User’s instructions of GLAD Mapper

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Definitions

(Elementary) flow

ISO 14040 defines elementary flows as "*material or energy entering the system being studied that has been drawn from the environment without previous human transformation, or material or energy leaving the system being studied that is released into the environment without subsequent human transformation*". They include emissions to compartments of nature (e.g., "emissions of lead to seawater", "emissions of PM 2.5 to urban air close to ground", etc) or resources taken from natural compartments (e.g., "lead from ground resources", "occupation of forest from land resources", etc). In the context of the *GLAD Mapper*, elementary flows consist of three components, (i) the **flowable** (or name of the flow), (ii) the flow **context** meaning the environmental compartment(s) and subcompartment(s) involved and (iii) the flow **unit** (e.g., "kg of lead to water/seawater", "m2y of occupation of forest from natural resources/land", etc).

Flowable

Name of the compound, element, and material in an elementary flow, regardless of the sub-compartment (e.g., "lead", "occupation of forest", "PM 2.5", etc). It can also refer to a family or group of substances (e.g., "hydrocarbons", "pesticides", "sulphur oxides", etc).

Context

Direction (to/from), compartment and sub-compartment of an elementary flow, regardless of the flowable (e.g., "to water/seawater", "from water/freshwater", "from natural resources/land", "to air/unspecified" etc).

Elementary flow list (EF list, flow list)

List of elementary flows in a nomenclature system. Each elementary flow of a flow list may include additional details such as CAS number, identification string, and list of synonyms.

Source flow list

List of the elementary flows to which matching flows from a target flow list is mapped.

Target flow list

List of elementary flows that can be mapped to a source flow.

Manual Mapping file

File containing mapping rules used by the mapping tool to map elementary flows, flowables, and contexts between a "source" and a "target" flow list as well as the conversion between specific flowables when provided in different units. These manual mappings are needed wherever automated mapping, e.g., of flowables by CAS number or by name, was not possible or wanted.

Mapped file

File containing the correspondences between elementary flows of the source and the target flow lists. It represents the output of the *GLAD Mapper* and it includes unmapped source elementary flows (or "orphans") and matching criteria applied for each elementary flow (Section 3.1).

UUID

Universally Unique Identifier, a standardized system to label and uniquely identify information, such as individual flows defined in elementary flow list (ISO/IEC 9834-8:2014, Part 8).

1. Introduction

The GLAD Mapper is a software developed by the JRC and it has been specifically designed to work specifically formatted excel files containing elementary flow (EF) lists (i.e., lists of substances emitted to the environment or resources consumed, in specific contexts (e.g., Carbon Dioxide emission to air, urban or freshwater resources from lake) from different data system owners in the framework of Life Cycle Assessment Databases. The tool has been developed in the context of the Global LCA Data Access (GLAD) under the United Nations Environmental Programme (UNEP) Life Cycle Initiative in order to support the activities of the GLAD Nomenclature Working Group (NWG).

Representatives of four major nomenclature systems were involved in the NWG. The four flow lists object of the mapping activities are:

- **ecoinvent version 3.7 (ecoinvent3.7)**
- **U.S. Federal LCA Commons version 1.0.3 (FEDEFL1.0.3)**
- **IDEA version 2.3 (IDEA2.3)**
- **European Commission's Environmental Footprint version 3.0 (EF3.0)**

Which are available in the public repository on GitHub[1] in both xlsx and csv format

Besides the source and the target flow lists, the Mapper tool requires in input the manual mapping file containing the criteria to match the elements of the two flow lists in input. The manual mapping files for to match the 12 source target combinations given by the four flow lists as defined by the NWG are made publicly available on the GLAD NWG GitHub repository [2] . The files are provided in excel (xlsx) format, named "*mapping_input_[SOURCE_LIST]_[TARGET]*". The GitHub repository finally includes the 12 mapped files[3] between the 4 flow lists which represent the main outputs of the mapping activity.

2. Functionalities of the software

The functionalities of the GLAD Mapper are the following:

1. Create Manual Mapping
2. Assign labels according to the criteria adopted for mapping

[1] https://github.com/UNEP-Economy-Division/GLAD-ElementaryFlowResources/tree/master/Mapping/Input/Flowlists
[2] https://github.com/UNEP-Economy-Division/GLAD-ElementaryFlowResources/tree/master/Mapping/Input/Mapping_files
[3] https://github.com/UNEP-Economy-Division/GLAD-ElementaryFlowResources/tree/master/Mapping/Output/Mapped_files

2.1. Preliminary operations and needed object

The mapping script uses one source list, one target list, and the relevant mapping inputs to match the single flows in a 1:1 comparison. To establish a bidirectional mapping between two EF lists, the tool needs to be executed in both directions, with the source list and target list exchanged, resulting in two Manual Mapping files.

The tool procedure to match flows and establish these initial Manual Mapping files can be summarized by the information requirements and the algorithm outlined below. The tool is fed by three input files: Manual mapping, Source Elementary Flow List and Target Elementary Flow List.

2.1.1. Manual mapping file

The Manual Mapping File is an excel file which includes sheets where the user defines the criteria for the matches of the main element (context, flowable, elementary flows and conversion factors) between the flow lists. The match criteria are provided in the following sheets:

- DEFAULT_CONTEXT_MATCH: definition of the primary (i.e. best possible proxy) match of compartments/sub-compartments for a given combination of source and target EF lists. This table establishes the default exact match (or the best proxy available) for each entry from the source to the target list

- PROXY_CONTEXT_MATCH: specification of secondary proxies, where applicable, for the compartments/sub-compartments (i.e., contexts) identified in the source to the target list can be more than one in the "target" list, if this is the case, they are hierarchically ordered for proximity to the source list. For example:

Source compartment: *emission/air/urban/ground level*

Target best proxy → *emission/air/urban/close to ground*
Target second proxy → *emission/air/urban/low*
Target third proxy → *emission/air/ urban/high/unspecified*, and so on.

Proxies too far from the source compartment shall be avoided, in the example above e.g., emission/air/non-urban/low shall be avoided, usually the "unspecified" proxy should close the list of proxies unless the "unspecified" itself is the source context).

- NO_FLOW_MATCH_MANUAL: identifies a list of flows that don't have to be mapped at all, because it will lead to wrong matches, it includes both flow name and context in case a specific flow doesn't have to be matched for specific compartments but can find matches in others.

- ONE2ONE_FLOW_ MANUAL: includes groups of flows that do not match with the criteria assigned by the mapping tool (e.g., land use flows that carry different names, have no CAS and no synonyms) or for which

the criteria can lead to mismatches (e.g., carbon dioxide that carries the same CAS irrespective of list-specific differentiations based on the source of the carbon, i.e., biogenic/non-fossil, fossil, land-use change, etc.) this table includes names and contexts for the specific entries both for source and target lists, target flows can be repeated, while the source list shall include each flow only once.

o FLOWNAME_MANUAL: includes the group of flows that don't get a match with the logical iterations of the mapping script, in this table only flow names are reported in source and target lists, the context (that can be multiple for each flow) is resolved by the mapping script at the level of DEFAULT_CONTEXT_MATCH and PROXY_CONTEXT_MATCH tables, as above the source side of the list shall include each flow only once, while the target list can contain multiple entries for the same flow.

o FLOWNAME_MANUAL_PROXY: same rules and function as FLOWNAME_MANUAL, but it comes after all the other checks and it's typically meant for matches that have a lower quality rank, e.g. specific substances to the group of substances (for example a specific chemical to "pesticides unspecified" or a specific Hydrocarbon to "hydrocarbons unspecified") the rationale of the second level for FLOWNAME_MANUAL is that if a better proxy is captured by other iterations then is captured before the "low-rank" match.

o ONE2MANY_FLOW_MANUAL: specific for IDEA2.3 land transformation flows which include "from" and "to" in one single flow, while in other systems the "from" and "to" are listed as two separate flows.

o MULTIMATCH (PROCESS ONLY): not meant for the mapping script, essentially is available only in context mapping from all other systems to IDEA, reverting the "ONE2MANY_FLOW_MANUAL" ratio, but given that the "from" and "to" in the process dataset may include different land transformation paths, the information can be used at the level data conversion assigning the proper (equal) quantities in the "from" and "to" entries coming from IDEA process datasets.

2.1.2. Source and target elementary flow lists.

Two files are formatted according to the common GLAD EF format for mapping purposes, including the following flow attributes: flow name, CAS [optional], synonyms [optional], unit, unique identifier in the native lists (UUID), context (i.e., the flow compartment and sub-compartments merged into one string, e.g., "emission/air/urban/close to ground"). Beyond the information provided in the native lists, an additional field is provided, containing any (secondary) CAS registry numbers according to those available in PubChem[4]. The additional CASs are provided through the use of the URL-based API "PUG REST"[5] released by PubChem. An Ad-hoc excel function was developed to query the API via VBA code. The function accepts in input the name of

[4] https://pubchem.ncbi.nlm.nih.gov/
[5] https://pubchemdocs.ncbi.nlm.nih.gov/pug-rest/

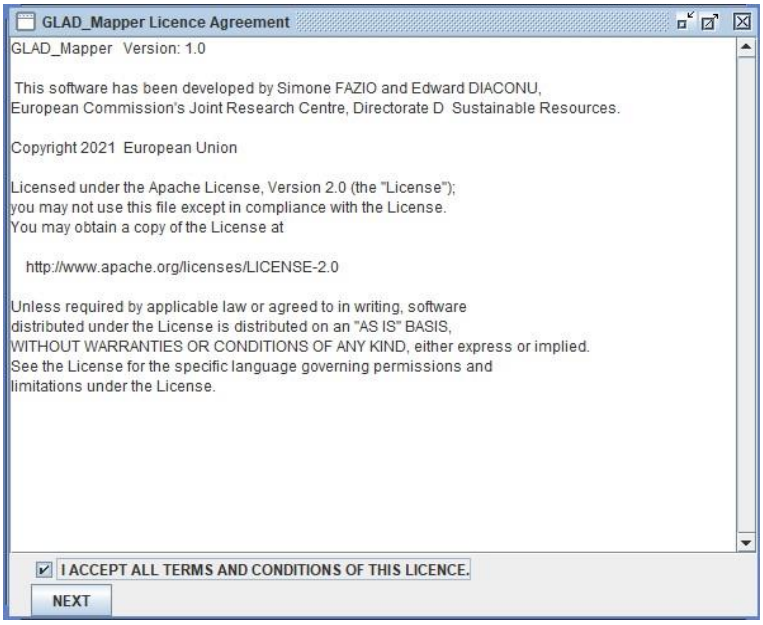
a substance as the only parameter[6]. The PubChem PUG REST API provides CAS numbers as a synonym of a substance or compound. The output of the VBA function is a list of CAS numbers (as a string separated by semicolons), which is used to fill the secondary CAS field for each substance in the GLAD flow lists.

Based on the abovementioned files, the tool performs the mapping according to a series of sequential logical steps, and for the matches found reports the string is taken from the specific flow from the source with all the info, from the target flow list. The steps are in a logical and hierarchical sequence, and once a match is identified on the source side, the flow is excluded from any further checks (i.e., the source flows are reported only once in the Manual Mapping file). The only exception to that rule is for land transformation flows where IDEA is the source, according to the framework defined in ONE2MANY_FLOW_MATCH above the flows have indeed to be split (so mentioned twice in the source), to be matched with both the “from” and the “to” in the target list.

2.2. How to run the mapping

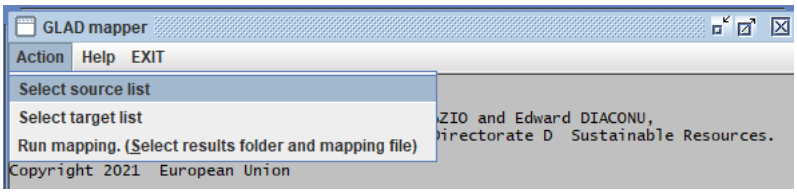
Below is the step-by-step procedure to run the mapping:

1. **Run the GLAD Mapper Jar application and accept the license agreement, then click “next”**

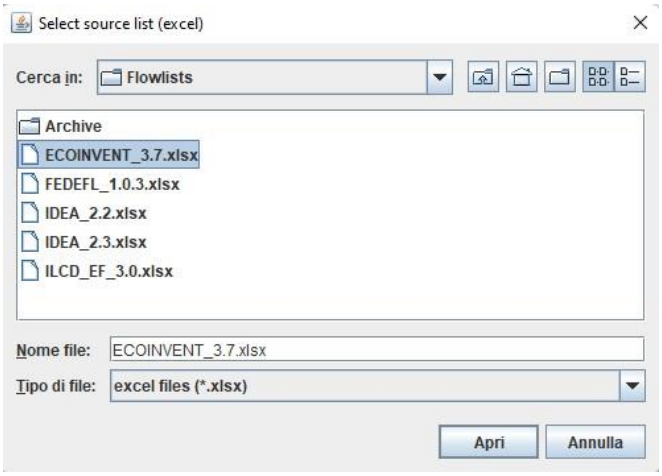


[6] This parameter is used to query the PUG REST API using the string “https://pubchem.ncbi.nlm.nih.gov/rest/pug/compound/name/**[SUBSTANCE_NAME]**/synonyms/txt" via HTTP request, the PubChem server returns the list of synonyms of “SUBSTANCE_NAME” in text-plain format. The list of synonyms is then screened by the VBA function to identify the CAS-like items.

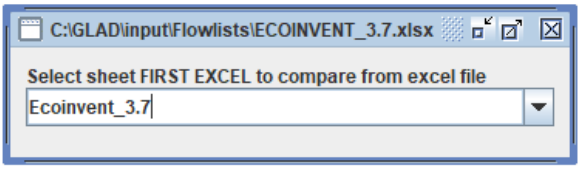
2. **Select “Select source list” from the menu “action”**



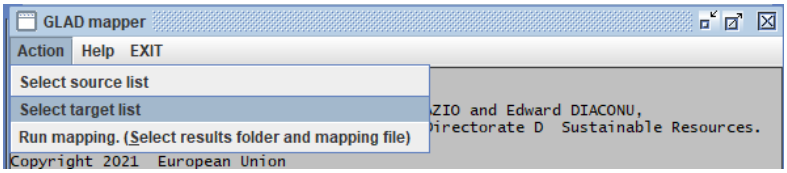
3. **Choose the excel file with the Source flow list and click “open”**



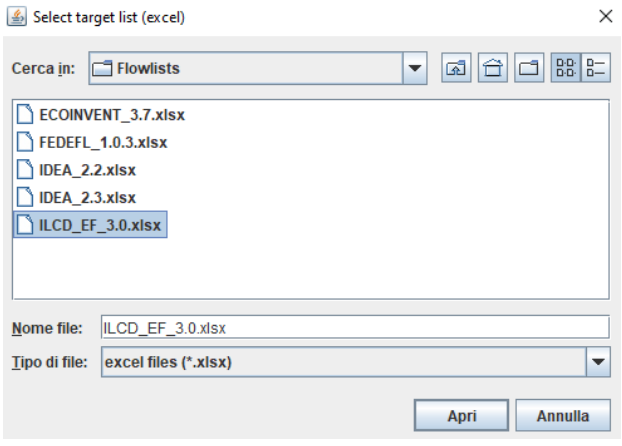
4. **Choose the sheet with the proper flow list**



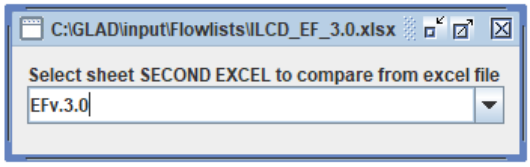
5. **Select “Select target list” from the menu “action”**



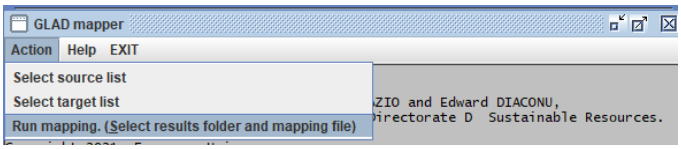
6. **Choose the excel file with the target flow list and click “open”**



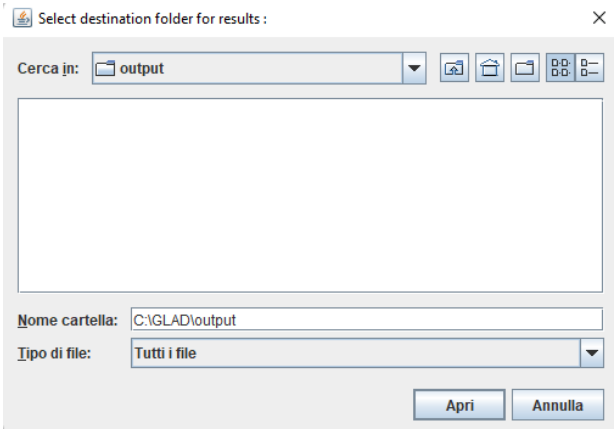
7. **Choose the sheet with the proper flow list**



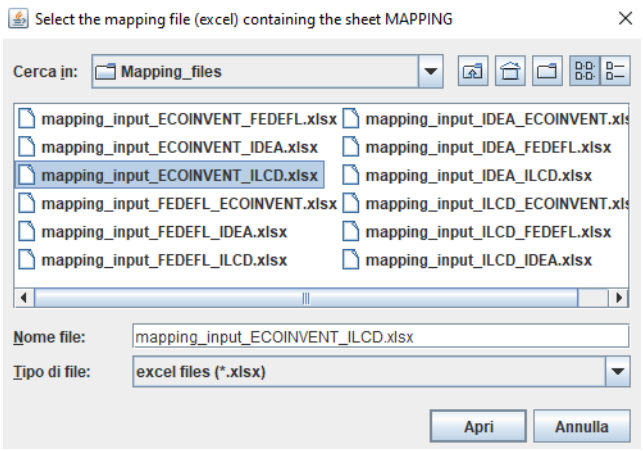
8. **Select "Run mapping" from the menu "action"**



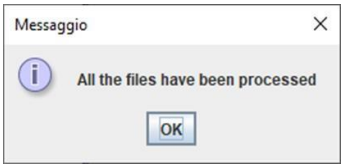
9. **Select the destination folder where the new mapped file will be generated and click "open".**



10. **Select the Manual Mapping file and click "open"**



11. **Wait until the message "all files have been processed" appears then the Mapped file is generated in the destination folder selected in step 9.**



3. Example of Manual Mapping file and description of the content

Based on the abovementioned files, the tool performs the mapping according to a series of sequential logical steps, and for the matches found reports the string is taken from the specific flow from the source with all the info, from the target flow list. The steps are in a logical and hierarchical sequence, and once a match is identified in the source side, the flow is excluded from other checks (i.e., the source flows are reported only once in the Manual Mapping file). The only exception to that rule is for land transformation flows where IDEA is the source, according to the framework defined in ONE2MANY_FLOW_MATCH above the flows have indeed to be split (so mentioned twice in the source), to be matched with both the "from" and the "to" in the target list.

3.1. Label assignment and match types

The logical checks performed by the tools are in hierarchical order, each step includes 2 iterations (exceptions are mentioned below), the first one checks DEFAULT_CONTEXT_MATCH for primary context, while the second one checks PROXY_CONTEXT_MATCH contexts. The tool assigns a specific mapping type label to the entries that are matched, the matches found in each step are excluded from further checks in the subsequent steps (i.e., each flow is reported only once on the source side[7]).

case 1) Manual checks based on tables created by users (ONE2ONE_FLOW_MANUAL, NO_FLOW_MATCH_MANUAL, FLOWNAME_MANUAL and ONE2MANY_FLOW_MANUAL), in this first block the iterations for name-name are performed against the primary context mapping before, then secondary context (PROXY_CONTEXT_MATCH)

a. NO_FLOW_MATCH_MANUAL (i.e., no matches by input): excludes the listed flows from any type of iteration of the mapping script
b. FLOWNAME_MANUAL checks: matches the names provided in source and target.
c. ONE2MANY_FLOW_MANUAL checks: matches the names of land transformation flows from IDEA to the two pre-selected flows in the target list, also this step doesn't search for a context match in DEFAULT_CONTEXT_MATCH and PROXY_CONTEXT_MATCH since it is established a priori.
d. ONE2ONE_FLOW_MANUAL checks: matches the names and contexts provided in source and target, this step doesn't search for a contexts match in DEFAULT_CONTEXT_MATCH and PROXY_CONTEXT_MATCH since it is established *a priori*.

case 2) Automated checks: the iterations are performed against the primary context mapping for CAS and name, then steps C and D are performed, then, a second iteration in the same order for CAS and NAME is performed for the secondary context (PROXY_CONTEXT_MATCH).

[7] except from IDEA land transformation

a. By CAS: the source and target CAS are identical, some formats include CAS with a fixed number of characters, filling with a set of "0" prefix the gaps to reach the fixed value, this is ignored by the mapping script (e.g. 000110-63-4 is considered identical to 110-63-4).

b. By name: the name is identical in the source and target list (non case-sensitive).

c. By name to synonyms: the name of the source is identical to one of the synonyms of the target.

d. By synonyms to name: a synonym of the source matches one of the names in the target.

case 3) Additional checks: the iterations are performed against the primary context mapping for secondary CAS, then for the secondary context (PROXY_CONTEXT_MATCH), then step b is performed.

a. By secondary CAS: either the main (already in the native flow list) or one of the secondary CAS (provided in PubChem) matches with either the primary or one of the secondary CAS in the target.

b. By FLOWNAME_MANUAL_PROXY final checks: performs the last check on remaining unmapped, according to the same rules as point 1.a (but using table FLOWNAME_MANUAL_PROXY), the entries in this last check are those with a lower match ranking and therefore are checked as the last iteration so that if one of the previous steps capture a better proxy, the match is excluded from this last step.

case 4) All the remaining flows on the source list that don't find a match are considered unmapped.

This section summarises the labels assigned by the tool according to the above-mentioned iterations[8], in the logical order of the mapping script[9]:

- **NO_FLOW_MATCH_MANUAL:** Case 1.a.
- **FLOWNAME_MANUAL:** Case 1.b. primary context mapped
- **FLOWNAME_MANUAL (*PROXY)*:** Case 1.b. proxy context mapped
- **ONE2MANY_FLOW_MANUAL:** Case 1.c.
- **ONE2ONE_FLOW_MANUAL:** Case 1.d.
- **CAS:** Case 2.a. primary context mapped
- **NAME:** Case 2.b. primary context mapped
- **SYNONYM_TO_NAME:** Case 2.c.
- **NAME_TO_SYNONYM:** Case 2.d.
- **CAS (*PROXY)*:** Case 2.a. secondary context mapped
- **NAME (*PROXY)*:** Case 2.b. secondary context mapped
- **SECOND_CAS:** Case 3.a. primary context mapped
- **SECOND_CAS (*PROXY)*:** Case 3.a. secondary context mapped
- **FLOWNAME_MANUAL _PROXY:** Case 3.b. primary context mapped
- **FLOWNAME_MANUAL _PROXY (*PROXY)*:** Case 3.b. secondary context mapped
- **NO_MAPPING:** Case 4.
- **Additional info:** if the flow on the target side is repeated more than once, the label starts y "dash" sign ("-"), and the whole text is coloured in red.

[8] The string "*(PROXY)*" indicates that the context of an elementary flow in the source list matched a proxy sub-compartment in the target list (i.e., the context is mapped by PROXY_CONTEXT_MATCH).

[9] Where applicable, a conversion factor is assigned. If the conversion field is empty, the factor to be assigned is 1, if it is reported as "N/A" the mapping shall be excluded (see further explanations in chapter "Guidance for developers of data format converters")

3.2. Results: Example of Mapped file

	B	C	D	E	G	H	J	K	L	M
1	SourceFlowName	SourceFlowUUID	SourceFlowContext	SourceU	Conver	MapType	TargetFlowName	TargetFlowUUID	TargetFlowContext	TargetU
2	uranium, in ground	2ba5e39b-adb6-4767-a51d-90c1cf32fe98	natural resource/in ground	kg	560000	CAS (PROXY)	uranium	3e4d2966-6556-11dd	resource/ground/non renewable/energy	mj
3	water, salt, ocean	629ffbca-ca71-4e4b-a006-ca9bdd9cd1df	natural resource/in water	m3	1025	ONE2ONE_FLOW_MANUAL	sea water	172a3db9-6556-11dd	resource/water/renewable/material	kg
4	oil, crude, in ground	88d06db9-59a1-4719-9174-afeb1fa4026a	natural resource/in ground	kg	45.8	FLOWNAME_MANUAL (PROXY)	crude oil	fe0acd60-3ddc-11dd	resource/ground/non renewable/energy	mj
5	gas, natural, in ground	7c337428-fb1b-45c7-bbb2-2ee4d29e17ba	natural resource/in ground	m3	38.29	FLOWNAME_MANUAL (PROXY)	natural gas	fe0acd60-3ddc-11dd	resource/ground/non renewable/energy	mj
6	coal, hard, unspecified, in groun	b6d0042d-0ef8-49ed-9162-a07ff1ccf750	natural resource/in ground	kg	19.1	FLOWNAME_MANUAL (PROXY)	hard coal	fe0acd60-3ddc-11dd	resource/ground/non renewable/energy	mj
7	coal, brown, in ground	024c9722-1e88-412b-8c4b-10c532be8dca	natural resource/in ground	kg	9.9	FLOWNAME_MANUAL (PROXY)	brown coal	fe0acd60-3ddc-11dd	resource/ground/non renewable/energy	mj
8	peat, in ground	c5035ce2-5ee5-431f-a287-4b25da42be74	natural resource/biotic	kg	1	NAME (PROXY)	peat, in ground	126514fa-415f-454a-	resource/biosphere/renewable/material	kg
9	tio2, 54% in ilmenite, 18% in cruc	90a94ea5-bca4-483d-a591-2e886c0ff47f	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
10	tio2, 54% in ilmenite, 18% in cruc	90a94ea5-bca4-483d-a591-2e886c0ff47f	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
11	tio2, 54% in ilmenite, 2.6% in cru	78cd4852-e7b9-4301-adf7-51e730b0356a	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
12	tio2, 54% in ilmenite, 2.6% in cru	78cd4852-e7b9-4301-adf7-51e730b0356a	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
13	tio2, 95% in rutile, 0.40% in crude	ec0fa5ce-51b4-4792-a8e8-c4ee668eddc3	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
14	tio2, 95% in rutile, 0.40% in crude	ec0fa5ce-51b4-4792-a8e8-c4ee668eddc3	natural resource/in ground	kg	0.6	FLOWNAME_MANUAL	titanium	2906898f-6556-11dd	resource/ground/non renewable/element	kg
15	1,3-dioxolan-2-one	5b7d620e-2238-5ec9-888a-6999218b6974	water/unspecified	kg		CAS	1,3-dioxolan-2-on	888f2557-42ee-4fb5-	emission/water/unspecified	kg
16	1,4-butanediol	d21da01e-f96f-4db5-9746-7b70db8a1f2c	air/low population density, long-term	kg		NO_FLOW_MATCH_MANUAL				
17	1,4-butanediol	90653a29-2f53-4b1b-88bd-9ae2fe64a8d6	air/lower stratosphere + upper troposphere	kg		NO_FLOW_MATCH_MANUAL				
18	1,4-butanediol	83bafcf1-2f2e-4a32-89a0-f1f16ca10626	air/non-urban air or from high stacks	kg		NO_FLOW_MATCH_MANUAL				
19	1,4-butanediol	09db39be-d9a6-4fc3-8d25-1f80b23e9131	air/unspecified	kg		NO_FLOW_MATCH_MANUAL				
20	1,4-butanediol	38a622c6-f086-4763-a952-7c6b3b1c42ba	air/urban air close to ground	kg		NO_FLOW_MATCH_MANUAL				
21	1,4-butanediol	c5de5e4d-85cf-4102-9ff1-5248d8928ba1	water/ground-	kg		NO_FLOW_MATCH_MANUAL				
22	1,4-butanediol	564dde7f-e713-4baf-84aa-7a11ffa7e2cd	water/ground-, long-term	kg		NO_FLOW_MATCH_MANUAL				
23	1,4-butanediol	aae8aac7-b81d-41e4-b356-912b369d1c55	water/ocean	kg		NO_FLOW_MATCH_MANUAL				
24	1,4-butanediol	d6911d36-3fec-41fe-8ef9-540f6543a240	water/surface water	kg		NO_FLOW_MATCH_MANUAL				
25	1,4-butanediol	d835b7aa-288b-4b3a-966b-3f64f36ed220	water/unspecified	kg		NO_FLOW_MATCH_MANUAL				
26	1-pentanol	9dd01d5b-3677-4822-9cd4-36d21b0e23d1	air/low population density, long-term	kg		CAS	pentan-1-ol	476a81ff-60ca-44bf-	emission/air/unspecified long term	kg
27	1-pentanol	b78e77cb-7636-4420-855e-17239984f8b3	air/lower stratosphere + upper troposphere	kg		CAS	pentan-1-ol	fb1af5bd-4ee5-402b	emission/air/lower stratosphere and upper	kg
28	1-pentanol	cc9a442f-c96a-4bdc-990d-8b58f72b4e07	air/non-urban air or from high stacks	kg		CAS	pentan-1-ol	9578fb76-9c00-44ff-	emission/air/non urban or from high stack	kg
29	1-pentanol	048baf1e-6cdc-44a5-92e2-32d15ff54885	air/unspecified	kg		CAS	pentan-1-ol	11851a5e-7169-4d44	emission/air/unspecified	kg
30	1-pentanol	541a823c-0aad-4dc4-9123-d4af4647d942	air/urban air close to ground	kg		CAS	pentan-1-ol	9758dad7-53a4-4b38	emission/air/urban/close to ground	kg
31	1-pentanol	5074e239-b510-49aa-928c-fcdb462481d8	water/ground-	kg		CAS	pentan-1-ol	09183939-8fb4-4c8a-	emission/water/fresh water	kg
32	1-pentanol	cfa50eaf-a817-4352-b9fe-aa834240d269	water/ground-, long-term	kg		CAS	pentan-1-ol	061a2617-bece-4ace	emission/water/unspecified long term	kg
33	1-pentanol	8d28a5b3-1b1c-41e9-9eba-90c607aad7db	water/ocean	kg		CAS	pentan-1-ol	dc58fab4-3357-496d	emission/water/sea water	kg
34	1-pentanol	e4526360-b2a1-4e77-9f00-57dbfe228bde	water/surface water	kg		-CAS	pentan-1-ol	09183939-8fb4-4c8a-	emission/water/fresh water	kg
35	1-pentanol	070dc6b3-0976-45a0-803e-0a87d7e96959	water/unspecified	kg		CAS	pentan-1-ol	ac56e764-b13b-4dcd	emission/water/unspecified	kg
36	1-pentene	47a8dfb8-f1e5-4460-b7ca-eeea1ca44596	air/low population density, long-term	kg		CAS	1-pentene	fe0acd60-3ddc-11dd	emission/air/unspecified long term	kg
37	1-pentene	87eed31b-5a6b-43ae-9a02-778a8c6e4ff8	air/lower stratosphere + upper troposphere	kg		CAS	1-pentene	f214d52f-6555-11dd	emission/air/lower stratosphere and upper	kg

Mapped lists