

Summary Life Cycle Assessment Report

in accordance with EN ISO 14040 and EN ISO 14044 and in line with EN ISO
14020, EN ISO 14021 and EN ISO 14024

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This Life Cycle Assessment study was conducted internally by
Nemak's Global Sustainability Team

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1 Background

1.1 General Information

The LCA comprises the following four phases [1]:

- Definition of the goal and scope
- Life cycle inventory analysis
- Life cycle impact assessment
- Life cycle interpretation

1.2 Profile of the company under review

Nemak is a leading provider of innovative lightweight solutions for the global automotive industry and specializes in the development and manufacture of aluminium components for e-mobility, structure and chassis, and ICE powertrain applications. In 2023, the company employed approximately 24,000 people in 38 production facilities worldwide, generating a revenue of US \$5.0 billion.

1.3 Interested parties

Interested parties have the opportunity to participate in the process, e.g. by contacting the life cycle assessor or Nemak itself. If available, their views were taken into consideration.

2 Definition of the goal and scope of the Life Cycle Assessment

2.1 Goal of the study

Nemak intends to use the life cycle assessment in accordance with EN ISO 14040/44 and in line with EN ISO 14020/21/24 to determine the environmental impact of the transmission housing (DL382) and engine blocks (M254 E20 and MPC I4). [2] [1] [3] [4] [5]

The Environmental Footprint (EF 3.1) is used to present the environmental impact indicators.

The life cycle assessment was calculated over the partial life cycle “cradle to gate”.

This comprehensive study provides a representative statement and can be used for internal and external B2B communication in accordance with EN 15942. However, due to the confidentiality of the data, it is recommended that only the results and not the LCA data (basic data) itself be communicated.

The results of the study are not intended for use in comparative statements intended for publication.

2.2 System boundaries and scope

2.2.1 Functional and declared unit

The declared unit is 1 kg Engine Block & Transmission Housing.

The functional unit is one piece.

Product	Piece weight
DL382	28.71Kg
M254 E20	38.59 Kg
MPC I4	36.03 Kg

All inputs and outputs were related to this as a reference.

2.2.2 Composition

The materials included are as follows:

Material	% per declared unit
Aluminium	100

2.2.3 System boundaries

The boundaries refer to engine blocks with the locations in Chongqing, China. Basis of the study is the company itself with the locations mentioned and all inputs and outputs relating to the product.

No supplier-specific upstream data were considered. The production of the upstream suppliers is used as an "ecological backpack" from the database, if available. No additional data was collected from other locations or for outsourced processes.

The data collection refers to the year 2024. All data was based on this base year.

Building or plant components that are not relevant for product manufacture are excluded by means of estimates (e.g. electricity consumption for IT, building heating).

2.2.4 Allocation procedure

The following allocations occur:

- Allocations for the data as annual values in relation to the functional unit
- Use of secondary raw materials (see chapter 2.2.4.1)
- Allocations for reuse and recycling (see chapter 2.2.4.1)

2.2.4.1 Allocation procedure for reuse and recycling

For the treatment of scrap, the End of Life recycling approach (also known as avoided burden) was chosen as the allocation method of processes and impacts. This choice fits the goal and scope definition of the assessment.

- Recycling or recovery processes beyond the system boundary (after the end-of-waste properties have been reached) are included in the product system burden-free.
- Benefits are allocated for recycling. A justified value correction factor (VCF), which reflects the difference in functional equivalence between output flow and substitution material, was used. The VCF is for dross 13,1%, for aluminium scrap 94,56%.
- In the case of sand, no benefits are allocated for the secondary content (regranulate).
- In the case of aluminium, no benefits are allocated for the secondary content. The VCF were adjusted for aluminium by the secondary material content (see table below).

Product	Secondary content
Transmission Housing and Engine Blocks	70.0%

The study by Classen and Althaus (Chapter 6.2) was used to determine the VCF. [3] The following table summarises the results:

Abfall	Collection yield	Processing yield	Remelting yield	VCF
Dross	100%	93,25%	14%* [4]	13,06%
Aluminium scrap	100%	98,50%	96,00%	94,56%

*Other sources were used as a more appropriate reference

2.2.5 Assumptions and limitations

The “LCA for Experts” software from Sphera Solutions in version 10.9.0.20 incl. the current version of the professional database of “LCA for Experts” 2024.2) was used as the basis for the calculation. The data was all updated in 2024.

Data gaps are replaced by corresponding data. The system boundaries are adhered to. Generic data is used where necessary.

In some cases, not all the data for the materials could be covered by the database. Similar substances and compositions were therefore selected. The following assumptions were made.

Melting:

- SECONDARY/SCRAP ALUMINUM, Scrap and Secondary ingot are scrap and therefore were summed up and modelled as secondary material.
- The given quantity of Waste of recovery and Scrap (White dross) was adjusted to achieve a correct mass balance.

Degassing:

- The given quantity of white dross/scrap/waste to recovery was adjusted to achieve a correct mass balance.

Casting:

- The given quantity of scrap was adjusted to achieve a correct mass balance.

Machining:

- The given quantity of scrap was adjusted to achieve a correct mass balance.

Trimming:

- The given quantity of scrap was adjusted to achieve a correct mass balance.

Packaging and Quality control:

- Processes are considered in Machinning.
- Packaging material was not considered.

Energy:

- The China electricity mix and China mix for thermal energy from natural gas were assumed for the energy consumptions.

Water:

- Production-relevant water consumption was not considered.

Transport:

- The transport of raw materials and pre-products to the manufacturer, as well as the transport of production waste to the processor, was not considered.

2.2.6 Cut-off criteria

It can be assumed that the neglected materials or energies and water per value do not exceed 1 percent. The sum of the neglected processes is less than 5 percent.

The following processes were excluded:

Excluded process	Justification	Action
Water	Cannot be quantified.	Nemak will collect data within the next five years.
Transport	Cannot be quantified.	Nemak will collect data within the next five years.
Packaging	Cannot be quantified.	Nemak will collect data within the next five years.

3 Life cycle inventory analysis

3.1 Product description

DL382- Transimission housing.

- Type: 7 speed.
- Power output: NA.
- Weight: 28.71 Kg.
- SOP: 2016.
- Engine Factory: Tianjing VM Audi (China).
- Vehicle Application: Audi A4,A5,A6,Q3,Q5,Q6.



M254 E20- Engine Block.

- Type: 2.0 L
- Power output: 190 Kw
- Weight: 38.59 Kg
- SOP: 2021
- Engine Factory: BBAC (China)
- Vehicle Application: GLC, Eclass, C class.



MPC I4 2.0 HO - Engine Block.

- Type: 2.0 L
- Power output: 210 Kw
- Weight: 36.03 Kg
- SOP: 2022
- Engine Factory: CAF (China)
- Vehicle Application: Ford Edge, Lincoln Z, Lincoln Nautilun, Lincoln Corsair, Ford Explorer, Ford Mondeo.



3.2 Manufacturing process

The manufacturing process is as follows:



Figure 1: Manufacturing process (DL382)

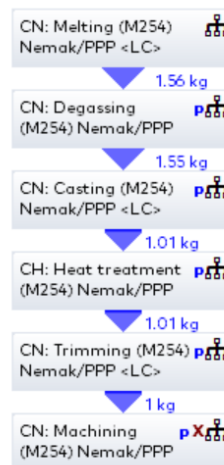


Figure 2: Manufacturing process (M254)



Figure 3: Manufacturing process (MPC I4)

3.3 Data collection

The processes involved in the production of the products were identified.

All relevant inputs, such as raw materials and energy used, as well as relevant outputs generated during the production processes, including by-products, atmospheric emissions, wastewater, solid and liquid waste, were identified and quantified using excel spreadsheets, like parameter sheets and weight tables from Logistics and Controlling, and the company's internal ERP systems NORIS and SAP. In addition, further data was requested directly, e.g. by e-mail.

All data relates to the functional units. These were collected as an annual average.

3.3.1 Life cycle phases

3.3.1.1 Resource extraction

The data for the extraction of raw materials originate, if available, from upstream suppliers and the raw materials, auxiliary materials, etc. These were modeled in the software.

3.3.1.2 Transport to the manufacturer

The upstream transport routes have not yet been considered.

3.3.1.3 Production

Besides the production-relevant data, it also includes the complete waste treatment up to the end of the waste status or disposal.

3.3.2 Biogenic carbon

As the products do not contain any biogenic carbon, it is not shown accumulated in the LCIA table.

3.3.3 Level of data quality

Quality level	Geographical representativeness	Technical representativeness	Temporal representativeness
Very good	The processes included in the dataset are fully representative of the region specified in the metadata under "Location".	Technological aspects have been modeled exactly as described in the title and metadata, there is no significant need for improvement.	The data is not older than 0 years, as indicated in the ILCD field ("Record valid until" and the difference between "valid until" and the "reference year" is no more than 8 years).
good	The processes included in the dataset are quite representative of the region specified in the metadata under "Location".	The technological aspects are very similar to those described in the title and metadata, there is a limited need for improvement. For example: Use of generic technology data instead of modeling all individual plants.	The data is not older than 3 years, as indicated in the ILCD field ("Record valid until" and the difference between "valid until" and the "reference year" is not more than 8 years).
medium	The processes included in the dataset are sufficiently representative of the region specified in the "Location" metadata. For example, a different country has been shown, but it has a very similar electricity mix profile.	The technological aspects are like those described in the title and metadata, but there is room for improvement. Some of the relevant processes are not modeled with specific data but using proxy data.	The data is not older than 6 years, as indicated in the ILCD field ("Record valid until" and the difference between "valid until" and the "reference year" is no more than 8 years).
bad	The processes included in the dataset are only partially representative of the region specified in the metadata under "Location". For example, a different country with a very different electricity mix profile was shown.	The technological aspects differ from what is described in the title and metadata. Major improvements are needed.	The data is not older than 10 years, as indicated in the ILCD field ("Dataset valid until" and the difference between "valid until" and the "reference year" is not more than 8 years, as confirmed by the verifier(s)).
Very bad	The processes included in the dataset are not representative of the region specified in the metadata under "Location".	The technological aspects are completely different from what is described in the title and metadata. A significant improvement is needed.	The data is older than 10 years, as indicated in the ILCD field ("Dataset valid until" and the difference between "valid until" and the "reference year" is no more than 8 years).

3.2 Data validation

Data validation was carried out for all data provided. The data was checked for both validity and consistency. The inputs and outputs were analysed for this purpose.

4 Life cycle impact assessment

The method developed by the Joint Research Centre (JRC) was chosen to assess the impacts: The Environmental Footprint (EF 3.1). The European Union recommends this method as a life cycle assessment (LCA)-based method for quantifying the environmental impact of products (goods or services) and organisations. This method is considered suitable due to the normative presentation and internal and external communication.

The LCIA factors were selected in accordance with the current version of the “LCA for experts” life cycle assessment software.

The significant parameters were identified on the basis of the results of the quantification of the results in accordance with the life cycle inventory phases and the impact assessment.

The following indicators are presented as results in the LCA:

- Climate Change, divided into fossil, biogenic and land use.
- Ecotoxicity freshwater.
- Destruction of the stratospheric ozone layer.
- Human toxicity, divided into cancer and non-cancer.
- Ionising radiation (human health)
- Land use
- Acidification of water and soil.
- Eutrophication divided into saltwater, freshwater and terrestrial.
- Particulate matter
- Formation of photochemical oxidants.
- Depletion of fossil and mineral/metal resources.
- Water use.

5 Results of the assessment including conclusions

The results of the impact assessment are relative statements. The results of the impact assessment do not make any statements about endpoints of the impact categories, exceedances of threshold values, safety margins or risks.

5.1 Interpretation of the results

The LCA was conducted with a cradle-to-gate scope and a functional unit of 1 kg for three components produced in China DL382, M254 E20, and MPC I4 classified as engine blocks and transmission housings. The results show that the melting process is the dominant contributor to the overall environmental impact, although the high proportion of secondary aluminium (70%) significantly reduces the footprint compared to other aluminium-intensive components.

Among the three products, MPC I4 shows the highest carbon footprint at 3.93 kg CO₂e/kg, followed by DL382 at 3.17 kg CO₂e/kg, and M254 E20 at 3.08 kg CO₂e/kg. These values are relatively close to each other, reflecting the similar input composition and production setup across the products. The differences are mainly attributed to variations in process energy demand and minor differences in auxiliary material use.

Other environmental indicators show similar patterns. Acidification potential (AP) and eutrophication (EP freshwater and saltwater) are slightly higher for MPC I4, consistent with its higher GWP. Resource depletion (ADPF, ADPE) and water use (WU) also follow this trend, with MPC I4 showing the largest values.

The casting and heat treatment stages represent the second most relevant contributions after melting. While their impact is smaller, they add to the overall footprint mainly through energy consumption and use of process chemicals. Other life cycle stages, such as machining and surface treatments, contribute marginally but are visible in categories such as human toxicity (HTCE, HTNCE) and particulate matter formation (PME).

In summary, the results confirm that the environmental performance of these components is largely driven by energy demand during melting, casting, and heat treatment. The use of 70% secondary aluminium already contributes to relatively

low impacts, and further reductions could be achieved through process energy efficiency improvements.

The nine key environmental indicators are shown in the following diagram.

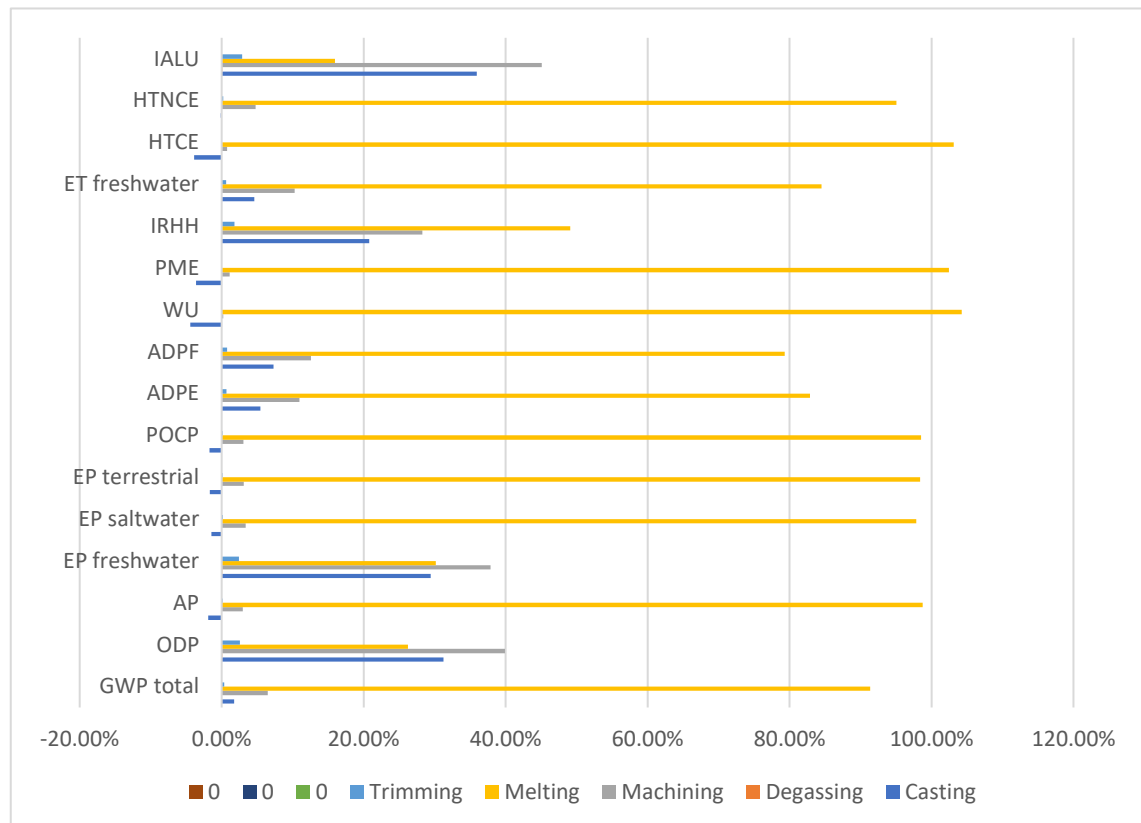


Figure 4: Shares of the modules for selected environmental indicators (DL 382)

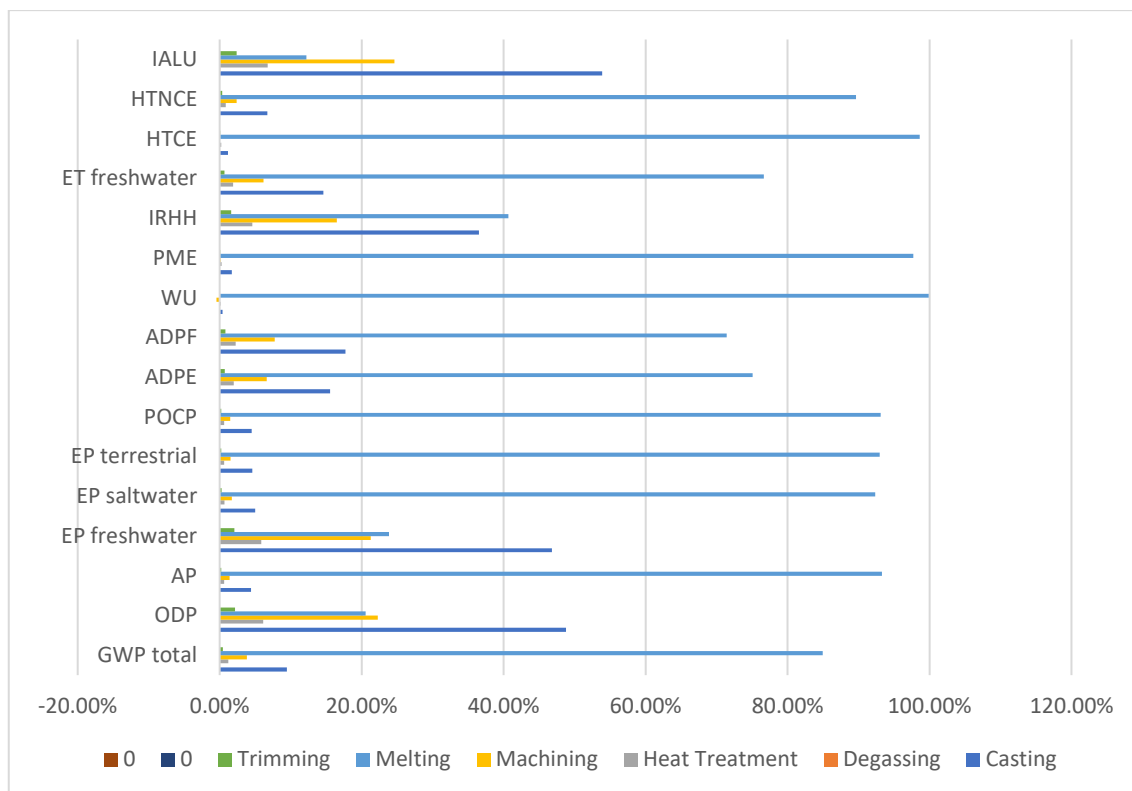


Figure 5: Shares of the modules for selected environmental indicators (MPC I4)

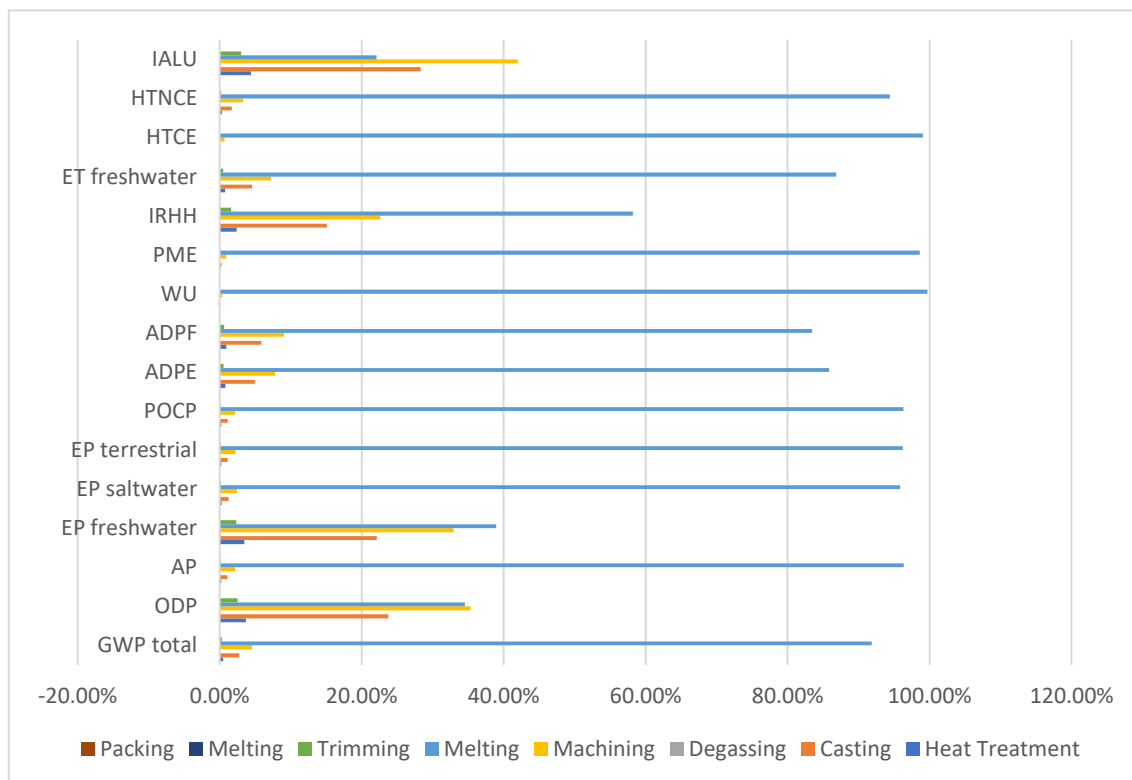


Figure 6: Shares of the modules for selected environmental indicators (M254 E20)

The study is limited to system boundaries and assumptions utilised. For further improvement to the values, assumptions listed in chapter 2.2.5 should be refined and further improved.

5.2 Temporal validity

If there are no significant changes to the manufacturing methods or processes, the study is valid for 5 years from the date of publication.

5.3 Documentation procedure

All references used are documented in the bibliography. Manufacturer information used can be requested directly from the company. All calculations were carried out on the basis of applicable laws and standards.

5.4 Consistency check

Audit	Information	Assessment	Action
Data source	manufacturer	Ok	none
Data accuracy	Good	Ok	none
Data age	2 years	Ok	none
Technological coverage	State of the art	Ok	none
Time-related	Current	Ok	none
Coverage	Poland plus upstream suppliers	Ok	none

5.5 Critical review

No critical review was carried out yet.

5.6 Results of the study

Per declared Unit (1 kg)

Indicator	Unit	DL382	M254	MPC I4
GWP total	kg CO2 e	3.17	3.08	3.93
GWP fossil	kg CO2 e	3.16	3.07	3.92
GWP	kg CO2 e	9.90E-03	9.22E-03	1.27E-02
GWP land	kg CO2 e	5.70E-04	5.58E-04	7.20E-04
ODP	kg CFC-	5.65E-12	4.20E-12	8.31E-12
AP	Mole H+ e	1.38E-02	1.38E-02	1.68E-02
EP freshwater	kg P e	2.52E-06	1.90E-06	3.66E-06
EP saltwater	kg N e	2.81E-03	2.80E-03	3.43E-03
EP terrestrial	Mole N e	3.06E-02	3.06E-02	3.74E-02
POCP	kg	8.24E-03	8.24E-03	1.01E-02
ADPF	MJ	1.98E-07	1.87E-07	2.53E-07
ADPE	kg Sb e	4.43E+01	4.11E+01	5.67E+01
WU	m³ world e	1.02	1.04	1.22
PME	disease	2.47E-07	2.51E-07	2.99E-07
IRHH	kBq U235	2.72E-01	2.25E-01	3.79E-01
ET freshwater	CTUe	1.02E+01	9.71E+00	1.30E+01
HTCE total	CTUh	3.35E-09	3.41E-09	4.04E-09
HTNCE total	CTUh	2.77E-08	2.72E-08	3.38E-08
IALU	-	5.45	3.84	8.21

GWP – Climate change	ODP – Stratospheric ozone depletion
AP – Acidification potential	EP – Eutrophication potential
POCP – Photochemical oxidation (mineral and metals)	ADPE – Abiotic depletion potential elements
ADPF – Abiotic depletion potential fossils	WU – Water use
PEM – Particulate matter emissions	IRHH – Ionizing radiation, human health
ET – Eco toxicity	HTCE – Human toxicity, carcinogenic effects
HTNCE – Human toxicity, non-carcinogenic effects quality	IALU – Impacts associated with land use/soil

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