

Special Issue: Inventory Database

[Commentary and Discussion]

ecoinvent – An Introduction to the LCI Database and the Organization Behind itEmilia MORENO-RUIZ¹, Lucia VALSASINA^{1,*}, Carl VADENBO¹ and Avraam SYMEONIDIS¹¹ ecoinvent Association

*Corresponding author: valsasina@ecoinvent.org

Synopsis: The year 2023 marks both the tenth anniversary of the ecoinvent association and twenty years since the first release of the ecoinvent life cycle inventory (LCI) database. In this article, we reflect on the achievements of ecoinvent and its LCI database to date, introduce its main features and application areas, and invite the LCA community in Japan and more broadly to engage and benefit from the resources and support provided. Through continuous development and updates, the ecoinvent database has evolved into a valuable resource for LCA practitioners worldwide, offering reliable, transparent, and consistent background data to support sustainable decision-making and environmental assessments. Looking forward ecoinvent plans to enhance its data framework, collaborate with global data providers, improve user-friendliness, facilitate data exchange, and support future extensions to advance sustainable decision-making worldwide.

Keywords: life cycle assessment (LCA); life cycle inventory (LCI) data; LCI background database; regionalisation; ecoinvent

1. Introduction

In June 2023, the ecoinvent association is celebrating its tenth anniversary. This milestone is closely followed by the two-decade mark since the first release of the ecoinvent life cycle inventory (LCI) database. This article reflects on the achievements so far and outlines what comes next, highlighting links or aspects of relevance to the life cycle assessment (LCA) community of Japan and the Asia-Pacific region.

The creation of the ecoinvent database in Switzerland shares key similarities and roughly the timeline with Japan's national LCI/LCA database initiatives. The IDEA database of Japan (and its predecessors) and ecoinvent both sprung out of public research institutes and have remained under the governance or closely associated with the founding institutions. Both databases have also evolved from primarily focusing on products and processes in the national context to increasingly providing data on global supply chains. While direct collaboration between the initiatives has been limited, representatives from the organizations have worked together on various projects and working groups within the UNEP/SETAC Life Cycle Initiative and most recently for the Global LCA Data Access (GLAD) network.

Initially, LCAs mainly focused on assessing the environmental impact of products and services. This remains a major area of application, but LCA is also increasingly being used to drive transformative strategies such as decarbonization, transitioning to a circular economy, and promoting sustainable consumption and finance (Hellweg et al. 2023). Recent examples include Japan's national Green Growth Strategy (METI 2021) and the International Maritime Organization's MEPC 80 resolutions (IMO 2023) for the shipping industry. Expanding uptake and new applications of LCA means that the demand for, and expectations on, LCI data and background databases is evolving quickly.

The purpose of the article is to introduce ecoinvent (both organization and database) to the LCA community in Japan and the wider Asia-Pacific region. Next, we provide a historical overview of ecoinvent and its current organization. This is followed by an overview of the main features, application areas, and data coverage of the ecoinvent LCI database, highlighting selected sectors. The article also summarizes other activities undertaken by the ecoinvent association and how the global LCA community can engage with and receive support from the organization. Finally, we offer an outlook with ambitions

and some examples of how ecoinvent aims to meet evolving user needs and expectations.

2. Background – The History of ecoinvent

The origins of the ecoinvent database dates back to the 1990s when Swiss Federal Offices and research institutes collaborated on projects to generate LCI data. These initiatives, such as the BUWAL250 data pool, provided structured information on Swiss supply chains for packaging, energy systems, transport, and waste treatment services. In 2000, the ecoinvent project was launched to harmonize, update, and expand the LCI data, resulting in the release of the initial versions of the ecoinvent database in 2003 and 2004 (Frischknecht et al. 2005).

Following the project's success, the ecoinvent Centre was established and hosted by the Swiss Federal Laboratories for Material Science and Technology (Empa). A complete revision and extension of the database led to the release of ecoinvent version 2 in 2007 (Frischknecht et al. 2007; Hedemann and König 2007), followed by subsequent updates in 2009 and 2010. By this point, the ecoinvent database had become one of the most widely used sources of background data in LCA worldwide.

The goal for the next generation of the database, known as version 3, was to further develop the technological foundation and methodological basis (Weidema et al. 2013; Wernet et al. 2016). The aim was to support the regionalization of data and enhance its applicability globally. Version 3 of the ecoinvent database was first released in May 2013, and yearly updates have been made since. Concurrently, ecoinvent transformed into an independent, not-for-profit association with five founding members: the Swiss Federal Institutes of Technology in Zurich and Lausanne (ETH Zurich and EPFL, respectively), the energy research institute Paul Scherrer Institute (PSI), Empa, and Agroscope, the Swiss Federal agricultural research organization.

3. About the Organization

Since its inception, the ecoinvent association has been a mission-driven organization, independent from political, ideological, and private sector interests. The founding members from the Swiss federal research institutions continue to support the work of the association through their representatives on the ecoinvent board and in a

technical expert group. Activities are funded through the license fees for the ecoinvent database as well as over project-based incomes. All revenues are reinvested into the development and maintenance of the association's products and services. Starting from only a handful of staff at the outset, the ecoinvent team has grown steadily (exceeding 50 people in mid-2023) to include a wide range of nationalities and cultural backgrounds. With education and expertise spanning from environmental studies and LCA expertise, software development, various aspects of business and product development, communications and marketing, as well as finance and administration, the ecoinvent team is committed to the organization's mission to promote and support the availability of high-quality data for sustainability assessments worldwide.

4. The ecoinvent Database

4.1 Overview

Background data and LCI databases play a critical role in LCA by providing the foundation and reducing the effort for conducting comprehensive and accurate environmental assessments. Background data refers to the inventory data and information related to processes, materials, and energy flows that are not directly under the influence or associated with the specific product or system being assessed. These datasets serve as the building blocks for LCA studies, enabling the assessment to include upstream and downstream impacts across the entire life cycle of a product or process (UNEP 2011).

As a background database of global scope, the ecoinvent database covers a wide range of industrial sectors and is used worldwide by thousands of users from academia to industry as a supporting tool for decision-making, and for the implementation of studies, such as Life Cycle Assessment (LCA), Greenhouse Gas (GHG) reporting, Environmental Product Declarations (EPDs), Sustainable Product Design, Corporate Sustainability Reporting, etc.

The key feature of the ecoinvent database is its modularity, as the database is built on fully documented individual unit processes. A unit process is the smallest element in the LCI analysis, for which input and output data are quantified (ISO 2006a). In ecoinvent, each unit process is generated as Undefined, that is, valid independently of certain methodological choices, e.g., allocation,

which derives from the goal of a study. LCA is a tool that can be used to answer various types of questions, which in turn will require different methodological approaches and normative choices. The main international guiding standards for LCA, i.e., ISO14040 (ISO 2006a)/14044 (ISO 2006b), are equivocal on several central aspects, leaving flexibility that has resulted in various interpretations especially regarding allocation and the applicability of attributional and consequential modelling (Schrijvers et al. 2016; Weidema 2018; Heijungs et al. 2021).

The ecoinvent database is calculated by applying three different system models to those Undefined unit processes. Two models follow the attributional approach, “Allocation, cut-off by classification” and “Allocation at the point of substitution”. In contrast, the “Substitution, consequential, long-term” is based on the consequential approach. Since the release of version 3.8 (2022) a fourth system model has been introduced, “Allocation, cut-off, EN15804”. This system model has been developed to support the generation of Environmental Product Declarations (EPDs), following the attributional interpretation of EN15804 (European Committee for Standardization 2012), ISO21930 (ISO 2017), and ISO14025 (ISO 2006c). The modularity of the ecoinvent database, therefore, allows for catering to different methodologies and standards as well as integration into or connections with other systems, data, and databases. Interconnections are also enabled by the transparency of the data, which allows for traceability across the supply chain.

Each activity (process) in the database is classified as transforming or market activity. Transforming activities transform inputs into outputs (e.g., a hard coal mine that extracts hard coal in the ground to deliver the marketable product hard coal). Market activities represent the trading of a product from producer to consumer, including transport and eventual losses. Markets represent consumption mixes (marginal in the consequential system model) for a product in a specific region.

The latest version of the ecoinvent database (version 3.9.1, published in 2022) contains over 3,500 distinct products, including raw materials and commodities, (semi-)finished goods, and services. For each product, “product information”¹⁾ is provided as well as properties²⁾. Properties allow for assessing balances of water, mass, and carbon, and therefore to calculate carbon and water footprints.

All products, except waste materials, are assigned a price. Prices are used for economic allocation and can be applied in simplified life cycle cost analysis (without externalities and human resource consumption).

Dataset documentation includes information regarding the process in general, the technology, the boundaries of the activity, authors, and references. Each exchange (flow) in an activity is assigned uncertainty and other supporting information is encouraged, such as comments, mathematical relations, variable names, etc. The database employs the International Standard Industrial Classification (ISIC) system and the Central Product Classification (CPC) system to categorize and organize the economic sectors and products covered by the database.

Data is provided to the ecoinvent database by different actors. The main source of data is data collected by organizations such as industry, industry associations, and governmental initiatives. Data is also created based on ad-hoc models developed by academia or consultants. Lastly, the ecoinvent team is constantly engaged in the maintenance, development, and harmonization of the data to ensure that methodologies are properly implemented, and that data is consistent across different technologies and sectors.

Data and database quality are not only assured by the ecoinvent team but also by external experts who are entrusted with the review of the inventories and overall adherence to rigorous quality standards. Experts are also called to support the ecoinvent team in larger

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- 1) Since v3.9, all products in the database come with a description to support users in choosing inputs or outputs for their modelling. Products are defined from a physical perspective and key properties are presented, e.g., related to its appearance, dimensions, and other physical characteristics. The product information feature strictly reflects the products as they are defined and produced from processes available in the database. Products may as well refer to service provision. In that case, the unit of the service offered may not be intuitive directly. The product information offers a service description that helps users understand the most crucial parameters related to the provision of a service. Additional guidance is in some instances offered on how the product should be applied within LCA models.
 - 2) Products (with a mass) have six mandatory properties: dry mass, wet mass, water content, water in wet mass, biogenic and fossil carbon. Additional properties are added according to product specificities, e.g., metal content of metal ore, lifetime and lifetime capacity of built infrastructure, or energy content of energy carriers.

methodological discussions and choices to ensure the accuracy, reliability, and consistency of the data included in the database. This independent review service is offered for free by ecoinvent.

The ecoinvent database is released yearly and with each release, a Report of Changes is published, where all updated and new data is reported. Additional files are provided to ease access to information, e.g., the market shares file, which summarizes all consumption mixes. Finally, a correspondence file is available to all users and software tools that implement ecoinvent. This file maps all activities from the previous to the subsequent version of the database, thereby providing support for updating ongoing projects and studies.

4.2 Data Format

The ecoinvent database is available in the ecoSpold2 format, which is an XML-based format (Meinshausen et al. 2016; ecoinvent n.d.). The four types of data, i.e., Undefined and linked UPRs, LCI, and LCIA, are published for access/download on ecoQuery, ecoinvent's web-interface. While the Undefined version is only available on ecoQuery, the other types of data are integrated into the main LCA software tools.

Parts of the ecoinvent database are also available in the .xlsx-format. Files in the .xlsx-format include the cumulative LCI- and the cumulative LCIA-files, which are available for download for license holders. Other parts of the database, such as the list of datasets in each system model, and lists of intermediate and elementary exchanges, are provided on ecoinvent's website (ecoinvent 2023).

4.3 Database Content Highlights and Outlooks

Version 3.9.1 of the ecoinvent database contains 18,740 activities (as Undefined datasets). About two-thirds of the datasets are transforming activities, and the rest are market activities or market groups. As illustrated in Figure 1, Europe has the highest share of regionally specific datasets (32% of the total, including global and rest-of-the-world RoW activities). The coverage for Latin America (8%), Asia (7%), and North America (6%) is comparable in terms of number of datasets, but while agriculture makes up the largest sector in Latin America, utilities (mainly electricity and gas) dominate in the other two regions. Within Asia, China constitutes about

half of the datasets.

The relevance of the global activity coverage, introduced with version 3 in 2013, was discussed by Steubing et al. (2016). This was considered an important step towards a global LCI database, especially for more accurate representation of supply chains with large regional variations such as inputs of electricity. But the authors also emphasized further regionalization to decrease the influence of RoW datasets. Since then, the goal for each new release has been to enhance the geographical and technological coverage with new data, alongside maintaining and updating existing datasets. In the rest of this section, we present highlights and outlooks for selected sectors in the database based on the content of the latest (v3.9.1 in 2022) and upcoming releases.

4.3.1 Agriculture and Forestry

The agriculture sector in the ecoinvent database comprises more than 2,400 datasets, covering the growing of perennial and non-perennial crops, production of seedlings, transportation, animal husbandry, fishery, supporting activities, and treatment of various by-products. The geographies covered include more than 40 countries and various regions within countries. Additional datasets, belonging to other sectors but contributing almost exclusively to the agricultural sector (e.g., fertilizer and pesticide production, textile-fiber crops, and irrigation), are available.

Looking forward, new datasets are expected for Australia and the United States, covering additional crops and more precise geographies (i.e., at state-level). For Australia, data will be added for barley, wheat, rapeseed, maize (non-irrigated), and oat, while potato, sweet corn, soybean, and maize are foreseen for the US. Additional field operation activity data used in the above-mentioned datasets will also be introduced.

Australia, Brazil, and the US are among the ten most significant exporters of food products to Japan, crucially for cereal grains and oilseeds import (World Bank n.d.). The USA is Japan's primary corn supplier, but Brazil's share increased during the winter of 2019-2020, reaching over 70% of the market (USDA 2020). Brazil also served as Japan's major coffee supplier until 2021 (OEC 2023). Canada and Australia contribute 90% and 9%, respectively, of the oilseeds (rape/colza seeds) imported by Japan from the global market (World Bank n.d.).

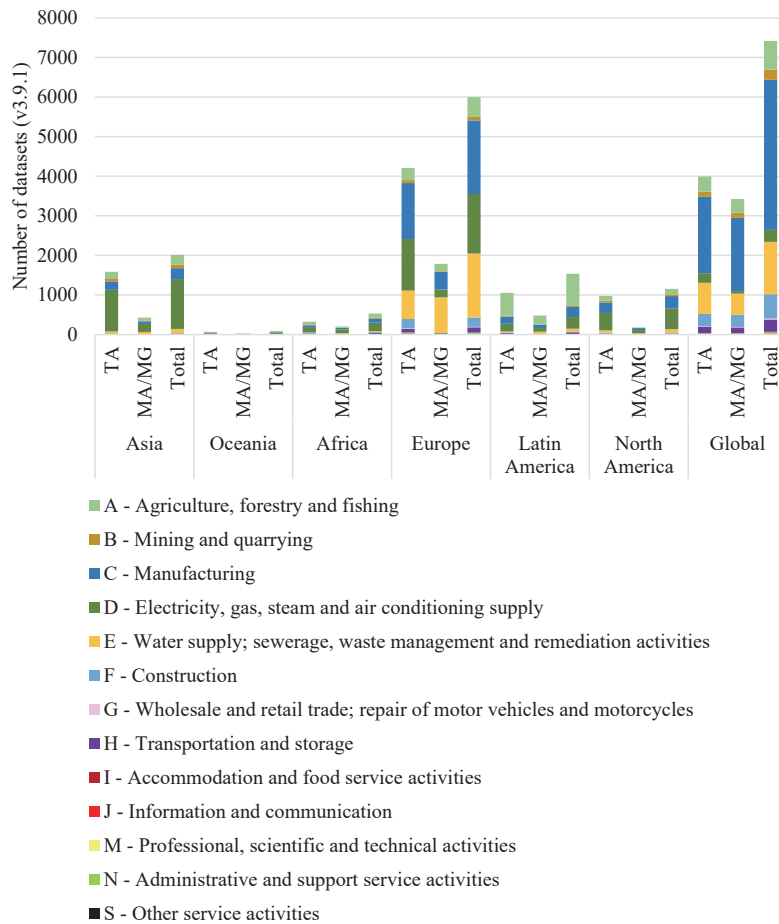


Figure 1 count of datasets available in the ecoinvent database (v3.9.1), before linking ('undefined'), split into transforming activities (TA), market and market group activities (MA/MG), and a total number of datasets.

Furthermore, ecoinvent has partnered with Ademe/Agribalyse³⁾. Beyond data exchanges, the collaboration encompasses the development of new datasets, methodological improvement, and alignment on agricultural modeling and nomenclature used in LCIs. France is also among the top 10 exporters of food to Japan based on the cited sources.

4.3.2 Electricity Generation and Supply

Since v3.9, all electricity mixes in the ecoinvent database are updated with every new release (except for the consequential system model; see Figure 2). Currently, more than 3,500 datasets in over 250 geographies model electricity supply and consumption, covering electricity generation including power plants, transformation, transmission, distribution, and use. A wide range of fossil,

renewable as well as secondary electricity production datasets are available.

With v3.9.1, the State Grid Corporation of China (CN-SGCC) subregion was split into six subregions adding more granularity to Chinese electricity mixes. Furthermore, residual mixes were introduced for most European countries for compliance with various standards. The mixes are calculated based on statistics from the Association of Issuing Bodies (AIB) following the methodology of Grexel (Kuronen et al. 2020). Due to data limitations outside of Europe, the country-specific residual mixes provided so far only encompass EU27 members, Great Britain, Iceland, Norway, Serbia, and Switzerland.

The attributional and consequential system models assume different electricity mixes for the calculation of their results. The cut-off and APOS attributional system model contain specific electricity mixes for 142 countries, representing 100% of statistically represented global

3) <https://agribalyse.ademe.fr/>

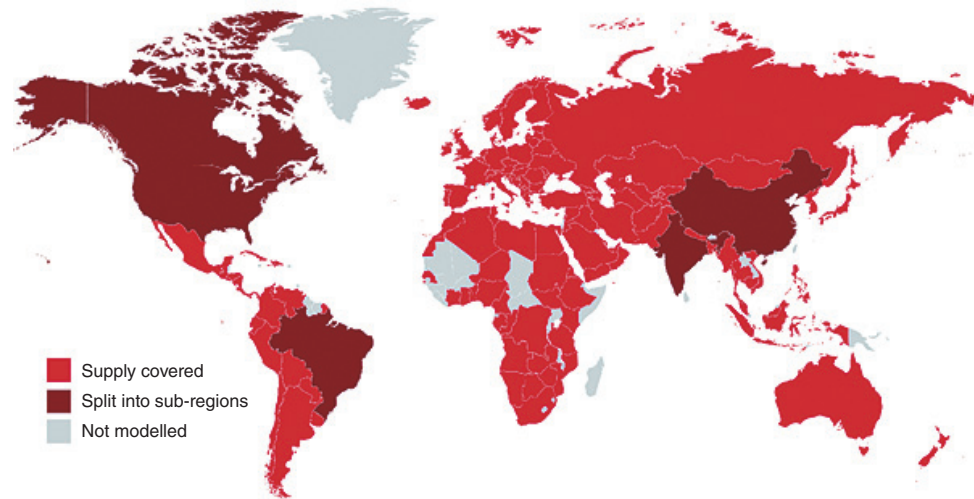


Figure 2 Map of geographical coverage of electricity markets in the ecoinvent database (in version 3.9.1, 2022) in for the attributional system models Cut-off and APOS.

electricity generation. Several large countries such as Brazil, Canada, China, India, and the USA are split into subregions or grids based on national statistics (see Figure 2). The electricity mixes in the consequential system model are based on projections of future electricity market compositions of 40 countries, including Japan and China. Together these countries represent 76.5% of the global electricity generation (Vandepaer 2019).

Table 1 summarizes the reference years for electricity supply in all versions of the ecoinvent database from v3.01 onwards including the release in 2023. The reference years correspond to the fiscal years of the individual countries according to the documentation of the IEA World Energy Balances (IEA 2022a).

4.3.3 Petroleum Oil and Natural Gas

Crude petroleum oil, and increasingly also natural gas, are among the most important commodities traded globally. The ecoinvent database provides data on the extraction, transport, and refining of crude petroleum oil to liquid and gaseous fuels, as well as other refined petroleum products. An extensive overhaul for version 3.9 increased data coverage to 27 major production countries. Taken together, they represented approximately 90% of the global production of petroleum and nearly 80% of natural gas output in 2019 (BP 2022). Oil and gas extraction in v3.9 is modeled using a common approach based on country- or regional statistics from datasets of global scope (BP 2022; IEA 2022b; IOGP 2020; World Bank 2022), to ensure consistency between the geographies covered

in the database. The production of crude petroleum oil and natural gas is modeled as the average combined production of oil and gas, distinguishing between offshore and onshore operations, for each country. Natural gas supply (at high pressure) is provided for 44 countries in v3.9, based on the situation in 2019. This included Japan and China, but high dependence on LNG imports from Australia (not available in v3.9) limited the representativeness of these markets. Improving the geographical coverage to enable better consumption mixes in major economies in Asia and Latin America, therefore, became a key objective for subsequent updates.

The release in 2023 will include further countries of production and reflect the supply situation in 2021. Through the addition of countries like Australia, Oman, or Turkmenistan, the modeled gas imports to Japan, South Korea, and China reflects 89%, 98%, and 92%, respectively, of total imports in 2021 (Table 2).

4.3.4 Chemicals and Plastics

The ecoinvent database's chemicals and plastics sector contains over 1,900 datasets covering a wide range of bulk, specialty, and fine chemicals, including monomers used in plastics manufacturing. The sector encompasses data on diverse categories, including fertilizers and pesticides, ink and paints, plastics and rubber, cleaning agents, and bulk and specialty chemicals.

The chemical sector, responsible for 40% of the total demand for hydrogen in both pure and mixed forms, also generates a substantial amount of by-product hydrogen.

Table 1 Validity of electricity market mixes for versions 3.01 up to the release in 2023 of the ecoinvent database.

Version Release year		v3.0 2013	v3.1 2014	v3.2/ v3.3 2015	v3.4/ v3.5 2017	v3.6 2019	v3.7.1 2020	v3.8 2021	v3.9 2022	v3.10 2023
Attributional electricity markets and production mixes	BR (4 sub-grids)					2014	2014	2014	2020	2021
	CA (provincial level)				2014	2014	2018	2019	2020	2021
	CH				2014	2017	2017	2019	2020	2021
	CN (7 sub-grids, 2 sub-grids up to v3.8)			2012	2014	2014	2014	2014	2020	2021
	IN (5 sub-grids)				2016/17*	2016/17*	2016/17*	2016/17*	2019/20*	2020/21*
	US (8 NERC regions)				2014	2016	2018	2019	2020	2021
	remaining markets	2008	2008	2012	2014	2016	2017	2018	2019	2020
Residual mixes	EU28, CH, IS, NO, RS								2021	2022
Marginal electricity mixes (consequential)					2017 vs. 2030**	2017 vs. 2030**	2017 vs. 2030**	2017 vs. 2030**	2017 vs. 2030**	2017 vs. 2030**

* The fiscal year in India starts on the 1st April of year x and ends on the 31st March of year x+1 and is reported as x/x+1.

** See Vandepaer et al. (2019) for details.

Table 2 Overview of the supply of natural gas to Japan, South Korea, and China in v3.10 in the release of 2023 of the ecoinvent database (2023), based on BP (2022).

	Japan		South Korea		China	
	total	of which LNG	total	of which LNG	total	of which LNG
Indigenous production	2.4*	-	0.0	-	209.2	-
Import, total	101.3	100%	64.1	100%	162.7	67%
Export, total	-	-	-	-	5.4*	-
Consumption	103.6	-	62.5	-	378.7	-
Share of imports by partner country						
United Arab Emirates	2%	100%	1%	100%	1%	100%
Australia	36%	100%	20%	100%	27%	100%
Algeria	0%	0%	0%	0%	0%	100%
Egypt	0%	100%	0%	100%	1%	100%
Indonesia	3%	100%	5%	100%	4%	100%
Kazakhstan	0%	0%	0%	0%	4%	0%
Malaysia	14%	100%	8%	100%	7%	100%
Nigeria	1%	100%	1%	100%	1%	100%
Oman	3%	100%	10%	100%	1%	100%
Peru	1%	100%	2%	100%	0%	100%
Qatar	12%	100%	25%	100%	8%	100%
Russian Federation	9%	100%	9%	100%	8%	45%
Turkmenistan	0%	0%	0%	0%	19%	0%
Trinidad & Tobago	0%	0%	0%	100%	0%	100%
United States	10%	100%	19%	100%	8%	100%
Uzbekistan	0%	0%	0%	0%	3%	0%
Modelled imports, total (abs.)	90.0		62.8		150.5	
Modelled imports, total (rel.)	89%		98%		92%	
Not modelled imports (rel.)	11%		2%		8%	

* Based on EIA (2023); not modelled, but shown here for completeness

The importance of hydrogen supply has increased significantly in recent years, with uses including but not limited to serving as alternative pathways for chemical feedstock, fuel production, energy storage, and as a reducing agent (IEA 2019). This trend is reflected, together with ammonia, in the priority areas set in Japan's Green Growth Strategy (METI 2021). For better representation of hydrogen in the ecoinvent database, the release in 2023 will include new datasets for coal- and natural gas-based hydrogen production, as well as by-product hydrogen production from chloralkali-electrolysis and steam cracking operations.

The upcoming release will also feature updated data for essential chemical precursors and their derivatives, such as short-chain alkenes (ethylene, propylene, butene, and butadiene), monocyclic aromatics (benzene, toluene, and xylenes, or BTX), ethylene oxide, ethylene glycol, and methanol.

4.3.5 Metals

The metals sector in ecoinvent comprises activities from the mining and beneficiation of natural resources to the production of metal and mineral commodities. For some metals, datasets are available for multiple production routes based on different technologies. In total, over 1,000 datasets related to metal production exist. The availability of background data is pivotal to modeling metals supply chains, whose processes are rarely completed within a single country, and metal resources flow through international supply chains connected by international trade (U.S. National Research Council 2008).

Japan relies heavily on metal imports due to limited domestic mineral resources (Hatayama and Tahara 2015; USGS 2018). Data on these commodities are therefore crucial for assessing the sustainability and supporting the transition of Japan's metal and manufacturing industry. The relevance of these supply chains increases further when considering the country's projected expanding overall demand for critical metals to respond to increasing demand for electric vehicles, fuel cells, wind power generation, photovoltaics, and other emerging technologies (Nansai et al. 2017; Miyamoto et al. 2019).

The ecoinvent association is collaborating closely with data providers from industry (associations) and research institutions. Among the updates in version 3.9, the production of antimony has been adapted to better represent

the ore grade and recovery rates observed in China. The new data also cover the production of nuclear-grade zirconium sponge and hafnium sponge, as well as Lithium Iron Phosphate (LFP) batteries.

4.3.6 Waste Management

The waste management sector in the ecoinvent database entails more than 300 different wastes, generated in a wide variety of processes and sectors. One or more treatment activities are provided for each waste. The sector can be subdivided into solid waste management (SWM) and wastewater treatment (WWT). SWM covers treatment, recycling, and disposal (landfilling) activities. Enhanced granularity is offered for the most common urban waste fractions⁴ for which specific market mixes have been set up to cover the mix of treatment technologies taking place in every country of the European Union and a dozen other countries all around the world including India.

Several projects are underway to expand and improve the sector coverage: The first project focuses on refining the level of aggregation for WWT and SWM treatment activities. Treatment processes in the database had up until v3.8 been modelled as aggregated datasets by merging multiple inventories. This modeling approach combines the full fate of a given waste input and all treatment by-products generated along the way into one single dataset. For better clarity and improved flexibility, these aggregated inventories are subdivided, by transparently separating and quantifying all waste flows and emissions generated during subsequent treatment steps (Figure 3). This brings several advantages, such as allowing database users to model their own collection and transportation schemes and supporting regional parameterization. The project started in v3.9 by disaggregating all wastewater treatment datasets.

4.3.7 Elementary Flows and LCIA Methods

We constantly improve our list of elementary flows, aligning nomenclature with others, and updating and adding meta-data such as CAS numbers, formulas, synonyms, or links to PubChem. This work has benefitted from

4) Such as plastics (polypropylene, polystyrene, polyurethane, polyvinylchloride, polyethylene, polyethylene terephthalate, plastic mixture), paper (graphical paper, packaging paper, paperboard), glass, wood, and mixed municipal solid waste (MSW)

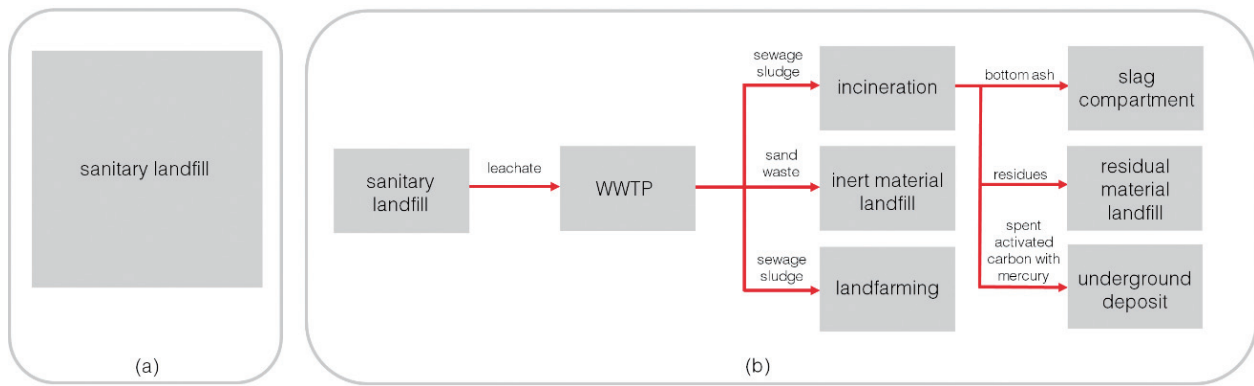


Figure 3 Waste aggregation (a) and waste disaggregation (b) of a sanitary landfill.

the collaboration with other database providers within the GLAD network (Valente et al. In preparation). An improved elementary flow list facilitates the connection to and implementation of LCIA methods, which we are constantly adding and updating to make more and more and the most up-to-date impact assessment scores available to our users.

5 Knowledge, Service, and Data Provider

Over the past decade, the management and continuous development of the ecoinvent database have remained the core of the ecoinvent association's work. Building on the experiences and capabilities derived thereof, ecoinvent also engages as a knowledge, service, or data provider in other contexts that are aligned with the organization's mission. With LCA data aspects and database management as common elements, examples include international and regional efforts to support or enhance data availability, quality and interoperability, dataset creation, database development, and distribution, as well as capacity building and awareness raising for LCA:

- Major research and development (R&D) projects: ORIENTING⁵⁾, REFINE⁶⁾, WISER⁷⁾.
- Within UNEP's Life Cycle Initiative and the Global LCA Data Network (GLAD) network as coordinators of the National LCA Database Roadmaps Project⁸⁾. Additionally, as the lead of the GLAD Elementary Flow Mapping project⁹⁾ for improved data interoperability in LCA, also in collaboration with the IDEA database of Japan (Valente et al. In preparation).
- Project partner for the implementation of life cycle approaches within the Innovative Business Practices and Economic Models in the Textile Value Chain

(InTex)¹⁰⁾ project, commissioned by UNEP with funding from the European Commission.

- Members of advisory bodies of the Environmental Footprint Data initiative of the European Commission and different LCA databases (WALDB¹¹⁾, Agribalyse¹²⁾).
- Data provider for the Environmental Footprint (EF) data initiative of the European Commission¹³⁾.

6 Engagement Opportunities

The ecoinvent database can be accessed through various licensing options. These options range from complete access to the entire database, including all features and documentation, to impact assessment results designed for specific purposes. Additionally, ecoinvent partners with organizations and companies to support them with products and solutions related to the ecoinvent database and data management¹⁴⁾.

To provide technical support to users, an e-learning¹⁵⁾ course covering the fundamentals of the ecoinvent database

5) <https://orienting.eu/>

6) <https://www.ifeu.de/en/project/refine/>

7) <https://wiser-climate.com>

8) <https://ecoinvent.org/activities/development-of-national-lca-database-roadmaps-project/>

9) <https://ecoinvent.org/activities/global-lca-data-access-network/>

10) <https://www.unep.org/intex>

11) <https://quantis.com/who-we-guide/our-impact/sustainability-initiatives/waldb/>

12) <https://doc.agribalyse.fr/documentation-en/agribalyse-program/agribalyse-ecoinvent-partnership>

13) <https://ecoinvent.org/activities/environmetal-footprint-data/>

14) More information on different solutions can be found on the ecoinvent website at this link <https://ecoinvent.org/the-ecoinvent-association/database-initiatives/>

15) The e-learning course can be accessed at this link <https://support.ecoinvent.org/e-learning-fundamentals-database>. Webinars are available here <https://ecoinvent.org/offerings/webinars/>

was published. The ecoinvent team also offers on-demand technical support to users seeking assistance with understanding specific data and methodological connections within the database.

7 Outlook

Looking forward, ecoinvent will continue to build on its strengths, while improving our data framework and better integrating with the research community, to fulfill our mission. Maintaining existing datasets and adding new data to the database to enhance geographical and technological coverage remains central. This will be achieved by deepening and expanding collaborations with existing and novel data providers worldwide. For this, we hope to work more with data providers in Asia in the future.

We are revising the way data enter the database. Current data format and software for database submissions enforce a high degree of data quality and allow for the application of multiple system models. However, they require extensive training and feature a dated user interface design. By making the software more user-friendly, even allowing direct links from common LCA software to the ecoinvent submission system, we can reduce the barriers for individuals to contribute to the database.

Furthermore, data exchange, both with ecoinvent but also within the broader LCA community, can be made more efficient. We are reviewing major nomenclature systems and data exchange formats, such as ILCDC, to explore how ecoinvent can act as a resource for translating across these systems following a community consensus. Nomenclature systems are different from data exchange formats and should be treated separately. In parallel, we are also revising our metadata (flows, units, locations, etc.) to make them easier to understand, reference, and use, both inside and outside of the database.

ecoinvent's roots are with the research community, and that community has built on ecoinvent in amazing ways. For example, the prospective LCA community has created future versions of ecoinvent following different scenarios and shared socio-economic pathways (Sacchi et al. 2022; Langkau et al. 2023); the environmentally extended input-output (EE-IO) community has similarly built hybrid databases combining ecoinvent with EE-MRIO tables (Agez et al. 2020; Jakobs et al. 2021). Several challenges remain to make these approaches

widely applicable, including establishing and accessing reliable background databases for prospective LCA (Steubing et al. 2023). We intend to contribute to further advance these extensions by helping make them easier to consume by all ecoinvent clients. The exact form this can take depends on data licensing and the needs of different applications, but we are determined to help such interesting work be widely available.

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