type of conversion: Complex (direct).
    - ○ Importance: Other metadata.
    - ○ EcoSpold 2 correspondent fields:
        - ■ ../flowData/…exchange/comment

### 3.1.12. Timestamp and Versioning

To maintain the file versioning from the ILCD file, some considerations had to be done during the conversion. File versions are handled in EcoSpold 2 as four integer fields with minor and major revisions and releases. For ILCD, the field dataSetVersion uses a string for versioning in which the two first numbers are for major updates, the two middle numbers are for minor revisions, and the final three numbers are for automatic counting (01.01.001, for example).

In this conversion, the ILCD major updates (two first digits) were converted to the EcoSpold 2 majorRelease attribute, and the ILCD minor revisions (two middle digits) were converted to the EcoSpold 2 minorRevision.

It is highlighted here that the use of only major fields in the conversion comes from their resetting property over the minor fields every time they update. With that, there is a chance of two versions of different ILCD processes being converted to the same version of the EcoSpold 2 process.

The ILCD fields involved in the conversion were:

- ● ../administrativeInformation/publicationAndOwnership/dataSetVersion {m}
    - ○ Type of conversion: Complex (direct).
    - ○ Importance: Essential metadata. Versioning.
    - ○ EcoSpold 2 correspondent fields:
        - ■ ../fileAttributes/@majorRelease

■ ../fileAttributes/@minorRevision

Lavoisier has the capacity of identifying the information from review versions related to EcoSpold 2 review structure and converting them.

ILCD has two major timestamps: the timeStamp field and the dateOfLastRevision field. The timeStamp field identifies the creation of the dataset and is directly converted to the @creationTimestamp field in EcoSpold 2. For the dateOfLastRevision, the information was not converted as there was no proper field. The field @lastEditTimestamp received the conversion date.

The ILCD fields in this conversion were:

- ../administrativeInformation/dataEntryBy/timeStamp {r}
  - Type of conversion: Complex (direct).
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../fileAttributes/@creationTimestamp

- ../administrativeInformation/publicationAndOwnership/dateOfLastRevision {r}
  - Type of conversion: Complex (not converted).
  - Importance: Other metadata.

### 3.1.13.  Review

Review fields are important to assure the quality of the data, and both ILCD and EcoSpold 2 treat reviews using a set of similar structures.

For ILCD the structure has more fields in the form of a set of indicators based on a structure of scopes and methods, each one with a set of quality indicators for which the dataset was assessed in the review. Aside from that, the field has two major comment sections with review details, which EcoSpold 2 has as well (covered in the General comment sections' section). EcoSpold 2 has additional fields for date and version of the review.

The ILCD indicator information for each review is transformed to text and placed in the review details' text in EcoSpold 2. For the date, a default date (01/01/1990) is placed as a placeholder as no information is available in ILCD and the field is required in the EcoSpold 2 format. As for the review version, the default 1.0.1.0 is assumed for the major and minor releases and revisions. If Lavoisier specific information is present, the date and versions are gathered from specific text strings placed by Lavoisier when converting the original EcoSpold 2.

The ILCD fields considered in this conversion were:

- ../modellingAndValidation/validation/review/@type {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../review/details/text

- ../modellingAndValidation/validation/review/scope/@name {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../review/details/text

- ../modellingAndValidation/validation/review/scope/method/@name {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../review/details/text

- ../modellingAndValidation/validation/review/dataQualityIndicators/dataQualityIndicator/@name {o}
    - Type of conversion: Complex (incomplete).
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../review/details/text

- ../modellingAndValidation/validation/review/dataQualityIndicators/dataQualityIndicator/@value {o}
  - Type of conversion: Complex (incomplete).
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../review/details/text

## 3.2. Direct conversions

These fields are converted simply by copy-pasting the ILCD field text in an EcoSpold 2 field. The ILCD fields that underwent that type of conversion in Lavoisier are the following:

- ../dataSetInformation/synonyms {o}
  - Type of conversion: Direct.
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../activity/synonym

- ../geography/locationOfOperationSupplyOrProduction/@location {r}
  - Type of conversion: Direct.
  - Importance: Essential data. Use mappings to gather geographyId
  - EcoSpold 2 correspondent fields:
    - ../geography/shortname
    - ../geography/@geographyId

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/percentageSupplyOrProductionCovered {r}
  - Type of conversion: Direct.
  - Importance: Essential data. Percentage of market share.
  - EcoSpold 2 correspondent fields:
    - ../modellingAndValidation/representativeness/percent

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentat iveness/dataCollectionPeriod {o}
    - Type of conversion: Direct.
    - Importance: Other metadata.
    - EcoSpold 2 correspondent fields:
        - ../modellingAndValidation/representativeness/samplin gProcedure

- ../administrativeInformation/publicationAndOwnership/copyright {r}
    - Type of conversion: Direct.
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:
        - ../administrativeInformation/dataGeneratorAndPublica tion/isCopyrightProtected

### 3.3. Indirect conversions

Lavoisier uses mappings or data modifications for indirect conversions of fields. As such, the information in these fields undergo some transformation before their assignment to an EcoSpold 2 field or serve as supporting information for other field conversions. The ILCD fields that underwent that type of conversion in Lavoisier are the following:

- ../time/referenceYear {r}
    - Type of conversion: Indirect.
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:
        - ../timePeriod/@startDate
    - Obs: Year transformed to date by considering 01/01/Year

- ../time/dataSetValidUntil {r}
    - Type of conversion: Indirect.
    - Importance: Essential metadata.
    - EcoSpold 2 correspondent fields:

- ../timePeriod/@endDate
  - Obs: Year transformed to date by considering 31/12/Year

- ../modellingAndValidation/LCIMethodAndAllocation/typeOfData Set {r}
  - Type of conversion: Indirect.
  - Importance: Essential metadata.
  - EcoSpold 2 correspondent fields:
    - ../activity/@type
  - Obs: Follows the table:

| Unit process, single operation | 1 |
|---|---|
| Unit process, black box | 1 |
| LCI result | 2 |
| Partly terminated system | 1 |
| Avoided product system | 1 |

- ../modellingAndValidation/LCIMethodAndAllocation/LCIMethodA pproaches {r}
  - Type of conversion: Indirect.
  - Importance: Essential metadata.
  - EcoSpold 2 correspondent fields:
    - ../modellingAndValidation/representativeness/system ModelId
    - ../modellingAndValidation/representativeness/system ModelName
  - Obs: Follows the table (uses, as default, the 'Undefined'):

| Allocation - market value | Allocation by revenue |
|---|---|
| Allocation - gross calorific value | Undefined |
| Allocation - net calorific value | Undefined |

| | |
|---|---|
| Allocation - exergetic content | Undefined |
| Allocation - element content | Undefined |
| Allocation - mass | Allocation by dry mass |
| Allocation - volume | Undefined |
| Allocation - ability to bear | Allocation by revenue |
| Allocation - marginal causality | Undefined |
| Allocation - physical causality | Undefined |
| Allocation - 100% to main function | Allocation, cut-off by classification |
| Allocation - other explicit assignment | Allocation, manually linked |
| Allocation - equal distribution | Allocation, manually linked |
| Substitution - BAT | Undefined |
| Substitution - average, market price correction | Allocation at the point of substitution |
| Substitution - average, technical properties correction | Substitution, constrained by-products |
| Allocation - recycled content | Undefined |
| Substitution - recycling potential | Undefined |
| Substitution - average, no correction | Substitution, constrained by-products |
| Substitution - specific | Substitution, constrained by-products |
| Consequential effects - other | Substitution, consequential, long-term |
| Not applicable | Undefined |
| Other | Undefined |

- ../administrativeInformation/publicationAndOwnership/workflowA
  ndPublication {o}
  - Type of conversion: Indirect.
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../administrativeInformation/dataGeneratorAndPublica
      tion/dataPublishedIn
  - Obs: Follows the table:

| | |
|---|---|
| Working draft | 0 |
| Final draft for internal review | 0 |
| Final draft for external review | 0 |
| Data set finalised; unpublished | 0 |
| Under revision | 0 |
| Withdrawn | 0 |
| Data set finalised; subsystems published | 1 |
| Data set finalised; entirely published | 2 |

### 3.4.  Incomplete conversions

Incomplete conversions are defined as reallocation of ILCD information that has no corresponding field in EcoSpold 2 to related comment sections. This is related to the loss of functionality due to the specific field purposes in ILCD that could not be matched in EcoSpold's structure. Lavoisier uses this type of conversion as a workaround since the direct or indirect conversion is not possible due to the lack of proper EcoSpold 2 fields that could encompass the same information. The ILCD fields that underwent that type of conversion in Lavoisier are the following:

- ../administrativeInformation/commissionerAndGoal/project {o}
  - Type of conversion: Incomplete.
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../activity/generalComment/text

- ../administrativeInformation/commissionerAndGoal/intendedApplications {r}
  - Type of conversion: Incomplete.
  - Importance: Other metadata.
  - EcoSpold 2 correspondent fields:
    - ../activity/generalComment/text

## 3.5. Not converted

These fields' information was not converted to EcoSpold 2. They are represented by 6 classes:

- ILCD 'other' fields for additional information that are rarely used
- ILCD LCIAResults structure, which is not often used in an ILCD inventory. Still, this is considered loss of information if an ILCD that goes beyond just inventory usage uses Lavoisier for its conversion.
- ILCD references to contacts and sources that do not have a proper generic field to be accommodated in EcoSpold 2. This is considered loss of information.
- ILCD Classifications. This is considered a loss of important information.
- ILCD specific entries for quality and compliance. These entries are specific for ILCD and not used in EcoSpold 2 as their context differs. This is considered a loss of important metadata.
- Other specific ILCD fields with additional metadata.

Some fields can be considered as loss of information as they comprise valuable metadata. Nevertheless, no essential data was not converted.

Fields not converted with loss of information usually are the ones related to extra fields added by ILCD to cover their purposes (compliance and quality), fields that had poor mappings (such as classifications) and fields with no generic entry in EcoSpold 2 (such as references).

Additionally, the elementary flow list from ILCD is considered much larger than the EcoSpold 2 one. This causes a considerable percentage of elementary flows to not be converted as they could not be mapped. This issue is outside the scope of Lavoisier and enters the realm of harmonization efforts.

The ILCD fields that underwent that type of conversion in Lavoisier are the following:

- ../quantitativeReference/@type {r}
    - Type of conversion: Complex (not converted).
    - Importance: Other metadata. Characterizes what type is the reference flow, but does not indicate which one is.

- ../quantitativeReference/functionalUnitOrOther {r}
    - Type of conversion: Complex (not converted).
    - Importance: Other metadata. Extra information about the reference flow.

- ../geography/locationOfOperationSupplyOrProduction/@latitude AndLongitude {o}
    - Type of conversion: Not Converted.
    - Importance: Other metadata.

- ../geography/subLocationOfOperationSupplyOrProduction/@loca tion {o}
    - Type of conversion: Not Converted.
    - Importance: Other metadata.

- ../geography/subLocationOfOperationSupplyOrProduction/@latituteAndLongitude {o}
  - Type of conversion: Not Converted.
  - Importance: Other metadata.

- ../modellingAndValidation/LCIMethodAndAllocation/LCIMethodPrinciple {r}
  - Type of conversion: Not Converted.
  - Importance: Essential metadata.
  - Obs: Converted directly in LCIMethodApproaches.

- ../modellingAndValidation/dataSourcesTreatmentAndRepresentativeness/annualSupplyOrProductionVolumed {o}
  - Type of conversion: Not Converted.
  - Importance: Other metadata.
  - Obs: Production Volume.

- ../administrativeInformation/publicationAndOwnership/permanentDataSetURI {r}
  - Type of conversion: Not Converted.
  - Importance: Other metadata.
  - Obs: Similar to imageURL in EcoSpold 2, but not an image.

- ../administrativeInformation/publicationAndOwnership/registrationNumber {r}
  - Type of conversion: Not Converted.
  - Importance: Other metadata.