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ORIGINAL ARTICLE

Some Digressions on the Life Cycle Analysis of a Nuclear Power Plant in France

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Abstract:
Life Cycle Assessment (LCA) evaluates the potential environmental, social and economic impacts of a system (product, service, process, value chain). It is based on an inventory of material and energy flows for the different phases of a product's life cycle, from the extraction of raw materials to waste management. LCA, which is governed by ISO standards, makes it possible to account for pollution transfers between different stages of a process ("cradle to grave") and between pollutants (multi-criteria approach). Our study aims to identify the challenges of applying LCA to a nuclear power plant, using system dynamics tools (Causal Loop Diagrams, Stock and Flow Diagrams via STELLA software) and the latest developments in Life Cycle Analysis (OpenLCA software).
Keywords: EROI, LCA, Nuclear Plant, Stocks and Flows Diagrams, System Dynamics

Introduction

Given the urgent need to limit the global temperature rise to 2°C by the end of the century, it is imperative to reconsider the various forms of energy production, mainly fossil fuels, and to adapt technologies accordingly (IPPC, 2014). In this context, all low-carbon production technologies are currently being encouraged by heavy investment in infrastructure, as demonstrated by the Green Pact for Europe launched by the European Commission in 2023. Moreover, until recently, Europe's electricity mix was based entirely on renewable energies (solar photovoltaic, onshore and offshore wind power, hydropower), with constant, controllable production from gas-fired or coal-fired power plants in countries such as Germany and Spain. The stated aim is to compensate for intermittence and, consequently, insecurity of supply when there is no wind or sun. With its historic investment in thermonuclear power at the turn of the 1970s, France opted for a degree of independence from fossil fuels for its electricity supply. Nowadays, with the declared desire and obligation to move away from fossil fuels to guarantee a sustainable future in terms of climate, nuclear power is back in the spotlight. Indeed, initiated by President Macron's 2022 Belfort announcements, France launched a major program to build new-generation reactors, with commissioning expected by 2035. These announcements reopen the debate on the place of nuclear power in the global energy mix, and raise pertinent questions about its overall life cycle (EDF, 2022). Consequently, this is an opportunity to compare the greenhouse gas (GHG) emissions, Co2, of each means of electricity generation currently deployed, and to draw conclusions as to whether or not installed French nuclear power is "low-carbon", in a context of climate change as recently established by ADEME (2022) or EDF (2022).

This article addresses the following question: What is the carbon impact of one kWh of electricity produced by a French nuclear power plant? To answer this question, the following study will first develop the Life Cycle Assessment

(LCA) method, its principles and implementation. We will then develop the notion of energy rate of return. The various stages in the life cycle of a nuclear power plant will then be detailed, drawing on existing literature, in order to understand its actual environmental impact as measured by various stakeholders. Next, we will detail the impact study approach undertaken for this assessment, its assumptions and limitations, in order to determine, based on existing data, the accuracy or otherwise of the life cycle analysis results through dedicated simulation work using OpenLCA software.

2. Material and Methods for life cycle assessment in the nuclear cycle

2.1 Foundations of Life Cycle Assessment (LCA)

2.1.1 History, definition and objectives of LCA

First, in the mid-1970s, because of economic growth, governments and industrialists in Western countries sought to assess their energy dependence on oil, which was then in crisis, due to the oil shocks of 1973 and 1979. At the same time, the aim was to reduce energy consumption, particularly by energy-intensive industries. To achieve this, various methods were developed to assess energy and resource consumption. Thus, after several developments and the establishment of calculation standards and a precise study framework, at the turn of the 1990s, the Life Cycle Assessment (LCA) tool was born (Hunt, Franklin, 1997; Klöpffer, 1997)). The aim was to make the method unique, to have a common basis on which to properly exploit the results obtained and compare different products (Lecouls, 1999). Most of the problems involved in setting up a homogeneous data system and defining a method specific to this objective. Numerous studies have therefore been carried out, especially in Europe, to improve LCA.

Life cycle assessment (LCA) is an environmental evaluation method that aims to examine the ecological impacts of a product, process or service throughout its existence, from the extraction of raw materials to its final disposal, including the production, use and recycling stages (Norris, 2001). This systematic approach focuses on various environmental aspects, such as energy consumption, greenhouse gas emissions, water and air pollution, depletion of natural resources and many other factors (Pehnt, 2006). To summarize, the different objectives of LCA can be classified in the following order (Fava & al., 1991):

- Identifying and quantifying environmental impacts: One of the fundamental aims of LCA is to identify and quantify the environmental impacts of a product or service at every stage of its life cycle, from raw material extraction through manufacture, use and recycling to end-of-life. This enables us to understand where and how interventions can be most effective in reducing the ecological footprint.

- Decision-making support: LCA provides crucial information to corporate decision-makers, engineers, policy-makers and consumers, helping them to make informed choices. Whether for the development of more sustainable products, the selection of low-impact materials or the elaboration of environmental policies, LCA is a decision-making tool.

- Process optimization: By highlighting the most impactful phases of a product's life cycle, LCA enables companies to optimize their production, distribution and waste management processes. This can result in energy savings, reduced greenhouse gas emissions, better resource management and lower costs.

- Communication and marketing: The results of an LCA can be used in communication with stakeholders, including consumers, to demonstrate a company's commitment to sustainability. This can strengthen the brand and offer a competitive advantage in an increasingly environmentally conscious market.

- Development of standards and regulations: LCA helps establish industry standards and environmental regulations by providing a scientific basis for assessing environmental impacts. This creates a level playground where sustainable practices are encouraged and valued.

- Innovation and sustainable design: By providing detailed insights into environmental impacts throughout the life cycle, LCA encourages innovation and sustainable product design. This can lead to the development of new products or processes that are both efficient and environmentally friendly. The objectives of LCA are to achieve the right trade-offs between environmental impact and industrial need. These objectives are then used to inform the various parties involved: manufacturers, scientists, consumers and, finally, political decision-makers and public authorities.

Figure 1: Diagram of the life cycle of a product or service

2.1.2 LCA Methodology: standards, scope definition, life cycle inventory, impact assessment and interpretation of results

To achieve these objectives, LCA is based on standards that provide common criteria and guidelines for carrying out consistent and, above all, comparable analyses. Standardization defines the methodology and procedures to be followed in order to carry out an analysis and obtain a coherent assessment of environmental impacts[1] (Caseau, 2021, Diemer, 2023).

In addition to enabling results to be compared, these standards guarantee the reliability of these analyses. As LCA is based on the use of databases and scientific methods, standards aim to guarantee the quality and reliability of these data and of the scientific methods used, thus reinforcing the credibility of the analysis. LCA must be transparent in the way it has been carried out. Thanks to LCA standards, details such as how the analysis was carried out, data collection, assumptions, study limitations and data sources are known and enable the evaluation process to be understood (ISO 14040, 14020, 14021, 14025, 14040).

Life Cycle Assessment (LCA) is governed by a series of international standards, mainly issued by the International Organization for Standardization (ISO). These standards define the principles, framework, methodology and applications of LCA (ISO, 2006, 2016, 2022). The following is a summary of the main ISO standards relating to LCA:

- ISO 14040: 2006 - Principles and framework

Defines the principles and framework for conducting an LCA.

Includes definitions of terms, purpose and scope of LCA, basic principles, and phases of LCA.

- ISO 14044 :2006 - Requirements and guidelines:

Provides detailed requirements and guidelines for conducting an LCA.

Covers methodological aspects such as inventory analysis, impact assessment, interpretation of results, critical studies and reporting.

- ISO 14045 :2012 - Eco-efficiency of product systems

Describes how to conduct an eco-efficiency assessment, which combines environmental assessment and product performance.

[1] Analyse du cycle de vie (ACV). Techniques de l'Ingénieur Available at : https ://wwwtechniques-ingenieur-fr. ezproxy. uca.fr/base-documentaire/procedes-chimie-bio-agro-th2/ chimieverte-principes-reglementations-et-outils-d-evaluation-42490210/analyse-du-cycle-de-vie-acvg5500/

Enables both environmental aspects and product performance to be assessed from a sustainability perspective.

 ISO 14046: 2014 - Water footprint

Specifies principles, requirements and guidelines for assessing water footprint.

Enables a quantitative assessment of the potential water impacts associated with a product, considering regional water use.

 ISO 14071 :2014 - Additional information to complement ISO 14044 on sensitivity analysis

Provides additional information on how to perform a sensitivity analysis as part of an LCA.

 ISO 14072 :2014 - Additional LCA for organizations

Extends LCA principles and requirements to organizations, in addition to products.

 ISO/TS 14067 :2013 - Carbon footprint of products

Contains principles, requirements and guidelines for quantifying and communicating the carbon footprint of products, including greenhouse gases emitted throughout their life cycle.

 ISO/TR 14049: 2012 - Illustrative examples for understanding ISO 14044

Provides practical examples and case studies to help understand and apply ISO 14044.

The above-mentioned standards set out a four-step process for carrying out a strict life cycle assessment. These steps are summarized in the figure 2:

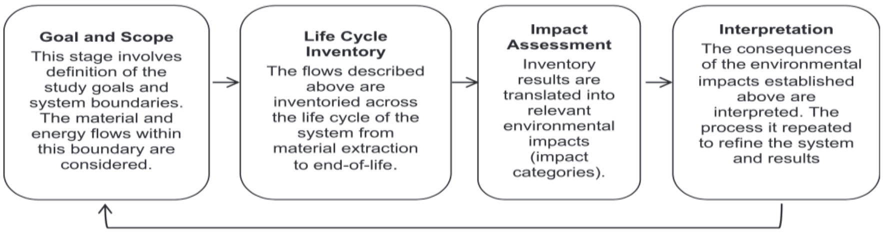

Figure 2: The four steps of Life Cycle Assessment
Source: Whitehead & al. (2015)

1) Defining the goal and scope of the study

This first step involves clearly defining the objectives of the LCA study and delimiting its scope. It involves specifying details such as the product system to be studied, the system boundaries (what is included or excluded in the study), the product function, the functional unit (which serves as a measure of comparison), and the assumptions and limitations of the study. The functional unit is particularly important as it provides a reference for all measured inputs and outputs, enabling fair comparison between different systems (Bjorn & al., 2018a).

A new concept is added, that of the elementary process. The product analyzed during the LCA is generally made up of several parts/components. An elementary process corresponds to the smallest part of a product for which data is collected. The aim is to divide the product studied into different components that can be easily studied in subsequent stages (Diemer, 2023). Each of these elementary processes will capture and emit flows which are called elementary flows. It is important to carry out this step, without which the rest of the study cannot be carried out. In fact, this stage enables us to set out the objectives, assumptions, boundaries of the study, etc., on which the rest of the LCA will be based. Once this information has been correctly defined, the second stage, the life cycle inventory, can be carried out (Bjorn & al., 2018b).

2) Life Cycle Inventory

This stage involves collecting data and calculating the inputs and outputs for each process in the product's life cycle (Pinto, Sverdrup, Diemer, 2019). Inputs include raw materials and energy, while outputs include emissions to air, water and soil, as well as other environmental impacts (Klöpffer, 1997). The aim is to draw up a complete inventory of incoming and outgoing flows associated with the production, use and disposal of the product. For each elementary process in the study, the analysis will consider five phases. The 5 phases analyze the impact of the product during each stage of its life, from raw material extraction to product recycling.

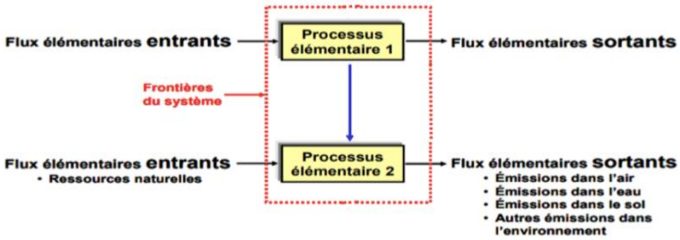

Figure 3: Inventory of flows
Source: Authors

3) Life Cycle Impact Assessment

During this phase, the data collected during the inventory analysis are used to assess their potential environmental impacts. This involves assigning the various inventory flows to specific impact categories, such as climate change, which refers to the ability of a greenhouse gas to trap infrared radiation in the atmosphere. In this case, the unit will be kg of CO2 equivalent. Our subsequent study will focus on this particular category (EDF, 2022). Ozone depletion, toxicity, resource use, acidification, eutrophication, etc. are also included. Impact assessment methods are applied to quantify the extent of these impacts, enabling us to understand the overall impact of the product or service. Details of all impact categories are given in figure 4.

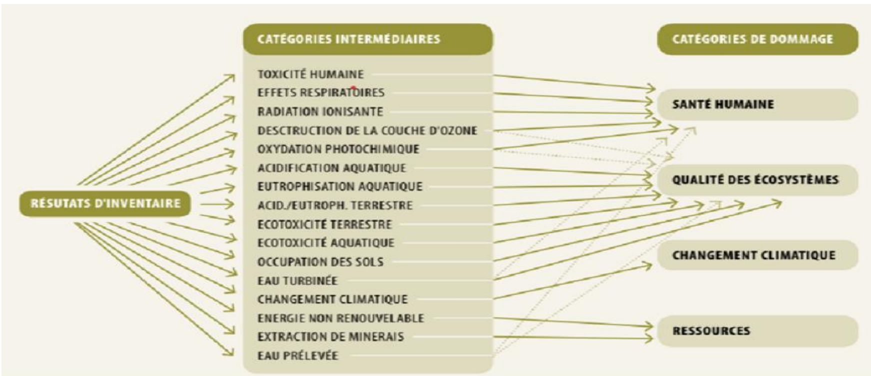

Figure 4: few categories of impacts
Source: The Authors

The LCA inventory must then be classified into these categories. A result can be classified in one or more categories. It is necessary to ensure that there is no redundancy of the same result in the categories, even if certain results may influence another category (serial effect). For example, the climate change indicator used by EDF (2022) in its kWh LCA includes results that also concern the "ozone depletion" category. These results then have an impact on another indicator (parallel effect).

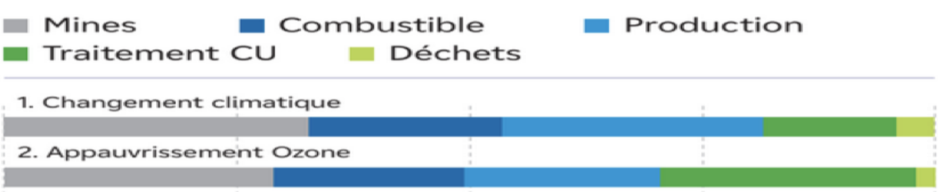

Figure 5: Composition of results for EDF indicators 1 and 2
Source: EDF (2022)

4) Interpretation of results

Key issues are identified based on data collected during the life cycle inventory and environmental impact assessment phase. Specialized software is available to facilitate the identification and assessment of these environmental issues during this phase. Verification, which involves many checks, aims to ensure that the results of the study are in line with the predefined objectives and scope. Three types of checks are essential: completeness checks ensure that all the information required for interpretation is present. The sensitivity check assesses the reliability of the results, considering information from previous phases of the LCA, expert assessments and assumptions linked to the objectives and scope of the study. This check may require an in-depth analysis if the results are inconclusive. The consistency check verifies that the methods and assumptions used are consistent with the objectives and scope of the study, thus helping to assess the quality of the data and the consistency of the study (EDF, 2022). Finally, the conclusion, limitation and recommendation phase of the study synthesizes all the information from the previous phases. Writing this section involves highlighting the major issues identified, analyzing the results in the light of the various checks carried out, and drawing preliminary conclusions by examining the relevance of the results to the objectives set. This step is crucial for putting the study's findings into perspective, highlighting potential limitations and proposing recommendations based on the analyses carried out (Caseau, 2021)

2.1.3 LCA in the energy sector: Issues and applications

To quantify their impact on the environment, energy producers need to carry out impact studies using life cycle analysis (Gibon, Menacho, Guiton, 2021). There are many issues at stake, but one stands out: the carbon intensity of the various means of electricity production, in our case. Indeed, depending on the resources used, whether fossil (coal, gas, fuel oil, uranium fission) or renewable, carbon intensity varies greatly. According to ADEME GhG Balance, a "seasonalized by use" method whose main conclusions for each energy source are presented in figure 6, fossil resources emit the most CO2eq/kWh of electricity produced, with 1kgCO2eq/kWh for coal, making it currently the most CO2-emitting resource in the global energy mix. In addition, nuclear fuel emits an average of 6 gCO2eq/kWh, which, according to these analyses, is a very low-emission resource, ahead of renewable resources such as wind power (9 g CO2eq/kWh) and hydroelectricity (10 g CO2eq/kWh).

Les émissions des énergies pour la production d'électricité en équivalent CO2 (CO2e) en gramme par kilowattheure d'énergie finale :

Combustible	Emission de CO2
Centrale à nucléaire	6 gCO2e/kWh (France)*
Eolien (en mer)	9 gCO2e/kWh
Eolien (en terre)	10 gCO2e/kWh
Hydroélectrique	10 gCO2e/kWh
Biomasse (déchets de bois avec turbine à vapeur)	32 gCO2e/kWh
Géothermie	38 gCO2e/kWh
Electricité (chauffage)	210 gCO2e/kWh
Gaz naturel	443 gCO2e/kWh
Pile à combustible	664 gCO2e/kWh
Centrale fioul-vapeur	730 gCO2e/kWh
Pétrole lourd	778 gCO2e/kWh
Centrale à charbon	1 058 gCO2e/kWh

*La moyenne monde se situe à 6 gCO2e/kWh

Figure 6: Energy emissions for electricity generation in CO2 equivalent, in grams per kilowatt-hour of final energy.
Source: ADEME (2022)

In addition, LCA via the "climate change" indicator mentioned above also provides comparable results for assessing the CO2eq/kWh emissions of each means of electricity generation. In France, EDF has applied this indicator to its nuclear plants to establish, in its own words, that nuclear power is "low-carbon". Indeed, via the impact study carried out using 2019 data, EDF applied a life-cycle analysis to the 58 nuclear reactors then in service, establishing a value of 3.7 gCO2eq/kWh electricity produced for the "climate change" indicator by assessing the entire nuclear fuel cycle, construction, operation, dismantling and recycling of the nuclear installation (EDF, 2022).

2.2 Energy Return on Investment or EROI

EROI, or Energy Return on Investment, is a key indicator for assessing the viability and efficiency of different energy sources (Dumas & al., 2022). This ratio measures the amount of energy obtained from an energy source in relation to the amount of energy expended to obtain that energy. In other words, it calculates how many units of energy are produced for each unit of energy invested in producing and supplying that energy (Wei Bach. & al., 2013). EROI is generally expressed by the formula: EROI = Energy produced (kWh) / Energy invested (kWh). For example, if producing a barrel of oil requires the energy equivalent of 1/10 of a barrel, then the EROI of oil would be 10:1.

The EROI is important for assessing the efficiency of an energy conversion (Inman, 2013). Indeed, a high EROI indicates that an energy source is efficient in terms of the energy produced compared to the energy required to produce it (Dierickx, Diemer, 2020). Conversely, a low EROI means that the amount of energy required to produce the energy is relatively high, which may call into question the long-term viability of this energy source (Kubiszewski & al., 2010).

The EROI is a tool for comparing energy sources to determine which power generation technologies are the most sustainable and least harmful to the environment, such as nuclear, photovoltaic, onshore or offshore wind power (Dumas &. al. 2022). This calculation is influenced by a range of factors, depending on the technology used, process efficiency, location, quality of the energy resource, and extraction or production methods (SFEN, 2022).

A high EROI score is often associated with greater sustainability, as it indicates greater energy efficiency and less impact on the resources required for energy production (Dupont, Germain and Jeanmart, 2020).

Intensités partielles et totales (Energie amont / Electricité produite) et EROI

source Weisbach & al.2013	centrale charbon	CC gaz fossile	CC gaz biogaz	nucléaire (1)	nucléaire (2)	éolien terrestre	hydro fil de l'eau	solaire PV ferme
construction	0,30%	0,07%		**0,22%**		6,0%	1,91%	25%
maintenance	1,06%	0,03%		**0,30%**		0,14%	0,08%	0,00%
combustible	2,08%	3,45%	27%	**0,81%**	**0,42%**	0%	0%	0%
intensité TOTALE	3,44%	3,55%	27%	**1,33%**	**0,94%**	6,1%	1,99%	25%
EROI (1/intensité)	29:1	28:1	3,7:1	**75:1**	**106:1**	16:1	50:1	4,0:1
avec back-up (stockage) pour l'intermittence						4:1	35:1	2,3:1

nucléaire, technique d'enrichissement : (1) en moy.dans le monde avant 2013, (2) 100% centrifugation gazeuse

Figure 7: EROI of different electricity generation methods

Nuclear power generation in France has the highest EROI, at around 100 :1, followed by hydroelectric power, fossil-fired power plants (gas, coal) with an EROI 4 times lower, and renewable energies (solar PV, onshore wind) with a very low EROI of around 4 :1 (Tremblay, 2013). This is due to the intermittent nature of production, subject to the vagaries of the weather and general sunshine in the case of solar PV. On the other hand, nuclear power generation appears to be very energy-dense, due to the availability of its output, which is sometimes affected by maintenance operations and outages for safety reasons. What's more, the competitiveness of nuclear power seems to be confirmed in terms of the reduction in GHG emissions linked to plant construction. According to the IPCC, the full life cycle assessment (LCA) gives 12gCO2eq/kWh. A lifecycle analysis study published in 2022 by the United Nations Economic Commission for Europe concluded that nuclear power was the least carbon-intensive, with an average value of between 4.9gCO2eq/kWh and 6.3gCO2eq/kWh for Europe (shown in grey in Figure 7). The data considered are for 2020. For comparison, this represents a global warming impact 30 times lower than a natural gas power plant equipped with a carbon capture and sequestration system (CCS).

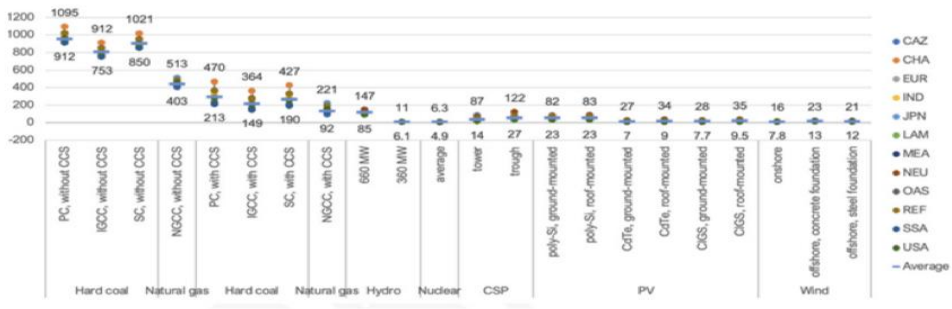

Figure 8: Greenhouse gas emissions (CO2eq) for the various means of electricity generation worldwide, by LCA.

Finally, EDF's life cycle analysis study, published in 2022 and based on 2019 production data, puts total emissions at 3.7 gCO2eq/kWh. Figure 9 shows the various results obtained by national and international energy players. The order of magnitude of emissions is very similar, with estimates ranging from 4gCO2eq/kWh (EDF) to 12gCO2eq/kWh, according to the IPCC (2012, 2015).

Figure 9: Estimates of GHG emissions for nuclear power according to different operators Source: IPPC, ADEME, CEA, EDF

Like the national results, the IPCC study contained in its 2014 report paints a picture of emissions by means of generation in CO2eq/kWh (Figure 10). The report considers the calculated minimum, median and maximum values of emissions per means of generation over the plant's life cycle. The minimum value for nuclear power is 3.7 gCO2eq/kWh, like the result presented by EDF (2022) LCA study for the French plant fleet. The median value of 12 gCO2eq/kWh is of the same order of magnitude as the ADEME result. The maximum value of 110 gCO2eq/kWh is a value for which the process assumptions are probably not like EDF's assumptions, particularly about recycling of the various wastes and a lack of technological progress and efficiency (old reactor).

Options	Direct emissions	Infrastructure & supply chain emissions	Biogenic CO_2 emissions and albedo effect	Methane emissions	Lifecycle emissions (incl. albedo effect)
	Min/Median/Max	Typical values			Min/Median/Max
Currently Commercially Available Technologies					
Coal—PC	670/760/870	9.6	0	47	740/820/910
Gas—Combined Cycle	350/370/490	1.6	0	91	410/490/650
Biomass—cofiring	n.a. [i]	–	–	–	620/740/890 [iii]
Biomass—dedicated	n.a. [i]	210	27	0	130/230/420 [iv]
Geothermal	0	45	0	0	6.0/38/79
Hydropower	0	19	0	88	1.0/24/2200
Nuclear	0	18	0	0	3.7/12/110
Concentrated Solar Power	0	29	0	0	8.8/27/63
Solar PV—rooftop	0	42	0	0	26/41/60
Solar PV—utility	0	66	0	0	18/48/180
Wind onshore	0	15	0	0	7.0/11/56
Wind offshore	0	17	0	0	8.0/12/35
Pre-commercial Technologies					
CCS—Coal—Oxyfuel	14/76/110	17	0	67	100/160/200
CCS—Coal—PC	95/120/140	28	0	68	190/220/250
CCS—Coal—IGCC	100/120/150	9.9	0	62	170/200/230
CCS—Gas—Combined Cycle	30/57/98	8.9	0	110	94/170/340
Ocean	0	17	0	0	5.6/17/28

Figure 10: GHG emissions from different means of electricity generation
Source: IPPC (2014)

The results obtained at national level are very similar. In fact, the calculation method used by EDF was developed jointly with ADEME, the French agency for energy transition. Strictly in line with ISO LCA standards, the data were also extracted from the reference environmental database, EcoInvent (ISO, 2006, 2016, 2022)?

3. Applications, Results and Dissemination

3.1 Uranium Processing

Uranium is a radioactive metal found deep underground. Before it can be used as fuel in nuclear power plant reactors, it must be extracted and processed (Dolzikova, 2024).

→*Uranium mining*

Uranium is a widespread metal in the earth's subsoil. It is contained in ores, which are extracted from open-pit or underground deposits. These deposits are found mainly in Australia, the United States, Canada, South Africa and Russia (Figure 11). In France, there are some in the Vendée and Limousin regions, but they are in the process of being depleted.

→ *Processing*

The ore is reduced to small pieces, finely ground and subjected to chemical operations to extract the uranium. This produces highly concentrated uranium, in the form of a yellow powder known as yellow cake. 1,000 t of ore yield 1.5 to 10 t of yellow cake, containing 75% uranium. The yellow cake is then refined to remove impurities and obtain completely pure uranium.

→ *Enrichment*

At this stage, 1 kg of natural uranium is made up of 993 g of uranium 238 and 7 g of uranium 235. Only uranium 235 is fissile, but it is not in sufficient proportion to be used in power plant reactors. Uranium must therefore be enriched in uranium 235, so that it contains between 30 and 50 g.

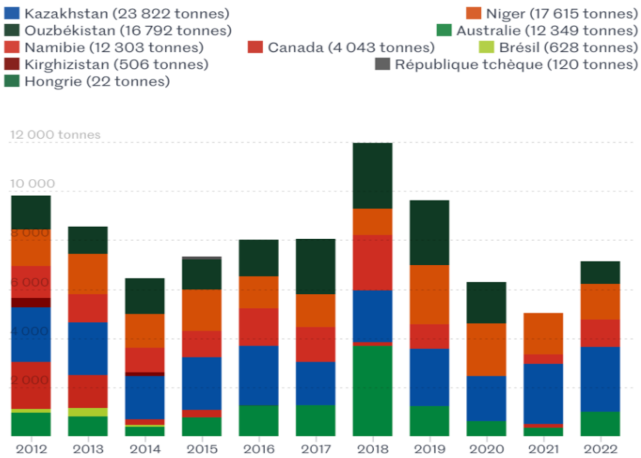

Figure 11: Geographical Origins of the Uranium Importations for France
Source: Comité technique d'Euratom (ESA, 2023)

→Fuel fabrication

Once enriched, uranium is transformed into black powder. Compressed and baked in a furnace, it is converted into small cylinders, called pellets, weighing around 7 g and measuring 1 cm in length. Each pellet can release as much energy as 1 t of coal. The pellets are threaded into 4 m-long metal tubes, the ends of which are plugged to form what are known as pencils. These rods are grouped together in batches to form fuel assemblies. These assemblies are placed in the reactor core to power it.

→ Consumption

The pellets will remain in the reactor for between 4 and 5 years, undergoing nuclear fission reactions. Over time, they will become depleted in uranium 235 and will need to be replaced. This operation is carried out in water, which traps radioactive radiation. The spent fuel then remains in the cooling pool for 3 years, until it gradually loses some of its radioactivity.

→ Reprocessing

In most countries, spent fuel is placed in steel containers and transported to a reprocessing plant (ESA, 2023). AREVA's La Hague plant in France is the world's largest reprocessing facility. Reprocessing involves separating the various elements of the fuel by mechanical and chemical treatments, so that they can be reused, and also separating the waste. In this way, uranium is enriched once again to produce nuclear fuel. 96% of spent fuel is reused. The part of the spent fuel that cannot be reused, known as ultimate waste, is cast in molten glass and stored for 30 to 40 years at the La Hague plant.

Using System Dynamics Modelling with Stella Software, we designed the Uranium Process (figure 12) and stocks and flows impacts (figure 13) to define the scope of LCA’s analysis and the impacts of uranium on energy sector

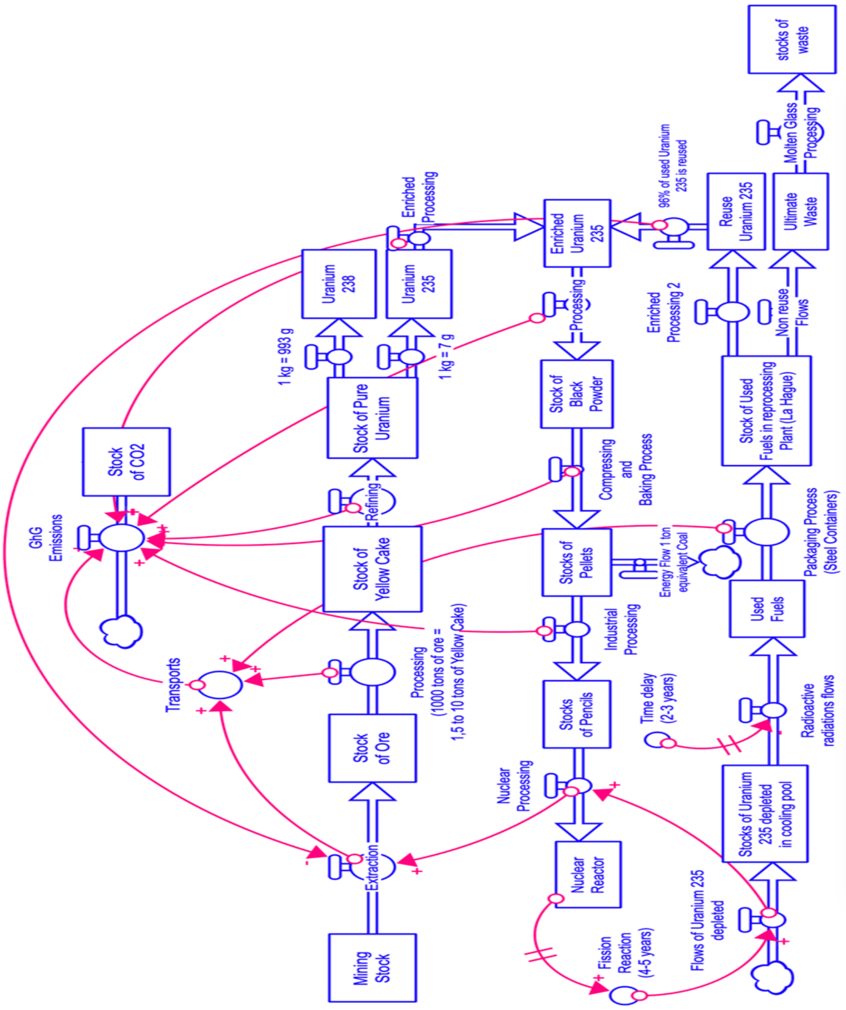

Figure 12: System Dynamics Modelling of Uranium Process
Source: The Authors

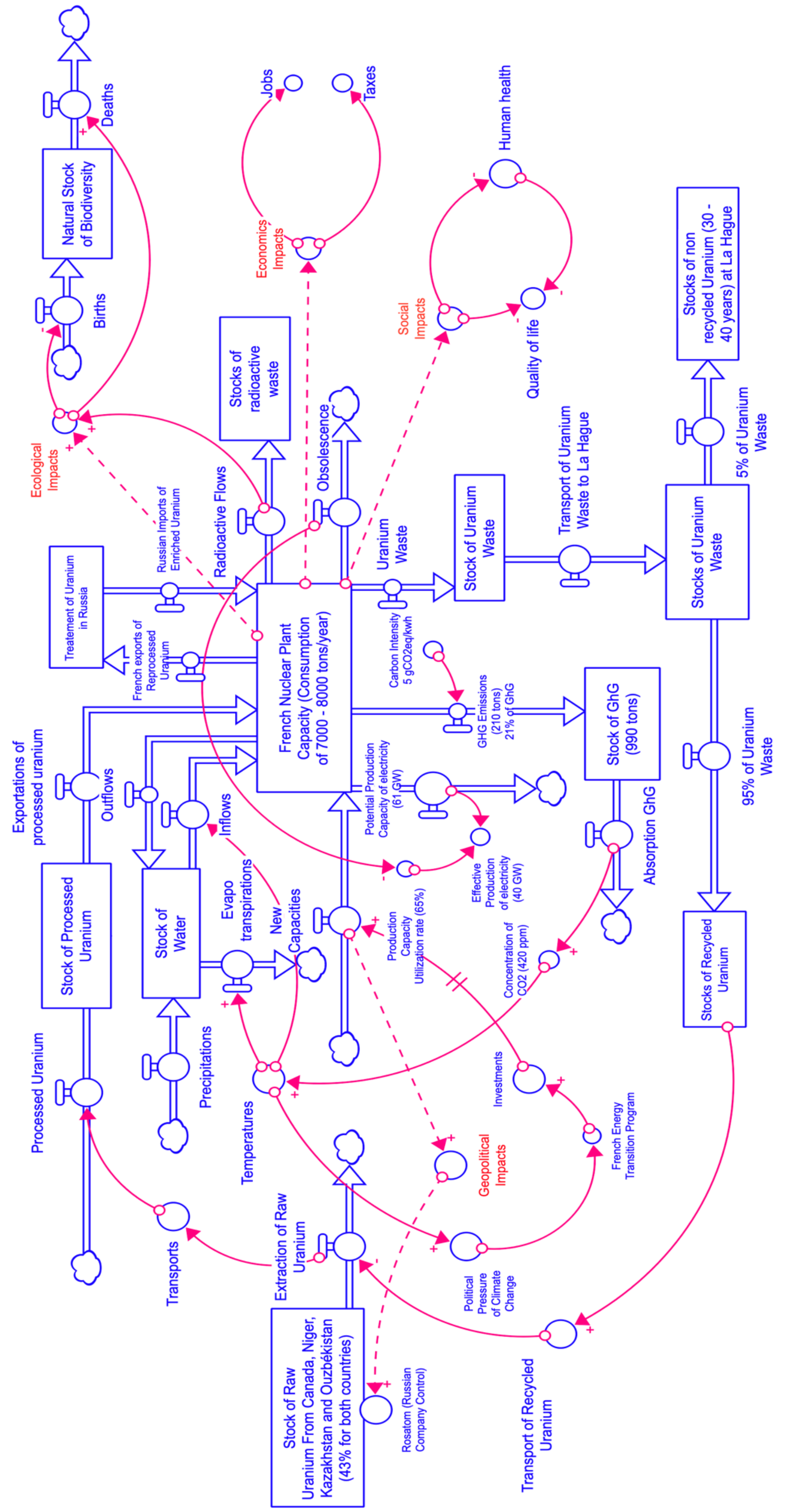

Figure 13: Stocks and Flows Diagram for Uranium Processing with impacts
Source: The Authors

Figures 12 and 13 are useful for understanding both the French uranium import situation, life cycle analysis issues and the energy transition program (with heavy investment in nuclear power) launched by President Emmanuel Macron in 2023. Firstly, France closed its last uranium mine in 2001, making it highly dependent on imports (IRSN, 2024). French power plants consume between 7,000 and 8,000 tons of uranium per year. They have a production capacity of 61 GWh, but an effective output of 40 GWh (the capacity utilization rate is only 65%). Of course, the carbon intensity is relatively low (5 gCO2eq/kwh), enabling the nuclear system to emit just 210 tonnes of CO2 (compared to 990 tonnes emitted by the energy sector). However, the need for water to cool the reactors, the effects of global warming, the constraints on biodiversity when discharging water into rivers and the many corrosion problems (due to the advanced age of the plants) raise the question of the resilience of the French nuclear power plants. In his speech of February 10, 2022, French President Emmanuel Macron proposed the construction of 6 second-generation EPRs, and that studies be launched on 8 additional EPR2s. Secondly, natural uranium is essentially composed of two isotopes, uranium-238 and uranium-235, plus traces of uranium-234. Only uranium-235 is fissile, but its natural content is only 0.72%. The majority of nuclear power reactors use fuel enriched to between 3% and 5% uranium-235. The two main isotopes of natural uranium must therefore be physically separated after a series of chemical conversions, to obtain, on the one hand, enriched uranium from which fuel is manufactured and, on the other, depleted uranium which has very few outlets. Figure 12 raises questions about life-cycle analysis, the calculation of CO2 emissions within the cycle, and the time delays to be taken into account in the modeling process of the uranium cycle. The use of life cycle assessment within a system dynamics model is particularly interesting, even if it raises quantitative challenges. Thirdly, enrichment is a strategic step for the nuclear industry, with only 4 major players: Rosatom in Russia covers 46% of world production; Urenco, with plants in the UK, Germany, the Netherlands and the USA, has a 30% market share; Orano, with a plant in France, 12%; and CNNC in China, 11% (the latter supplies only China, whose market is closed). The Russian market is also closed to Western enrichers, but Rosatom also supplies the West, notably via deposits in Kazakhstan and Uzbekistan (Greenpeace, 2023). Despite conflicts between Russia and Ukraine (Dolzikova, 2024), and France's determination to sanction Russia, Rosatom continues to play a key role in French uranium imports. In Figure 13, Rosatom plays the role of a control variable (constraint) that is difficult to escape (it should be remembered that uranium imports are not affected by European sanctions). In its latest report, Greenpeace (2023, p. 29) recalls that French uranium imports from Kazakhstan and Uzbekistan represented over 19 billion dollars between 2000 and 2020 (or almost 298,000 tonnes).

Figure 14: Uranium routes via Russia
Source: Tenex[2] (2018)

[2] TENEX (2018), Публичный годовой отчет АО «Техснабэкспорт», Rapport annuel public, p.24-25.

This map shows the points at which nuclear materials pass through Russia (represented by the central "Rosatom" point), before being shipped abroad. The Lokot station in the south represents the border point with Kazakhstan. The transit route runs from Lokot to St. Petersburg.

3.2 Defining the scope of the study for LCA

3.2.1 Functions and functional units

We have already seen the importance of this step, which will guide the implementation of our LCA. Our study therefore focuses on the electricity production of a nuclear power plant. Our functional unit is defined as follows: Producing one kWh from a Pressurized Water Reactor in France. The study aims to assess the impact of this production via global warming and an EROI (energy rate of return) calculation, to study the efficiency of this energy source.

3.2.2 System boundaries and assumptions

Defining the system boundaries is essential for identifying the stages of the system under study. Below are the different phases in the life cycle of nuclear power generation (Mayer, 2022).

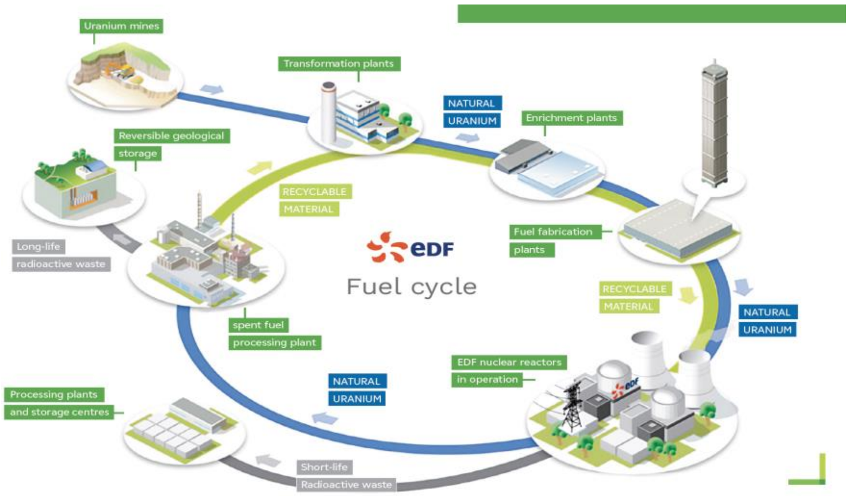

Figure 15: Phases in the life cycle of nuclear power generation
Source: EDF (2022)

For our study, we will carry out a "cradle to grave" analysis of the life cycle of nuclear power generation by the reactor. This means that the entire life cycle is taken into account, from ore to waste (Hatch, 2014). Only the fuel processing, recycling and plant dismantling stages are not considered. The analysis begins with the uranium mine and ends with the end-of-life of the fuel and the storage of nuclear waste (Pratiwi & al., 2023). For the remainder of our study, we will make the following assumptions:

- The nuclear power plant consists of a single reactor.

- The impact of fuel processing is therefore neglected, as no data are available on this stage.

- The impact of dismantling the plant is neglected, as no data are available for this stage.

- Fuel cannot be recycled and is completely transformed into radioactive waste when consumed.

- The means of transport for each resource is not specified, so it is assumed that they are all transported equitably by the various types of transport.

- The transport stage includes all the transports involved in each stage.

- The exact origin of the ores extracted is not known, but is assumed to be included in the transport data.

- The processes of each stage are not clearly specified in the database, so we assume that the impact of transforming all ores into the finished product is included in the input heat losses

- As we have no precise information on the usefulness of each of the ores entering the system, we'll assume that the extraction and processing stages for the various ores form part of a more general stage that groups them all together.

- As the uranium cycle is not clearly defined in our data source, the processing, conversion, enrichment and fuel fabrication stages are assumed to be an integral part of the uranium data, and are therefore included in the general stage mentioned above.

- In the absence of sufficiently precise information, we have sometimes arbitrarily assigned a stage to certain input resources.

3.3 Life cycle inventory

3.3.1 Data quality

The decision to exclude certain stages is based on the database we have been working with. This database, published and available since 2007, does not take recycling and dismantling into account, as was the case in the studies carried out at the time. We use the free NEEDS (New Energy Externalities Developments for Sustainability) LCI (Life Cycle Inventory) database provided on OpenLCA . This database contains industrial life cycle inventory information on:

- future electricity supply systems (advanced fossil fuels, hydrogen, fuel cells, offshore wind, photovoltaics, solar thermal, biomass, advanced nuclear, wave energy),

- future materials supplies, future transportation services.

The section of the nuclear database we are going to use was created by Denis Le-Boulch, an engineer with EDF for 33 years, who has over 20 years' experience in the field of life-cycle analysis. This gives us confidence that the database is reliable and can be relied upon. Of course, we would have preferred to use a more recent database, but unfortunately we were unable to find one. Our results may therefore differ from those of more recent studies. The data in this database, including those relating to nuclear power, are presented in the form of "processes" and can be found in the software in the following format:

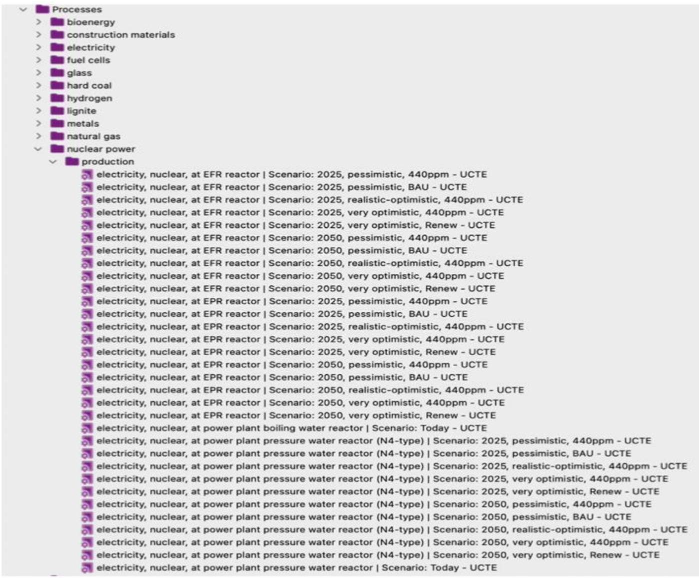

Figure 16: Processes available on OpenLCA software for the nuclear sector

There are different processes for different types of reactor - EFR, EPR or PWR - and associated scenarios that can be pessimistic, optimistic or realistic. These scenarios are used to assess the vulnerability of systems to climatic hazards. These scenarios can be extended to 2025 or 2050. In addition, they take into account greenhouse gas (GHG) and CO2 emissions into the atmosphere: we distinguish between a "Business As Usual" (BAU) scenario, where current activities continue without any effort to reduce emissions; and a 440 ppm scenario, where emissions would be maintained at a concentration of 440 ppm (parts per million), a more optimistic vision. All these different scenarios will have an impact on our analysis and results (Hainsch & al., 2022). The reactor involved in our study is of the N4 series, and corresponds to one of the 1450 MW reactors of the largest production plant in France. It comprises 4 reactors, commissioned around 2000 and built between 1984 and 1999. Thus, the data used for the analysis relate this situation .

The data provided by our data source therefore allows us to carry out an analysis on a single reactor only. To begin with, we decided to adopt the most pessimistic scenario possible, in order to obtain the most alarmist estimate of the impact on the environment, for comparison with other scenarios, and to study the consequences of the latter on the study in a second phase. We have therefore chosen the case of "electricity, nuclear, at power plant pressure water reactor (N4-type) | Scenario: 2025, pessimistic, BAU", and we will study the impact of the scenario in a later section. We have chosen a scenario stretching to 2025, i.e. 25 years of operation for the reactors, to get an idea of the current impact of electricity production from a PWR reactor.

3.3.2 Life cycle data

In this section, we will attempt to list each of the resources and emissions associated with the life-cycle stages of reactor electricity production. The appendix contains two lists (inputs and outputs) of the various inputs/outputs involved in this cycle.

1) Extraction and processing of ores, including uranium

The life cycle of a nuclear reactor involves the extraction and processing of a large number of materials, whether for the construction of the power plant or the production of electricity, which requires precise processing of uranium, as well as the transportation of all the necessary materials. All these extractions will have an impact on our study and are considered in our data source. We find bulk data on uranium, coal or gas, but also on the transformations that take place directly on the mining sites and on a very large number of raw ores of all types. Our inputs include data on heat lost and potential and kinetic energy converted, corresponding to the various processing stages included in this stage. As we do not have precise data on the locations of the various mine sites, we assume that this information is included either in the raw ore data or in the mine site processing or transportation data. We also note that our data source includes the crude oil and gas extractions required for transport. The resources associated with this stage, highlighted in green, can be found in the inputs in Appendix 1.

2) Reactor construction

In our case, the data associated with reactor construction involves the transformations carried out on specific sites, as well as site-specific occupancy data during plant construction. In particular, the "Occupation, construction site" data is quite significant, and plays a key role in the impact of plant construction in our study. We also find information on specific sites such as industrial zones, forests or arable land, for example. Similarly, the resources associated with this stage are shown in orange in the APPENDIX.

3) Reactor operation

As far as reactor operation is concerned, only water from different sources is used here. This water is used both for the primary circuit and to cool the system, as specified in the database. It is important that the data that will influence the impact of this step is the reactor operating time and the associated scenario. It should be remembered that for our study, the reactor's operating life is 25 years, and that we are assuming the most pessimistic scenario possible. The resources associated with this stage are highlighted in red in Appendix 1.

4) Transportation

As mentioned in our hypotheses, we assume that the transport data provided to us in the database include all transport requirements, whether for the movement of ores useful for electricity production (uranium), or for the construction of the reactor. It should be noted that our source provides us with traffic occupancy values for both road and rail, again echoing the transport needs of the various stages in the cycle. The resources associated with this stage are highlighted in blue in Appendix 1.

5) Waste emissions and storage

All these resources, once the reactor has produced electricity, will lead to different types of emissions. These include emissions to air, water and soil. The population impacted by these emissions can be specified, or a more precise description of the emission location can be given. We do not go into more specific details about these emissions, and separate only non-radioactive and radioactive emissions. This is because our study is limited to the storage of waste after the reactor has produced electricity. We will therefore distinguish radioactive waste produced by the reactor and associated emissions from other emissions. Appendix 1 and Appendix 2 list and provide data on all these emissions, as well as on the nuclear waste produced, particularly in terms of volume and radioactivity, which are highlighted in yellow.

3.4 Life-cycle impact assessment

The aim of this section is to provide information on how we obtained a result and assessed the environmental impact of the reactor's life cycle by classifying and combining the material, energy and emission flows from the inventory by type of impact, for the system under study, through LCA environmental impact indicators. After various investigations, we determined that to meet our needs, we should use a LCIA (Life Cycle Impact Assessment) method to obtain these indicators. The ReCiPe (2016) method proposed by OpenLCA seemed to be entirely appropriate and used by many users for similar purposes . However, this method proposes two approaches for determining environmental impacts: the Midpoint approach and the Endpoint approach. The use of these two approaches gives a fairly accurate idea of the impact of our system. The literature informs us that the ReCiPe method proposes indicators for both approaches: 18 indicators for Midpoint and 3 for Endpoint.

The Midpoint approach provides a range of information on environmental impact. These include key elements that people might naturally think of, such as greenhouse gas emissions. The Endpoint approach takes the impact assessment a step further, focusing on the impact on people and ecosystems. It is therefore much more suitable for non-scientists, who can better visualize the effects of these impacts. Unlike the Midpoint approach, the Endpoint approach does not use scientific units. We therefore find the notation species.yr, which is a measure of the number of species that disappear per year, and the notation DALY, which represents the number of years of healthy life lost due to premature death or the onset of disability.

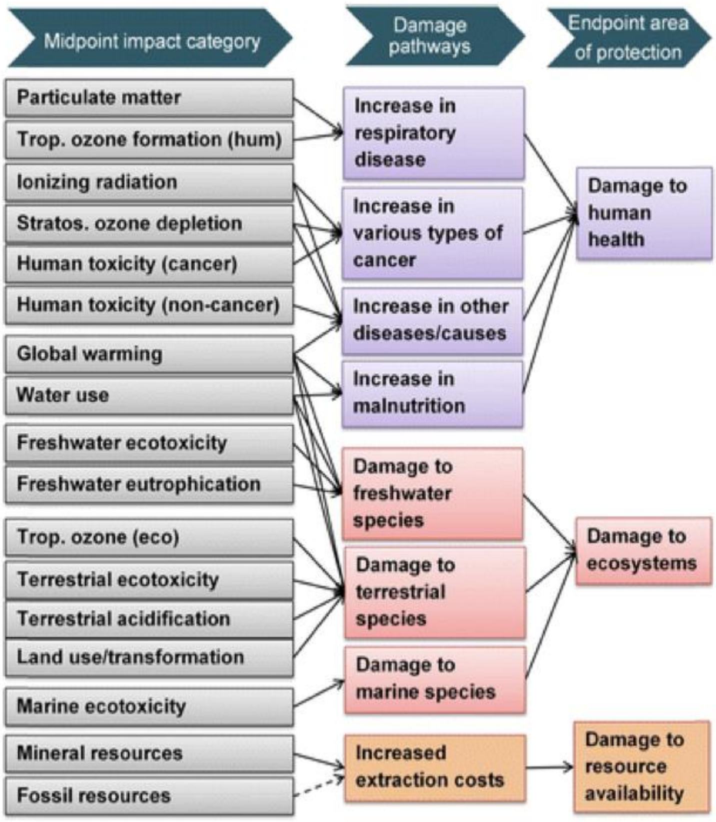

Figure 17: Impact assessment of the Midpoint and Endpoint approaches using the LCAI ReCiPe method
Source: ReCipe (2016)

The aim of our study is to characterize this impact in terms of global warming, as stated in the context of our study. We have therefore chosen the "Global Warming" indicator, as it enables us to fully address our problem. In terms of approach, there are three different perspectives:

- Individualist (I): short-term optimism that technology can avoid many future problems.

- Hierarchist (H): consensual model, often considered the default model in scientific models.

- Egalitarian (E): long-term, based on the precautionary principle.

To continue our study and carry out the impact assessments, we will therefore use the consensual, default model used in scientific models: Midpoint (H).

3.4 Results and interpretations

3.4.1 Results

We calculate this indicator from the life-cycle inventory and present the result in the following table.

Name	Category	Inv	Char	Impact assessment result
Fine particulate matter formation	ReCiPe 2016 Midpoint (H)			1.43317E-5 kg PM2.5 eq
Fossil resource scarcity	ReCiPe 2016 Midpoint (H)			0.00183 kg oil eq
Freshwater ecotoxicity	ReCiPe 2016 Midpoint (H)			0.00012 kg 1,4-DCB
Freshwater eutrophication	ReCiPe 2016 Midpoint (H)			1.21950E-7 kg P eq
Global warming	ReCiPe 2016 Midpoint (H)			0.00618 kg CO2 eq
Human carcinogenic toxicity	ReCiPe 2016 Midpoint (H)			0.00074 kg 1,4-DCB
Human non-carcinogenic toxicity	ReCiPe 2016 Midpoint (H)			0.00265 kg 1,4-DCB
Ionizing radiation	ReCiPe 2016 Midpoint (H)			1.18867 kBq Co-60 eq
Land use	ReCiPe 2016 Midpoint (H)			0.00029 m2a crop eq
Marine ecotoxicity	ReCiPe 2016 Midpoint (H)			0.00019 kg 1,4-DCB
Marine eutrophication	ReCiPe 2016 Midpoint (H)			2.21437E-6 kg N eq
Mineral resource scarcity	ReCiPe 2016 Midpoint (H)			0.00092 kg Cu eq
Ozone formation, Human health	ReCiPe 2016 Midpoint (H)			2.96435E-5 kg NOx eq
Ozone formation, Terrestrial ecosy	ReCiPe 2016 Midpoint (H)			3.03923E-5 kg NOx eq
Stratospheric ozone depletion	ReCiPe 2016 Midpoint (H)			7.61963E-9 kg CFC11 eq
Terrestrial acidification	ReCiPe 2016 Midpoint (H)			3.45834E-5 kg SO2 eq
Terrestrial ecotoxicity	ReCiPe 2016 Midpoint (H)			0.03344 kg 1,4-DCB
Water consumption	ReCiPe 2016 Midpoint (H)			-1.95980 m3

Figure 18: Indicator results using the Midpoint (H) approach on OpenLCA (highlighted is the global warming indicator)
Source: The authors

We can also observe the other indicators, but we will only interpret the one we have selected, i.e. the global warming indicator. The software allows us to obtain this result.

Global warming	ReCiPe 2016 Midpoint (H)			0.00618 kg CO2 eq
Carbon dioxide, fossil	Elementary flows/Emission to air/high population density	0.00280 kg	1.00000 kg CO2 eq/kg	0.00280 kg CO2 eq
Carbon dioxide, fossil	Elementary flows/Emission to air/low population density	0.00188 kg	1.00000 kg CO2 eq/kg	0.00188 kg CO2 eq
Carbon dioxide, fossil	Elementary flows/Emission to air/unspecified	0.00090 kg	1.00000 kg CO2 eq/kg	0.00090 kg CO2 eq
Methane, fossil	Elementary flows/Emission to air/low population density	1.00232E-5 kg	36.00000 kg CO2 eq/kg	0.00036 kg CO2 eq
Dinitrogen monoxide	Elementary flows/Emission to air/high population density	3.65941E-7 kg	298.00000 kg CO2 eq/kg	0.00011 kg CO2 eq
Dinitrogen monoxide	Elementary flows/Emission to air/low population density	2.17076E-7 kg	298.00000 kg CO2 eq/kg	6.46886E-5 kg CO2 eq

Figure 19: Influence of greenhouse gases on the global warming indicator using OpenLCA
Source: The Authors

Also, included in the appendix are the indicators obtained using the Endpoint (H) method, which are not at the heart of our study but are of particular interest (Appendix 3).

3.4.2 Interpretation and analysis

For the purposes of interpretation and analysis, we will present the results obtained for the indicator selected after calculation. For this indicator, we will study the influence of the various greenhouse gases, then we will observe the impact of different scenarios on the indicator and finally, for the same scenario, we will study the differences that can occur for different operating times for similar scenarios. We also wanted to show the impact on the indicator by stage, but the software doesn't give us data on CO2 emissions over the life cycle. So, for the "Global Warming" indicator, we obtain the following result.

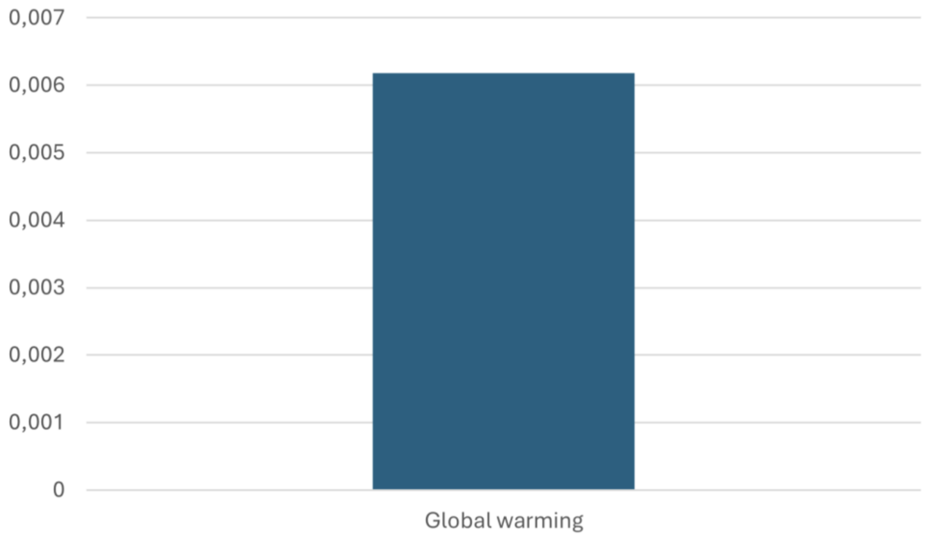

Figure 20: Climate change indicator for a Pressurized Water Reactor over a 25-year operating life and for a pessimistic scenario with changes in atmospheric CO2 concentration
Source: The Authors

After calculating and modeling our results, we obtain a global warming indicator value of 6.18 g eq CO2/kWh for the Pressurized Water Reactor operated for 25 years in a pessimistic scenario. We have presented the influence of each greenhouse gas on the indicator in our results. The percentage share of each of these gases can be estimated and modeled in the following figure.

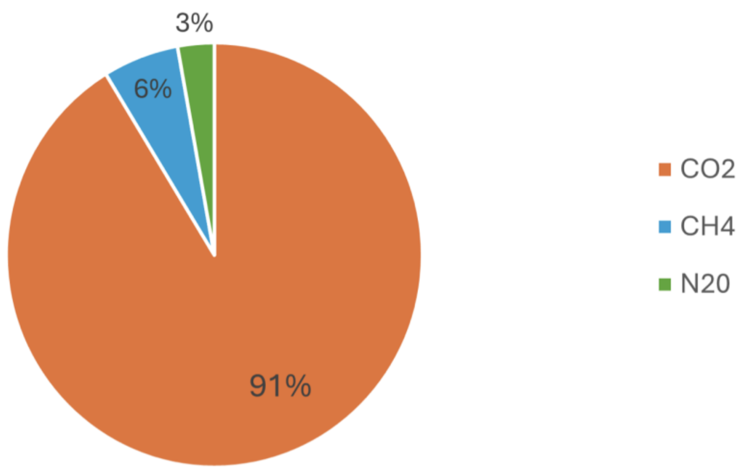

Figure 21: Climate change indicator - analysis for each greenhouse gas
Source: The authors

CO2 dominates the influence on this indicator with 5.58 gCO2eq/kWh, or 91% of the indicator. Next, methane (CH4) accounts for 6% at 0.36 gCO2eq/kWh. Nitrous oxide (N20) accounts for 3% of the indicator, with 0.17 gCO2eq/kWh. The rest of the indicator is shared between greenhouse gases, which have a minority impact. The global warming indicator for different scenarios is also shown in figure 22.

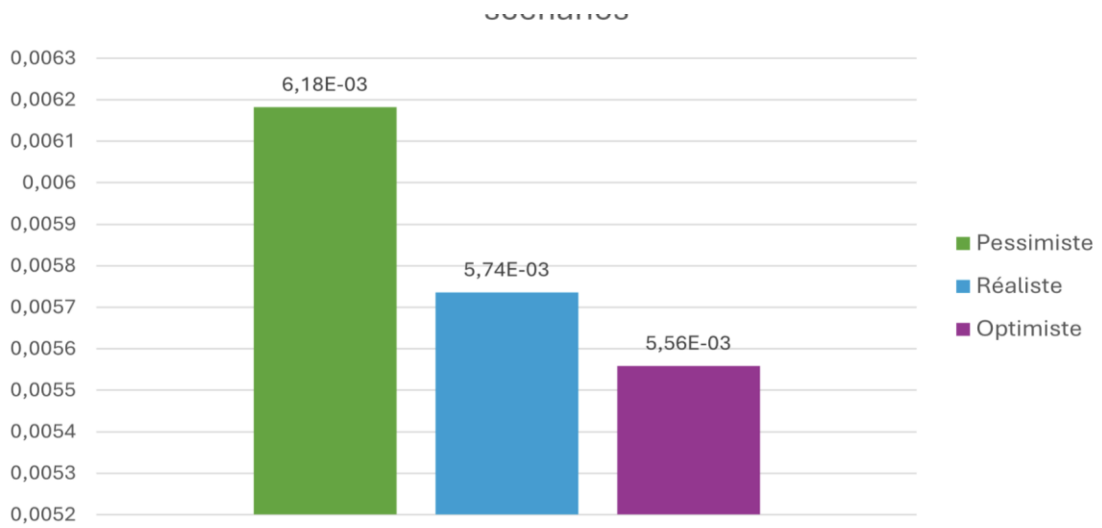

Figure 22: Global warming indicators for different scenarios
Source: The authors

These scenarios are for operating times of 25 years. The pessimistic scenario is the one we used for the study. The realistic and optimistic scenarios predict an atmospheric CO2 concentration of 440 ppm, but the optimistic scenario has a greater influence on life-cycle processes. Thus, we obtain 5.74gCO2eq/kWh for the realistic scenario and 5.56 gCO2eq/kWh for the optimistic scenario. The scenario slightly modifies the value of the indicator, but does not upset the order of magnitude of the value. As expected, a pessimistic scenario leads to a higher indicator, while an optimistic scenario leads to a lower indicator. Nevertheless, we calculate a maximum drop of 10% between the most extreme scenarios. For each scenario, we observe similar influences of the various greenhouse gases on the global warming indicator. Finally, the influence of reactor operating time on the global warming indicator is shown in the following figure.

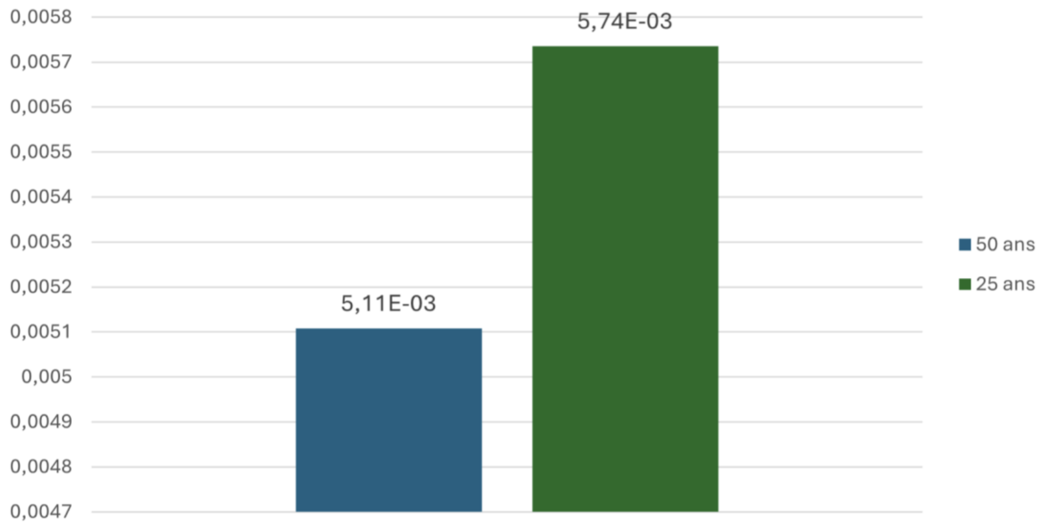

Figure 23: Global warming indicator for a realistic scenario with different reactor operating times.
Source: The authors

We calculate an 11% drop in the value of the indicator for a longer operating time. This seems logical, since it is not the operating phase that has the greatest influence on this indicator. In other words, 25 more years of operation smoothes out the indicator, and the polluting phases merge with operation in a global calculation such as this.

We now turn to the calculation of the EROI using the information in the database. Adding up all the energies entering the system gives 0.040104 MJ. To compare with electricity production, which is 1 kWh, we need to convert mega joules. We therefore obtain 0.01114 KWh of consumption to produce 1 KWh of electrical energy. Applying the formula EROI=Energy produced/Energy invested, we get an EROI of 89.77. This gives a very high EROI of around 90 :1. As we saw earlier, this is the energy source with the highest EROI. This tells us that nuclear power has a very high energy efficiency. We can therefore conclude that it is a sustainable energy source. It also tells us that the system is economically viable, since it produces far more than it consumes.

Our model seems fairly accurate. Indeed, when compared with the values obtained (Figure 9), we obtain values for the global warming indicator close to the values calculated during LCAs carried out on nuclear power plants. This confirms the reliability of our Life Cycle Assessment of the Pressurized Water Reactor. Despite the approximations and assumptions made throughout, we have arrived at values close to those obtained by the various players in the sector (Pratiwi & al., 2023).

4. Conclusion

Life Cycle Assessment is emerging as an essential approach for assessing the environmental impact of products and processes throughout their life cycle. The many benefits of LCA testify to its growing importance in decisions aimed at sustainability and responsible resource management (Diemer, 2023). It provides a comprehensive view of environmental impacts, encompassing the extraction of raw materials, production, distribution, use and even the product's end-of-life (Nakagawa & al., 2022). This global vision makes it possible to identify the critical stages where improvements can be made to minimize negative impacts.

LCA also enables an objective comparison between different options and alternatives (Hartman, Donnet, 2023). Whether choosing between materials for manufacturing a product or determining the best recycling strategy, LCA provides reliable data to inform these decisions.

In the case of a nuclear reactor, LCA reveals that nuclear power is a low-carbon energy source (World Nuclear Association, 2021). It also boasts very high energy efficiency (even if the capacity utilization rate of a nuclear plant is not optimal). This makes it an extremely interesting source of energy, and one that addresses a number of issues, particularly from an environmental and economic point of view.

Bibliography

1. Bjorn A., Laurent A., Owsianak M., Olsen S.I (2018a), Goal definition in M.Z Hauschild, R.K Rosenbaum and S.I Olsen (eds), *Life Cycle Assessment: theory and practice*, Springer, p. 67-74.
2. Bjorn A., Laurent A., Owsianak M., Olsen S.I, Corona A., Hauschild M.Z (2018b), *Scope Definition* in M.Z Hauschild, R.K Rosenbaum and S.I Olsen (eds), Life Cycle Assessment: theory and practice, Springer, p. 75 - 116.
3. Caseau P. (2021), *Les Analyses de Cycle de Vie*. Académie des Technologies.
4. Diemer A. (2023), From Life Cycle Assessment (LCA) to Life Cycle Sustainability Assessment (LCSA), methodological issues and prospects for implementing circular business models, *International Journal of Scientific Engineering and Applied Science*, vol 9, issue 12, p. 1 – 50.
5. Dierickx F., Diemer A. (2020), Energy Use and Climate Change: History and Foresight, in *Encyclopedia of the UN Sustainable Development Goals affordable and clean Energy*, Springer International Publishing, p. 1 – 14.
6. Dolzikova D. (2024), Power plays – Development in Russian Enriched Uranium Trade, Royal United Service Institute (RUSI), *London, UK, Special Report*, http://www.rusi.org
7. Dumas, J., Dubois, A., Thiran, P. *et al.* The Energy Return on Investment of Whole-Energy Systems: Application to Belgium . *Biophys Econ Sust* **7**, 12 (2022). https://doi.org/10.1007/s41247-022-00106-0
8. Dupont E., Germain M., Jeanmart H. (2020), Estimation du Energy Return on Investment (EROi) Societal, Document de travail du LEM – 2020 – 10, p. 1 – 21.
9. EDF (2022), Analyse du cycle de vie du kwh nucléaire, *Note technique*, 5 mai, EDF R&D.
10. EDF (2022), Life Cycle Assessment of Electricity from Torness Nuclear Power Plant Development, 24th May, *Final Report*, Ref ED13018105, 49 p.
11. ESA (2023), Euratom Supply Agency, *Annual Report 2022*. Publications Office of the

European Union, 98 p. https://euratom-supply.ec.europa.eu/document/download/416f638d-1928-44b6-a9d9-d9180b6eb2ad_en?filename=ESA%20Annual%20Report%202022%20-%20Final%20%28website%29_2.pdf&prefLang=fr
12. Gibon T., Menacho A.H (2023), Parametric Life Cycle Assessment of Power for Simplified Models, *Environmental Science Technology*, vol 38, p. 14194 – 14205.
13. Gibon T., Menacho A.H, Guiton M. (2021), *Life Cycle Assessment of Electricity Generation Options*, Union Nations Economic Commission for Europe (UNECE), Geneva.
14. Greenpeace (2023), *La Russie, plaque tournante de l'uranium*, Rapport, mars, Greenpeace France (Greenpeace.fr).
15. Fava J., Denison R., Jones B., Currran M.S, Vigo B., Selke S., Barnum J. (1991), A Technical Framework for Life-Cycle Assessments. *Workshop Report. Society of Environmental Toxicology and Chemistry*, Washington DC.
16. Hainsch K., Löffler K., Burandt T., Auer H., Crespodel Granado P., Pisciella P., Zwickl−Bernhard S., (2022), What policies, societal attitudes, and technology developments will realize the EU Green Deal? *Energy*, 2122067.doi:10.1016/j.energy.2021.1 22067
17. Hartman D., Donnet L. (2023), LCA Modeling of different Nuclear Cycles, the CEA Experience, March 10th, *Energy Division* (DES), 23 p.
18. Hatch (2014), Life Cycle Assessment Literature, Review of Nuclear, Wind and Natural, Gas Power Generation, The Canadian Nuclear Association, *October 9th, 103 p.*
19. Hunt R.G, Franklin W.E (1997), LCA – How it Came About, *International Journal of Life Cycle Assessment*, vol 1, p. 4 – 7.
20. Inman M. (2013), Behind the numbers on energy Return on Investment, *Scientific American*, April 1st. https://www.scientificamerican.com/article/eroi-behind-numbers-energy-return-investment/
21. ISO 14040(2006), Environmental management — Life cycle assessment — Principles and framework. Available at : https ://www.iso.org/obp/ui/fr/iso :std :iso :14040:ed-2 :v1 ?
22. ISO 14020 (2022), Environmental statements and programmes for products — Principles and general requirements. Available at : https ://www.iso.org/obp/ui/iso :std :iso :14020 :ed3 :v1.
23. ISO 14021 (2016), Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling). Available at : https ://www.iso.org/obp/ui/iso :std :iso :14021 :e 2 :v1.
24. ISO 14025 (2006), Environmental labels and declarations — Type III environmental declarations — Principles and procedures. Available at : https ://www.iso.org/obp/ui/iso :std :iso :14025 :ed1 :v1.
25. ISO 14040 (2006), Environmental management — Life cycle assessment — Principles and framework. Available at: https ://www.iso.org/obp/ui/fr/iso :std :iso :14040 :ed-2 :v1.
26. Intergovernmental Panel on Climate Change – IPCC (2014), mitigation of climate - Working Group III contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.
27. Klöpffer W. (1997), Life Cycle Assessment: From the Beginning to the Current State, *Environmental Science and Pollution Research*, vol 4, p. 223 – 228.
28. Kubiszewski I., Cleveland C.J, Endres P.K (2010), Meta-Analysis of Net Energy Return for Wind Power Systems, *Renewable Energy*, vol 35 (1), p. 218 – 225.
29. Lecouls H. (1999), ISO 14043: environmental management - life cycle assessment - life cycle, interpretation. *International Journal of Life Cycle Assessment* 4 (5).
30. Mayer N. (2022), Le nucléaire français, c′est moins de 4gCO2e/kWh! Futura Science, 22 juin, https://www.futura−sciences.com/planete/actualites/transition − energetique − nucleaire francais − cest − moins − 4 − gco2e − kwh − 99227
31. Nakagawa N., Kosai S., Yamasue E. (2022), Life Cycle Resource Use of Nuclear Power Generation Considering Total Material Requirement, *Journal of Cleaner Production*, vol 363, p. 1 – 10.
32. Norris G.A (2001), Integrating Life Cycle Cost Analysis and LCA, *International Journal of LCA*, vol 6 (2), p. 118 -120.
33. Pehnt M. (2006), Dynamic Life Cycle Assessment (LCA) of renewable energy technologies. *Renewable Energy*, Vol 31, p. 55 - 71.
34. Pinto T.M.J, Sverdrup H.U, Diemer A. (2019),

Integrating Life Cycle Analysis into System Dynamics, the case steel in Europe, *Environmental Systems Research*, vol 8 (15). https://environmentalsystemsresearch.springeropen.com/articles/10.1186/s40068-019-0144-2#citeas
35. Pratiwi S.A, Nasruddin N., Sasongko A. (2023), Comparative Assessment of the Environmental impact of nuclear power plant technology using life cycle assessment approach: A review, IOP Conferences series: Earth and Environmental Science, vol 1267, p. 2 – 8.
36. SFEN (2022), Combien coûte le nucléaire ? Économie du nucléaire, *Société Française d'Énergie Nucléaire*. https://www.sfen.org/wp−content/uploads/2022/12/Note−de−compe% CC% 81titivite%CC%81V 2.pdf
37. Tremblay H. (2013), Le rendement énergétique net, principe cardinal d'une politique québécoise à l'égard des hydrocarbures, Globe, Vol 16, n°2, p. 143-160.
38. Turconi R., Boldrin A., Fruergaard A.T (2013), Life Cycle Assessment (LCA) of Electricity Generation Technology: Overview, Comparability and Limitations, *Renewable and Sustainable Energy Reviews*, Vol 28, p. 555 – 565.
39. WeirBach D., Ruprecht G., Huke A., Czerski K., Gottlieb S., Hussein A. (2013), Energy intensities, EROIs (Energy Returned on Invested) and Energy Payback Times of Electricity Generating Power Plants, *Energy*, Vol 52, April, p. 210 – 221.
40. Whitehead B., Andrews D., Shah A., Maidment G. (2015), Assessing the environmental impact of data centres part 2: Building Environmental Assessment Methods and Life Cycle Assessment, *Building and Environment*, Vol 93, p. 395 – 405.
41. World Nuclear Association (2021), Comparison of Life Cycle Greenhouse Gas Emissions of Various Electricity Generation Sources, WNA Report, July, 12 p.

Appendix 1: Inputs to the system studied

Flow	Category	Amount	Unit
Aluminium, 24% in bauxite, 11% in crude ore, in ground	Elementary flows/Emission to air/low population density	7,20464E-06	kg
Anhydrite, in ground	Elementary flows/Emission to water/ocean	4,6423E-10	kg
Barite, 15% in crude ore, in ground	Elementary flows/Resource/biotic	4,58004E-06	kg
Basalt, in ground	Elementary flows/Resource/biotic	4,10707E-06	kg
Borax, in ground	Elementary flows/Resource/biotic	1,98591E-10	kg
Calcium carbonate, in ground	Elementary flows/Resource/biotic	0,000696583	kg
Carbon dioxide, in air	Elementary flows/Resource/biotic	0,000376018	kg
Chromium, 25.5% in chromite, 11.6% in crude ore, in ground	Elementary flows/Resource/in air	3,73929E-05	kg
Chrysotile, in ground	Elementary flows/Resource/in air	1,20749E-09	kg
Cinnabar, in ground	Elementary flows/Resource/in air	1,12327E-10	kg
Clay, bentonite, in ground	Elementary flows/Resource/in ground	0,00011794	kg
Clay, unspecified, in ground	Elementary flows/Resource/in ground	0,000281906	kg
Coal, brown, in ground	Elementary flows/Resource/in ground	0,000258607	kg
Coal, hard, unspecified, in ground	Elementary flows/Resource/in ground	0,000756765	kg
Cobalt, in ground	Elementary flows/Resource/in ground	1,66307E-11	kg
Colemanite, in ground	Elementary flows/Resource/in ground	2,20207E-07	kg
Copper, 0.99% in sulfide, Cu 0.36% and Mo 8.2E-3% in crude ore, in ground	Elementary flows/Resource/in ground	3,94095E-07	kg
Copper, 1.18% in sulfide, Cu 0.39% and Mo 8.2E-3% in crude ore, in ground	Elementary flows/Resource/in ground	2,18699E-06	kg
Copper, 1.42% in sulfide, Cu 0.81% and Mo 8.2E-3% in crude ore, in ground	Elementary flows/Resource/in ground	5,79341E-07	kg
Copper, 2.19% in sulfide, Cu 1.83% and Mo 8.2E-3% in crude ore, in ground	Elementary flows/Resource/in ground	2,87756E-06	kg
Diatomite, in ground	Elementary flows/Resource/in ground	4,27061E-11	kg
Dolomite, in ground	Elementary flows/Resource/in ground	9,00528E-07	kg
Energy, gross calorific value, in biomass	Elementary flows/Resource/in ground	0,00413754	kg
Energy, kinetic (in wind), converted	Elementary flows/Resource/in ground	0,00119757	kg
Energy, potential (in hydropower reservoir), converted	Elementary flows/Resource/in ground	0,00506529	kg
Energy, primary, from solar energy	Elementary flows/Resource/in ground	4,23705E-06	kg
Feldspar, in ground	Elementary flows/Resource/in ground	6,87025E-13	kg
Fluorine, 4.5% in apatite, 1% in crude ore, in ground	Elementary flows/Resource/in ground	9,58977E-08	kg
Fluorine, 4.5% in apatite, 3% in crude ore, in ground	Elementary flows/Resource/in ground	4,21084E-08	kg
Fluorspar, 92%, in ground	Elementary flows/Resource/in ground	2,66765E-05	kg
Gas, mine, off-gas, process, coal mining	Elementary flows/Resource/in ground	7,19952E-06	kg
Gas, natural, in ground	Elementary flows/Resource/in ground	0,000812542	kg
Granite, in ground	Elementary flows/Resource/in ground	1,53241E-09	kg
Gravel, in ground	Elementary flows/Resource/in ground	0,0037634	kg
Gypsum, in ground	Elementary flows/Resource/in ground	3,53328E-09	kg
Heat, waste	Elementary flows/Resource/in ground	7,74442	kg
Iron, 46% in ore, 25% in crude ore, in ground	Elementary flows/Resource/in ground	0,000338903	kg
Kaolinite, 24% in crude ore, in ground	Elementary flows/Resource/in ground	8,61756E-07	kg
Kieserite, 25% in crude ore, in ground	Elementary flows/Resource/in ground	1,15131E-08	kg
Lead, 5%, in sulfide, Pb 2.97% and Zn 5.34% in crude ore, in ground	Elementary flows/Resource/in ground	3,97729E-07	kg
Lithium, 0.15% in brine, in ground	Elementary flows/Resource/in ground	3,37422E-17	kg
Magnesite, 60% in crude ore, in ground	Elementary flows/Resource/in ground	5,34084E-06	kg
Magnesium, 0.13% in water	Elementary flows/Resource/in ground	2,37116E-11	kg
Manganese, 35.7% in sedimentary deposit, 14.2% in crude ore, in ground	Elementary flows/Resource/in ground	1,25452E-06	kg
Metamorphous rock, graphite containing, in ground	Elementary flows/Resource/in ground	8,06229E-12	kg
Molybdenum, 0.010% in sulfide, Mo 8.2E-3% and Cu 1.83% in crude ore, in ground	Elementary flows/Resource/in ground	5,34757E-08	kg
Molybdenum, 0.014% in sulfide, Mo 8.2E-3% and Cu 0.81% in crude ore, in ground	Elementary flows/Resource/in ground	7,60968E-09	kg
Molybdenum, 0.022% in sulfide, Mo 8.2E-3% and Cu 0.36% in crude ore, in ground	Elementary flows/Resource/in ground	3,9052E-07	kg
Molybdenum, 0.025% in sulfide, Mo 8.2E-3% and Cu 0.39% in crude ore, in ground	Elementary flows/Resource/in ground	2,79223E-08	kg
Molybdenum, 0.11% in sulfide, Mo 4.1E-2% and Cu 0.36% in crude ore, in ground	Elementary flows/Resource/in ground	7,88165E-07	kg
Nickel, 1.13% in sulfide, Ni 0.76% and Cu 0.76% in crude ore, in ground	Elementary flows/Resource/in ground	3,04526E-07	kg
Nickel, 1.98% in silicates, 1.04% in crude ore, in ground	Elementary flows/Resource/in ground	8,31391E-05	kg
Occupation, arable	Elementary flows/Resource/in ground	7,04289E-17	kg
Occupation, arable, non-irrigated	Elementary flows/Resource/in ground	3,84383E-07	kg
Occupation, construction site	Elementary flows/Resource/in ground	0,000010241	kg
Occupation, dump site	Elementary flows/Resource/in ground	9,92725E-05	kg
Occupation, dump site, benthos	Elementary flows/Resource/in ground	4,46341E-07	kg
Occupation, forest, intensive	Elementary flows/Resource/in ground	1,83496E-05	kg

Occupation, forest, intensive, normal	Elementary flows/Resource/in ground	0,000441627	kg
Occupation, forest, intensive, short-cycle	Elementary flows/Resource/in ground	0,00003224	kg
Occupation, industrial area	Elementary flows/Resource/in ground	1,92615E-05	kg
Occupation, industrial area, benthos	Elementary flows/Resource/in ground	4,08777E-09	kg
Occupation, industrial area, built up	Elementary flows/Resource/in ground	2,71934E-05	kg
Occupation, industrial area, vegetation	Elementary flows/Resource/in ground	4,85105E-06	kg
Occupation, mineral extraction site	Elementary flows/Resource/in ground	4,99337E-05	kg
Occupation, permanent crop, fruit, intensive	Elementary flows/Resource/in ground	1,1067E-07	kg
Occupation, shrub land, sclerophyllous	Elementary flows/Resource/in ground	8,87038E-07	kg
Occupation, traffic area, rail embankment	Elementary flows/Resource/in ground	1,4717E-06	kg
Occupation, traffic area, rail network	Elementary flows/Resource/in ground	1,62743E-06	kg
Occupation, traffic area, road embankment	Elementary flows/Resource/in ground	4,93242E-06	kg
Occupation, traffic area, road network	Elementary flows/Resource/in ground	6,11185E-06	kg
Occupation, urban, continuously built	Elementary flows/Resource/in ground	2,33967E-18	kg
Occupation, urban, discontinuously built	Elementary flows/Resource/in ground	8,21669E-10	kg
Occupation, water bodies, artificial	Elementary flows/Resource/in ground	4,93803E-06	kg
Occupation, water courses, artificial	Elementary flows/Resource/in ground	3,96342E-06	m2
Oil, crude, in ground	Elementary flows/Resource/in ground	0,000777447	m2
Olivine, in ground	Elementary flows/Resource/in ground	1,50026E-10	m2
Pd, Pd 2.0E-4%, Pt 4.8E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Elementary flows/Resource/in ground	9,54576E-13	m2
Pd, Pd 7.3E-4%, Pt 2.5E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Elementary flows/Resource/in ground	2,29402E-12	m2
Peat, in ground	Elementary flows/Resource/in ground	2,13837E-08	m2
Phosphorus, 18% in apatite, 12% in crude ore, in ground	Elementary flows/Resource/in ground	1,7612E-07	m2
Phosphorus, 18% in apatite, 4% in crude ore, in ground	Elementary flows/Resource/in ground	3,83591E-07	m2
Pt, Pt 2.5E-4%, Pd 7.3E-4%, Rh 2.0E-5%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Elementary flows/Resource/in ground	2,6275E-14	m2
Pt, Pt 4.8E-4%, Pd 2.0E-4%, Rh 2.4E-5%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Elementary flows/Resource/in ground	9,41935E-14	m2
Rh, Rh 2.0E-5%, Pt 2.5E-4%, Pd 7.3E-4%, Ni 2.3E+0%, Cu 3.2E+0% in ore, in ground	Elementary flows/Resource/in ground	2,18005E-14	m2
Rh, Rh 2.4E-5%, Pt 4.8E-4%, Pd 2.0E-4%, Ni 3.7E-2%, Cu 5.2E-2% in ore, in ground	Elementary flows/Resource/in water	6,82817E-14	m2
Rhenium, in crude ore, in ground	Elementary flows/Resource/in water	3,83666E-14	m2
Rutile, in ground	Elementary flows/Resource/in water	6,32953E-13	m2
Sand, unspecified, in ground	Elementary flows/Resource/in water	1,04963E-08	m2
Shale, in ground	Elementary flows/Resource/in water	1,3138E-09	m2
Silver, 0.01% in crude ore, in ground	Elementary flows/Resource/in water	3,67879E-11	m2
Sodium chloride, in ground	Elementary flows/Resource/in water	0,000154466	m2
Sodium sulphate, various forms, in ground	Elementary flows/Resource/in water	7,96119E-07	m2
Stibnite, in ground	Elementary flows/Resource/in water	4,43809E-12	m2
Sulfite	Elementary flows/Resource/in water	6,53472E-19	m2
Sulfur, in ground	Elementary flows/Resource/in water	1,2716E-08	m2
Sylvite, 25 % in sylvinite, in ground	Elementary flows/Resource/land	6,7191E-08	m2
Talc, in ground	Elementary flows/Resource/land	8,8819E-09	m2
Tin, 79% in cassiterite, 0.1% in crude ore, in ground	Elementary flows/Resource/land	6,56039E-09	m2
TiO2, 45-60% in Ilmenite, in ground	Elementary flows/Resource/land	1,60837E-06	m2
Transformation, from arable	Elementary flows/Resource/land	4,51225E-09	m2
Transformation, from arable, non-irrigated	Elementary flows/Resource/land	7,08006E-07	m2
Transformation, from arable, non-irrigated, fallow	Elementary flows/Resource/land	1,3857E-09	m2
Transformation, from dump site, inert material landfill	Elementary flows/Resource/land	1,31748E-07	m2
Transformation, from dump site, residual material landfill	Elementary flows/Resource/land	4,43069E-08	m2
Transformation, from dump site, sanitary landfill	Elementary flows/Resource/land	1,04246E-09	m2
Transformation, from dump site, slag compartment	Elementary flows/Resource/land	2,39387E-10	m2
Transformation, from forest	Elementary flows/Resource/land	1,12192E-06	m2
Transformation, from forest, extensive	Elementary flows/Resource/land	3,3322E-06	m2
Transformation, from industrial area	Elementary flows/Resource/land	2,69734E-06	m2
Transformation, from industrial area, benthos	Elementary flows/Resource/land	3,01785E-11	m2
Transformation, from industrial area, built up	Elementary flows/Resource/land	1,58033E-10	m2
Transformation, from industrial area, vegetation	Elementary flows/Resource/land	2,42053E-10	m2
Transformation, from mineral extraction site	Elementary flows/Resource/land	3,14551E-07	m2
Transformation, from pasture and meadow	Elementary flows/Resource/land	1,00392E-06	m2
Transformation, from pasture and meadow, intensive	Elementary flows/Resource/land	5,70518E-10	m2
Transformation, from sea and ocean	Elementary flows/Resource/land	4,46811E-07	m2
Transformation, from shrub land, sclerophyllous	Elementary flows/Resource/land	1,97737E-07	m2

Transformation, from unknown	Elementary flows/Resource/land	6,80785E-06	m2
Transformation, to arable	Elementary flows/Resource/land	5,81288E-08	m2
Transformation, to arable, non-irrigated	Elementary flows/Resource/land	7,08579E-07	m2
Transformation, to arable, non-irrigated, fallow	Elementary flows/Resource/land	1,9744E-09	m2
Transformation, to dump site	Elementary flows/Resource/land	8,9852E-07	m2
Transformation, to dump site, benthos	Elementary flows/Resource/land	4,46341E-07	m2
Transformation, to dump site, inert material landfill	Elementary flows/Resource/land	1,31748E-07	m2*a
Transformation, to dump site, residual material landfill	Elementary flows/Resource/land	4,4307E-08	m2*a
Transformation, to dump site, sanitary landfill	Elementary flows/Resource/land	1,04246E-09	m2*a
Transformation, to dump site, slag compartment	Elementary flows/Resource/land	2,39387E-10	m2*a
Transformation, to forest	Elementary flows/Resource/land	4,63077E-07	m2*a
Transformation, to forest, intensive	Elementary flows/Resource/land	1,22303E-07	m2*a
Transformation, to forest, intensive, normal	Elementary flows/Resource/land	3,17417E-06	m2*a
Transformation, to forest, intensive, short-cycle	Elementary flows/Resource/land	0,000001612	m2*a
Transformation, to heterogeneous, agricultural	Elementary flows/Resource/land	5,25456E-08	m2*a
Transformation, to industrial area	Elementary flows/Resource/land	3,43222E-07	m2*a
Transformation, to industrial area, benthos	Elementary flows/Resource/land	4,76761E-10	m2*a
Transformation, to industrial area, built up	Elementary flows/Resource/land	6,90438E-07	m2*a
Transformation, to industrial area, vegetation	Elementary flows/Resource/land	1,25334E-07	m2*a
Transformation, to mineral extraction site	Elementary flows/Resource/land	4,59685E-06	m2*a
Transformation, to pasture and meadow	Elementary flows/Resource/land	4,92414E-09	m2*a
Transformation, to permanent crop, fruit, intensive	Elementary flows/Resource/land	1,80564E-09	m2*a
Transformation, to sea and ocean	Elementary flows/Resource/land	2,38537E-11	m2*a
Transformation, to shrub land, sclerophyllous	Elementary flows/Resource/land	1,77337E-07	m2*a
Transformation, to traffic area, rail embankment	Elementary flows/Resource/land	3,42453E-09	m2*a
Transformation, to traffic area, rail network	Elementary flows/Resource/land	3,76628E-09	m2*a
Transformation, to traffic area, road embankment	Elementary flows/Resource/land	3,40499E-08	m2*a
Transformation, to traffic area, road network	Elementary flows/Resource/land	1,2767E-07	m2*a
Transformation, to unknown	Elementary flows/Resource/land	2,70499E-06	m2*a
Transformation, to urban, discontinuously built	Elementary flows/Resource/land	1,63671E-11	m3

Transformation, to water bodies, artificial	Elementary flows/Resource/land	2,45533E-07	m3
Transformation, to water courses, artificial	Elementary flows/Resource/land	4,63409E-08	m3
Ulexite, in ground	Elementary flows/Resource/land	5,79798E-10	m3
Uranium, in ground	Elementary flows/Resource/land	2,38653E-05	m3
Vermiculite, in ground	Elementary flows/Resource/land	2,1107E-10	m3
Volume occupied, final repository for low-active radioactive waste	Elementary flows/Resource/land	4,9448E-08	m3
Volume occupied, final repository for radioactive waste	Elementary flows/Resource/land	1,36784E-08	m3
Volume occupied, reservoir	Elementary flows/Resource/land	6,75684E-05	m3
Volume occupied, underground deposit	Elementary flows/Resource/land	9,23457E-10	m3
Water, cooling, unspecified natural origin	Elementary flows/Resource/land	4,81312E-05	m3
Water, lake	Elementary flows/Resource/land	2,15334E-07	m3
Water, river	Elementary flows/Resource/land	0,00681751	m3
Water, salt, ocean	Elementary flows/Resource/land	0,00211674	m3
Water, salt, sole	Elementary flows/Resource/land	5,85753E-07	m3
Water, turbine use, unspecified natural origin	Elementary flows/Resource/land	0,0332037	m3
Water, unspecified natural origin	Elementary flows/Resource/land	0,000137964	m3*a
Water, well, in ground	Elementary flows/Resource/land	3,43015E-06	MJ
Wood, hard, standing	Elementary flows/Resource/land	1,91877E-07	MJ
Wood, soft, standing	Elementary flows/Resource/land	1,83407E-07	MJ
Wood, unspecified, standing	Elementary flows/Resource/land	3,15662E-12	MJ
Zinc 9%, in sulfide, Zn 5.34% and Pb 2.97% in crude ore, in ground	Elementary flows/Resource/land	3,71843E-07	MJ

Appendix 2: Outputs of the system studied

Flow	Category	Amount	Unit
Acenaphthene	Elementary flows/Emission to air/high population density	2,33779E-15	kg
Acenaphthene	Elementary flows/Emission to water/ocean	9,53724E-14	kg
Acenaphthene	Elementary flows/Emission to water/river	1,9919E-13	kg
Acenaphthylene	Elementary flows/Emission to water/ocean	5,96461E-15	kg
Acenaphthylene	Elementary flows/Emission to water/river	1,24574E-14	kg
Acetaldehyde	Elementary flows/Emission to air/high population density	1,60203E-09	kg
Acetic acid	Elementary flows/Emission to air/high population density	1,21643E-08	kg
Acetic acid	Elementary flows/Emission to air/unspecified	1,1876E-08	kg
Acetic acid	Elementary flows/Emission to water/river	1,08566E-09	kg
Acetone	Elementary flows/Emission to air/high population density	1,55442E-09	kg
Acetone	Elementary flows/Emission to air/low population density	3,16697E-11	kg
Acidity, unspecified	Elementary flows/Emission to water/river	1,46113E-09	kg
Aclonifen	Elementary flows/Emission to soil/agricultural	8,07801E-13	kg
Acrolein	Elementary flows/Emission to air/high population density	1,34344E-12	kg
Acrolein	Elementary flows/Emission to air/low population density	3,90817E-14	kg
Actinides, radioactive, unspecified	Elementary flows/Emission to air/low population density	4,89673E-10	kBq
Actinides, radioactive, unspecified	Elementary flows/Emission to water/ocean	8,59801E-05	kBq
Aerosols, radioactive, unspecified	Elementary flows/Emission to air/low population density	1,38396E-05	kBq
Aerosols, radioactive, unspecified	Elementary flows/Emission to air/unspecified	4,5361E-16	kBq
Aldehydes, unspecified	Elementary flows/Emission to air/high population density	1,00137E-10	kg
Aldehydes, unspecified	Elementary flows/Emission to air/low population density	1,90488E-08	kg
Aluminium	Elementary flows/Emission to air/high population density	2,79856E-08	kg
Aluminium	Elementary flows/Emission to air/low population density	2,45148E-09	kg
Aluminium	Elementary flows/Emission to air/unspecified	1,13986E-06	kg
Aluminium	Elementary flows/Emission to soil/agricultural	2,05758E-09	kg
Aluminium	Elementary flows/Emission to soil/industrial	2,49933E-08	kg
Aluminium	Elementary flows/Emission to water/ground water	4,36402E-09	kg
Aluminium	Elementary flows/Emission to water/ground water, long-term	1,94188E-06	kg
Aluminium	Elementary flows/Emission to water/ocean	5,74084E-09	kg
Aluminium	Elementary flows/Emission to water/river	7,64164E-06	kg
Aluminium	Elementary flows/Emission to water/unspecified	7,73482E-11	kg
Ammonia	Elementary flows/Emission to air/high population density	1,63662E-07	kg
Ammonia	Elementary flows/Emission to air/low population density	6,42788E-08	kg
Ammonia	Elementary flows/Emission to air/unspecified	4,721E-07	kg
Ammonium carbonate	Elementary flows/Emission to air/high population density	2,44452E-12	kg
Ammonium, ion	Elementary flows/Emission to water/ground water	5,50682E-10	kg
Ammonium, ion	Elementary flows/Emission to water/ground water, long-term	4,39441E-09	kg
Ammonium, ion	Elementary flows/Emission to water/ocean	2,25449E-09	kg
Ammonium, ion	Elementary flows/Emission to water/river	2,72101E-06	kg
Antimony	Elementary flows/Emission to air/high population density	5,44264E-12	kg
Antimony	Elementary flows/Emission to air/low population density	2,00423E-10	kg
Antimony	Elementary flows/Emission to air/unspecified	8,89198E-13	kg
Antimony	Elementary flows/Emission to soil/agricultural	2,39933E-14	kg
Antimony	Elementary flows/Emission to water/ground water	8,70322E-10	kg
Antimony	Elementary flows/Emission to water/ground water, long-term	3,24264E-09	kg
Antimony	Elementary flows/Emission to water/river	1,74485E-09	kg
Antimony-122	Elementary flows/Emission to water/river	5,70913E-11	kBq
Antimony-124	Elementary flows/Emission to air/low population density	1,41609E-13	kBq
Antimony-124	Elementary flows/Emission to water/river	1,20345E-05	kBq
Antimony-125	Elementary flows/Emission to air/low population density	1,4778E-12	kBq
Antimony-125	Elementary flows/Emission to water/river	8,79241E-06	kBq
AOX, Adsorbable Organic Halogen as Cl	Elementary flows/Emission to water/ocean	6,87707E-12	kg
AOX, Adsorbable Organic Halogen as Cl	Elementary flows/Emission to water/river	5,30992E-10	kg
AOX, Adsorbable Organic Halogen as Cl	Elementary flows/Emission to water/unspecified	1,31907E-11	kg
Argon-41	Elementary flows/Emission to air/low population density	6,00306E-07	kBq
Arsenic	Elementary flows/Emission to air/high population density	2,06708E-10	kg
Arsenic	Elementary flows/Emission to air/low population density	2,21974E-09	kg
Arsenic	Elementary flows/Emission to air/unspecified	5,33561E-12	kg
Arsenic	Elementary flows/Emission to soil/agricultural	5,82545E-13	kg

Arsenic	Elementary flows/Emission to soil/industrial	9,99733E-12	kg
Arsenic, ion	Elementary flows/Emission to water/ground water	1,08575E-08	kg
Arsenic, ion	Elementary flows/Emission to water/ground water, long-term	8,34306E-11	kg
Arsenic, ion	Elementary flows/Emission to water/ocean	3,69422E-11	kg
Arsenic, ion	Elementary flows/Emission to water/river	5,40879E-09	kg
Arsenic, ion	Elementary flows/Emission to water/unspecified	2,35941E-09	kg
Atrazine	Elementary flows/Emission to soil/agricultural	7,55593E-14	kg
Barite	Elementary flows/Emission to water/ocean	2,78104E-07	kg
Barium	Elementary flows/Emission to air/high population density	3,28543E-10	kg
Barium	Elementary flows/Emission to air/low population density	1,13958E-10	kg
Barium	Elementary flows/Emission to soil/agricultural	9,40139E-13	kg
Barium	Elementary flows/Emission to soil/industrial	1,24967E-08	kg
Barium	Elementary flows/Emission to water/ground water	3,0305E-07	kg
Barium	Elementary flows/Emission to water/ground water, long-term	1,76709E-08	kg
Barium	Elementary flows/Emission to water/ocean	1,35622E-08	kg
Barium	Elementary flows/Emission to water/river	6,71785E-08	kg
Barium-140	Elementary flows/Emission to air/low population density	9,6129E-11	kBq
Barium-140	Elementary flows/Emission to water/river	2,5009E-10	kBq
Bentazone	Elementary flows/Emission to soil/agricultural	4,114E-13	kg
Benzaldehyde	Elementary flows/Emission to air/high population density	7,00925E-13	kg
Benzene	Elementary flows/Emission to air/high population density	1,78953E-08	kg
Benzene	Elementary flows/Emission to air/low population density	4,54972E-09	kg
Benzene	Elementary flows/Emission to air/lower stratosphere + upper troposphere	5,16867E-17	kg
Benzene	Elementary flows/Emission to air/unspecified	5,88301E-09	kg
Benzene	Elementary flows/Emission to water/ocean	1,26899E-09	kg
Benzene	Elementary flows/Emission to water/river	9,53061E-09	kg
Benzene, ethyl-	Elementary flows/Emission to air/high population density	1,02459E-09	kg
Benzene, ethyl-	Elementary flows/Emission to water/ocean	3,68077E-10	kg
Benzene, ethyl-	Elementary flows/Emission to water/river	7,6863E-10	kg
Benzene, hexachloro-	Elementary flows/Emission to air/high population density	5,76954E-14	kg
Benzene, hexachloro-	Elementary flows/Emission to air/unspecified	3,5383E-12	kg
Benzene, pentachloro-	Elementary flows/Emission to air/high population density	1,44827E-13	kg
Benzo(a)pyrene	Elementary flows/Emission to air/high population density	8,84398E-13	kg
Benzo(a)pyrene	Elementary flows/Emission to air/low population density	1,42733E-11	kg
Benzo(a)pyrene	Elementary flows/Emission to air/unspecified	1,63063E-11	kg
Beryllium	Elementary flows/Emission to air/high population density	3,29347E-12	kg
Beryllium	Elementary flows/Emission to air/low population density	1,55469E-11	kg
Beryllium	Elementary flows/Emission to air/unspecified	1,3338E-12	kg
Beryllium	Elementary flows/Emission to water/ground water	7,62395E-14	kg
Beryllium	Elementary flows/Emission to water/ground water, long-term	8,26584E-11	kg
Beryllium	Elementary flows/Emission to water/river	3,031E-10	kg
BOD5, Biological Oxygen Demand	Elementary flows/Emission to water/ground water	1,0851E-10	kg
BOD5, Biological Oxygen Demand	Elementary flows/Emission to water/ground water, long-term	0,000002135	kg
BOD5, Biological Oxygen Demand	Elementary flows/Emission to water/ocean	1,66589E-06	kg
BOD5, Biological Oxygen Demand	Elementary flows/Emission to water/river	8,49147E-06	kg
BOD5, Biological Oxygen Demand	Elementary flows/Emission to water/unspecified	3,56491E-06	kg
Boron	Elementary flows/Emission to air/high population density	1,33793E-09	kg
Boron	Elementary flows/Emission to air/low population density	5,83446E-09	kg
Boron	Elementary flows/Emission to soil/agricultural	1,76852E-13	kg
Boron	Elementary flows/Emission to soil/industrial	2,49933E-10	kg
Boron	Elementary flows/Emission to soil/unspecified	1,45014E-10	kg
Boron	Elementary flows/Emission to water/ground water	2,02331E-10	kg
Boron	Elementary flows/Emission to water/ground water, long-term	1,80928E-08	kg
Boron	Elementary flows/Emission to water/ocean	1,55219E-10	kg
Boron	Elementary flows/Emission to water/river	1,6079E-09	kg
Bromate	Elementary flows/Emission to water/river	6,41538E-09	kg
Bromine	Elementary flows/Emission to air/high population density	5,59831E-11	kg
Bromine	Elementary flows/Emission to air/low population density	6,4762E-10	kg
Bromine	Elementary flows/Emission to water/ground water	1,9272E-10	kg
Bromine	Elementary flows/Emission to water/ground water, long-term	1,14558E-09	kg

Bromine	Elementary flows/Emission to water/ocean	1,07332E-08	kg
Bromine	Elementary flows/Emission to water/river	2,69865E-08	kg
Butadiene	Elementary flows/Emission to air/low population density	8,05735E-18	kg
Butadiene	Elementary flows/Emission to air/lower stratosphere + upper troposphere	4,89668E-17	kg
Butadiene	Elementary flows/Emission to air/unspecified	1,14256E-16	kg
Butane	Elementary flows/Emission to air/high population density	5,99133E-08	kg
Butane	Elementary flows/Emission to air/low population density	7,42128E-09	kg
Butene	Elementary flows/Emission to air/high population density	1,007E-09	kg
Butene	Elementary flows/Emission to water/river	7,41491E-13	kg
Cadmium	Elementary flows/Emission to air/high population density	3,52322E-10	kg
Cadmium	Elementary flows/Emission to air/low population density	6,27229E-10	kg
Cadmium	Elementary flows/Emission to air/lower stratosphere + upper troposphere	2,59084E-20	kg
Cadmium	Elementary flows/Emission to air/unspecified	1,63472E-11	kg
Cadmium	Elementary flows/Emission to soil/agricultural	1,64251E-12	kg
Cadmium	Elementary flows/Emission to soil/unspecified	1,71894E-12	kg
Cadmium, ion	Elementary flows/Emission to water/ground water	1,56949E-10	kg
Cadmium, ion	Elementary flows/Emission to water/ground water, long-term	2,12949E-10	kg
Cadmium, ion	Elementary flows/Emission to water/ocean	1,39175E-11	kg
Cadmium, ion	Elementary flows/Emission to water/river	1,86669E-09	kg
Cadmium, ion	Elementary flows/Emission to water/unspecified	2,42739E-09	kg
Calcium	Elementary flows/Emission to air/high population density	7,56579E-09	kg
Calcium	Elementary flows/Emission to air/low population density	4,97418E-10	kg
Calcium	Elementary flows/Emission to soil/agricultural	2,31904E-08	kg
Calcium	Elementary flows/Emission to soil/industrial	9,99733E-08	kg
Calcium, ion	Elementary flows/Emission to water/ground water	1,80699E-08	kg
Calcium, ion	Elementary flows/Emission to water/ground water, long-term	7,96909E-06	kg
Calcium, ion	Elementary flows/Emission to water/lake	2,33072E-08	kg
Calcium, ion	Elementary flows/Emission to water/ocean	8,97444E-07	kg
Calcium, ion	Elementary flows/Emission to water/river	1,61203E-05	kg
Carbetamide	Elementary flows/Emission to soil/agricultural	1,99404E-13	kg

Carbon	Elementary flows/Emission to soil/agricultural	2,4367E-08	kg
Carbon	Elementary flows/Emission to soil/industrial	7,498E-08	kg
Carbon dioxide, biogenic	Elementary flows/Emission to air/high population density	0,000117768	kg
Carbon dioxide, biogenic	Elementary flows/Emission to air/low population density	6,20529E-07	kg
Carbon dioxide, biogenic	Elementary flows/Emission to air/unspecified	6,71344E-06	kg
Carbon dioxide, fossil	Elementary flows/Emission to air/high population density	0,00280458	kg
Carbon dioxide, fossil	Elementary flows/Emission to air/low population density	0,00187585	kg
Carbon dioxide, fossil	Elementary flows/Emission to air/lower stratosphere + upper troposphere	8,16114E-12	kg
Carbon dioxide, fossil	Elementary flows/Emission to air/unspecified	0,000903573	kg
Carbon disulfide	Elementary flows/Emission to air/high population density	6,40917E-13	kg
Carbon disulfide	Elementary flows/Emission to air/low population density	5,69368E-08	kg
Carbon monoxide, biogenic	Elementary flows/Emission to air/high population density	4,39714E-08	kg
Carbon monoxide, biogenic	Elementary flows/Emission to air/low population density	8,09815E-08	kg
Carbon monoxide, biogenic	Elementary flows/Emission to air/unspecified	3,56546E-07	kg
Carbon monoxide, fossil	Elementary flows/Emission to air/high population density	6,57267E-07	kg
Carbon monoxide, fossil	Elementary flows/Emission to air/low population density	8,39087E-06	kg
Carbon monoxide, fossil	Elementary flows/Emission to air/lower stratosphere + upper troposphere	9,5861E-15	kg
Carbon monoxide, fossil	Elementary flows/Emission to air/unspecified	1,11317E-05	kg
Carbon-14	Elementary flows/Emission to air/low population density	0,0508757	kBq
Carbon-14	Elementary flows/Emission to water/river	3,79928E-07	kBq
Carbonate	Elementary flows/Emission to water/river	7,90451E-07	kg
Carboxylic acids, unspecified	Elementary flows/Emission to water/ocean	8,76894E-08	kg
Carboxylic acids, unspecified	Elementary flows/Emission to water/river	1,17851E-07	kg
Cerium-141	Elementary flows/Emission to air/low population density	2,33038E-11	kBq
Cerium-141	Elementary flows/Emission to water/river	9,99901E-11	kBq
Cerium-144	Elementary flows/Emission to water/river	3,04402E-11	kBq
Cesium	Elementary flows/Emission to water/ocean	1,53332E-11	kg
Cesium	Elementary flows/Emission to water/river	3,20241E-11	kg
Cesium-134	Elementary flows/Emission to air/low population density	1,1161E-12	kBq
Cesium-134	Elementary flows/Emission to water/river	8,76922E-06	kBq

Cesium-136	Elementary flows/Emission to water/river	1,77463E-11	kBq
Cesium-137	Elementary flows/Emission to air/low population density	1,97849E-11	kBq
Cesium-137	Elementary flows/Emission to water/ocean	0,00985253	kBq
Cesium-137	Elementary flows/Emission to water/river	1,72582E-05	kBq
Chlorate	Elementary flows/Emission to water/river	7,737E-08	kg
Chloride	Elementary flows/Emission to soil/agricultural	2,42832E-10	kg
Chloride	Elementary flows/Emission to soil/industrial	8,74766E-08	kg
Chloride	Elementary flows/Emission to soil/unspecified	3,30261E-07	kg
Chloride	Elementary flows/Emission to water/ground water	7,0832E-06	kg
Chloride	Elementary flows/Emission to water/ground water, long-term	2,16626E-07	kg
Chloride	Elementary flows/Emission to water/ocean	7,69969E-06	kg
Chloride	Elementary flows/Emission to water/river	6,33594E-05	kg
Chloride	Elementary flows/Emission to water/unspecified	1,04843E-05	kg
Chlorinated solvents, unspecified	Elementary flows/Emission to water/ocean	7,81979E-19	kg
Chlorinated solvents, unspecified	Elementary flows/Emission to water/river	7,33587E-11	kg
Chlorine	Elementary flows/Emission to air/high population density	2,12431E-08	kg
Chlorine	Elementary flows/Emission to air/low population density	4,52544E-15	kg
Chlorine	Elementary flows/Emission to air/unspecified	1,96288E-13	kg
Chlorine	Elementary flows/Emission to water/ground water	1,72089E-07	kg
Chlorine	Elementary flows/Emission to water/river	2,31242E-09	kg
Chloroform	Elementary flows/Emission to air/high population density	1,94663E-10	kg
Chloroform	Elementary flows/Emission to water/river	6,23536E-17	kg
Chlorothalonil	Elementary flows/Emission to soil/agricultural	5,39432E-11	kg
Chromium	Elementary flows/Emission to air/high population density	2,32714E-10	kg
Chromium	Elementary flows/Emission to air/low population density	1,20917E-07	kg
Chromium	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,29543E-19	kg
Chromium	Elementary flows/Emission to air/unspecified	5,23473E-10	kg
Chromium	Elementary flows/Emission to soil/agricultural	4,99103E-11	kg
Chromium	Elementary flows/Emission to soil/industrial	1,24967E-10	kg
Chromium	Elementary flows/Emission to soil/unspecified	1,54928E-11	kg

Chromium VI	Elementary flows/Emission to air/high population density	9,00802E-12	kg
Chromium VI	Elementary flows/Emission to air/low population density	3,01938E-09	kg
Chromium VI	Elementary flows/Emission to air/unspecified	2,7965E-13	kg
Chromium VI	Elementary flows/Emission to soil/unspecified	8,18636E-10	kg
Chromium VI	Elementary flows/Emission to water/ground water	9,53894E-11	kg
Chromium VI	Elementary flows/Emission to water/ground water, long-term	6,25026E-08	kg
Chromium VI	Elementary flows/Emission to water/river	2,05175E-08	kg
Chromium VI	Elementary flows/Emission to water/unspecified	2,37272E-09	kg
Chromium, ion	Elementary flows/Emission to water/ground water	4,29683E-08	kg
Chromium, ion	Elementary flows/Emission to water/ocean	9,51513E-11	kg
Chromium, ion	Elementary flows/Emission to water/river	2,17855E-08	kg
Chromium, ion	Elementary flows/Emission to water/unspecified	2,5507E-10	kg
Chromium-51	Elementary flows/Emission to air/low population density	1,49331E-12	kBq
Chromium-51	Elementary flows/Emission to water/river	3,01035E-06	kBq
Cobalt	Elementary flows/Emission to air/high population density	3,72647E-10	kg
Cobalt	Elementary flows/Emission to air/low population density	1,72097E-09	kg
Cobalt	Elementary flows/Emission to air/unspecified	8,86643E-11	kg
Cobalt	Elementary flows/Emission to soil/agricultural	1,61813E-12	kg
Cobalt	Elementary flows/Emission to water/ground water	1,24486E-09	kg
Cobalt	Elementary flows/Emission to water/ground water, long-term	1,17722E-07	kg
Cobalt	Elementary flows/Emission to water/ocean	2,968E-10	kg
Cobalt	Elementary flows/Emission to water/river	4,73953E-10	kg
Cobalt-57	Elementary flows/Emission to water/river	5,63334E-10	kBq
Cobalt-58	Elementary flows/Emission to air/low population density	2,07949E-12	kBq
Cobalt-58	Elementary flows/Emission to water/river	6,32614E-05	kBq
Cobalt-60	Elementary flows/Emission to air/low population density	1,83704E-11	kBq
Cobalt-60	Elementary flows/Emission to water/river	0,000042404	kBq
COD, Chemical Oxygen Demand	Elementary flows/Emission to water/ground water	1,0851E-10	kg
COD, Chemical Oxygen Demand	Elementary flows/Emission to water/ground water, long-term	6,4712E-06	kg
COD, Chemical Oxygen Demand	Elementary flows/Emission to water/ocean	1,68674E-06	kg

COD, Chemical Oxygen Demand	Elementary flows/Emission to water/river	9,10556E-06	kg
COD, Chemical Oxygen Demand	Elementary flows/Emission to water/unspecified	3,56891E-06	kg
Copper	Elementary flows/Emission to air/high population density	1,25892E-09	kg
Copper	Elementary flows/Emission to air/low population density	1,0101E-08	kg
Copper	Elementary flows/Emission to air/lower stratosphere + upper troposphere	4,4043E-18	kg
Copper	Elementary flows/Emission to air/unspecified	2,6928E-10	kg
Copper	Elementary flows/Emission to soil/agricultural	9,00837E-11	kg
Copper	Elementary flows/Emission to soil/industrial	3,44751E-11	kg
Copper	Elementary flows/Emission to soil/unspecified	5,37082E-10	kg
Copper, ion	Elementary flows/Emission to water/ground water	1,41254E-08	kg
Copper, ion	Elementary flows/Emission to water/ground water, long-term	5,87775E-08	kg
Copper, ion	Elementary flows/Emission to water/ocean	2,48935E-11	kg
Copper, ion	Elementary flows/Emission to water/river	5,213E-09	kg
Copper, ion	Elementary flows/Emission to water/unspecified	1,19516E-08	kg
Cumene	Elementary flows/Emission to air/high population density	3,28379E-09	kg
Cumene	Elementary flows/Emission to water/river	7,89091E-09	kg
Cyanide	Elementary flows/Emission to air/high population density	1,57998E-10	kg
Cyanide	Elementary flows/Emission to air/low population density	1,33672E-09	kg
Cyanide	Elementary flows/Emission to water/ocean	6,71452E-11	kg
Cyanide	Elementary flows/Emission to water/river	2,75521E-09	kg
Cyanide	Elementary flows/Emission to water/unspecified	2,35941E-08	kg
Cypermethrin	Elementary flows/Emission to soil/agricultural	5,89721E-15	kg
Dichromate	Elementary flows/Emission to water/river	2,13861E-11	kg
Dinitrogen monoxide	Elementary flows/Emission to air/high population density	3,65941E-07	kg
Dinitrogen monoxide	Elementary flows/Emission to air/low population density	2,17076E-07	kg
Dinitrogen monoxide	Elementary flows/Emission to air/lower stratosphere + upper troposphere	7,77254E-17	kg
Dinitrogen monoxide	Elementary flows/Emission to air/unspecified	3,91212E-08	kg
Dinoseb	Elementary flows/Emission to soil/agricultural	1,46616E-11	kg
Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	Elementary flows/Emission to air/high population density	5,84526E-16	kg
Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	Elementary flows/Emission to air/low population density	7,28005E-16	kg

Dioxins, measured as 2,3,7,8-tetrachlorodibenzo-p-dioxin	Elementary flows/Emission to air/unspecified	3,15473E-15	kg
Dissolved solids	Elementary flows/Emission to water/ground water	1,1677E-07	kg
Dissolved solids	Elementary flows/Emission to water/river	1,54463E-05	kg
DOC, Dissolved Organic Carbon	Elementary flows/Emission to water/ground water, long-term	2,79621E-06	kg
DOC, Dissolved Organic Carbon	Elementary flows/Emission to water/lake	9,05126E-11	kg
DOC, Dissolved Organic Carbon	Elementary flows/Emission to water/ocean	5,47441E-07	kg
DOC, Dissolved Organic Carbon	Elementary flows/Emission to water/river	2,53732E-06	kg
DOC, Dissolved Organic Carbon	Elementary flows/Emission to water/unspecified	1,39657E-06	kg
electricity, nuclear, at power plant pressure water reactor (N4-type)	**nuclear power/production**	**1**	**kWh**
Ethane	Elementary flows/Emission to air/high population density	1,8404E-08	kg
Ethane	Elementary flows/Emission to air/low population density	1,30024E-07	kg
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Elementary flows/Emission to air/high population density	2,19164E-14	kg
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Elementary flows/Emission to air/low population density	1,75061E-12	kg
Ethane, 1,1,1,2-tetrafluoro-, HFC-134a	Elementary flows/Emission to air/unspecified	3,26512E-10	kg
Ethane, 1,2-dichloro-	Elementary flows/Emission to air/high population density	1,08798E-09	kg
Ethane, 1,2-dichloro-	Elementary flows/Emission to water/river	2,18183E-09	kg
Ethane, 1,2-dichloro-1,1,2,2-tetrafluoro-, CFC-114	Elementary flows/Emission to air/low population density	7,66648E-12	kg
Ethane, hexafluoro-, HFC-116	Elementary flows/Emission to air/unspecified	1,08869E-10	kg
Ethanol	Elementary flows/Emission to air/high population density	3,10229E-09	kg
Ethanol	Elementary flows/Emission to air/low population density	8,78501E-12	kg
Ethene	Elementary flows/Emission to air/high population density	1,22352E-08	kg
Ethene	Elementary flows/Emission to air/low population density	5,80771E-09	kg
Ethene	Elementary flows/Emission to water/river	4,45008E-09	kg
Ethene, chloro-	Elementary flows/Emission to air/high population density	2,28805E-10	kg
Ethene, chloro-	Elementary flows/Emission to water/river	5,05518E-12	kg
Ethylene diamine	Elementary flows/Emission to air/high population density	2,5051E-14	kg
Ethylene diamine	Elementary flows/Emission to water/river	6,07297E-14	kg
Ethylene oxide	Elementary flows/Emission to air/high population density	4,2903E-11	kg
Ethylene oxide	Elementary flows/Emission to air/low population density	7,78872E-17	kg
Ethylene oxide	Elementary flows/Emission to air/lower stratosphere + upper troposphere	4,73337E-16	kg

Ethylene oxide	Elementary flows/Emission to air/unspecified	1,10449E-15	kg
Ethylene oxide	Elementary flows/Emission to water/river	4,48393E-12	kg
Ethyne	Elementary flows/Emission to air/high population density	1,3239E-09	kg
Ethyne	Elementary flows/Emission to air/low population density	1,87003E-10	kg
Ethyne	Elementary flows/Emission to air/unspecified	5,10762E-10	kg
Fenpiclonil	Elementary flows/Emission to soil/agricultural	2,15024E-12	kg
Fluoride	Elementary flows/Emission to soil/industrial	1,24967E-09	kg
Fluoride	Elementary flows/Emission to soil/unspecified	5,54239E-10	kg
Fluoride	Elementary flows/Emission to water/ground water	1,73235E-09	kg
Fluoride	Elementary flows/Emission to water/ground water, long-term	5,96575E-08	kg
Fluoride	Elementary flows/Emission to water/ocean	6,19739E-09	kg
Fluoride	Elementary flows/Emission to water/river	1,4789E-07	kg
Fluoride	Elementary flows/Emission to water/unspecified	1,76652E-09	kg
Fluorine	Elementary flows/Emission to air/high population density	2,42261E-11	kg
Fluorine	Elementary flows/Emission to air/low population density	6,97186E-10	kg
Fluorine	Elementary flows/Emission to air/unspecified	1,42822E-16	kg
Fluosilicic acid	Elementary flows/Emission to air/high population density	1,27943E-10	kg
Fluosilicic acid	Elementary flows/Emission to water/river	2,29033E-10	kg
Formaldehyde	Elementary flows/Emission to air/high population density	1,04164E-08	kg
Formaldehyde	Elementary flows/Emission to air/low population density	1,94061E-09	kg
Formaldehyde	Elementary flows/Emission to air/lower stratosphere + upper troposphere	4,08072E-16	kg
Formaldehyde	Elementary flows/Emission to air/unspecified	3,334E-09	kg
Formaldehyde	Elementary flows/Emission to water/river	4,00284E-11	kg
Formaldehyde	Elementary flows/Emission to water/unspecified	1,31907E-09	kg
Glutaraldehyde	Elementary flows/Emission to water/ocean	3,43339E-11	kg
Glyphosate	Elementary flows/Emission to soil/agricultural	7,89783E-12	kg
Glyphosate	Elementary flows/Emission to soil/industrial	9,90567E-11	kg
Heat, waste	Elementary flows/Emission to air/high population density	0,0472576	MJ
Heat, waste	Elementary flows/Emission to air/low population density	14	MJ
Heat, waste	Elementary flows/Emission to air/low population density, long-term	0,000034232	MJ
Heat, waste	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,18142E-10	MJ
Heat, waste	Elementary flows/Emission to air/unspecified	0,0094877	MJ
Heat, waste	Elementary flows/Emission to soil/industrial	3,84098E-06	MJ
Heat, waste	Elementary flows/Emission to soil/unspecified	9,32372E-05	MJ
Heat, waste	Elementary flows/Emission to water/ground water, long-term	7,08712E-05	MJ
Heat, waste	Elementary flows/Emission to water/river	0,000979123	MJ
Heat, waste	Elementary flows/Emission to water/unspecified	7,49346E-06	MJ
Helium	Elementary flows/Emission to air/low population density	2,13845E-09	kg
Helium	Elementary flows/Emission to air/unspecified	1,03104E-17	kg
Heptane	Elementary flows/Emission to air/high population density	1,00669E-08	kg
Hexane	Elementary flows/Emission to air/high population density	2,38664E-08	kg
Hexane	Elementary flows/Emission to air/low population density	4,11282E-07	kg
Hydrocarbons, aliphatic, alkanes, cyclic	Elementary flows/Emission to air/high population density	2,18681E-10	kg
Hydrocarbons, aliphatic, alkanes, unspecified	Elementary flows/Emission to air/high population density	1,00429E-08	kg
Hydrocarbons, aliphatic, alkanes, unspecified	Elementary flows/Emission to air/low population density	9,28447E-09	kg
Hydrocarbons, aliphatic, alkanes, unspecified	Elementary flows/Emission to air/unspecified	3,99841E-08	kg
Hydrocarbons, aliphatic, alkanes, unspecified	Elementary flows/Emission to water/ocean	1,99331E-09	kg
Hydrocarbons, aliphatic, alkanes, unspecified	Elementary flows/Emission to water/river	4,16314E-09	kg
Hydrocarbons, aliphatic, unsaturated	Elementary flows/Emission to air/high population density	3,03535E-09	kg
Hydrocarbons, aliphatic, unsaturated	Elementary flows/Emission to air/low population density	2,08065E-09	kg
Hydrocarbons, aliphatic, unsaturated	Elementary flows/Emission to water/ocean	1,83998E-10	kg
Hydrocarbons, aliphatic, unsaturated	Elementary flows/Emission to water/river	3,84289E-10	kg
Hydrocarbons, aromatic	Elementary flows/Emission to air/high population density	2,55507E-09	kg
Hydrocarbons, aromatic	Elementary flows/Emission to air/low population density	3,83891E-09	kg
Hydrocarbons, aromatic	Elementary flows/Emission to air/unspecified	1,36224E-08	kg
Hydrocarbons, aromatic	Elementary flows/Emission to water/ocean	8,64885E-09	kg
Hydrocarbons, aromatic	Elementary flows/Emission to water/river	1,68611E-08	kg
Hydrocarbons, chlorinated	Elementary flows/Emission to air/high population density	2,98773E-11	kg
Hydrocarbons, chlorinated	Elementary flows/Emission to air/unspecified	8,73316E-10	kg
Hydrocarbons, unspecified	Elementary flows/Emission to water/ocean	5,2286E-09	kg

Hydrocarbons, unspecified	Elementary flows/Emission to water/river	8,00581E-08	kg
Hydrocarbons, unspecified	Elementary flows/Emission to water/unspecified	8,36849E-10	kg
Hydrogen	Elementary flows/Emission to air/high population density	1,29453E-06	kg
Hydrogen	Elementary flows/Emission to air/unspecified	7,03072E-10	kg
Hydrogen chloride	Elementary flows/Emission to air/high population density	1,20628E-07	kg
Hydrogen chloride	Elementary flows/Emission to air/low population density	5,65897E-08	kg
Hydrogen chloride	Elementary flows/Emission to air/lower stratosphere + upper troposphere	2,22813E-18	kg
Hydrogen chloride	Elementary flows/Emission to air/unspecified	2,39312E-08	kg
Hydrogen fluoride	Elementary flows/Emission to air/high population density	4,82823E-09	kg
Hydrogen fluoride	Elementary flows/Emission to air/low population density	8,41099E-08	kg
Hydrogen fluoride	Elementary flows/Emission to air/unspecified	8,14411E-09	kg
Hydrogen peroxide	Elementary flows/Emission to water/river	4,00236E-11	kg
Hydrogen sulfide	Elementary flows/Emission to air/high population density	9,19108E-11	kg
Hydrogen sulfide	Elementary flows/Emission to air/low population density	2,34274E-08	kg
Hydrogen sulfide	Elementary flows/Emission to air/unspecified	2,78243E-09	kg
Hydrogen sulfide	Elementary flows/Emission to water/ground water, long-term	6,5719E-09	kg
Hydrogen sulfide	Elementary flows/Emission to water/river	3,02212E-10	kg
Hydrogen-3, Tritium	Elementary flows/Emission to air/low population density	0,296204	kBq
Hydrogen-3, Tritium	Elementary flows/Emission to water/ocean	20,47	kBq
Hydrogen-3, Tritium	Elementary flows/Emission to water/river	1,91966	kBq
Hydroxide	Elementary flows/Emission to water/river	8,44531E-12	kg
Hypochlorite	Elementary flows/Emission to water/ocean	1,43372E-10	kg
Hypochlorite	Elementary flows/Emission to water/river	1,6906E-10	kg
Iodide	Elementary flows/Emission to water/ground water	2,45701E-11	kg
Iodide	Elementary flows/Emission to water/ground water, long-term	1,35032E-14	kg
Iodide	Elementary flows/Emission to water/ocean	1,53332E-09	kg
Iodide	Elementary flows/Emission to water/river	3,24018E-09	kg
Iodine	Elementary flows/Emission to air/high population density	2,9691E-11	kg
Iodine	Elementary flows/Emission to air/low population density	2,91847E-10	kg
Iodine-129	Elementary flows/Emission to air/low population density	5,29344E-05	kBq

Iodine-131	Elementary flows/Emission to air/low population density	2,2074E-07	kBq
Iodine-131	Elementary flows/Emission to water/river	1,58817E-06	kBq
Iodine-133	Elementary flows/Emission to air/low population density	1,1494E-10	kBq
Iodine-133	Elementary flows/Emission to water/river	1,57001E-10	kBq
Iron	Elementary flows/Emission to air/high population density	1,34088E-08	kg
Iron	Elementary flows/Emission to air/low population density	1,67755E-09	kg
Iron	Elementary flows/Emission to air/unspecified	2,92095E-09	kg
Iron	Elementary flows/Emission to soil/agricultural	6,10104E-09	kg
Iron	Elementary flows/Emission to soil/industrial	4,99866E-08	kg
Iron	Elementary flows/Emission to soil/unspecified	1,87809E-07	kg
Iron, ion	Elementary flows/Emission to water/ground water	4,16629E-07	kg
Iron, ion	Elementary flows/Emission to water/ground water, long-term	1,96945E-06	kg
Iron, ion	Elementary flows/Emission to water/ocean	8,67529E-10	kg
Iron, ion	Elementary flows/Emission to water/river	3,99537E-06	kg
Iron, ion	Elementary flows/Emission to water/unspecified	9,054E-08	kg
Iron-59	Elementary flows/Emission to water/river	4,31629E-11	kBq
Isocyanic acid	Elementary flows/Emission to air/high population density	7,73802E-09	kg
Krypton-85	Elementary flows/Emission to air/low population density	1,94539E-06	kBq
Krypton-85m	Elementary flows/Emission to air/low population density	1,4104E-06	kBq
Krypton-87	Elementary flows/Emission to air/low population density	3,2779E-07	kBq
Krypton-88	Elementary flows/Emission to air/low population density	4,22457E-07	kBq
Krypton-89	Elementary flows/Emission to air/low population density	1,74458E-07	kBq
Lanthanum-140	Elementary flows/Emission to air/low population density	8,21577E-12	kBq
Lanthanum-140	Elementary flows/Emission to water/river	2,66367E-10	kBq
Lead	Elementary flows/Emission to air/high population density	8,26857E-10	kg
Lead	Elementary flows/Emission to air/low population density	8,34972E-09	kg
Lead	Elementary flows/Emission to air/lower stratosphere + upper troposphere	5,1818E-20	kg
Lead	Elementary flows/Emission to air/unspecified	1,85549E-09	kg
Lead	Elementary flows/Emission to soil/agricultural	1,594E-11	kg
Lead	Elementary flows/Emission to soil/unspecified	8,61582E-12	kg

Lead	Elementary flows/Emission to water/ground water	2,22578E-13	kg
Lead	Elementary flows/Emission to water/ground water, long-term	9,39505E-09	kg
Lead	Elementary flows/Emission to water/ocean	1,49813E-10	kg
Lead	Elementary flows/Emission to water/river	3,73964E-07	kg
Lead	Elementary flows/Emission to water/unspecified	4,86929E-09	kg
Lead-210	Elementary flows/Emission to air/high population density	1,20259E-07	kBq
Lead-210	Elementary flows/Emission to air/low population density	4,33504E-05	kBq
Lead-210	Elementary flows/Emission to water/ground water	9,26426E-10	kBq
Lead-210	Elementary flows/Emission to water/ocean	1,08902E-06	kBq
Lead-210	Elementary flows/Emission to water/river	1,60703E-07	kBq
Linuron	Elementary flows/Emission to soil/agricultural	6,25138E-12	kg
m-Xylene	Elementary flows/Emission to air/high population density	5,33679E-11	kg
Magnesium	Elementary flows/Emission to air/high population density	1,00888E-08	kg
Magnesium	Elementary flows/Emission to air/low population density	9,6445E-10	kg
Magnesium	Elementary flows/Emission to soil/agricultural	2,61687E-09	kg
Magnesium	Elementary flows/Emission to soil/industrial	1,99947E-08	kg
Magnesium	Elementary flows/Emission to water/ground water	1,44677E-09	kg
Magnesium	Elementary flows/Emission to water/ground water, long-term	6,61944E-07	kg
Magnesium	Elementary flows/Emission to water/ocean	8,63453E-08	kg
Magnesium	Elementary flows/Emission to water/river	2,54996E-06	kg
Mancozeb	Elementary flows/Emission to soil/agricultural	7,02285E-11	kg
Manganese	Elementary flows/Emission to air/high population density	1,38483E-10	kg
Manganese	Elementary flows/Emission to air/low population density	1,19273E-09	kg
Manganese	Elementary flows/Emission to air/unspecified	3,80369E-10	kg
Manganese	Elementary flows/Emission to soil/agricultural	1,52696E-09	kg
Manganese	Elementary flows/Emission to soil/industrial	9,99733E-10	kg
Manganese	Elementary flows/Emission to water/ground water	2,79883E-08	kg
Manganese	Elementary flows/Emission to water/ground water, long-term	3,02059E-08	kg
Manganese	Elementary flows/Emission to water/ocean	7,06048E-10	kg
Manganese	Elementary flows/Emission to water/river	9,68523E-07	kg
Manganese	Elementary flows/Emission to water/unspecified	2,71333E-10	kg
Manganese-54	Elementary flows/Emission to air/low population density	7,64738E-13	kBq
Manganese-54	Elementary flows/Emission to water/river	3,59509E-06	kBq
Mercury	Elementary flows/Emission to air/high population density	4,79472E-11	kg
Mercury	Elementary flows/Emission to air/low population density	4,87907E-11	kg
Mercury	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,81358E-22	kg
Mercury	Elementary flows/Emission to air/unspecified	4,31649E-10	kg
Mercury	Elementary flows/Emission to soil/agricultural	6,91384E-14	kg
Mercury	Elementary flows/Emission to water/ground water	2,45812E-16	kg
Mercury	Elementary flows/Emission to water/ground water, long-term	9,96616E-11	kg
Mercury	Elementary flows/Emission to water/ocean	5,23367E-13	kg
Mercury	Elementary flows/Emission to water/river	1,69286E-11	kg
Mercury	Elementary flows/Emission to water/unspecified	2,49241E-10	kg
Metaldehyde	Elementary flows/Emission to soil/agricultural	5,1105E-14	kg
Methane, biogenic	Elementary flows/Emission to air/high population density	2,66726E-09	kg
Methane, biogenic	Elementary flows/Emission to air/low population density	8,63443E-08	kg
Methane, bromochlorodifluoro-, Halon 1211	Elementary flows/Emission to air/low population density	3,83397E-11	kg
Methane, bromotrifluoro-, Halon 1301	Elementary flows/Emission to air/low population density	2,69187E-11	kg
Methane, chlorodifluoro-, HCFC-22	Elementary flows/Emission to air/high population density	3,1089E-13	kg
Methane, chlorodifluoro-, HCFC-22	Elementary flows/Emission to air/low population density	1,33529E-10	kg
Methane, dichloro-, HCC-30	Elementary flows/Emission to air/high population density	5,8406E-12	kg
Methane, dichloro-, HCC-30	Elementary flows/Emission to water/river	6,3284E-10	kg
Methane, dichlorodifluoro-, CFC-12	Elementary flows/Emission to air/high population density	4,85503E-14	kg
Methane, dichlorodifluoro-, CFC-12	Elementary flows/Emission to air/low population density	1,31267E-13	kg
Methane, dichlorofluoro-, HCFC-21	Elementary flows/Emission to air/high population density	6,23536E-17	kg
Methane, fossil	Elementary flows/Emission to air/high population density	3,3414E-07	kg
Methane, fossil	Elementary flows/Emission to air/low population density	1,00232E-05	kg
Methane, fossil	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,29543E-16	kg
Methane, fossil	Elementary flows/Emission to air/unspecified	3,90708E-08	kg
Methane, monochloro-, R-40	Elementary flows/Emission to air/high population density	3,83278E-15	kg

Methane, tetrachloro-, R-10	Elementary flows/Emission to air/high population density	5,04795E-11	kg
Methane, tetrafluoro-, R-14	Elementary flows/Emission to air/unspecified	9,7982E-10	kg
Methane, trichlorofluoro-, CFC-11	Elementary flows/Emission to air/high population density	1,01228E-16	kg
Methane, trifluoro-, HFC-23	Elementary flows/Emission to air/high population density	1,98398E-14	kg
Methanol	Elementary flows/Emission to air/high population density	7,66978E-09	kg
Methanol	Elementary flows/Emission to air/low population density	7,20668E-09	kg
Methanol	Elementary flows/Emission to air/unspecified	5,98549E-09	kg
Methanol	Elementary flows/Emission to water/ocean	5,09469E-10	kg
Methanol	Elementary flows/Emission to water/river	1,27916E-10	kg
Methanol	Elementary flows/Emission to water/unspecified	3,95722E-10	kg
Metolachlor	Elementary flows/Emission to soil/agricultural	4,52697E-11	kg
Metribuzin	Elementary flows/Emission to soil/agricultural	2,46834E-12	kg
Molybdenum	Elementary flows/Emission to air/high population density	1,8485E-10	kg
Molybdenum	Elementary flows/Emission to air/low population density	3,35732E-12	kg
Molybdenum	Elementary flows/Emission to air/unspecified	1,52073E-12	kg
Molybdenum	Elementary flows/Emission to soil/agricultural	4,30142E-13	kg
Molybdenum	Elementary flows/Emission to water/ground water	8,2489E-09	kg
Molybdenum	Elementary flows/Emission to water/ground water, long-term	6,99918E-11	kg
Molybdenum	Elementary flows/Emission to water/ocean	3,88047E-12	kg
Molybdenum	Elementary flows/Emission to water/river	3,01476E-07	kg
Molybdenum-99	Elementary flows/Emission to water/river	9,18375E-11	kBq
Monoethanolamine	Elementary flows/Emission to air/high population density	2,96513E-09	kg
Napropamide	Elementary flows/Emission to soil/agricultural	9,04404E-14	kg
Nickel	Elementary flows/Emission to air/high population density	6,69846E-09	kg
Nickel	Elementary flows/Emission to air/low population density	4,94402E-09	kg
Nickel	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,81358E-19	kg
Nickel	Elementary flows/Emission to air/unspecified	3,57827E-10	kg
Nickel	Elementary flows/Emission to soil/agricultural	2,72349E-11	kg
Nickel	Elementary flows/Emission to soil/unspecified	1,37656E-11	kg
Nickel, ion	Elementary flows/Emission to water/ground water	5,60955E-11	kg

Nickel, ion	Elementary flows/Emission to water/ground water, long-term	4,54967E-07	kg
Nickel, ion	Elementary flows/Emission to water/ocean	3,20568E-10	kg
Nickel, ion	Elementary flows/Emission to water/river	3,88258E-09	kg
Nickel, ion	Elementary flows/Emission to water/unspecified	1,21871E-08	kg
Niobium-95	Elementary flows/Emission to air/low population density	9,07811E-14	kBq
Niobium-95	Elementary flows/Emission to water/river	1,71972E-09	kBq
Nitrate	Elementary flows/Emission to air/high population density	5,13328E-11	kg
Nitrate	Elementary flows/Emission to water/ground water	1,51967E-08	kg
Nitrate	Elementary flows/Emission to water/ground water, long-term	1,87662E-08	kg
Nitrate	Elementary flows/Emission to water/ocean	6,42875E-06	kg
Nitrate	Elementary flows/Emission to water/river	8,98342E-07	kg
Nitrite	Elementary flows/Emission to water/ground water, long-term	2,39146E-10	kg
Nitrite	Elementary flows/Emission to water/ocean	1,33407E-07	kg
Nitrite	Elementary flows/Emission to water/river	3,72458E-10	kg
Nitrogen	Elementary flows/Emission to water/ocean	7,84918E-11	kg
Nitrogen	Elementary flows/Emission to water/river	2,3607E-07	kg
Nitrogen oxides	Elementary flows/Emission to air/high population density	3,5785E-06	kg
Nitrogen oxides	Elementary flows/Emission to air/low population density	1,83411E-05	kg
Nitrogen oxides	Elementary flows/Emission to air/lower stratosphere + upper troposphere	3,62711E-14	kg
Nitrogen oxides	Elementary flows/Emission to air/unspecified	6,49886E-06	kg
Nitrogen, organic bound	Elementary flows/Emission to water/ground water, long-term	7,17607E-09	kg
Nitrogen, organic bound	Elementary flows/Emission to water/ocean	3,78414E-09	kg
Nitrogen, organic bound	Elementary flows/Emission to water/river	2,35872E-08	kg
NMVOC, non-methane volatile organic compounds, unspecified origin	Elementary flows/Emission to air/high population density	1,85075E-07	kg
NMVOC, non-methane volatile organic compounds, unspecified origin	Elementary flows/Emission to air/low population density	4,75804E-06	kg
NMVOC, non-methane volatile organic compounds, unspecified origin	Elementary flows/Emission to air/lower stratosphere + upper troposphere	1,73834E-15	kg
NMVOC, non-methane volatile organic compounds, unspecified origin	Elementary flows/Emission to air/unspecified	0,000001208	kg
Noble gases, radioactive, unspecified	Elementary flows/Emission to air/low population density	508,717	kBq
Occupation, industrial area	Elementary flows/Resource/land	502	m2*a
Oils, biogenic	Elementary flows/Emission to soil/forestry	3,69405E-09	kg

Oils, biogenic	Elementary flows/Emission to soil/unspecified	1,06557E-09	kg
Oils, unspecified	Elementary flows/Emission to soil/forestry	3,27336E-06	kg
Oils, unspecified	Elementary flows/Emission to soil/industrial	3,84571E-09	kg
Oils, unspecified	Elementary flows/Emission to soil/unspecified	1,52091E-08	kg
Oils, unspecified	Elementary flows/Emission to water/ocean	5,39594E-07	kg
Oils, unspecified	Elementary flows/Emission to water/river	2,64236E-06	kg
Oils, unspecified	Elementary flows/Emission to water/unspecified	2,36971E-07	kg
Orbencarb	Elementary flows/Emission to soil/agricultural	1,33203E-11	kg
Ozone	Elementary flows/Emission to air/high population density	7,35064E-12	kg
Ozone	Elementary flows/Emission to air/unspecified	2,38658E-08	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/high population density	2,32234E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/low population density	4,84365E-11	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/unspecified	7,75483E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to water/ocean	1,22749E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to water/river	2,6885E-09	kg
Paraffins	Elementary flows/Emission to air/high population density	1,74569E-14	kg
Paraffins	Elementary flows/Emission to water/river	5,06616E-14	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/high population density	4,77292E-07	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/low population density	3,47333E-06	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/lower stratosphere + upper troposphere	9,84526E-17	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/unspecified	4,22639E-07	kg
Particulates, > 10 um	Elementary flows/Emission to air/high population density	1,98434E-07	kg
Particulates, > 10 um	Elementary flows/Emission to air/low population density	8,83012E-06	kg
Particulates, > 10 um	Elementary flows/Emission to air/unspecified	1,70248E-07	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/high population density	1,63921E-07	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/low population density	1,96159E-06	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/unspecified	2,08303E-07	kg
Pentane	Elementary flows/Emission to air/high population density	8,32639E-08	kg
Pentane	Elementary flows/Emission to air/low population density	1,29536E-09	kg
Phenol	Elementary flows/Emission to air/high population density	7,33387E-11	kg

Oils, biogenic	Elementary flows/Emission to soil/unspecified	1,06557E-09	kg
Oils, unspecified	Elementary flows/Emission to soil/forestry	3,27336E-06	kg
Oils, unspecified	Elementary flows/Emission to soil/industrial	3,84571E-09	kg
Oils, unspecified	Elementary flows/Emission to soil/unspecified	1,52091E-08	kg
Oils, unspecified	Elementary flows/Emission to water/ocean	5,39594E-07	kg
Oils, unspecified	Elementary flows/Emission to water/river	2,64236E-06	kg
Oils, unspecified	Elementary flows/Emission to water/unspecified	2,36971E-07	kg
Orbencarb	Elementary flows/Emission to soil/agricultural	1,33203E-11	kg
Ozone	Elementary flows/Emission to air/high population density	7,35064E-12	kg
Ozone	Elementary flows/Emission to air/unspecified	2,38658E-08	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/high population density	2,32234E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/low population density	4,84365E-11	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to air/unspecified	7,75483E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to water/ocean	1,22749E-10	kg
PAH, polycyclic aromatic hydrocarbons	Elementary flows/Emission to water/river	2,6885E-09	kg
Paraffins	Elementary flows/Emission to air/high population density	1,74569E-14	kg
Paraffins	Elementary flows/Emission to water/river	5,06616E-14	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/high population density	4,77292E-07	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/low population density	3,47333E-06	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/lower stratosphere + upper troposphere	9,84526E-17	kg
Particulates, < 2.5 um	Elementary flows/Emission to air/unspecified	4,22639E-07	kg
Particulates, > 10 um	Elementary flows/Emission to air/high population density	1,98434E-07	kg
Particulates, > 10 um	Elementary flows/Emission to air/low population density	8,83012E-06	kg
Particulates, > 10 um	Elementary flows/Emission to air/unspecified	1,70248E-07	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/high population density	1,63921E-07	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/low population density	1,96159E-06	kg
Particulates, > 2.5 um, and < 10um	Elementary flows/Emission to air/unspecified	2,08303E-07	kg
Pentane	Elementary flows/Emission to air/high population density	8,32639E-08	kg
Pentane	Elementary flows/Emission to air/low population density	1,29536E-09	kg
Phenol	Elementary flows/Emission to air/high population density	7,33387E-11	kg

Phenol	Elementary flows/Emission to air/low population density	8,0119E-10	kg
Phenol	Elementary flows/Emission to air/unspecified	7,91036E-12	kg
Phenol	Elementary flows/Emission to water/ocean	1,95535E-09	kg
Phenol	Elementary flows/Emission to water/river	2,73806E-09	kg
Phenol	Elementary flows/Emission to water/unspecified	1,31907E-10	kg
Phenol, pentachloro-	Elementary flows/Emission to air/high population density	1,94556E-14	kg
Phenol, pentachloro-	Elementary flows/Emission to air/low population density	2,5755E-12	kg
Phosphate	Elementary flows/Emission to water/ground water	3,77868E-11	kg
Phosphate	Elementary flows/Emission to water/ground water, long-term	3,22434E-07	kg
Phosphate	Elementary flows/Emission to water/ocean	1,83714E-08	kg
Phosphate	Elementary flows/Emission to water/river	1,43335E-08	kg
Phosphorus	Elementary flows/Emission to air/high population density	3,30168E-10	kg
Phosphorus	Elementary flows/Emission to air/low population density	1,2365E-11	kg
Phosphorus	Elementary flows/Emission to air/unspecified	2,08306E-13	kg
Phosphorus	Elementary flows/Emission to soil/agricultural	7,43673E-10	kg
Phosphorus	Elementary flows/Emission to soil/industrial	1,24967E-09	kg
Phosphorus	Elementary flows/Emission to water/ocean	2,70797E-09	kg
Phosphorus	Elementary flows/Emission to water/river	1,04729E-08	kg
Phosphorus	Elementary flows/Emission to water/unspecified	1,31921E-10	kg
Pirimicarb	Elementary flows/Emission to soil/agricultural	3,89973E-14	kg
Platinum	Elementary flows/Emission to air/high population density	5,43719E-17	kg
Platinum	Elementary flows/Emission to air/unspecified	9,06339E-17	kg
Plutonium-238	Elementary flows/Emission to air/low population density	7,22111E-12	kBq
Plutonium-alpha	Elementary flows/Emission to air/low population density	1,65535E-11	kBq
Polonium-210	Elementary flows/Emission to air/high population density	2,19838E-07	kBq
Polonium-210	Elementary flows/Emission to air/low population density	6,50425E-05	kBq
Polonium-210	Elementary flows/Emission to water/ground water	1,40978E-09	kBq
Polonium-210	Elementary flows/Emission to water/ocean	1,66194E-06	kBq
Polonium-210	Elementary flows/Emission to water/river	1,60703E-07	kBq
Polychlorinated biphenyls	Elementary flows/Emission to air/unspecified	5,85665E-12	kg

Potassium	Elementary flows/Emission to air/high population density	1,38236E-08	kg
Potassium	Elementary flows/Emission to air/low population density	2,51632E-10	kg
Potassium	Elementary flows/Emission to soil/agricultural	4,13573E-09	kg
Potassium	Elementary flows/Emission to soil/industrial	8,74766E-09	kg
Potassium, ion	Elementary flows/Emission to water/ground water	4,60423E-08	kg
Potassium, ion	Elementary flows/Emission to water/ground water, long-term	3,1115E-07	kg
Potassium, ion	Elementary flows/Emission to water/ocean	6,54791E-08	kg
Potassium, ion	Elementary flows/Emission to water/river	2,50987E-07	kg
Potassium-40	Elementary flows/Emission to air/high population density	3,49055E-08	kBq
Potassium-40	Elementary flows/Emission to air/low population density	2,70453E-08	kBq
Potassium-40	Elementary flows/Emission to water/ground water	1,11977E-10	kBq
Potassium-40	Elementary flows/Emission to water/ocean	1,3163E-07	kBq
Potassium-40	Elementary flows/Emission to water/river	2,01733E-07	kBq
Propanal	Elementary flows/Emission to air/high population density	7,00925E-13	kg
Propane	Elementary flows/Emission to air/high population density	5,14322E-08	kg
Propane	Elementary flows/Emission to air/low population density	4,01415E-08	kg
Propene	Elementary flows/Emission to air/high population density	4,58033E-09	kg
Propene	Elementary flows/Emission to air/low population density	5,1603E-10	kg
Propene	Elementary flows/Emission to water/river	2,98291E-09	kg
Propionic acid	Elementary flows/Emission to air/high population density	4,39775E-10	kg
Propylene oxide	Elementary flows/Emission to air/high population density	2,3813E-11	kg
Propylene oxide	Elementary flows/Emission to water/river	5,73001E-11	kg
Protactinium-234	Elementary flows/Emission to air/low population density	5,84453E-06	kBq
Protactinium-234	Elementary flows/Emission to water/river	0,000108232	kBq
Radioactive species, alpha emitters	Elementary flows/Emission to water/river	5,10479E-09	kBq
Radioactive species, Nuclides, unspecified	Elementary flows/Emission to water/ocean	0,0514045	kBq
Radioactive species, Nuclides, unspecified	Elementary flows/Emission to water/river	0,000215259	kBq
Radioactive species, other beta emitters	Elementary flows/Emission to air/high population density	6,84973E-05	kBq
Radioactive species, other beta emitters	Elementary flows/Emission to air/low population density	3,04699E-11	kBq
Radium-224	Elementary flows/Emission to water/ocean	7,66659E-07	kBq

Radium-224	Elementary flows/Emission to water/river	1,60121E-06	kBq
Radium-226	Elementary flows/Emission to air/high population density	3,10351E-08	kBq
Radium-226	Elementary flows/Emission to air/low population density	0,000198951	kBq
Radium-226	Elementary flows/Emission to water/ground water	1,03921E-09	kBq
Radium-226	Elementary flows/Emission to water/ocean	2,45299E-06	kBq
Radium-226	Elementary flows/Emission to water/river	0,067323	kBq
Radium-228	Elementary flows/Emission to air/high population density	1,67574E-07	kBq
Radium-228	Elementary flows/Emission to air/low population density	7,57895E-09	kBq
Radium-228	Elementary flows/Emission to water/ocean	1,53332E-06	kBq
Radium-228	Elementary flows/Emission to water/river	3,20241E-06	kBq
Radon-220	Elementary flows/Emission to air/high population density	2,60446E-09	kBq
Radon-222	Elementary flows/Emission to air/high population density	2,60446E-09	kBq
Radon-222	Elementary flows/Emission to air/low population density	18,0661	kBq
Radon-222	Elementary flows/Emission to air/low population density, long-term	757,624	kBq
Radon-222	Elementary flows/Emission to air/unspecified	1,90994E-15	kBq
Rubidium	Elementary flows/Emission to water/ground water	4,18317E-09	kg
Rubidium	Elementary flows/Emission to water/ocean	1,53332E-10	kg
Rubidium	Elementary flows/Emission to water/river	3,20241E-10	kg
Ruthenium-103	Elementary flows/Emission to air/low population density	1,99452E-14	kBq
Ruthenium-103	Elementary flows/Emission to water/river	1,93785E-11	kBq
Scandium	Elementary flows/Emission to air/high population density	3,25154E-12	kg
Scandium	Elementary flows/Emission to air/low population density	4,87037E-13	kg
Scandium	Elementary flows/Emission to water/ground water	1,73487E-11	kg
Scandium	Elementary flows/Emission to water/ground water, long-term	2,36036E-10	kg
Scandium	Elementary flows/Emission to water/river	3,14524E-11	kg
Selenium	Elementary flows/Emission to air/high population density	1,54572E-10	kg
Selenium	Elementary flows/Emission to air/low population density	2,14111E-10	kg
Selenium	Elementary flows/Emission to air/lower stratosphere + upper troposphere	2,59084E-20	kg
Selenium	Elementary flows/Emission to air/unspecified	1,77118E-12	kg
Selenium	Elementary flows/Emission to water/ground water	3,08411E-09	kg
Selenium	Elementary flows/Emission to water/ground water, long-term	1,4931E-10	kg
Selenium	Elementary flows/Emission to water/ocean	5,81634E-12	kg
Selenium	Elementary flows/Emission to water/river	4,20193E-08	kg
Silicon	Elementary flows/Emission to air/high population density	4,31615E-08	kg
Silicon	Elementary flows/Emission to air/low population density	3,50701E-09	kg
Silicon	Elementary flows/Emission to air/unspecified	4,07203E-17	kg
Silicon	Elementary flows/Emission to soil/agricultural	7,19921E-09	kg
Silicon	Elementary flows/Emission to soil/industrial	2,49933E-09	kg
Silicon	Elementary flows/Emission to water/ground water	3,32424E-08	kg
Silicon	Elementary flows/Emission to water/ground water, long-term	0,000110695	kg
Silicon	Elementary flows/Emission to water/ocean	8,13631E-12	kg
Silicon	Elementary flows/Emission to water/river	2,66825E-07	kg
Silicon tetrafluoride	Elementary flows/Emission to air/low population density	2,90012E-12	kg
Silver	Elementary flows/Emission to air/high population density	7,19514E-13	kg
Silver	Elementary flows/Emission to air/low population density	3,06152E-14	kg
Silver	Elementary flows/Emission to soil/agricultural	6,8429E-13	kg
Silver, ion	Elementary flows/Emission to water/ground water	1,87241E-10	kg
Silver, ion	Elementary flows/Emission to water/ground water, long-term	1,72081E-11	kg
Silver, ion	Elementary flows/Emission to water/ocean	9,19991E-12	kg
Silver, ion	Elementary flows/Emission to water/river	1,1758E-10	kg
Silver-110	Elementary flows/Emission to air/low population density	1,97672E-13	kBq
Silver-110	Elementary flows/Emission to water/river	4,95427E-05	kBq
Sodium	Elementary flows/Emission to air/high population density	1,05331E-08	kg
Sodium	Elementary flows/Emission to air/low population density	1,24342E-10	kg
Sodium	Elementary flows/Emission to air/unspecified	5,16146E-14	kg
Sodium	Elementary flows/Emission to soil/industrial	4,99866E-08	kg
Sodium	Elementary flows/Emission to soil/unspecified	6,33348E-10	kg
Sodium chlorate	Elementary flows/Emission to air/high population density	5,69653E-10	kg
Sodium dichromate	Elementary flows/Emission to air/high population density	5,9149E-12	kg
Sodium formate	Elementary flows/Emission to air/high population density	1,21388E-12	kg

Sodium formate	Elementary flows/Emission to water/river	2,91627E-12	kg
Sodium hypochlorite	Elementary flows/Emission to air/high population density	3,45027E-21	kg
Sodium, ion	Elementary flows/Emission to water/ground water	8,05073E-08	kg
Sodium, ion	Elementary flows/Emission to water/ground water, long-term	7,52161E-07	kg
Sodium, ion	Elementary flows/Emission to water/ocean	4,71593E-06	kg
Sodium, ion	Elementary flows/Emission to water/river	7,59426E-05	kg
Sodium, ion	Elementary flows/Emission to water/unspecified	2,38003E-07	kg
Sodium-24	Elementary flows/Emission to water/river	6,94867E-10	kBq
Solids, inorganic	Elementary flows/Emission to water/ground water	9,27853E-07	kg
Solids, inorganic	Elementary flows/Emission to water/river	2,79008E-06	kg
Strontium	Elementary flows/Emission to air/high population density	4,91525E-10	kg
Strontium	Elementary flows/Emission to air/low population density	7,69329E-11	kg
Strontium	Elementary flows/Emission to soil/agricultural	1,76885E-12	kg
Strontium	Elementary flows/Emission to soil/industrial	2,49933E-10	kg
Strontium	Elementary flows/Emission to water/ground water	2,76645E-09	kg
Strontium	Elementary flows/Emission to water/ground water, long-term	1,20286E-08	kg
Strontium	Elementary flows/Emission to water/ocean	9,22703E-08	kg
Strontium	Elementary flows/Emission to water/river	1,9252E-07	kg
Strontium-89	Elementary flows/Emission to water/river	2,64755E-09	kBq
Strontium-90	Elementary flows/Emission to water/ocean	0,00109541	kBq
Strontium-90	Elementary flows/Emission to water/river	5,89673E-06	kBq
Styrene	Elementary flows/Emission to air/low population density	3,27927E-14	kg
Sulfate	Elementary flows/Emission to air/high population density	3,45191E-06	kg
Sulfate	Elementary flows/Emission to air/unspecified	6,91588E-13	kg
Sulfate	Elementary flows/Emission to water/ground water	1,78242E-06	kg
Sulfate	Elementary flows/Emission to water/ground water, long-term	3,31998E-06	kg
Sulfate	Elementary flows/Emission to water/ocean	1,0073E-06	kg
Sulfate	Elementary flows/Emission to water/river	0,000521353	kg
Sulfate	Elementary flows/Emission to water/unspecified	6,75923E-11	kg
Sulfide	Elementary flows/Emission to water/ocean	1,11443E-08	kg
Sulfide	Elementary flows/Emission to water/river	1,41323E-09	kg
Sulfite	Elementary flows/Emission to water/river	1,69944E-09	kg
Sulfur	Elementary flows/Emission to soil/agricultural	1,18567E-09	kg
Sulfur	Elementary flows/Emission to soil/industrial	1,4996E-08	kg
Sulfur	Elementary flows/Emission to water/ocean	2,52529E-10	kg
Sulfur	Elementary flows/Emission to water/river	8,34785E-09	kg
Sulfur dioxide	Elementary flows/Emission to air/high population density	1,63359E-05	kg
Sulfur dioxide	Elementary flows/Emission to air/low population density	5,92108E-06	kg
Sulfur dioxide	Elementary flows/Emission to air/lower stratosphere + upper troposphere	2,59084E-15	kg
Sulfur dioxide	Elementary flows/Emission to air/unspecified	7,23726E-07	kg
Sulfur hexafluoride	Elementary flows/Emission to air/low population density	1,10595E-13	kg
Sulfur hexafluoride	Elementary flows/Emission to air/unspecified	9,59695E-10	kg
Suspended solids, unspecified	Elementary flows/Emission to water/ocean	9,96187E-07	kg
Suspended solids, unspecified	Elementary flows/Emission to water/river	2,42301E-05	kg
Suspended solids, unspecified	Elementary flows/Emission to water/unspecified	7,28912E-08	kg
t-Butyl methyl ether	Elementary flows/Emission to air/high population density	1,08435E-11	kg
t-Butyl methyl ether	Elementary flows/Emission to water/ocean	1,22954E-10	kg
t-Butyl methyl ether	Elementary flows/Emission to water/river	1,68544E-13	kg
Tebutam	Elementary flows/Emission to soil/agricultural	2,14331E-13	kg
Technetium-99m	Elementary flows/Emission to water/river	2,11065E-09	kBq
Teflubenzuron	Elementary flows/Emission to soil/agricultural	1,64373E-13	kg
Tellurium-123m	Elementary flows/Emission to water/river	1,31781E-06	kBq
Tellurium-132	Elementary flows/Emission to water/river	5,31757E-12	kBq
Thallium	Elementary flows/Emission to air/high population density	4,08096E-12	kg
Thallium	Elementary flows/Emission to air/low population density	1,24437E-13	kg
Thallium	Elementary flows/Emission to air/unspecified	5,77978E-12	kg
Thallium	Elementary flows/Emission to water/ground water	3,72538E-15	kg
Thallium	Elementary flows/Emission to water/ground water, long-term	2,53836E-11	kg
Thallium	Elementary flows/Emission to water/river	1,65547E-12	kg
Thorium	Elementary flows/Emission to air/high population density	4,91727E-12	kg

Thorium	Elementary flows/Emission to air/low population density	4,87056E-13	kg
Thorium-228	Elementary flows/Emission to air/high population density	1,42249E-08	kBq
Thorium-228	Elementary flows/Emission to air/low population density	4,08951E-09	kBq
Thorium-228	Elementary flows/Emission to water/ground water	1,13588E-11	kBq
Thorium-228	Elementary flows/Emission to water/ocean	3,07999E-06	kBq
Thorium-228	Elementary flows/Emission to water/river	6,40482E-06	kBq
Thorium-230	Elementary flows/Emission to air/low population density	2,16565E-05	kBq
Thorium-230	Elementary flows/Emission to water/river	0,0147672	kBq
Thorium-232	Elementary flows/Emission to air/high population density	9,05144E-09	kBq
Thorium-232	Elementary flows/Emission to air/low population density	6,49158E-09	kBq
Thorium-232	Elementary flows/Emission to water/river	3,76113E-08	kBq
Thorium-234	Elementary flows/Emission to air/low population density	5,84453E-06	kBq
Thorium-234	Elementary flows/Emission to water/river	0,000108232	kBq
Tin	Elementary flows/Emission to air/high population density	4,81141E-12	kg
Tin	Elementary flows/Emission to air/low population density	9,65659E-10	kg
Tin	Elementary flows/Emission to air/unspecified	7,94736E-11	kg
Tin	Elementary flows/Emission to soil/agricultural	6,72269E-13	kg
Tin, ion	Elementary flows/Emission to water/ground water	2,32629E-13	kg
Tin, ion	Elementary flows/Emission to water/ground water, long-term	2,07195E-09	kg
Tin, ion	Elementary flows/Emission to water/river	1,71092E-10	kg
Titanium	Elementary flows/Emission to air/high population density	9,96481E-10	kg
Titanium	Elementary flows/Emission to air/low population density	7,50084E-11	kg
Titanium	Elementary flows/Emission to air/unspecified	4,36692E-12	kg
Titanium	Elementary flows/Emission to soil/agricultural	1,04721E-10	kg
Titanium, ion	Elementary flows/Emission to water/ground water	1,79681E-07	kg
Titanium, ion	Elementary flows/Emission to water/ground water, long-term	1,40946E-07	kg
Titanium, ion	Elementary flows/Emission to water/ocean	1,27306E-12	kg
Titanium, ion	Elementary flows/Emission to water/river	2,62223E-08	kg
TOC, Total Organic Carbon	Elementary flows/Emission to water/ground water, long-term	2,79621E-06	kg
TOC, Total Organic Carbon	Elementary flows/Emission to water/ocean	5,47444E-07	kg
TOC, Total Organic Carbon	Elementary flows/Emission to water/river	2,54952E-06	kg
TOC, Total Organic Carbon	Elementary flows/Emission to water/unspecified	1,39657E-06	kg
Toluene	Elementary flows/Emission to air/high population density	1,09658E-08	kg
Toluene	Elementary flows/Emission to air/low population density	1,43532E-09	kg
Toluene	Elementary flows/Emission to air/unspecified	1,86012E-09	kg
Toluene	Elementary flows/Emission to water/ocean	2,29965E-09	kg
Toluene	Elementary flows/Emission to water/river	3,70377E-09	kg
Tributyltin compounds	Elementary flows/Emission to water/ocean	8,96671E-11	kg
Triethylene glycol	Elementary flows/Emission to water/ocean	4,2403E-10	kg
Tungsten	Elementary flows/Emission to water/ground water	1,73038E-09	kg
Tungsten	Elementary flows/Emission to water/ground water, long-term	1,22846E-10	kg
Tungsten	Elementary flows/Emission to water/river	2,57932E-11	kg
Uranium	Elementary flows/Emission to air/high population density	6,55469E-12	kg
Uranium	Elementary flows/Emission to air/low population density	2,47641E-13	kg
Uranium alpha	Elementary flows/Emission to air/low population density	0,000320359	kBq
Uranium alpha	Elementary flows/Emission to water/river	0,00623719	kBq
Uranium-234	Elementary flows/Emission to air/low population density	6,81915E-05	kBq
Uranium-234	Elementary flows/Emission to water/river	0,000129878	kBq
Uranium-235	Elementary flows/Emission to air/low population density	3,3119E-06	kBq
Uranium-235	Elementary flows/Emission to water/river	0,000214299	kBq
Uranium-238	Elementary flows/Emission to air/high population density	2,58631E-08	kBq
Uranium-238	Elementary flows/Emission to air/low population density	6,86362E-05	kBq
Uranium-238	Elementary flows/Emission to water/ground water	4,75297E-10	kBq
Uranium-238	Elementary flows/Emission to water/ocean	5,58717E-07	kBq
Uranium-238	Elementary flows/Emission to water/river	0,000326939	kBq
Vanadium	Elementary flows/Emission to air/high population density	2,60169E-08	kg
Vanadium	Elementary flows/Emission to air/low population density	3,00534E-11	kg
Vanadium	Elementary flows/Emission to air/unspecified	1,42515E-11	kg
Vanadium	Elementary flows/Emission to soil/agricultural	2,99746E-12	kg
Vanadium, ion	Elementary flows/Emission to water/ground water	8,49663E-08	kg

Vanadium, ion	Elementary flows/Emission to water/ground water, long-term	1,95751E-08	kg
Vanadium, ion	Elementary flows/Emission to water/ocean	1,15978E-11	kg
Vanadium, ion	Elementary flows/Emission to water/river	1,25039E-07	kg
VOC, volatile organic compounds, unspecified origin	Elementary flows/Emission to water/ocean	5,36661E-09	kg
VOC, volatile organic compounds, unspecified origin	Elementary flows/Emission to water/river	2,84797E-07	kg
Volume occupied, final repository for low-active radioactive waste	Elementary flows/Resource/in ground	433	m3
Volume occupied, final repository for radioactive waste	Elementary flows/Resource/in ground	463	m3
Water	Elementary flows/Emission to air/low population density	5,2862E-13	kg
Water	Elementary flows/Emission to air/lower stratosphere + upper troposphere	3,21256E-12	kg
Water	Elementary flows/Emission to air/unspecified	1,75132E-06	kg
Water, cooling, unspecified natural origin	Elementary flows/Resource/in water	474	m3
Water, well, in ground	Elementary flows/Resource/in water	472	m3
Xenon-131m	Elementary flows/Emission to air/low population density	1,69998E-06	kBq
Xenon-133	Elementary flows/Emission to air/low population density	6,16564E-05	kBq
Xenon-133m	Elementary flows/Emission to air/low population density	7,37936E-08	kBq
Xenon-135	Elementary flows/Emission to air/low population density	0,000024701	kBq
Xenon-135m	Elementary flows/Emission to air/low population density	1,55081E-05	kBq
Xenon-137	Elementary flows/Emission to air/low population density	4,77581E-07	kBq
Xenon-138	Elementary flows/Emission to air/low population density	3,58822E-06	kBq
Xylene	Elementary flows/Emission to air/high population density	4,347E-09	kg
Xylene	Elementary flows/Emission to air/low population density	8,3869E-09	kg
Xylene	Elementary flows/Emission to air/unspecified	1,78995E-09	kg
Xylene	Elementary flows/Emission to water/ocean	1,82142E-09	kg
Xylene	Elementary flows/Emission to water/river	3,03483E-09	kg
Zinc	Elementary flows/Emission to air/high population density	1,25179E-09	kg
Zinc	Elementary flows/Emission to air/low population density	1,56133E-08	kg
Zinc	Elementary flows/Emission to air/lower stratosphere + upper troposphere	2,59084E-18	kg
Zinc	Elementary flows/Emission to air/unspecified	4,68241E-09	kg
Zinc	Elementary flows/Emission to soil/agricultural	6,52569E-09	kg
Zinc	Elementary flows/Emission to soil/industrial	3,749E-10	kg
Zinc	Elementary flows/Emission to soil/unspecified	1,38753E-09	kg
Zinc, ion	Elementary flows/Emission to water/ground water	3,10095E-08	kg
Zinc, ion	Elementary flows/Emission to water/ground water, long-term	3,1218E-08	kg
Zinc, ion	Elementary flows/Emission to water/ocean	1,44716E-08	kg
Zinc, ion	Elementary flows/Emission to water/river	4,79826E-08	kg
Zinc, ion	Elementary flows/Emission to water/unspecified	4,87639E-08	kg
Zinc-65	Elementary flows/Emission to air/low population density	3,81852E-12	kBq
Zinc-65	Elementary flows/Emission to water/river	9,42082E-09	kBq
Zirconium	Elementary flows/Emission to air/low population density	6,00195E-12	kg
Zirconium-95	Elementary flows/Emission to air/low population density	3,73246E-12	kBq
Zirconium-95	Elementary flows/Emission to water/river	1,09096E-10	kBq

Appendix 3: Results obtained using OpenLCA software with the ReCiPe 2016 method and the Endpoint (H) approach

Name	Category	Inven	Cha	Impact assessment result
Fine particulate matter formation	ReCiPe 2016 Endpoint (H)			9.00554E-9 DALY
Fossil resource scarcity	ReCiPe 2016 Endpoint (H)			0.00063 USD2013
Freshwater ecotoxicity	ReCiPe 2016 Endpoint (H)			8.47305E-14 species.yr
Freshwater eutrophication	ReCiPe 2016 Endpoint (H)			8.16836E-14 species.yr
Global warming, Freshwater ecosystems	ReCiPe 2016 Endpoint (H)			4.72852E-16 species.yr
Global warming, Human health	ReCiPe 2016 Endpoint (H)			5.73667E-9 DALY
Global warming, Terrestrial ecosystems	ReCiPe 2016 Endpoint (H)			1.73101E-11 species.yr
Human carcinogenic toxicity	ReCiPe 2016 Endpoint (H)			2.44481E-9 DALY
Human non-carcinogenic toxicity	ReCiPe 2016 Endpoint (H)			6.05500E-10 DALY
Ionizing radiation	ReCiPe 2016 Endpoint (H)			1.00846E-8 DALY
Land use	ReCiPe 2016 Endpoint (H)			2.59061E-12 species.yr
Marine ecotoxicity	ReCiPe 2016 Endpoint (H)			1.97785E-14 species.yr
Marine eutrophication	ReCiPe 2016 Endpoint (H)			3.76582E-15 species.yr
Mineral resource scarcity	ReCiPe 2016 Endpoint (H)			0.00021 USD2013
Ozone formation, Human health	ReCiPe 2016 Endpoint (H)			2.69768E-11 DALY
Ozone formation, Terrestrial ecosystems	ReCiPe 2016 Endpoint (H)			3.92056E-12 species.yr
Stratospheric ozone depletion	ReCiPe 2016 Endpoint (H)			4.04485E-12 DALY
Terrestrial acidification	ReCiPe 2016 Endpoint (H)			7.33146E-12 species.yr
Terrestrial ecotoxicity	ReCiPe 2016 Endpoint (H)			3.81625E-13 species.yr
Water consumption, Aquatic ecosystems	ReCiPe 2016 Endpoint (H)			-1.18372E-12 species.yr
Water consumption, Human health	ReCiPe 2016 Endpoint (H)			-4.35075E-6 DALY
Water consumption, Terrestrial ecosystem	ReCiPe 2016 Endpoint (H)			-2.64572E-8 species.yr