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Environmental Life-Cycle Inventories of Energy Systems

An Environmental Database for the Accounting of Energy Inputs in Product Life-Cycle Assessment and the Comparative Assessment of Energy Systems

English Guide to the German Report

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Contents

Glossary

Actinides	elements in the bottom row of the periodical table heavier than Actinium (*i.e.* Ac – Lw). These comprise four naturally occurring elements: Actinium (Ac), Thorium (Th), Protactinium (Pa), Uranium (U).
Allocation	the splitting of the fluxes for a multi-output process step. This is done according to an allocation criteria based on a common feature of the outputs (e.g. heating value, mass, moles).
AOX	adsorbable halogenated organic compounds
B	category of weakly and medium radioactive wastes
BaP	Benzo[*a*]pyrene
BOD5	biological oxygen demand within 5 days
BTEX	benzene, toluene, ethyl benzene and xylene aromatics
BWR	boiling water reactor (nuclear). Ger. SWR *«Siedewasserreaktor»*
C	category of highly radioactive and long living wastes
CFC	chlorofluorocarbons. Ger. FCKW *«Fluorchlorkohlenwasserstoffe»*
CH	Switzerland (*confoederatio helvetica*)
COD	chemical oxygen demand
Cumulated flux	total flux of a specified material, energy or service needed or delivered *up to* a certain step in a process chain (including the direct flux in the step itself). All the secondary, tertiary, etc. fluxes of preceding steps in the process chain («upstream processes») are added up. E.g. all steel requested in the precombustion of coal, in the caused transport and disposal services, and the manufacturing of an oven. Sometimes also referred to as result or output data since it is the result of the interconnecting calculation of the direct/input data.
Direct flux	the materials, energies or services needed or delivered *directly* in a certain step in a process chain, e.g. steel needed to build a oven requested in a partial process step accounting for a heating service.
DOC	dissolved organic carbon
Downstream	direction in the process chain towards the end user of an e.g. energy service. In the data structure of this inventory the «classic» downstream processes like waste disposal processes are formulated as services. These downstream processes will be linked up (or requested) at specific points in the process chain. That way they receive an upstream direction considering the logic of data management. From the logic of the process chain they are still placed downstream, however (cf. with the nuclear process chain figure in Annex C). Generally the «downstream» placed dismantling of plants will be inventoried in the same module as the construction. Sometimes the term refers to fluxes into the environment («downstream to the environment»).
EcoInvent	the relational database software used to handle input data and calculate cumulated output data therefrom.
EG	electronical grade silicon

El	suffix to German name for fuel oil meaning «extra leicht» (= extra light), signifying a very low sulphur content (*i.e.* ≤0.20 %-weight).
Euro	Europe
EVA	ethyl vinyl acetate plastic (in photovoltaic panels)
Final module	these «process units» represent either the final emission of a substance into the environment or the resources taken from the environment. Final modules are placed at the beginning (*i.e.* upstream end) or the end (*i.e.* downstream end) of a process chain.
FK	flat solar thermal collector. Ger. *«Flachkollektor»*
Flux	descriptor for all kinds of materials, energies or services needed (input flux) or delivered/emitted (output flux) by a process or system. All entries in the data modules are fluxes.
HDPE	high density polyethylene
HFC	fluorocarbons. Ger. FKW *«Fluorkohlenwasserstoffe»*
KKW	nuclear power plant. The reported Swiss plants are: KKL: Leibstadt, KKG: Gösgen.
LDPE	Low density polyethylene
LNG	liquefied natural gas
m-Si	monocristalline silicon
MFD	multiple family dwelling. Ger. MFH *«Mehrfamilienhaus»*
MG	metallurgical grade silicon
Module	corresponds to a process unit; also called data vector. A set of data accounting for the output specified in the name of the module, which generally constitutes a step in a process chain. The data can either represent the *direct* fluxes occurring only within that step (input data), or represent the *cumulated* fluxes for the whole process chain *up to* (and including) the specified step (result data). All fluxes are given per output unit of the module.
MTBE	methyl *tert*-butyl ether
NMVOC	non-methane volatile organic compound
output unit	the physical quantity the fluxes in a module are specified to (*i.e.* flux *per* unit). All modules are distinguished by their name and their output unit.
p-Si	polycrystalline silicon
PAH	polyaromatic hydrocarbons
PET	polyethylene terphtalate
PP	polypropylene
Precombustion	all processes taking place prior to and excluding the combustion - or more general energetic use - of an energy carrier. E.g. the emissions in the precombustion of coal (transports, processing, etc.) in distinction to the direct emissions in the actual burning of that coal.
PS	polystyrene
PV	photovoltaic
PWR	nuclear plant with pressurised water reactor. Ger. DWR *«Druckwasserreaktor»*

REA	flue gas desulphurization. Ger. *«Rauchgasentschwefelungsanlage»*
S	suffix to German name for residual oil meaning *«schwer»* (= heavy), signifying a relatively high sulphur content (<1.0 %-weight).
SAW	sound-absorbing wall by the side of a highway. In the photovoltaic process chain. Ger. SSW *«Schallschutzwand»*
SCR	selective catalytic reduction (of nitrogen oxides)
SFD	single family dwelling. Ger. EFH *«Einfamilienhaus»*
SPF	*«Solare Prüf- und Forschungsstelle am interkantonaien Technikum Rapperswil»*; Solar Testing and Research agency Rapperswil, SG, Switzerland
Standard modules	process units for common materials and services, that are used consistently in all parts of the report and described in the annexes.
TCDD	tetrachloride-dibenzo-dioxin
TJ	terajoule, 10^{12} Joule
UCPTE	*«Union pour la coordination de la production et du transport de l'électricité»* The European electricity network with 12 contributing countries.
VOC	volatile organic carbon compounds
VTC	solar thermal vacuum tube collector

1. Introduction

This is the English guide to the German report *«Ökoinventare für Energiesysteme»* (Environmental Life-Cycle Inventories for Energy Systems) <Frischknecht et al. 1994>. Its aim is to make the German report and the data therein available to a reader of English language, who wishes to use the data for environmental accounting. It does *not* represent a summary of the results. Some parts of the guide and the summary (systems description, methodology) are similar, however. Readers interested in the results and their discussion in English are requested to refer to the English Summary available under catalogue number 30–175 from:

ENET
Administration und Vertrieb
Postbox 142
CH- 3000 Bern 6
Switzerland

Fax No. ++41 31 / 352 77 56

The German report with a volume of ca. 2000 pages can be ordered under catalogue number 30–164.

2. Structure of the German Report

Part I of the German report contains the executive summary, part II the description of the aims of the project and of the structure of the report, part III the description of system boundaries and methodology.

Each energy system is described in a separate chapter (parts IV to XII), with its own introductory section, results section, annexes and list of references. These are:

IV:	oil, thermal and electric	VII:	nuclear, electric	X:	small scale geothermal plant
V:	natural gas, thermal and electric	VIII:	hydro, electric	XI:	solar, thermal
VI:	coal, thermal and electric	IX:	wood, thermal	XII:	solar, photovoltaic

In each part results are presented and discussed for the respective energy system. In part XIII follows a comparative analysis and discussion for all energy systems. In particular, the average electricity generation mix according to Swiss or UCPTE-European situation is calculated. Part XIV contains a short review and outlook.

The annexes contain standard data modules which are used by all energy systems throughout the report. These are:

A:	materials	D:	heat pump
B:	transport and construction services	E:	district heating
C:	electricity distribution	F:	disposal (downstream) processes

Annex G contains a description of the data bank software («EcoInvent») used to compute the results.

3. Structure of this guide

The chapters and some paragraphs *begin* with a source reference of the location in the German report in reference brackets e.g. <see III.8.4.1, p.13>. Roman numbers (I, II, III..., XIV) refer to one of the 14 parts, followed by the chapter number. For quick reference the page number in that part is indicated additionally. Capital letters (A–G) refer to one of the seven appendices e.g. <see F.3, p.23>.

Most tables originate from the German report. They are therefore numbered like in the German source and not necessarily in strictly ascending order.

The quote of references is the same as in the German report and will therefore not be repeated. The references are to be found in the corresponding part of the German report.

4. What is Where?

There are basically two locations to look up inventory data. The parts IV–XII of the German report contain a detailed description of the assessed energy systems. The evaluated energy and material fluxes are explained and displayed in several tables. At the end of each part the results of the energy system are included.

On the data diskettes are files with the input data and the complete result data for the various process modules of the process chain.

4.1. Partial Process Steps

The inventoried energy process chains and their partial steps are extensively described in the parts IV–XIII of the German report. The data diskettes only contain the input and the result data of the partial steps (direct and cumulated fluxes, please refer to the glossary). The process chain of all energy systems and the interconnections of modules within a particular energy system is shown in Appendix B of this report.

On the diskettes, the inventoried energy carriers are placed at the beginning of the data files (data modules No. 1–25). Other steps of the energy process chain are given in the respective category of that system (data modules No. 115–491). Please refer to Chapter 9 and Annex C.2 for a more detailed description.

4.2. Emission Factors

The material and energy fluxes occuring directly in a particular step of the process chain are usually listed at the end of each sub-chapter. For clarification the table below gives the titles and numbers of the chapters/annexes containing direct fluxes in column 2. Unfortunately some authors called direct *and* cumulated data results since the direct fluxes are the result of the analysis of a process step. Usually «result» signifies the output data from the interconnecting calculation of the direct/input data (please refer to the glossary).

On the data diskettes the emission factors per terajoule of an energy converting plant can be found in the *direct* flux entries (=input data) of the corresponding process module «[Fuel] in [plant]» with the output unit TJ. The files containing input data are explained in Annex C.2 «Structure of data files». Likewise the specific emission factors of other processes can be found in the input data entries of the corresponding process module. All input data are specified to the output unit of the module.

The above mentioned process module «[Fuel] in [plant]» accounts for the fluxes related to *end energy* consumption. If the delivered *useful energy* is of interest the next downstream module «[Heat/Electricity] from [plant]» should be considered.

4.3. Cumulated Results

For an explanation of cumulated results please refer to the Glossary entry «cumulated flux».

All parts of the German report contain the full listings of the output/result data (cumulated results) in the corresponding Annex of that part. Additionally summarised results and their discussion are presented within the main text body. Summarised results are assemblies from the cumulated results. The clustering systematics of summarised results are explained in Chapter 7.1 of this Guide. The table below gives titels and numbers of chapters or annexes containing summarised results or cumulated results, respectively.

On the data diskettes the *cumulated* results of a certain process are contained in the corresponding *result* data module of that process. The files containing result data are explained in Annex C.2 «Structure of data files».

Part	Chapters/Annexes containing *Input Data*	Chapters containing *Summarised Results*	Annexes containing *Cumulated Results*
IV Oil	Zusammenstellung der Eingabedaten (6.10, 7.11, 8.11, 9.11, 10.10, 11.8, 12.9)	Verknüpfung der Prozesse (14)	"Verknüpfung der Prozesse" (Annex 14.A1)
V Natural Gas	Resultatübersicht (6.4, 7.8, 8.6, 9.6, 10.8, 11.6, 12.8, 13.3.1, 15.2.5, 15.3.4, 15.4)	Verknüpfung für Stufe… (13.3.2, 13.4)	Ausdrücke der Resultate… (Annex 15.5)
VI Coal	Resultatübersicht, Zusammenstellung der Resultate/Ergebnisse (6.6, 7.8, 8.7, 9.10, 10.6)	Resultate… (11.2, 11.3)	Resultate… (Annex VI.11)
VII Nuclear	Resultatübersicht, Übersicht über die Eingabedaten (4.11, 5.10, 6.8, 7.8, 8.9, 9.7, 10.8, 11.6, 12.9	Resultate (13)	Resultatentabelle (Annex 8)
VIII Hydro	Eingabedaten (Table A.VIII.2.1 in Annex 2) according to Zusammenstellung der Kennziffern (3.4, 4.4)	Resultate (7)	Resultate (Annex 2)
IX Wood	Resultate (6.4, 7.4, 8.5, 9.4, 10.5, 11.4, 12.5, 13.5, 14.1.4, 14.2.2, 14.3.2)	Verknüpfung der Prozessschritte (15)	Anhang (Annex, p.62ff)
X Geothermy	Zusammenstellung der Eingabedaten (4.2.1, 5)	Resultate (7)	Anhang:Resultatstabelle (Annex)
XI Solar Thermal	Module für den Sonnenkollektor (Annex 2), Module für die Standardanlagenteile (Annex 3), Wärme hybrid/solar von Sonnenkollektoranlage (Annex 4)	Auswertung der Resultate (8)	Vollständige Resultattabellen (Annex 6)
XII Photovoltaic	Zusammenfassung und berücksichtigte Flüsse (4.3.6, 4.4.6, 4.5.1.6, 4.5.2.6, 4.5.3.6, 4.6.1.8, 4.6.2.7, 4.6.3.4, Annex A1, A2, A3, A4)	Resultate (10)	Ausdrücke der Resultate… (Annex C)

Tab. Guide1: Listing of the German titels and numbers of the chapters in the German report containing input data (emission factors), summarised and cumulated results.

5. Methodology

<see part III>

5.1. Method Type

<see III.1, p1>

In the report different energy systems are analysed using the *life cycle analysis (LCA).* A life cycle analysis consists of four parts (goal definition, inventorisation, impact analysis, and valuation). The Report comprises only the first two parts. The inventoried energy systems are splitted up into accurate parts. The parts are linked together to constitute the process chain of the analysed system. Each part is analysed for its direct fluxes. All parts are then linked up with their preceding («upstream») parts in a relational data bank (program «EcoInvent») to calculate the cumulated fluxes.

Results from Input-Output-Analysis are not used.

5.2. System Boundaries

<see III.2, p.2>

In the analysis of energy systems it is very important to indicate how system boundaries are defined. There are structural, spatial and temporal boundaries.

Temporal: The report covers the whole life-cycle of the energy systems («cradle-to-grave» analysis).

Spatial: All energy or material fluxes of the whole life cycle are accounted for, regardless of geographic or political boundaries, up to the stage of the taking of resources from the environment or down to the final point of emission into the environment.

Structural: An energy system consists of all the parts that are necessary to deliver a certain energy service (heat, electricity). This includes the construction, use, dismantling and disposal of the delivering plant (heater, oven, power plant) and all the services and materials used in the pre-combustion. All disposal and downstream processes, that are caused that way are also included. If necessary the distribution of end energy to the final user is accounted for, too (e.g. electricity).

The assessment of the energy chains is done for the situation of the average Swiss or UCPTE *final use* in the early nineties The environmental inventories contain data for average existing energy plants (1990 was used as reference year). The report does not indicate average regional emission levels for heating systems. These levels could be used to calculate country inventories. However, some localised information is contained in the power plant mixture for average UCPTE power generation.

As a rule, for all process steps in an energy chain all fluxes (energy and material inputs and outputs, transportation, disposal and other services) are considered. For the energy inputs, results from this report were used, leading to iterative loops between the systems (e.g. mining and refining of coal also has an input of electricity from coal). This leads to a consistent treatment of all energy inputs in the study. For electricity inputs results for the average UCPTE electricity generation were used throughout the report (even if they take place outside Europe, e.g. in Japan). Accounted services and materials are calculated for the European situation only, though.

An important aim of the study is to report not only concentrated emissions from plants but diffuse emissions along the process chain to give an accurate representation of the total environmental fluxes.

Chapter in the German report	Co-Products	What is allocated?	Allocation criteria
Part IV. Oil			
6.6.2	oil/ commercialised oil gas	emissions in test drilling	lower heating value
7.8.1–7.8.5	oil/ commercialised oil gas	losses in flare and other	lower heating value
8.7	oil and oil products/other goods	land use and energy consumption of harbours	weight
8.10.4	inland tanker/inland freighter	canal construction energies	transport operation (tkm)
9.4–9.10	refinery gas/ propane/ butane/ naphtha/ leaded petrol/ unleaded petrol/ kerosene/ diesel/ fuel oil/ refinery fuel oil/ residual oil/ bitumen	material, construction, and energy efforts[1]), operation materials[1]), process emissions in air and water[1]), wastes[1]), land use	weight
11.2	boilers of different power	construction efforts, packaging and wastes	according to factory practice
12.	electricity/ heat	flux of energies and materials in power plants	no criteria, all on electricity [2])
Part V. Natural Gas			
7.	natural gas/ natural gas liquids	all efforts and emissions in gas processing	lower heating value
12.	electricity/ heat	flux of energies and materials in power plants	Exergy
Part VI. Coal			
6.	coal/ used mine gas	material and energy fluxes in mining	no criteria, all on coal for coal mining
6.	coal/ used mine gas	discharge of mine gas	lower heating value or weight
7.3	coal coke/ coke-oven gas/ tar/ benzene	material and energy fluxes in coking plant	lower heating value, weight and profits (normalised for coal coke, 80%)
Part VII. Nuclear Energy			
7.	enriched uranium/ hydrofluoric acid	material and energy fluxes in enrichment	no criteria, all on enriched uranium
10.	uranium/ plutonium/ conditioned wastes	material and energy fluxes in fuel reprocessing	no criteria, all on conditioned wastes
11.	wastes from nuclear plants/ medicine/ research	material and energy fluxes in interim storage	volume
Part VIII. Hydro Power	hydro power/ flood protection	material and energy fluxes for dams and galleries	no criteria, all on hydro power
Part IX. Wood Energy			
7. & 8.	functions of forest: resource/ protection/ recreation	material and energy fluxes for forestry	no criteria, all on resource function [3])
Part XII. Photovoltaic Energy			
5.7	façade protection/ power generation	material and energy fluxes of 3kW façade PV-plant	price
Annex B			
1.–3.	transport of goods/ people	infrastructure for streets and railways	gross tonnage kilometres

Tab.III.3.1: Allocation criteria within the main energy processes, [1]): for partial process steps, [2]): the share of produced heat is negligible for the UCPTE system, [3]): as a sensitivity parameter

5.3. Allocation, Credits

<see III.3, p.4>

At different points in the study multi-output processes are analysed. In this case it was necessary to define criteria to allocate environmental burdens to the different products (e.g. cogeneration of heat and electricity, combined production of oil and gas at offshore platforms etc.). «Credits» based on some reference system are not used. Instead, always explicit allocation criteria based on the physical properties of the outgoing products were used. In most cases a criteria based on the heating value of the outputs was used. But also criteria based on mass, weight, and exergy were used. The allocation criteria used in different energy systems are listed in table III.3.1.

Also no additional credits are given to a system producing recycling materials. Gathering, refining and transportation of the recycling materials are allocated to the receiving system. The producing system has the advantage of not being burdened with additional waste.

5.4. Accidents

<see III.5, p.9>

Rare accidents are not considered in the report. The aim of the data bank is to analyse the average process chain of the energy system. Rare accident can have undeniably notable environmental consequences but they are better assessed with risk analysis tools. Nevertheless more common accidents, that occur often in standard operation are taken into consideration. The possibility of an accident per unit of delivered energy is used as the criteria to draw a distinction between «often» and «rare». In the report accidents with an occurrence of $\geq$ **$1 \cdot 10^{-3}$ accidents per GWy** were inventoried. Therefore, the consequences form big oil spills or nuclear accidents are not accounted for, but no judgement about the harmlessness of these accidents is intended hereby.

5.5. Environmental Interventions

<see III.8, p.15> The report covers a very broad spectrum of resources and air and water pollutants (more than 200). Also non-energetic resources, land depreciation and waste heat are reported. Organic compounds, trace elements and radioactive element emissions are indicated with a high level of detail.

5.5.1. Resources

<see III.8.1, p.15> These interventions represent the first input from the environment into a energy system. They are therefore the first data modules in the process chain analysis and are not linked up with further upstream processes. For that fact they are also referred to as «final modules». All resource interventions are clustered into two categories: non-energetic resources, energetic resources.

5.5.1.1. Non-Energetic Resources

<see III.8.1.1, p.15> Non-energetic resources are mostly materials like metals, ores, water and rocks. The unit is kilograms [kg] throughout, except for turbine water, where it is [m^3] (water used for hydroelectric generation is denoted here as turbine water to distinguish it from process water uses).

<see III.8.2, p.17> Land use is regarded in four types based on the classification system by IUCN/UNEP/WWF. Land use is defined as a measure of deterioration of ecosystem conditions and is calculated as follows:

land $use_{class\ a\text{->}class\ b} = area_{class\ a\text{->}class\ b} \times$ duration of construction, operation, dismantling $[m^2 \times yrs]$

Land of type I (natural systems) is no more available in the considerd systems. Therefore, land use is inventoried according to three classes: II->III, II->IV, and III->IV. Only few indications of land use in already built systems (IV->IV) are given (oil tanks and coal stocks). For mounted 3kWp photovoltaic systems, the photovoltaic SAW plant and mounted solar thermal plants the panel/collector area is reported as land use (IV->IV) purely for accounting reasons. This should not be considered as an environmental intervention, however.

Type	Criteria	Category
Natural Systems	Human impact is smaller than that of any other native species since the industrial revolution	I
Modified Systems	Human impact is greater than that of any other species, but the structural components of the ecosystem are not cultivated (e.g. self sustaining forests)	II
Cultivated Systems	Human impact is greater than that of any other species, and most of the structural components are cultivated (e.g. farmland, plantations)	III
Built Systems	Dominated by buildings, roads, railways, airports, mines etc.	IV

Tab. III.8.2: Applied classification of ecosystem conditions.

<see III.8.2.3, p.19> The land use for recultivation *i.e.* IV->III->II->I is also taken into account and expressed in the analogous land use categories. Average recultivation time spans were defined and used as standard in all systems (see table III.8.3).

Recultivation type	**Accounted for as...**	**Recultivation time**
Cat. IV to Cat. III	land use III->IV	5 y
Cat. III to Cat. II	land use II->III	50 y
Cat. III to Cat. I	land use II->I	100 000 y

Tab. III.8.3: Defined standard recultivation time spans used in all energy systems.

The use of natural air is not considered. But pure gases made from natural air (oxygen, nitrogen, argon) are within the list of standard material modules.

5.5.1.2. Energy Resources

<see III.8.1.2, p.15> The considered energy resources are shown in Tab. III.8.1. The inventoried data represents the actually hauled material from the sites. Material remaining in the Earth's crust is not accounted for.

Energy resource		lower heating value	upper heating value
	unit	MJ/unit	MJ/unit
gas from combined oil and gas fields	m^3	40.9	45
natural gas	m^3	35	39
mine gas (from coal mines)	kg	35.9	39.8
crude oil	t	42'600	45'600
lignite (in its natural state) *	kg	8	9.5
hard coal (in its natural state) *	kg	18	19
uranium (contained in uranium hexafluoride)	kg	–	900'000
potential energy of water [1)]	TJ	1'000'000	1'000'000
wood in forests (dry matter)	t	18'500	20'300

Tab. III.8.1: Inventoried energy resources and their lower and upper heating values. *: for average fuel in UCPTE-plants. [1)] The converted water *volume* is indicated by the non-energetic resource «turbine water».

5.5.2. Emissions

5.5.2.1. General

<see III.8, p.15> These interventions represent the last output from a energy system into the environment. They are therefore the last data modules in the process chain analysis and are not linked up with further downstream processes. For that fact they are - like resources - referred to as *final modules*. Emissions are grouped in three categories: atmospheric emissions, emissions in water and emissions in soil.

A large number of substances were considered. The standard unit is kilograms [kg]. Waste heat is reported in terajoule units [TJ]. The activity of radioactive elements is reported in kBq (=1000 decays per second).

Most emissions are split up and labelled into up to three sub-categories according to their origin:

- *label «m»:* the emission is from a *mobile* combustion source (*i.e.* relevant in transport).
- *label «s»:* the emission is from a *stationary* combustion source (*i.e.* relevant in energy plants).
- *label «p»:* the emission is from a manufacturing *processes* different from combustion.

Emissions of type m are often diffuse emissions. Type s and p are mostly concentrated emissions from smoke-stacks or plant sites.

All emissions are only accounted for once. Summarising entries contain only emissions that could not be associated with more detailed existing entries, e.g. ethyl benzene emissions are reported in the according entry and are not repeated in «various hydrocarbons» neither in «various aromatics». But, e.g., formic acid for which no separate entry exists, will be reported under «various acids».

<see I.3, p.2> Environmental interventions that could not be quantified because they occur in the distant future, were assessed with scenarios or were excluded (e.g. final disposal of industrial wastes and radioactive wastes). This should be held in mind while discussing the results.

The following environmental interventions were *not* considered in the study:

- electric and magnetic fields
- visible and infrared radiation
- noise, mechanical shock and vibration
- impacts on landscape and aesthetic values (partly included in the land-use categories)
- impacts on soil mechanics (partly included in the land-use categories) and changes in the regional hydrologic situation (some information was given for hydroelectric generation systems)
- use of soil volumes for landfills (considered via the land-use for landfills).
- emissions of waste heat from deep layers through mining or drilling processes
- the input of air to the system, and the output of the corresponding oxygen and nitrogen. Also steam emissions were not reported.

5.5.2.2. Nitrogen and Sulphur Oxides

<see III.8.5, p.21> NO_x emissions include NO and NO_2 and are reported as NO_2 equivalents. SO_x emissions include SO_2 and other oxides such as SO_3 and SO_4^{2-} , and are reported as SO_2 equivalents. If a splitting of these aggregated data into single chemical species is necessary the table III.8.4 gives an estimate of the fractions.

Fuel type	NO_2 fraction [weight-%]			SO_4^{2-} fraction [weight-%]		
	power plants	industrial	domestic	power plants	industrial	domestic
solid fuels	4	2	2	1	2	2
low sulphur fuel oil (EL)	2	1.5	no ref.	3	5	no ref.
other liquid fuels	10	4	5	3	3.5	3.5
fuel gases	1.5	3	30	–	–	–

Tab.III.8.4: Fractions of NO_2 in NO_x and SO_4^{2-} in SO_x in flue gases.

5.5.2.3. Polycyclic Aromatic Hydrocarbons (PAH)

<see III.8.7.2, p.25> Only benzo[*a*]pyrene (BaP) was explicitly expressed in a separate entry. Other PAHs are contained in the summarising category *«PAH various»*.

5.5.2.4. Dibenzodioxines, Dibenzofuranes

<see III.8.7.3, p.25> For chlorinated dibenzodioxines (PCDD) and dibenzofuranes (PCDF) a large number of substances were aggregated according to the methodology by NATO/CCMS. A toxicity equivalent (TE) is calculated for all species. The TEs are expressed in equivalents of 2,3,7,8-tetrachloride-dibenzodioxine (TCDD-equiv. in kg). The used TCDD-equivalents for all dioxines and furanes are shown in table III.8.7 in the German report.

5.5.2.5. Volatile Organic Compounds

<see III.8.7.1, p.23> A cumulative category for all volatile organic compounds (VOC) is not used. As a minimum requirement, methane is always reported separately from the remaining organic compounds (NMVOC). The clustering of reported hydrocarbons is represented in table III.8.6.

methane				
NMVOC (Non-methane hydrocarbons)	non halogenated hydrocarbons	alkanes	aliphatic	ethane
				propane
				butane
				pentane
				hexane
				heptane
			alicyclic	(cycloalkanes)
		alkenes		ethene
				propene
		alkines		ethine (acetylene)
		aromatics	monoaromatic	benzene
				ethyl benzene
				aromatic amines
				phenol
				toluene
				xylene
			polyaromatic	BaP
		aldehydes		acetaldehyde
				benzaldehyde
				formaldehyde
				glutaraldehyde
				propionaldehyde
		alcohols		methanol
				ethanol
		ketones		acetone
		ethers		MTBE
		organic acids		acetic acid
				propionic acid
		Amines	Diamines	
	halogenated hydrocarbons	halones		H 1301
		CFC		R11, R12, R113
		HFC		R134a
		halogenated aromatics		chlorobenzene
				hexachlorobenzene
				pentachlorophenol
		dioxins and furanes		TCDD-equiv.
		chlorinated hydrocarbons		methyl chloride
				ethyl chloride
				vinyl chloride
				tetrachloroethylene
				trichloroethylene
	AOX			
hydrocarbons various				
TOC				
fats and oils				

Tab.III.8.6: The volatile organic compound (VOC) categories used in the study.

5.5.2.6. Particles

<see III.8.8, p.26> Soot, dust and particle emissions (of all sizes) are all comprised in the emission category «particles».

5.5.2.7. Waste Heat

<see III.8.1.3, p.16>

Waste heat from renewable energy systems originally stems from the sun and is not an additional waste heat source. To avoid double counts a *negative* emission of waste heat has to be taken into account in the «production» of renewable final energy. The amount of negative waste heat corresponds to the energy content in the delivered final energy. When this energy is used it is most likely transformed into waste heat. This sums up to zero additional waste heat through these systems, which is a correct representation of the situation. The generation of domestic heat from geothermal sources is considered to contribute additional, positive waste heat from radioactive decays in the ground.

The waste heat from heating systems is accounted completely in the production step. Therefore the final user has not to be burdened with waste heat a second time. The waste heat from electricity use is accounted in the consuming not in the producing process.

5.5.2.8. Radioactive Radiation

<see III.8.4, p.20>

The radiative activity of various radioactive elements is inventoried in kilobequerel [kBq]. One kilobequerel represents 1000 decays per second. Emissions of radioactive species in mining processes (e.g. radon) and in the nuclear energy fuel cycle are reported. The reported radiation comprises α, β, and γ-type of radiation. Apart from γ-radiation, no other types of electromagnetic radiation like infrared, microwave, ultraviolet etc. radiation were inventoried in the report. However, no judgement about their harmlessness is implied hereby.

5.6. Standard modules: Materials, Transports, Services

A set of standard material, transport and disposal data modules were described. These so-called standard modules are used by all energy systems throughout the report. Because they often represent secondary inputs to the energy systems, a more approximate approach was used in describing the standard modules than in the rest of the report. The level of detail and accuracy of the standard modules corresponds to the needs of energy systems analysis and should not be used else wise.

Standard materials are described in Appendix A of the German report. A major effort was made to achieve good data quality for materials that are used in large quantities in energy systems (concrete, steel, aluminium). Special attention was also paid to materials used in small quantities but with high toxic emissions during production, use or disposal (e.g. platinum).

<see III.9, p.27> To avoid arbitrariness a set of standard transportation distances for the most important materials and their densities was used for all energy systems (see table III.9.1)

Road (trucks of different sizes, cars), rail (average rail transportation for Western European conditions), river (barges) and sea (ships and tankers) transportation systems are described in the report. The degree of utilization in road and rail transportation is set at an average of 50%. Also construction efforts and materials for road and rail infrastructure are included in the analysis.

Also a set of standard disposal systems was defined, covering landfills, contained repositories, industrial and communal incinerators. Disposal services are described in Appendix F of the German report.

	Density	Transportation distance for final use in Europe (km)		Transportation distance for final use in Switzerland (km)	
	kg/m^3	Rail	Road (28t)	Rail	Road (28t)
Steel	7900	200	100	600	50
Gravel, sand	2000		20		20
Cement	3150	100	50	100	20
Concrete	2200		20		20
Glass (panes)	2500	600	100	600	50
Copper	8900	200	100	600	50
Aluminium	2700	200	100	200	50
Plastics	*)	200	100	200	50

Tab.III.9.1: Densities and standard distances for transportation of materials between the production site and the final use in energy systems. *) PVC: 1400, PE: 950, PP: 900

6. Description of the Inventoried Energy Systems

6.1. Oil

<see part IV>

The various steps in the production and use of crude oil and oil products were assessed: exploration, production, transportation, refinement, regional distribution, final use. Different refinery oil products and energy systems for average Swiss (CH) and European conditions were inventoried. A sensitivity analysis of the energy use in refineries was carried our to demonstrate the influence within the fuel oil cycle (fuel oil 2000)

Oil products for energy use, from petrol stations or tanks, for average Swiss and European conditions:	• petrol leaded, CH/Euro • petrol unleaded CH/Euro • kerosene CH/Euro • diesel CH/Euro • fuel oil CH/Euro • fuel oil 2000 CH • residual oil CH/Euro •
Oil products for non-energy use, from refineries, for average Swiss and European conditions:	• naphtha, Euro • bitumen, CH/Euro • refinery fuel oil, Euro • refinery gas, CH/Euro
Heat from oil in residential and industrial boilers:	• 10kW system, CH • 100kW system, CH • 1000kW system, CH
Heat from fuel oil in industrial boilers, for average Swiss and European conditions:	• 1 MW system Euro • 5 MW system CH
Electricity from fuel oil in oil power plants:	• average Swiss plant • average UCPTE-European plant

6.2. Natural Gas

<see part V>

Typical natural gas systems for average Swiss and European end use are analysed. According to the origin of the natural gas different supply chains are described: gas from Germany, from the Netherlands, from Norway, from the Russian Federation, and from Algeria. Pipeline transport and regional distribution to the end user is reported. The high pressure distribution (HD grid) is inventoried for Switzerland and average Europe. The low pressure distribution (ND grid) is inventoried for Switzerland only.

Different energy services were inventoried:

Natural gas grid:
- high pressure distribution, CH and Euro
- high pressure distribution, CH

Heat from <100kW boilers:
- condensing
- atmospheric burner
- atmospheric burner, low-NOx
- blast burner
- blast burner, low-NOx

Heat from >100kW industrial furnaces:
- for Europe
- Low-NOx, Europe

Electricity from UCPTE power plant:
- European average

For the calculation of the average UCPTE electricity generation, a share of 8% coke gas and 8% blast-furnace gas was considered apart from 84% natural gas.

6.3. Coal

<see part VI>

The process chains for lignite and hard coal are inventoried. The opencast and underground mining of hard coal is described. As energy carriers raw lignite, lignite dust, lignite and hard coal briquets, coke, imported and European hard coals are described. On the level of final use, heat from a residential stove-heater using lignite briquets, coke, or anthracite (a special coal quality) are reported. Also industrial boilers in the range 1-10MW are described. Electricity generation with lignite is described for power plants Austria (A), Spain (E), ex-Yugoslavia (Ex-Yu), France (F), Greece (Gr), Italy (I) and Western Germany (W-D). Hard coal power plants are described for Austria, Belgium (B), Spain, ex-Yugoslavia, France, Italy, the Netherlands (NL), Portugal (P) and Western Germany. The average UCPTE electricity generation mix from lignite and hard coal is calculated.

The following coal products and energy services were inventoried:

Lignite products:	• lignite dust • lignite briquets
Hard coal products:	• hard coal briquets • coke • European hard coal • imported hard coal
Electricity from lignite power plant:	• for A, E, ex-Yu, F, Gr, I, W-D
Electricity from hard coal power plant:	• for A, B, E, ex-Yu, F, I, NL, P, W-D
Heat from residential stove, 5-15kW:	• with lignite briquets • with hard coal briquets • with coke • with anthracite
Heat from industrial furnace, 1-10MW:	• with hard coal

6.4. Nuclear Energy

<see part VII>

Basically Swiss nuclear power plants were analysed. Boiling water reactors (BWR) and pressurised water reactors (PWR) in the 1000 MW category were considered. Data from the Leibstadt (BWR) and Gösgen reactors (PWR) was used, respectively. The data from the Swiss power plants was extrapolated to describe the average nuclear power generation in the UCPTE grid. Diffusion and centrifugal concentration technologies were described for three different degrees of uranium concentration. The opencast and underground mining of uranium is reported. In all plants a 100% reprocessing of the spent fuel elements is considered. The disposal of weakly and medium radioactive wastes (type B) and of highly active and long living wastes (type C) is inventoried.

Uranium in fuel elements:	• 3.5% enriched for PWRs • 3.25/3.4% enriched for BWRs
Electricity from BWR CH:	• Swiss plant Leibstadt, 990MW
Electricity from PWR CH:	• Swiss plant Gösgen, 940MW
Electricity from BWR UCPTE	
Electricity from PWR UCPTE	
Average nuclear electricity production:	• for Switzerland and UCPTE

6.5. Hydroelectric Energy

<see part VIII>

Several hydroelectric power plants that are typical for Switzerland and the alpine region are described. A distinction was made for reservoir plants, flow-through plants and pumping storage plants. An extrapolation was made to describe the respective process units for the European UCPTE situation. The average hydroelectric production for Switzerland and Europe is reported. The converted potential energy and the water mass are reported as resources modules.

Electricity from reservoir hydro power plant:	• for CH and UCPTE
Electricity from flow-through hydro power plant:	• for CH and UCPTE
Electricity from pumping storage hydro power plant:	• for CH and UCPTE
Average hydroelectric production:	• for CH and UCPTE

6.6. Wood

<see part IX>

The use of wood for heating purposes is reported. Naturally growing wood typical for the Alpine region was assumed. Logs of wood and wood chips from beech and spruce, are inventoried. Eight different boiler types in the range between 30 and 300 kW are reported.

The whole chain leading from the natural growth of the trees to the final use in the boiler, including transportation, cutting, disposal of ashes in communal incinerators etc. is covered. The fixation of carbon during the growth of the trees is considered in the calculation of CO_2 emissions. Wood chips that are produced as a by-product of saw-mills are not burdened with the fluxes in forestry. The standard modules *«paper»*, *«cardboard»*, *«wood construction material, board»*, and *«wood construction material, massive»* are connected with the wood chain. Char coal (module No. 405) was solely used in the photovoltaic process chain and is inventoried there.

Wood fuels:	• beech chips • spruce chips • saw-mill chips • 1m logs of wood • char coal (in photovoltaics)
Heat from 30kW boiler:	• with logs of wood
Heat from 50kW boiler:	• with beech chips • with spruce chips • with saw-mill chips
Heat from 100kW boiler:	• with logs of wood
Heat from 300kW boiler:	• with beech chips • with spruce chips • with saw-mill chips

6.7. Small Scale Geothermy

<see part X> One typical low-temperature system for small scale residential use in a single family dwelling was analysed. It consists of an earth probe of 150m depth, an electrical heat-pump ($10.25kW_{th}$) and a heat distribution system. The earth probe is assumed to be close to the house. The case of larger systems for housing estates with larger heat distribution systems was not considered.

The inventoried system consists of two process units: *«useful heat from geothermal probe»* and *«heat pump 10kW»*.

6.8. Solar Thermal Energy

<see part XI>

Five different types of collectors for the production of warm water in the residential sector were analysed in the report. Single family dwellings (SFD) and multiple family dwellings (MFD) were distinguished. All systems are equipped with an additional electric boiler to compensate insufficient production in periods of bad weather. An average insolation for Switzerland is assumed. Two parallel calculations are made:

100% solar: The heat demand is covered solely by solar thermal energy. The environmental burden for producing, operating and disposing the collector system is related only to the heat produced by the collector.

Hybrid: The heat demand is covered 46–61% by solar thermal energy. The rest is covered by the electric heating system. The total environmental burden for producing, operating and disposing the hybrid collector system and for producing the consumed electricity is related to the total heat output of the hybrid system.

Other applications, e.g. for heating purposes or for industrial use, are not considered but can nevertheless by calculated by using results for the collectors and other standard modules.

The inventoried heating systems are listed below. The given percentages for hybrid systems show the share of solar generated heat.

Heat from FK 1 (Al absorber, black paint):
- solar for SFD and MFD
- hybrid for SFD (46%) and MFD (50%)

Heat from FK 2 (Al absorber, Ni-pigmented Al-oxide):
- solar for SFD
- hybrid for SFD (51% solar)

Heat from FK 3 (Cu absorber, black chromized):
- solar for SFD and MFD
- hybrid for SFD (50%) and MFD (50%)

Heat from FK 4 (Cu absorber, sputtered Mo coating):
- solar for SFD
- hybrid for SFD (59% solar)

Heat from vacuum tube collector (VTC):
- solar for SFD
- hybrid for SFD (61% solar)

6.9. Photovoltaic Energy

<see part XII>

Eight different, grid-connected photovoltaic systems were studied. Three types of building-integrated 3kW small scale plants for use in the residential and commercial sector were inventoried with either monocristalline or polycrystalline cells. The remaining two plants are a 100kW plant mounted on a sound absorbing wall (SAW) at the edge of a Swiss highway and the PHALK 500kW power plant in operation in the Swiss Jura Alps (Mont Soleil). These plants were inventoried with the panel production of 1992. In addition the six different small scale plants were inventoried for 1995, taking expected improvements in production of essentially the same technology into account. A total of 14 differently specified plants are reported.

The 3kW systems were analysed according to an average location in Switzerland with a relatively good yield (for Central European conditions) of 3.6 GJ_e per year. Larger modular systems can be calculated by using a multiple of the 3kW system. The analysis of the larger plants, on the other hand, is plant- and location-specific and should not be used for other conditions and locations.

Mono- and polycrystalline cells and modules were analyzed separately, mostly based on German production data (also Japanese production data was used). Because production data could not be completely disaggregated, the production of EG silicon from MG silicon is inventoried together with the wafer manufacturing process step. The production of aluminium framed panels and unframed laminates from both cell types is reported.

m-Si modules:
- framed panels and unframed laminates for 1992 and 1995, respectively

p-Si modules:
- framed panels for 1992 and framed panels and unframed laminates for 1995

3kWp small scale plants:

façade installation:
- mounted m-Si or p-Si panels for 1992
- integrated m-Si or p-Si laminates for 1995

flat roof installation:
- m-Si or p-Si panels for 1992
- m-Si or p-Si panels for 1995

slope roof installation:
- mounted m-Si or p-Si panels for 1992
- integrated m-Si or p-Si laminates for 1995

Large scale plants:
- PHALK, 500kWp m-Si laminates
- mounted on sound absorbing wall (SAW), 100kWp p-Si panels

7. Structure of Result Tables

<see III.6.2, p.11> In part XIII summarised results are given for the analysed energy systems. These results are specially summarised extracts from the cumulated results to give an comprehensive overview of *some* environmental interventions. No valuation about the importance of environmental interventions is intended hereby. The translation of the summarised entries are given in Appendix A.

7.1. Aggregation Systematics for Summarised Results

Land use: The categories are unaggregated copies from the cumulated results. No further aggregation is valid.

Energetic resources: Are the same values and unit as in the cumulated result tables.

Water: All water uses including turbine water and cooling water are added up. The water is utilised and not necessarily wasted.

Electricity: The modules «electricity mixture CH» , «electricity mixture UCPTE», and «electricity from gas turbine 10MW» were added. This represents the net production and contains all transportation losses. Energy systems using other electricity generating systems need to add them extra.

Materials: Some of the materials in the standard modules are intermediate products, e.g., ammonia can be used for production of explosives. Therefore materials can not be simply added up without making double counts. To avoid this, the following materials were *not* counted: concrete, converter steel, hydrogen fluoride (HF), coated and uncoated glass panes, cast iron, wood construction material massive and board, burnt and hydrated lime (CaO, $Ca(OH)_2$), mineral wool, nickel-pigmented aluminium oxide, phosphoric acid, propylene glycol, nitric acid, soda, explosive, high-, low-alloy and plain steel, decarbonized and completely softened water and cement.

Concrete gravel: In some process units concrete and cement are requested directly to obtain specified concrete mixtures. Concrete gravel is reported to avoid double counts.

Limestone: Is the same value as in the cumulated result tables.

Steel and cast iron: The three types of steel (high-alloy, low-alloy and plain) were aggregated with cast iron. All alloying constituents (Cr, Mo, Ni) are included.

Copper: Is the same value as in the cumulated result tables.

Transport street: This comprises the services made by delivery van and the three types of trucks (16t, 28t, 40t). Passenger vehicle transport is not included.

Transport rail: Is the same value as in the cumulated result tables.

Transport ship: Here the transport services of transoceanic and inland water freighters are added up. The tanker transportation from the oil system is included.

Waste heat: All waste heat emission to water, air and soil are included.

CO_2, SO_x, NO_x, CH_4: As an example the emissions of carbon dioxide are listed unaggregated according to their emission origin (mobile, processing and stationary sources, see chapter 5.5.2.1 in this guide). For the other three species the total emission from all three origins is given.

BTEX aromatics: These comprise benzene, toluene, ethyl benzene and xylenes.

NMVOC: Includes all hydrocarbons except methane and BaP. Please refer to table III.8.6 in this report.

Radioactive emissions: All atmospheric and aquatic radioactive emissions were grouped into four categories, respectively according to Tab. III.6.1. A suffix «m» after the isotope number (e.g. Xe135m) indicates an isomer and *not* a mobile emission source.

Category	*Contributing units*				
Atmospheric emissions					
Rn, Ra, Radon and Radium total	Ra226 p	Ra226 s	Ra228 s	Rn220 s	Rn222 p
	Rn222 s				
noble gases total	noble gases various p		C14 p	H3p	Kr85 p
	Kr87 p	Kr88 p	Xe133	Xe135 p	Xe135m p
	Xe138 p				
rad. aerosols total	aerosols various p		Ba140 p	Ce141 p	Ce144 p
	Co58 p	Co60 p	Cr51 p	Cs134 p	Cs137 p
	Fe59 p	I129 p	I131 p	K40 s	La140 p
	Mn54 p	Nb95 p	Pb210 s	Pm147 p	Po 210 s
	Ru103 p	Ru106 p	Sb124 p	Sr90 p	Tc99 p
	Zn65 p	Zr95 p			
actinides in air total	Am241 p	actinides various p		Cm alpha p	Np237 p
	Pa234m p	Pu alpha p	Pu241 Beta p	Th228 s	Th230 p
	Th232 s	Th234 p	U alpha p	U234 p	U235 p
	U238 p	U238 s			
Aquatic emissions	*(modules «...in water...»)*				
Radon in water total	Ra224 p	Ra226 p	Ra228 p		
H3	H3 p				
Nuclides various	Co60 p	Cs134 p	Cs137 p	nuclides mix p	C14 p
	Ce144 p	Co58 p	Cr51 p	I129 p	I131 p
	K40 p	Mn54 p	Mn55 p	Nb95 p	Pb210 p
	Po210 p	Ru103 p	Ru106 p	Sb124 p	Sb125 p
	Sr90 p	Tc99 p	Zn65 p	Zr95 p	
actinides in water total	actinides various p		Am241 p	Cm alpha p	Np237 p
	Pu alpha p	Pu241 beta p	Th228 p	Th230 p	Th232 p
	Th234 p	Pa234m p	U alpha p	U234 p	U235 p
	U238 p				

Tab. III.6.1: Grouping of radioactive emissions into summarising categories according to Chapter VII.13 in the German report.

Chlorides: Includes ionic chloride, hypochlorous acid (HOCl) and ionic hypochlorite (OCl^-) since these species show similar reactions in water.

Aromatics: All aromatic emissions in water are reported: benzene, chlorobenzene, ethyl benzene, phenols, polycyclic aromatic hydrocarbons (PAH), toluene, xylene and the unspecified various aromatics.

Wastes: All non-radioactive wastes were grouped in six categories according to table III.6.2. *«Wood wastes in forest»* are not included since they do not enter anthropogenic waste processing.

Summarised wastes	***Included process units***		
wastes to sanitary landfill (SL)	waste to SL coating paint to SL limestone residue to SL steel to SL	construction waste to SL natural gas pipelines to SL copper to SL hard coal tailings in landfill	concrete to SL glass to SL mineral wool to SL zeolite to SL
wastes to low active chemical landfill (LCL)	waste to LCL drilling waste to LCL residue power plant in LCL	construction waste to LCL photovoltaic panel waste to LCL hard coal ash to landfill	disposed fly ash photovoltaic cell waste to LCL
wastes to high active chemical landfill (HCL)	waste to HCL electronic waste photovoltaic panel EVA-plastic waste	asphalt to HCL wood to HCL refinery sludge to HCL	bitumen to HCL plastics HCL sludge in HCL
wastes to community incineration (CI)	Al to CI wood ash mixture to CI plastics to CI propylene glycol to CI steel to CI	F to CI wood poles to CI polyethylene to CI PVC to CI	wood to CI cardboard to CI polystyrene soft to CI community waste to CI
industrial wastes (IW) in industrial incineration (II)	wastes to II ion exchange resin to IW photovoltaic production waste to II welding dust to IW treatment	used oil to II catalytic converter to IW landfill refinery sludge to II	bilge oil to II separator sludge to II ion exchange sludge to IW
wastes to landfarming	refinery sludge to landfarming	drilling waste to landfarming	

Tab. III.6.2: Grouping of non-radioactive wastes into six summarising categories.

Radioactive wastes: The three types of radioactive wastes were taken directly from the cumulated result tables.

8. Limitations in Applicability

<see I.3, p.2f>

No Valuation. The report only contains the first two steps of an environmental life cycle assessment: the goal definition and the inventory. The classification and valuation of the environmental impacts is not conducted. Therefore, the presented data give no direct information about the environmental damage of an energy system. The data is presented in a highly disaggregated way, without further valuation, with the aim of achieving a high level of consistency. The responsibility for the further valuation and use of the data lies with the user of the report.

No Geographical Boundaries. The reported results contain the cumulated environmental interventions without geographical restrictions. Therefore, the *results* may not be used for emission inventories of confined areas. The *input* data may provide some information about local interventions, but often refer to a mixture of plants or represent an average situation for various countries. The temporal and spatial structure of interventions has to be provided from other studies.

No distinction is made about the sensibility of the environments in which the emissions occur. Only physical quantities, *i.e.* Kilogramms, of emitted substances are reported. Different suceptibilities of e.g., alpine regions *vs.* marine regions were not distinguished.

Analysis of present systems only. The inventoried energy systems are inventoried according to the actual existing plants for the early nineties. No future technologies or today's best technologies are used (exceptions are the 1995 photovoltaic 3kWp plants). The results are to be used with precaution for energy planning studies.

No Demand-Side-Management-Systems. Only the production of energy carriers and their use in energy systems were inventoried. If the assessment of energy services as such (useful heat, useful electrical or mechanical power) is of interest, measures on the demand side have to be taken into account additionally. These comprise conservation measures improving the efficiencies of energy systems through better insulation techniques, heat recovery measures and the like.

Standard Modules. The level of detail and accuracy of the standard modules corresponds to the needs of energy systems analysis. This data should *not* be used for non-energy related studies *i.e.* transportation, disposal or material centred studies. The input data may be modified to meet the requirements, however.

Intended Uses. The archived inventory results can be used for product systems comparison. The results may also indicate optimisation criteria within an energy system. In energy planning the results provide information about the pros and cons of energy conservation. The necessary conservation measures are yet to be inventoried additionally.

Classification. For information about environmental impact of energy systems the results may be classified in a generic exposure effect analysis as proposed in <Heijungs et al. 1992>. There, the impacts of environmental interventions are modelled based on global average or representative conditions (e.g. soil types). This suits the type of emission assessment made here, since no differences of environmental sensibility of an emission site were reflected.

Avoid double counts! If you plan to use cumulated results, please check the process chain of the energy system you are interested in and make sure you do not make double counts.

Examples:

- Waste heat in the final use from heating systems is already fully accounted for. On the other hand, if you plan to assess final use of *electricity* you have to consider an additional waste heat flux.

- The reported energy services contain the construction, operation and the related *downstream* processes (dismantling and disposal) of the producing plants. If you use energy service results, do not re-assess the plant dismantling (see Glossary: *downstream*)

9. Database

9.1. Data Structure

<see III.6.1, p.11 and Appendix G>

For every single step in an analysed process chain, the direct fluxes (input of materials, services and output of emissions) are defined, representing a data vector or module. On every step the directly occurring fluxes are expressed *per output unit* of that step. All data entries in that module are normalised to the output specified in the title of the module and the given unit, e.g. the module called «hard coal from mine» with output unit tons [t] contains all necessary, *direct* fluxes in the mining process step *per ton* hard coal, free for and excluding transport to refining plants.

All process chain steps, *i.e.*, their data vector representations are linked together, their interconnections and recursive loops are calculated in the relational database program «EcoInvent». The result is a *cumulated* data vector that is given again for every process step. The entries in the cumulated result module represent the direct *and* indirect fluxes up to (and including) the process step in question. E.g. in the result module called «useful heat form coal stove» you can look up all cumulated fluxes caused by this energy service (within the methodical boundaries) including all the appropriate shares of the fluxes caused in upstream steps, for example in the coal mining.

9.2. Software

<see app. G>

For data input, filing and handling purposes a database program called EcoInvent was developed. It is a relational database program that works on Apple Macintosh personal computers based on the program «4th Dimension». It does not check the equality of input *vs.* output masses.

Cumulated results were calculated by inversion of the {491 by 491} process unit input matrix followed by multiplication with the emission matrix. Tjhis was don on a external CONVEX system. The input/output matrix is an algebraic representation of all interactions between the subsystems used in the study. The inversion of the matrix corresponds to the calculation of the total cumulated inputs to a system (sum of all first order, second order, third order etc. contributions from other processes). By multiplying the inverted matrix with the matrix of the environmental interventions (emissions and resource depletions) total cumulated emissions and resource depletions were calculated.

The accuracy of the matrix inversion was monitored by control of the sum of the diagonal elements of the matrix. At first, highly accurate calculations were performed with 32 significant digits. In a second step, it was shown that a satisfying accuracy could be achieved also with less significant digits or even by using an iterative algorithm developong in a power series, stopping after the n^{th} power.

Only the data files of the input matrices (direct fluxes) and the result matrices (cumulated fluxes) are on the diskettes, that come with the report. The application program is not included and not on sale either.

10. Literature

Frischknecht et al. 1994 — R.Frischknecht, P.Hofstetter, I.Knoepfel, R.Dones, E.Zollinger, *«Ökoinventare für Energiesysteme»*, Schlussbericht, Laboratorium für Energiesysteme (LES), ETH Zürich, 1994

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Annex A: English Translation of the Names of the Data Modules

A.1 Remarks

An overview of the different categories of modules (e.g. standard materials or modules from the oil chain) and their location in the list is given in Annex C «How to use the Data Diskettes».

The physical units are international standard and are not translated. The unit *Stk* signifies per piece (Ger. *«Stück»*) and shall not be confounded with the German abbreviation for *«Steinkohle»* (hard coal) which is also *Stk*. The unit *kgUTA* is used in the uranium fuel cycle and signifies enriched uranium (*«Uran-Trenn-Arbeit»*). The unit *a* stands for Lat. *«annum»* = year *(y)*. The unit *Nm3* signifies cubic meters *(m^3)* under standard conditions. The unit *tkm* indicates transportation of one ton of freight for one kilometre.

A.2 Process Modules

Data modules with both downstream and upstream links to other data modules:

No.	German Name of Data Module	Unit	English Translation
	Energy Carriers		
1.	Benzin bleifrei ab Regionallager C H	t	petrol unleaded from regional stock C H
2.	Benzin bleifrei ab Regionallager Euro	t	petrol unleaded from regional stock UCPTE
3.	Braunkohlen-Staub	TJ	lignite dust
4.	Braunkohlenbriketts	TJ	lignite briquets
5.	Diesel ab Regionallager C H	t	diesel from regional stock C H
6.	Diesel ab Regionallager Euro	t	diesel from regional stock UCPTE
7.	Erdgas HD-Abnehmer C H	TJ	natural gas, high pressure consumer C H
8.	Erdgas HD-Abnehmer Euro	TJ	natural gas, high pressure consumer Euro
9.	Erdgas ND-Abnehmer C H	TJ	natural gas, low pressure consumer C H
10.	Heizöl EL ab Regionallager C H	t	heating oil, low S, from regional stock C H
11.	Heizöl EL ab Regionallager Euro	t	heating oil, low S, from regional stock Euro
12.	Heizöl S ab Regionallager C H	t	heating oil, high S, from regional stock C H
13.	Heizöl S ab Regionallager Euro	t	heating oil, high S, from regional stock Euro
14.	Rohbraunkohle ab Bergbau UCPTE	t	lignite from mining UCPTE
15.	Steinkohlekoks	TJ	coal coke (from hard coal)
16.	Steinkohlen-Briketts	TJ	hard coal briquets
17.	Strom Hochspannung - Bezug in C H	TJ	electricity high voltage - supplied in C H
18.	Strom Hochspannung - Bezug in UCPTE	TJ	electricity high voltage - supplied in UCPTE
19.	Strom Mittelspannung - Bezug in C H	TJ	electricity medium voltage - supplied in C H
20.	Strom Mittelspannung - Bezug in UCPTE	TJ	electricity medium voltage - supplied in UCPTE
21.	Strom Niederspannung - Bezug in C H	TJ	electricity low voltage - supplied in C H
22.	Strom Niederspannung - Bezug in UCPTE	TJ	electricity low voltage - supplied in UCPTE
23.	transportierte europäische Stk frei UCPTE	t	transported European hard coal to UCPTE
24.	transportierte Import-Stk frei C H	t	transported imported hard coal to C H
25.	transportierte Import-Stk frei UCPTE	t	transported imported hard coal to UCPTE
	Standard Materials		
26.	Alkydharzlack	kg	alkyd varnish
27.	Aluminium 0% Rec.	kg	aluminium 0% recycling
28.	Aluminium 100% Rec.	kg	aluminium 100% recycling
29.	Ammoniak	kg	ammonia
30.	Argon ab Luftzerlegung	kg	argon from air decomposition
31.	Barit ab Verarbeitung	kg	barite from processing (heavy spar)

32.	Bentonit ab Verarbeitung	kg	bentonite clay from processing
33.	Beton (ohne Armierungseisen)	kg	concrete (without reinforcment steel)
34.	Betonkies	kg	concrete gravel
35.	Blasstahl	kg	converter steel
36.	Blei	kg	lead
37.	Cadmiumfreies Hartlot	kg	cadmiumfree brazing
38.	Chemikalien anorganisch	kg	chemicals inorganic
39.	Chemikalien organisch	kg	chemicals organic
40.	Chlorwasserstoff HCl (Salzsäure)	kg	hydrogen chloride as HCl
41.	Chrom	kg	Chromium
42.	Eisensulfat	kg	iron sulfate
43.	Elektrostahl	kg	electric-furnace steel
44.	Ethylen	kg	ethene
45.	Fluorwasserstoff HF (Flusssäure)	kg	hydrogen fluoride HF
46.	Glas (Flach-) beschichtet	kg	float glass, coated
47.	Glas (Flach-) unbeschichtet	kg	float glass, uncoated
48.	Gummi EPDM	kg	synthethic rubber
49.	Gusseisen	kg	cast iron
50.	Holzbaustoff Brettschichtholz	kg	wood construction material, board
51.	Holzbaustoff massiv	kg	wood construction material, massive
52.	Kalk (CaO)	kg	burnt lime, CaO
53.	Kalk Ca(OH)2	kg	hydrated lime, Ca(OH)2
54.	Kalkstein	kg	limestone
55.	Karton (Verpackungs-)	kg	cardboard (packaging)
56.	Keramik	kg	ceramics
57.	Kupfer	kg	copper
58.	Mangan	kg	manganese
59.	Mineralwolle	kg	mineral wool
60.	Natriumchlorid	kg	sodium chloride
61.	Natronlauge NaOH	kg	sodium hydroxide NaOH
62.	Nickel ab Anreicherung	kg	nickel from enrichment
63.	Nickelpigmentiertes Aluminiumoxid	m2	nickel-pigmentend aluminium oxide
64.	Palladium ab Anreicherung	kg	palladium from enrichment
65.	Papier	kg	paper
66.	PE (HD)	kg	polyethylene (HDPE, high density)
67.	PE (LD)	kg	polyethylene (LDPE, low density)
68.	PET 0% Rec.	kg	PET 0% recycling
69.	Phosphorsäure	kg	phosphoric acid
70.	Platin ab Anreicherung	kg	platinium from enrichment
71.	Polypropylen	kg	polypropylene (PP)
72.	Polystyrol schlagfest	kg	polystyrene, shock-resistant (PS)
73.	Polystyrol weich	kg	polystyrene, soft (PS)
74.	Propylen	kg	propylene
75.	Propylenglykol	kg	propylene glycol
76.	PUR-Hartschaum	kg	polyurethane foam, PUR
77.	PVC schlagfest	kg	polyvinyl chloride, shock-resistant
78.	PVC weich	kg	polyvinyl chloride, soft
79.	Roheisen	kg	crude iron
80.	Salpetersäure	kg	nitric acid (HNO3)
81.	Sand für Bau	kg	sand for construction
82.	Sauerstoff ab Luftzerlegung	kg	oxygen from air decomposition
83.	Schwefelsäure H2SO4	kg	sulphuric acid (H2SO4)
84.	Soda	kg	soda (sodium carbonate, H2CO3)
85.	Sprengstoff	kg	explosive
86.	Stahl hochlegiert	kg	steel, high-alloy
87.	Stahl niedriglegiert	kg	steel, low-alloy
88.	Stahl unlegiert	kg	steel, plain
89.	Stickstoff ab Luftzerlegung	kg	nitrogen from air decomposition

90.	Wasser entkarbonisiert	kg	water, decarbonized
91.	Wasser vollentsalzt	kg	water, completely softened
92.	Wasserstoff H2	kg	hydrogen H2
93.	Zement	kg	cement
94.	Zink für Verzinkung	kg	zinc for plating
	Services		
95.	Transport Fernwärme gross HW	TJ	transport, district heat, big, hot water
96.	Transport Fernwärme gross WW	TJ	transport, district heat, big, warm water
97.	Transport Fernwärme klein/alt	TJ	transport, district heat, small, old
98.	Transport Fernwärme klein/neu	TJ	transport, district heat, small, new
99.	Transport Frachter Binnengewässer	tkm	transport, freighter, inland waters (barge on river)
100.	Transport Frachter Uebersee	tkm	transport, freighter, transoceanic
101.	Transport Lieferwagen <3.5 t	tkm	transport, delivery van, <3.5t
102.	Transport LKW 16 t	tkm	transport, truck, 16t
103.	Transport LKW 28 t	tkm	transport, truck, 28t
104.	Transport LKW 40 t	tkm	transport, truck, 40t
105.	Transport PKW Westeuropa	km	transport, passenger vehicle, West Europa
106.	Transport Schiene	tkm	transport, rail
107.	Aushub Frontladerraupe	m3	excavation, skid-steer loader
108.	Aushub Hydraulikbagger	m3	excavation, hydraulic digger
109.	Diesel in Baumaschine	TJ	diesel in construction equipment
110.	Motorsäge	h	power saw
111.	NOx zurückgehalten in SCR	kg	NOx retained in SCR (selective catalytic reduction)
112.	SOx zurückgehalten in Brk-REA	kg	SOx retained in lignite flue gas desulphurization
113.	SOx zurückgehalten in REA	kg	SOx retained in flue gas desulphurization
114.	Sputtern	m2	sputtering
	Oil		
115.	Benzin Bleifrei ab Raffinerie C H	t	petrol, unleaded, from refinery C H
116.	Benzin Bleifrei ab Raffinerie Euro	t	petrol, unleaded, from refinery UCPTE
117.	Benzin verbleit ab Raffinerie C H	t	petrol, leaded, from refinery C H
118.	Benzin verbleit ab Raffinerie Euro	t	petrol, leaded, from refinery UCPTE
119.	Benzin verbleit ab Regionallager C H	t	petrol, leaded, from regional stock C H
120.	Benzin verbleit ab Regionallager Euro	t	petrol, leaded, from regional stock UCPTE
121.	Binnentankschiff	tkm	inland water tanker
122.	Bitumen ab Raffinerie C H	t	bitumen, from refinery C H
123.	Bitumen ab Raffinerie Euro	t	bitumen, from refinery UCPTE
124.	Bohrmeter für Exploration und Produktion	m	drilling metres in exploration and production
125.	Deckfarbe	kg	coating paint
126.	Diesel ab Raffinerie C H	t	diesel from refinery C H
127.	Diesel ab Raffinerie Euro	t	diesel from refinery UCPTE
128.	Diesel in Dieselaggregat Förderung	TJ	diesel in diesel-electric generating set for production
129.	Erdölgas Abblasen	Nm3	petroleum gas, blow-off
130.	Erdölgas in Fackel	Nm3	petroleum gas, flare
131.	Erdölgas in Gasturbine	TJ	petroleum gas in gas turbine
132.	Heizkessel Öl 1 MW	Stk	boiler, oil, 1MW
133.	Heizkessel Öl 10 kW	Stk	boiler, oil, 10kW
134.	Heizkessel Öl 100 kW	Stk	boiler, oil, 100kW
135.	Heizöl EL 2000 ab Raffinerie C H	t	fuel oil, low sulphur 2000, from refinery C H
136.	Heizöl EL 2000 ab Raffinerie Euro	t	fuel oil, low sulphur 2000, from refinery Euro
137.	Heizöl EL 2000 ab Regionallager C H	t	fuel oil, low sulphur 2000, from regional stock C H
138.	Heizöl EL 2000 ab Regionallager Euro	t	fuel oil, low sulphur 2000, from regional stock Euro

139.	Heizöl EL 2000 in Heizung 100 kW	TJ	fuel oil, low sulphur 2000, in boiler 100kW
140.	Heizöl EL ab Raffinerie C H	t	fuel oil, low sulphur, from refinery C H
141.	Heizöl EL ab Raffinerie Euro	t	fuel oil, low sulphur, from refinery Euro
142.	Heizöl EL in Heizung 1 MW	TJ	fuel oil, low sulphur, in boiler 1MW
143.	Heizöl EL in Heizung 10 kW	TJ	fuel oil, low sulphur, in boiler 10kW
144.	Heizöl EL in Heizung 10 kW Brennwert	TJ	fuel oil, low sulphur, in boiler 10kW condensing
145.	Heizöl EL in Heizung 100 kW	TJ	fuel oil, low sulphur, in boiler 100kW
146.	Heizöl EL in Heizung 100 kW Brennwert	TJ	fuel oil, low sulphur, in boiler 100kW condensing
147.	Heizöl Petro ab Raffinerie Euro	t	refinery fuel oil from refinery Euro
148.	Heizöl S ab Raffinerie C H	t	residual oil from refinery C H
149.	Heizöl S ab Raffinerie Euro	t	residual oil from refinery Euro
150.	Heizöl S in Kraftwerk C H	TJ	residual oil in power plant C H
151.	Heizöl S in Kraftwerk UCPTE	TJ	residual oil in power plant UCPTE
152.	Heizöl S in Raffineriefeuerung C H	t	residual oil in refinery furnace C H
153.	Heizöl S in Raffineriefeuerung Europa	t	residual oil in refinery furnace Euro
154.	Heizöl S, C H in Heizung >5 MW	TJ	residual oil, C H, in boiler >5MW
155.	Heizöl S, Euro in Heizung 1 MW	TJ	residual oil, Euro, in boiler 1MW
156.	Hochseetanker	tkm	transoceanic tanker (transport service)
157.	Kerosin ab Raffinerie C H	t	kerosene from refinery C H
158.	Kerosin ab Raffinerie Euro	t	kerosene from refinery Euro
159.	Kerosin ab Regionallager C H	t	kerosene from regional stock C H
160.	Kerosin ab Regionallager Euro	t	kerosene from regional stock Euro
161.	MTBE	kg	methyl tert-butyl ether
162.	Naphtha ab Raffinerie Europa	t	naphta from refinery Euro
163.	Nutzwärme ab Heizung 10 kW	TJ	useful heat from boiler 10kW
164.	Nutzwärme ab Heizung 10 kW Brennwert	TJ	useful heat from boiler 10kW condensing
165.	Nutzwärme ab Heizung 100kW	TJ	useful heat from boiler 100kW
166.	Nutzwärme ab Heizung 100kW Brennwert	TJ	useful heat from boiler 100kW condensing
167.	Nutzwärme ab Industriefeuerung EL, C H	TJ	useful heat from industrial furnace, fuel oil, C H
168.	Nutzwärme ab Industriefeuerung S, C H	TJ	useful heat from industrial furnace, residual oil, C H
169.	Nutzwärme ab Industriefeuerung S, Euro	TJ	useful heat from industrial furnace, residual oil, Euro
170.	Nutzwärme in Heizung EL 2000 100 kW	TJ	useful heat from boiler, fuel oil 2000, 100kW
171.	Pipeline Offshore	tkm	pipeline offshore transport (transport service)
172.	Pipeline Onshore	tkm	pipeline onshore transport (transport service)
173.	Propan/ Butan ab Raffinerie C H	t	propane/butane from refinery C H
174.	Propan/ Butan ab Raffinerie Euro	t	propane/butane from refinery Euro
175.	Raffineriegas ab Raffinerie C H	t	refinery gas from refinery C H
176.	Raffineriegas ab Raffinerie Euro	t	refinery gas from refinery Euro
177.	Raffineriegas in Feuerung C H	t	refinery gas in furnace C H
178.	Raffineriegas in Feuerung Europa	t	refinery gas in furnace Euro
179.	Rohöl ab Ferntransport	t	crude oil from transport
180.	Rohöl ab Förderung	t	crude oil from production
181.	Rohöl in Bohrungstests	kg	crude oil in drill tests
182.	Strom ölthermisch C H	TJ	electricity from oil plant C H
183.	Strom ölthermisch UCPTE	TJ	electricity from oil plant UCPTE
184.	TEL	kg	tetra ethyl lead
	Natural gas		
185.	Emission Lagerstättenwasser Erdgas	l	emissions production waters natural gas reservoir
186.	Emission Lagerstättenwasser Erdölgas	l	emissions production waters petroleum gas reservoir
187.	Erdgas frei C H	m3	natural gas to C H

188.	Erdgas frei C H , D	m3	natural gas to C H , D
189.	Erdgas frei C H , GUS	m3	natural gas to C H , GUS
190.	Erdgas frei C H , N	m3	natural gas to C H , N
191.	Erdgas frei C H , NL	m3	natural gas to C H , NL
192.	Erdgas frei UCPTE	m3	natural gas to UCPTE
193.	Erdgas frei UCPTE, Alg.	m3	natural gas to UCPTE, Alg.
194.	Erdgas frei UCPTE, Alg. LNG	m3	natural gas to UCPTE, Alg. LNG
195.	Erdgas frei UCPTE, D	m3	natural gas to UCPTE, D
196.	Erdgas frei UCPTE, GUS	m3	natural gas to UCPTE; GUS
197.	Erdgas frei UCPTE, N	m3	natural gas to UCPTE, N
198.	Erdgas frei UCPTE, NL	m3	natural gas to UCPTE, NL
199.	Erdgas in Heizung atm. Brenner <100 kW	TJ	natural gas in atmospheric burner boiler <100kW
200.	Erdgas in Heizung atm. LowNOx <100 kW	TJ	natural gas in boiler, atmospheric low-NOx <100kW
201.	Erdgas in Heizung atm. LowNOx KOND <100kW	TJ	natural gas in boiler, atmospheric, condensing <100kW
202.	Erdgas in Heizung Gebläsebr LowNOx <100kW	TJ	natural gas in boiler, blast burner, low-NOx <100kW
203.	Erdgas in Heizung Gebläsebr. <100 kW	TJ	natural gas in boiler, blast burner, <100kW
204.	Erdgas in Industrief. Low-NOx>100kW Euro	TJ	natural gas in industrial furnace, low-NOx >100kW Euro
205.	Erdgas in Industriefeuerung >100 kW Euro	TJ	natural gas in industrial furnace, >100kW Euro
206.	Fördergas, Alg.	m3	raw gas, Alg. (from reservoir)
207.	Fördergas, D	m3	raw gas, D (from reservoir)
208.	Fördergas, GUS	m3	raw gas, GUS (from reservoir)
209.	Fördergas, N	m3	raw gas, N (from reservoir)
210.	Fördergas, NL	m3	raw gas, NL (from reservoir)
211.	Leckage Erdgas H	m3	leakage nat. gas high (high heating value)
212.	Leckage Erdgas H/GUS	m3	leakage nat. gas high/GUS
213.	Leckage Erdgas L	m3	leakage nat. gas low (low heating value)
214.	Leckage Erdgas Mix	m3	leakage nat. gas average
215.	Leckage Erdgas Schweiz	m3	leakage nat. gas C H
216.	Leckage Erdgas vor Aufber. sauer	m3	leakage nat. gas prior conditioning sour
217.	Leckage Erdgas vor Aufber. süss	m3	leakage nat. gas prior conditioning sweet
218.	LNG Kette Algerien	Stk.	LNG chain Algeria
219.	Massivbau-Gebäude	m3	massive building
220.	Metallbau-Gebäude	m3	metal construction building
221.	Nutzwärme ab Heizung LowNOx KOND.<100 kW	TJ	useful heat from boiler, low-NOx, condensing <100kW
222.	Nutzwärme ab Heizung atm. <100 kW	TJ	useful heat from boiler, atmospheric <100kW
223.	Nutzwärme ab Heizung atm. LowNOx <100 kW	TJ	useful heat from boiler, atmospheric low-NOx <100kW
224.	Nutzwärme ab Heizung Gebl. <100 kW	TJ	useful heat from boiler, blast burner, <100kW
225.	Nutzwärme ab Heizung Gebl. LowNOx <100 kW	TJ	useful heat from boiler, blast burner, low-NOx <100kW
226.	Nutzwärme ab Industriefeuer.LowNOx>100 kW	TJ	useful heat from industrial furnace, low-NOx >100kW Euro
227.	Nutzwärme ab Industriefeuerung >100 kW	TJ	useful heat from industrial furnace, >100kW Euro
228.	Output Fackel Förderung (pro m3in)	m3	output from flare in production (per m3 input, from exhausting)
229.	Output Gasmotor (pro TJin)	TJ	output gas motor (per TJ input)
230.	Output Gasturbine (pro TJin)	TJ	output gas turbine (per TJ input)
231.	Output Gasturbine Förderung (pro m3)	m3	output gas turbine production (per TJ input)
232.	Output Gasturbine Pipeline (pro TJin)	TJ	output gas turbine pipeline (per TJ input)
233.	produziertes Erdgas, Alg.	m3	produced natural gas, Alg.
234.	produziertes Erdgas, D	m3	produced natural gas, D

235.	produziertes Erdgas, GUS	m3	produced natural gas, GUS
236.	produziertes Erdgas, N	m3	produced natural gas, N
237.	produziertes Erdgas, NL	m3	produced natural gas, NL
238.	Strom ab Brenngas-Kraftwerk UCPTE-Mix	TJ	electricity from UCPTE fuel gas power plants, average
239.	Transport Erdgas-Pipeline	tkm	transport natural gas pipeline
	Coal		
240.	Brk Kraftwerk in A	TJ	lignite power plant in A
241.	Brk Kraftwerk in E	TJ	lignite power plant in E
242.	Brk Kraftwerk in Ex-Ju	TJ	lignite power plant in Ex-Yugoslavia
243.	Brk Kraftwerk in F	TJ	lignite power plant in F
244.	Brk Kraftwerk in GR	TJ	lignite power plant in GR
245.	Brk Kraftwerk in I	TJ	lignite power plant in I
246.	Brk Kraftwerk in W-D	TJ	lignite power plant in West Germany
247.	Einzelofen Anthrazit 5-15kW	TJ	stove, hard coal 5-15kW
248.	Einzelofen Brk-Brikett 5-15kW	TJ	stove, lignite briquet 5-15kW
249.	Einzelofen Stk-Brikett 5-15kW	TJ	stove, coal briquet 5-15kW
250.	Einzelofen Stk-Koks 5-15kW	TJ	stove, coal coke 5-15kW
251.	Europäische Steinkohle ab Bergwerk	t	European hard coal from mine
252.	Europäische Steinkohle ab Lager	t	European hard coal from stock
253.	Import-Steinkohle ab Bergwerk	t	imported hard coal from mine
254.	Import-Steinkohle ab Lager	t	imported hard coal from stock
255.	Industriekohlefeuerung 1-10 MW	TJ	industrial furnace 1-10MW
256.	Nutzwärme Einzelofen Anthrazit 5-15kW	TJ	useful heat from stove, hard coal 5-15kW
257.	Nutzwärme Einzelofen Brk-Brikett 5-15kW	TJ	useful heat from stove, lignite briquet 5-15kW
258.	Nutzwärme Einzelofen Stk-Brikett 5-15kW	TJ	useful heat from stove, coal briquet 5-15kW
259.	Nutzwärme Einzelofen Stk-Koks 5-15kW	TJ	useful heat from stove, coal coke 5-15kW
260.	Nutzwärme Industriekohlenfeuerung 1-10 MW	TJ	useful heat from industrial furnace 1-10MW
261.	Steinkohle aus Tagbau ab Bergwerk	t	hard coal from opencast mine
262.	Steinkohle aus Untertagbau ab Bergwerk	t	hard coal from underground mine
263.	Stk Kraftwerk in A	TJ	hard coal power plant in A
264.	Stk Kraftwerk in B	TJ	hard coal power plant in B
265.	Stk Kraftwerk in E	TJ	hard coal power plant in E
266.	Stk Kraftwerk in Ex-Ju	TJ	hard coal power plant in Ex-Yugoslavia
267.	Stk Kraftwerk in F	TJ	hard coal power plant in F
268.	Stk Kraftwerk in I	TJ	hard coal power plant in I
269.	Stk Kraftwerk in NL	TJ	hard coal power plant in NL
270.	Stk Kraftwerk in P	TJ	hard coal power plant in P
271.	Stk Kraftwerk in W-D	TJ	hard coal power plant in West Germany
272.	Strom ab Braunkohlekraftwerk UCPTE-Mix	TJ	electricity from UPTCE lignite power plants, average
273.	Strom ab Brk-Kraftwerk in A	TJ	electricity from lignite power plant in A
274.	Strom ab Brk-Kraftwerk in E	TJ	electricity from lignite power plant in E
275.	Strom ab Brk-Kraftwerk in Ex-Ju	TJ	electricity from lignite power plant in Ex-Yugoslavia
276.	Strom ab Brk-Kraftwerk in F	TJ	electricity from lignite power plant in F
277.	Strom ab Brk-Kraftwerk in GR	TJ	electricity from lignite power plant in GR
278.	Strom ab Brk-Kraftwerk in I	TJ	electricity from lignite power plant in I
279.	Strom ab Brk-Kraftwerk in W-D	TJ	electricity from lignite power plant in West Germany
280.	Strom ab Steinkohlekraftwerk UCPTE-Mix	TJ	electricity from UPTCE hard coal power plants, average
281.	Strom ab Stk-Kraftwerk in A	TJ	electricity from hard coal power plant in A
282.	Strom ab Stk-Kraftwerk in B	TJ	electricity from hard coal power plant in B
283.	Strom ab Stk-Kraftwerk in E	TJ	electricity from hard coal power plant in E
284.	Strom ab Stk-Kraftwerk in Ex-Ju	TJ	electricity from hard coal power plant in Ex-Yugoslavia
285.	Strom ab Stk-Kraftwerk in F	TJ	electricity from hard coal power plant in F

286.	Strom ab Stk-Kraftwerk in I	TJ	electricity from hard coal power plant in I
287.	Strom ab Stk-Kraftwerk in NL	TJ	electricity from hard coal power plant in NL
288.	Strom ab Stk-Kraftwerk in P	TJ	electricity from hard coal power plant in P
289.	Strom ab Stk-Kraftwerk in W-D	TJ	electricity from hard coal power plant in West Germany
	Nuclear		
290.	Brennstoff in Wiederaufarbeitung	kg	spent fuel in reprocessing
291.	Rad-Abfälle in Zwilag zu Endlager B	m3	radioactive waste in interim storage, for final repository B
292.	Rad-Abfälle in Zwilag zu Endlager C	m3	radioactive waste in interim storage, for final repository C
293.	Rad. Abfälle in ZWILAG-Behandlungsanlage	m3	radioactive waste in interim storage conditioning
294.	Radioaktiver Abfall in Endlager B	m3	radioactive waste in final repository B
295.	Radioaktiver Abfall in Endlager C	m3	radioactive waste in final repository C
296.	schwach radioaktive abfälle	m3	low active wastes
297.	Strom ab DWR UCPTE	TJ	electricity from PWR UCPTE
298.	Strom ab KKW (KKG)	TJ	electricity from PWR C H (Gösgen)
299.	Strom ab KKW (KKL)	TJ	electricity from BWR C H (Leibstadt)
300.	Strom ab KKW C H	TJ	electricity from nuclear power plant C H
301.	Strom ab KKW UCPTE	TJ	electricity from nuclear power plant UCPTE
302.	Strom ab SWR UCPTE	TJ	electricity from BWR UCPTE
303.	Uran 3.25% in B.E. SWR C H	kg	uranium 3.25% in fuel element for BWR C H
304.	Uran 3.4% in B.E. SWR UCPTE	kg	uranium 3.4% in fuel element for BWR UCPTE
305.	Uran 3.5% in B.E. DWR UCPTE	kg	uranium 3.5% in fuel element for PWR UCPTE
306.	Uran 3.5% in B.E. DWR C H	kg	uranium 3.5% in fuel element for PWR C H
307.	Uran ab Mine	kg	uranium from mine
308.	Uran anger.3.25% durch Diffusion	kgUTA	uranium, enriched 3.25% by diffusion
309.	Uran anger.3.25% SWR C H	kgUTA	uranium, enriched 3.25% for BWR C H
310.	Uran anger.3.25% von Zentrifuge	kgUTA	uranium, enriched 3.25% by centrifuge
311.	Uran anger.3.4% durch Diffusion	kgUTA	uranium, enriched 3.4% by diffusion
312.	Uran anger.3.4% SWR UCPTE	kgUTA	uranium, enriched 3.4% for BWR UCPTE
313.	Uran anger.3.4% von Zentrifuge	kg UTA	uranium, enriched 3.4% by centrifuge
314.	Uran anger.3.5% durch Diffusion	kgUTA	uranium, enriched 3.5% by diffusion
315.	Uran anger.3.5% DWR UCPTE	kgUTA	uranium, enriched 3.5% for PWR UCPTE
316.	Uran anger.3.5% von Zentrifuge	kgUTA	uranium, enriched 3.5% by centrifuge
317.	Uran angereichert in Uranhexafluorid	kg	uranium, enriched, in uraniumhexafluoride (UF6)
318.	Uran in Uranerz aus Tagebau-Mine	kg	uranium in ore from opencast mine
319.	Uran in Uranerz aus Tiefbau-Mine	kg	uranium in ore from underground mine
320.	Uran natürlich in Uranexafluorid	kg	uranium, natural, in uraniumhexafluoride (UF6)
321.	Uran natürlich in Urankonzentrat	kg	uranium, natural, in uran concentrate
	Electricity		
322.	Strom - Mix C H *	TJ	electricity, mixture C H
323.	Strom - Mix UCPTE *	TJ	electricity, mixture UCPTE
324.	Strom ab Gasturbine 10 MW	TJ	electricity from gas turbine 10MW
325.	UCPTE-Strom Ferntransport	km	transport of electricity, UCPTE
	Hydroelectric		
326.	Laufwasserkraft C H	TJ	flow-through hydroelectric plant C H
327.	Laufwasserkraft UCPTE	TJ	flow-through hydroelectric plant UCPTE
328.	Speicherkraft C H	TJ	reservoir hydroelectric plant C H
329.	Speicherkraft UCPTE	TJ	reservoir hydroelectric plant UCPTE
330.	Strom ab Wasserkraft C H	TJ	electricity from hydro power C H
331.	Strom ab Wasserkraft UCPTE	TJ	electricity from hydro power UCPTE
332.	Umwälzwasserkraft C H	TJ	pumping storage hydroelectric plant C H
333.	Umwälzwasserkraft UCPTE	TJ	pumping storage hydroelectric plant UCPTE

	Waste Disposal		
334.	Abfälle in Inertstoffdeponie	kg	waste to sanitary landfill
335.	Abfälle in Reaktordeponie	kg	waste to high active chemical landfill
336.	Abfälle in Reststoffdeponie	kg	waste to low active chemical landfill
337.	Abfälle in SAVA	kg	wastes to industrial incineration
338.	Al in KVA	kg	Al to community incineration
339.	Altöl in SAVA	kg	used oil to industrial incineration
340.	Asphalt in Reaktordeponie	kg	asphalt to high active chemical landfill
341.	Bausperrgut in Inertstoffdeponie	kg	construction waste to sanitary landfill
342.	Bausperrgut in Reststoffdeponie	kg	construction waste to low active chemical landfill
343.	Beton in Inertstoffdeponie	kg	concrete to sanitary landfill
344.	Bilgenöl in SAVA	kg	bilge oil to industrial incineration
345.	Bitumen in Reaktordeponie	kg	bitumen to high active chemical landfill
346.	Bohrabfall in Landfarming	kg	drilling waste to landfarming
347.	Bohrabfall in Reststoffdeponie	kg	drilling waste to low active chemical landfill
348.	Deckfarbe in Inertstoffdeponie	kg	coating paint to sanitary landfill
349.	Deponierte Flugasche	kg	disposed fly ash
350.	Elektronikabfälle	kg	electronic waste
351.	Erdgasleitungen in Inertstoffdeponie	kg	natural gas pipelines to sanitary landfill
352.	F in KVA	kg	F to community incineration
353.	Glas in Inertstoffdeponie	kg	glass to sanitary landfill
354.	Holz in Reaktordeponie	kg	wood to high active chemical landfill
355.	Holzabfälle im Wald	t	wood wastes in forest
356.	Holzasche gemischt in KVA	kg	wood ash mixture to community incineration
357.	Holzmasten in KVA	kg	wood poles to community incineration
358.	Ionentauscherharz in Sonderabfall	l	ion exchange resin to industrial waste
359.	Kalksteinrückstände in Inertstoffdeponie	kg	limestone residue to sanitary landfill
360.	Karton in KVA	kg	cardboard to community incineration
361.	Katalysator in Sonderabfalldeponie	kg	catalytic converter to industrial waste landfill
362.	Kunststoffe in KVA	kg	plastics to community incineration
363.	Kunststoffe in Reaktordeponie	kg	plastics high active chemical landfill
364.	Kupfer in Inertstoffdeponie	kg	copper to sanitary landfill
365.	Leichtstoffabscheiderschlamm in SAVA	kg	separator sludge to industrial incineration
366.	Mineralwolle in Inertstoffdeponie	kg	mineral wool to sanitary landfill
367.	PE in KVA	kg	polyethylene to community incineration
368.	Polystyrol weich in KVA	kg	polysyrene soft to community incineration
369.	Propylenglykol in KVA	kg	propylene glycol to community incineration
370.	PV-Panelabfälle in Reststoffdeponie	kg	photovoltaic panel waste to low active chemical landfill
371.	PV-Produktionsabfälle in SAVA	kg	photovoltaic production waste to industrial incineration
372.	PV-Zellenabfälle in Reststoffdeponie	kg	photovoltaic cell waste to low active chemical landfill
373.	PV/EVA-Zellenabfälle	kg	photovoltaic panel EVA-plastic waste
374.	PVC in KVA	kg	PVC to community incineration
375.	Raffinerieschlamm in Landfarming	kg	refinery sludge to landfarming
376.	Raffinerieschlamm in Reaktordeponie	kg	refinery sludge to high active chemical landfill
377.	Raffinerieschlamm in SAVA	kg	refinery sludge to industrial incineration
378.	Rückstand Kraftwerk in Reststoffdeponie	kg	residue power plant in low active chemical landfill
379.	Schlamm in Reaktordeponie	kg	sludge in high active chemical landfill
380.	Schlamm Ionentauscher in Sonderabfall	kg	ion exchange sludge to industrial waste
381.	Schweissstaub in Sonderabfallbehandlung	kg	welding dust to industrial waste treatment
382.	Siedlungsabfall in KVA	kg	community waste to community incineration
383.	Stahl in Inertstoffdeponie	kg	steel to sanitary landfill

384.	Stahl in KVA	kg	steel to community incineration
385.	Steinkohle-Asche in Deponie	kg	hard coal ash to landfill
386.	Steinkohleberge-Deponie	kg	hard coal tailings in landfill
387.	Zeolithe in Inertstoffdeponie	kg	zeolite to sanitary landfill
	Photovoltaic		
388.	3 kWp Fassadenanlage 92 m-Si Pan/auf	stk	3kWp facade installation 92 m-Si mounted panels
389.	3 kWp Fassadenanlage 92 p-Si Pan/auf	stk	3kWp facade installation 92 p-Si mounted panels
390.	3 kWp Fassadenanlage 95 m-Si Lam/int	stk	3kWp facade installation 95 m-Si integrated laminates
391.	3 kWp Fassadenanlage 95 p-Si Lam/int	stk	3kWp facade installation 95 p-Si integrated laminates
392.	3 kWp Flachdachanlage 92 m-Si	stk	3kWp flat roof installation 92 m-Si panels
393.	3 kWp Flachdachanlage 92 p-Si	stk	3kWp flat roof installation 92 p-Si panels
394.	3 kWp Flachdachanlage 95 m-Si	stk	3kWp flat roof installation 95 m-Si laminates
395.	3 kWp Flachdachanlage 95 p-Si	stk	3kWp flat roof installation 95 p-Si laminates
396.	3 kWp Schrägdachanlage 92 m-Si Pan/auf	Stk	3kWp slope roof installation 92 m-Si mounted panels
397.	3 kWp Schrägdachanlage 92 p-Si Pan/auf	stk	3kWp slope roof installation 92 p-Si mounted panels
398.	3 kWp Schrägdachanlage 95 m-Si Lam/int	stk	3kWp slope roof installation 95 m-Si integrated laminates
399.	3 kWp Schrägdachanlage 95 p-Si Lam/int	stk	3kWp slope roof installation 95 p-Si integrated laminates
400.	Elektroinstallationen	stk	electronic equipment
401.	Fassadenkonstruktion 92	stk	facade construction 92
402.	Fassadenkonstruktion 95	stk	facade construction 95
403.	Flachdachkonstruktion 92	stk	flat roof construction 92
404.	Flachdachkonstruktion 95	stk	flat roof construction 95
405.	Holzkohle	kg	charcoal
406.	Laminat m-Si 92	kWp	laminate m-Si 92
407.	Laminat m-Si 95	kWp	laminate m-Si 95
408.	Laminat p-Si 95	kWp	laminate p-Si 95
409.	m-Si Wafer 92	stk	m-Si wafer 92
410.	m-Si Wafer 95	stk	m-Si wafer 95
411.	m-Si Zelle 92	stk	m-Si cell 92
412.	m-Si Zelle 95	stk	m-Si cell 95
413.	MG-Silizium	kg	MG silicon
414.	p-Si Wafer 92	stk	p-Si wafer 92
415.	p-Si Wafer 95	stk	p-Si wafer 95
416.	p-Si Zelle 92	stk	p-Si cell 92
417.	p-Si Zelle 95	stk	p-Si cell 95
418.	Panel m-Si 92	kWp	panel m-Si 92
419.	Panel m-Si 95	kWp	panel m-Si 95
420.	Panel p-Si 92	kWp	panel p-Si 92
421.	Panel p-Si 95	kWp	panel p-Si 95
422.	PHALK 500 PV-Anlage m-Si Lam	Stk	PV power plant PHALK, 500kWp m-Si laminates (free-standing)
423.	Schrägdachkonstruktion 92	stk	slope roof construction 92
424.	Schrägdachkonstruktion 95	stk	slope roof construction 95
425.	SSW 100kWp PV-Anlage p-Si Pan	Stk	PV power plant SAW, 100kWp p-Si panels (on sound absorbing wall)
426.	Strom ab 100 kWp SSW-Anlage	TJ	electricity from 100kWp SAW
427.	Strom ab 3kWp Fasssadenanlage 92 m-Si	TJ	electricity from 3kWp facade installation 92 m-Si
428.	Strom ab 3kWp Fasssadenanlage 92 p-Si	TJ	electricity from 3kWp facade installation 92 p-Si

429.	Strom ab 3kWp Fasssadenanlage 95 m-Si	TJ	electricity from 3kWp facade installation 95 m-Si i
430.	Strom ab 3kWp Fasssadenanlage 95 p-Si	TJ	electricity from 3kWp facade installation 95 p-Si
431.	Strom ab 3kWp Flachdachanlage 92 m-Si	TJ	electricity from 3kWp flat roof installation 92 m-Si
432.	Strom ab 3kWp Flachdachanlage 92 p-Si	TJ	electricity from 3kWp flat roof installation 92 p-Si
433.	Strom ab 3kWp Flachdachanlage 95 m-Si	TJ	electricity from 3kWp flat roof installation 95 m-Si
434.	Strom ab 3kWp Flachdachanlage 95 p-Si	TJ	electricity from 3kWp flat roof installation 95 p-Si
435.	Strom ab 3kWp Schrägdachanlage 92 m-Si	TJ	electricity from 3kWp slope roof installation 92 m-Si
436.	Strom ab 3kWp Schrägdachanlage 92 p-Si	TJ	electricity from 3kWp slope roof installation 92 p-Si
437.	Strom ab 3kWp Schrägdachanlage 95 m-Si	TJ	electricity from 3kWp slope roof installation 95 m-Si
438.	Strom ab 3kWp Schrägdachanlage 95 p-Si	TJ	electricity from 3kWp slope roof installation 95 p-Si
439.	Strom ab PHALK 500	TJ	electricity from 500kWp PHALK
440.	Wechselrichter Solcon 3300/92	stk	DC/AC converter Solcon 3300/92
441.	Wechselrichter Solcon 3400/95	stk	DC/AC converter Solcon 3400/95
	Solar Thermal		
442.	FK 1 (Aluabsorber, schwarze Farbe)	m2	FK 1 (Al absorber, black paint)
443.	FK 2 (Aluabsorber,nickelpigmen. Aluoxid)	m2	FK 2 (Al absorber, Ni-pigmented Al-oxide)
444.	FK 3 (Kupferabsorber, schwarzverchromt)	m2	FK 3 (Cu absorber, black chromized)
445.	FK 4 (Kupferabsorber, SPF-Anlage)	m2	FK 4 (Cu absorber, sputtered Mo coating)
446.	Standardanlagenteile EFH	Stk	standard construction parts, single family dwelling SFD
447.	Standardanlagenteile EFH-SPF	Stk	standard construction parts by SPF, SFD
448.	Standardanlagenteile MFH	Stk	standard residential construction parts, multiple family dwelling MFD
449.	Vakuumröhrenkollektor	m2	vacuum tube collector VTC
450.	Wärme ab EFH FK1 hybrid	TJ	useful heat from SFD FK 1 hybrid
451.	Wärme ab EFH FK1 solar	TJ	useful heat from SFD FK 1 solar
452.	Wärme ab EFH FK2 hybrid	TJ	useful heat from SFD FK 2 hybrid
453.	Wärme ab EFH FK2 solar	TJ	useful heat from SFD FK 2 solar
454.	Wärme ab EFH FK3 hybrid	TJ	useful heat from SFD FK 3 hybrid
455.	Wärme ab EFH FK3 solar	TJ	useful heat from SFD FK 3 solar
456.	Wärme ab EFH FK4 hybrid	TJ	useful heat from SFD FK 4 hybrid
457.	Wärme ab EFH FK4 solar	TJ	useful heat from SFD FK 4 solar
458.	Wärme ab EFH Vakumm hybrid	TJ	useful heat from SFD VTC hybrid
459.	Wärme ab EFH Vakuum solar	TJ	useful heat from SFD VTC solar
460.	Wärme ab MFH FK1 hybrid	TJ	useful heat from MFD FK 1 hybrid
461.	Wärme ab MFH FK1 solar	TJ	useful heat from MFD FK 1 solar
462.	Wärme ab MFH FK3 hybrid	TJ	useful heat from MFD FK 3 hybrid
463.	Wärme ab MFH FK3 solar	TJ	useful heat from MFD FK 3 solar
	Wood		
464.	1m-Rugel frei Waldstrasse	t	log of wood to forest road
465.	Diesel in Grosshacker	TJ	diesel in chopper
466.	Holz im Wald	t	wood in forest
467.	Holzabfall im Wald	t	wood waste in forest
468.	Holzschnitzel Buche frei Lager	t	wood chips beech
469.	Holzschnitzel Buche in Feuerung 300kW	TJ	wood chips beech in furnace 300kW
470.	Holzschnitzel Buche in Feuerung 50kW	TJ	wood chips beech in furnace 50kW
471.	Holzschnitzel Fichte frei Lager	t	wood chips spruce, to stock
472.	Holzschnitzel Fichte in Feuerung 300kW	TJ	wood chips spruce in furnace 300kW
473.	Holzschnitzel Fichte in Feuerung 50kW	TJ	wood chips spruce in furnace 50kW
474.	Holzschnitzel Sägerei frei Lager	t	wood chips saw-mill, to stock

475.	Holzschnitzel Sägerei in Feuerung 300kW	TJ	wood chips saw-mill in furnace 300kW
476.	Holzschnitzel Sägerei in Feuerung 50kW	TJ	wood chips saw-mill in furnace 50kW
477.	Nutzwärme ab Sägerei-HS 300 kW	TJ	useful heat from saw-mill chips 300kW
478.	Nutzwärme ab Sägerei-HS 50 kW	TJ	useful heat from saw-mill chips 50kW
479.	Nutzwärme ab Stückholz 100 kW	TJ	useful heat from logs 100kW
480.	Nutzwärme ab Stückholz 30 kW	TJ	useful heat from logs 30kW
481.	Nutzwärme ab Wald-HS Buche 300 kW	TJ	useful heat from beech chips 300kW
482.	Nutzwärme ab Wald-HS Buche 50 kW	TJ	useful heat from beech chips 50kW
483.	Nutzwärme ab Wald-HS Fichte 300 kW	TJ	useful heat from spruce chips 300kW
484.	Nutzwärme ab Wald-HS Fichte 50 kW	TJ	useful heat from spruche chips 50kW
485.	Schwachholz Buche frei Waldstrasse	t	timber beech to forest road
486.	Schwachholz Fichte frei Waldstrasse	t	timber spruce to forest road
487.	Stückholz frei Lager	t	logs to stock
488.	Stückholz in Feuerung 100kW	TJ	logs in furnace 100kW
489.	Stückholz in Feuerung 30kW	TJ	logs in furnace 30kW
	Small Scale Geothermy		
490.	Nutzwärme ab Erdwärmesonde	TJ	useful heat from geothermal probe
491.	Wärmepumpe 10 kW	Stk	heat pump 10kW

A.3 Final Modules

Final modules are modules at either the upstream end (resource depletion) or the downstream end (emissions) of the process chains. Emissions are divided into three parts: a) atmospheric emissions, b) emissions to water, and c) emissions to soil. To distinguish atmospheric and aqueous emissions the following rules apply:

- *Atmospheric emissions:* the module name consists of the substance name, ev. *preceeded* by a chemical formula, eg. «Al Aluminium p» or «Benzene m».
- *Aqueous emissions:* the module name consists of the substance name, ev. *followed* by a chemical formula. For clarification the label «in water» may be added eg. «Aluminium Al p» or «Benzene in water m».

For explanation of the suffixes *m, p,* and *s* in the names, please refer to the chapter 5.5.2.1. As a general rule the names of modules comprising more than one chemical substance are set in plural, often completed with «various». Only substances that can not be covered more precisely by other modules are reported in summarising modules.

No.	German Name of Data Module	Unit	English Translation
	Non-Energy Resources		
1.	Barit ab Erz	kg	barite
2.	Bauxit	kg	bauxite
3.	Bentonit ab Erz	kg	bentonite
4.	Blei ab Erz	kg	lead in ore
5.	Chlor	kg	chlorine as element (Cl)
6.	Chrom ab Erz	kg	chrome in ore
7.	Eisen ab Erz	kg	iron in ore
8.	Fläche II-III	m2a	land use II-III
9.	Fläche II-IV	m2a	land use II-IV
10.	Fläche III-IV	m2a	land use III-IV
11.	Fläche IV-IV	m2a	land use IV-IV
12.	Kalkstein vor Abbau	kg	limestone proir to working
13.	Kobalt	kg	cobalt
14.	Kupfer ab Erz	kg	copper in ore
15.	Mangan ab Erz	kg	manganese in ore
16.	Molybdän	kg	molybdenium

17.	Nickel ab Erz	kg	nickel in ore
18.	Palladium ab Erz	kg	palladium in ore
19.	Platin ab Erz	kg	platinium in ore
20.	Rhenium	kg	rhenium
21.	Rhodium	kg	rhodium
22.	Silber	kg	silver
23.	Steinsalz	kg	stone salt
24.	Turbinierwassermenge	m3	watermass turbine
25.	Wasser	kg	Water
26.	Zeolith	kg	zeolite
27.	Zink ab Erz	kg	zinc in ore
28.	Zinn	kg	tin
29.	Erdölgas	Nm3	oil gas (gas from combined oil/gas fields)
30.	Grubengas (Methan)	kg	mine gas (gas from coal mines)
31.	Holz	t	wood
32.	Nutzinhalt Speichersee	m3a	reservoir content (water)
33.	Potentielle Energie Wasser	TJ	potential energy water
34.	Rohbraunkohle vor Förderung	kg	crude lignite (prior to production)
35.	Rohfördersteinkohle vor Aufbereitung	kg	crude hard coal (prior to conditioning)
36.	Rohgas (Erdgas)	Nm3	crude natural gas
37.	Rohöl ab Bohrloch	t	crude oil (from well)
38.	Uran ab Erz	kg	natural uranium in ore
	Atmospheric Emissions		
39.	Abwärme in Luft m	TJ	waste heat to air m
40.	Abwärme in Luft p	TJ	waste heat to air p
41.	Abwärme in Luft s	TJ	waste heat to air s
42.	Acetaldehyd s	kg	acetaldehyde s
43.	Aceton s	kg	acetone s
44.	Acrolein s	kg	acrolein s
45.	Al Aluminium m	kg	Al Aluminium m
46.	Al Aluminium p	kg	Al Aluminium p
47.	Al Aluminium s	kg	Al Aluminium s
48.	Aldehyde p	kg	aldehydes p
49.	Alkane p	kg	alkanes p
50.	Alkane s	kg	alkanes s
51.	Alkene p	kg	alkenes p
52.	Alkene s	kg	alkenes s
53.	Aromaten p	kg	aromatics p
54.	Aromaten s	kg	aromatics s
55.	As Arsen p	kg	As arsenic p
56.	As Arsen s	kg	As arsenic s
57.	B Bor p	kg	B boron p
58.	B Bor s	kg	B boron s
59.	Ba Barium p	kg	Ba barium p
60.	Ba Barium s	kg	Ba barium s
61.	BaP Benzo(a)pyren m	kg	benzo(a)pyrene m
62.	BaP Benzo(a)pyren p	kg	benzo(a)pyrene p
63.	BaP Benzo(a)pyren s	kg	benzo(a)pyrene s
64.	Be Beryllium p	kg	Be beryllium p
65.	Be Beryllium s	kg	Be beryllium s
66.	Benzaldehyd s	kg	benzaldehyde s
67.	Benzol m	kg	benzene m (C6H6)
68.	Benzol p	kg	benzene p
69.	Benzol s	kg	benzene s
70.	Br Brom p	kg	Br bromine p
71.	Br Brom s	kg	Br bromine s
72.	Butan p	kg	butane p (C H 3(C H 2)C H 3)
73.	Butan s	kg	butane s

74.	Buten p	kg	butene p
75.	C2F6 p	kg	C2F6 p (hexafluoroethane)
76.	Ca Calcium m	kg	Ca calcium m
77.	Ca Calcium p	kg	Ca calcium p
78.	Ca Calcium s	kg	Ca calcium s
79.	Cd Cadmium m	kg	Cd cadmium m
80.	Cd Cadmium p	kg	Cd cadmium p
81.	Cd Cadmium s	kg	Cd cadmium s
82.	CF4 p	kg	CF4 p (tetrafluoromethane)
83.	C H 4 Methan m	kg	C H 4 methane m
84.	C H 4 Methan p	kg	C H 4 methane p
85.	C H 4 Methan s	kg	C H 4 methane s
86.	CN Cyanide p	kg	cyanides various p
87.	CN Cyanide s	kg	cyanides various s
88.	Co Cobalt p	kg	Co cobalt p
89.	Co Cobalt s	kg	Co cobalt s
90.	CO Kohlenmonoxid m	kg	CO carbon monoxide m
91.	CO Kohlenmonoxid p	kg	CO carbon monoxide p
92.	CO Kohlenmonoxid s	kg	CO carbon monoxide s
93.	CO2 Kohlendioxid m	kg	CO2 carbon dioxide m
94.	CO2 Kohlendioxid p	kg	CO2 carbon dioxide p
95.	CO2 Kohlendioxid s	kg	CO2 carbon dioxide s
96.	Cr Chrom p	kg	Cr chromium p
97.	Cr Chrom s	kg	Cr chromium s
98.	Cu Kupfer m	kg	Cu copper m
99.	Cu Kupfer p	kg	Cu copper p
100.	Cu Kupfer s	kg	Cu copper s
101.	Cycloalkane p	kg	cyclic alkanes p
102.	Essigsäure s	kg	acetic acid s (C H 3COOH)
103.	Ethan p	kg	ethane p (C H 3C H 3)
104.	Ethan s	kg	ethane
105.	Ethanol p	kg	ethanol (C H 3C H 2OH)
106.	Ethanol s	kg	ethanol
107.	Ethen p	kg	ethene (C H 2=C H 2)
108.	Ethen s	kg	ethene
109.	Ethin s	kg	ethyne (HCC H)
110.	Ethylbenzol p	kg	ethylbenzene (C6H5 (C H 2C H 3))
111.	Ethylbenzol s	kg	ethylbenzene
112.	Ethylen Dichlorid	kg	ethylene dichloride ((C H 2Cl)2)
113.	Fe Eisen m	kg	Fe iron m
114.	Fe Eisen p	kg	Fe iron p
115.	Fe Eisen s	kg	Fe iron s
116.	Formaldehyd p	kg	formaldehyde (H2CO)
117.	Formaldehyd s	kg	formaldehyde
118.	H 1301 Halon p	kg	halon H 1301 p
119.	H2S Schwefelwasserstoff p	kg	H2S hydrogen sulphide p
120.	H2S Schwefelwasserstoff s	kg	H2S hydrogen sulphide s
121.	HCl Salzsäure p	kg	HCl hydrogen chloride p
122.	HCl Salzsäure s	kg	HCl hydrogen chloride s
123.	He Helium p	kg	He helium p
124.	he Helium s	kg	He helium s
125.	Heptan p	kg	n-heptane p
126.	Hexan p	kg	hexane p
127.	HF Fluorwasserstoff p	kg	HF hydrogen fluoride p
128.	HF Fluorwasserstoff s	kg	HF hydrogen fluoride s
129.	Hg Quecksilber p	kg	Hg mercury p
130.	Hg Quecksilber s	kg	Hg mercury s
131.	I Iod p	kg	I iodine p

132.	I Iod s	kg	I iodine s
133.	K Kalium p	kg	K potassium p
134.	K Kalium s	kg	K potassium p
135.	La Lanthan p	kg	La lanthanum p
136.	La Lanthan s	kg	La lanthanum s
137.	Methanol s	kg	methanol s (C H 3OH)
138.	Mg Magnesium p	kg	Mg magnesium p
139.	Mg Magnesium s	kg	Mg magnesium s
140.	Mn Mangan p	kg	Mn manganese p
141.	Mn Mangan s	kg	Mn manganese s
142.	Mo Molybdän p	kg	Mo molybdenium p
143.	Mo Molybdän s	kg	Mo molybdenium s
144.	MTBE p	kg	MTBE p (methyl tert-butyl ether)
145.	N2 Stickstoff p	kg	N2 nitrogen p
146.	N2O Lachgas m	kg	N2O nitrous oxide m
147.	N2O Lachgas p	kg	N2O nitrous oxide p
148.	N2O Lachgas s	kg	N2O nitrous oxide s
149.	Na Natrium m	kg	Na sodium m
150.	Na Natrium p	kg	Na sodium p
151.	Na Natrium s	kg	Na sodium s
152.	NH3 Ammoniak p	kg	NH3 ammonia p
153.	NH3 Ammoniak s	kg	NH3 ammonia s
154.	Ni Nickel m	kg	Ni nickel m
155.	Ni Nickel p	kg	Ni nickel p
156.	Ni Nickel s	kg	Ni nickel s
157.	NMVOC m	kg	NMVOC m (non-methane VOC)
158.	NMVOC p	kg	NMVOC p
159.	NMVOC s	kg	NMVOC s
160.	NOx Stickoxide als NO2 m	kg	NOx nitrogen oxides as NO2 m
161.	NOx Stickoxide als NO2 p	kg	NOx nitrogen oxides as NO2 p
162.	NOx Stickoxide als NO2 s	kg	NOx nitrogen oxides as NO2 s
163.	P Phosphor m	kg	P phosphorous m
164.	P Phosphor p	kg	P phosphorous p
165.	P Phosphor s	kg	P phosphorous s
166.	PAH Polyzyklische aromatische HC s	kg	PAH various s (polycyclic aromatics)
167.	Partikel m	kg	particles m
168.	Partikel p	kg	particles p
169.	Partikel s	kg	particles s
170.	Pb Blei m	kg	Pb lead m
171.	Pb Blei p	kg	Pb lead p
172.	Pb Blei s	kg	Pb lead s
173.	Pentan p	kg	n-pentane p (C H 3 (C H 2)3 C H 3)
174.	Pentane s	kg	n-pentane s
175.	Phenol s	kg	phenol s (C6H5OH)
176.	Propan p	kg	propane p (C H 3 C H 2 C H 3)
177.	Propan s	kg	propane s
178.	Propen p	kg	propene p (C H 2=C H C H 3)
179.	Propen s	kg	propene s
180.	Propionaldehyd s	kg	propionaldehyde (C H 3 C H 2 C H O)
181.	Propionsäure s	kg	propionic acid (C H 3 C H 2 COOH)
182.	Pt Platin m	kg	Pt platinum m
183.	R134a FKW p	kg	HFC 134a p
184.	R22 FCKW p	kg	HCFC 22 p
185.	Radio. Aerosole p	kBq	rad.aerosols various p
186.	Radio. Aktinide p	kBq	rad.actinides various p
187.	Radio. Am241 p	kBq	rad.Am241 p
188.	Radio. Ba140 p	kBq	rad.Ba140 p
189.	Radio. C14 p	kBq	rad.C14 p

190.	Radio. Ce141 p	kBq	rad.Ce141 p
191.	Radio. Ce144 p	kBq	rad.Ce144 p
192.	Radio. Cm alpha p	kBq	rad.Cm alpha p
193.	Radio. Co58 p	kBq	rad.Co58 p
194.	Radio. Co60 p	kBq	rad.Co60 p
195.	Radio. Cr51 p	kBq	rad.Cr51 p
196.	Radio. Cs134 p	kBq	rad.Cs134 p
197.	Radio. Cs137 p	kBq	rad.Cs137 p
198.	Radio. Edelgase p	kBq	rad. noble gases various p
199.	Radio. Fe59 p	kBq	rad.Fe59 p
200.	Radio. H3 p	kBq	rad.H3 p
201.	Radio. I129 p	kBq	rad.I129 p
202.	Radio. I131 p	kBq	rad.I131 p
203.	Radio. K40 s	kBq	rad.K40 s
204.	Radio. Kr85 p	kBq	rad.Kr85 p
205.	Radio. Kr87 p	kBq	rad.Kr87 p
206.	Radio. Kr88 p	kBq	rad.Kr88 p
207.	Radio. La140 p	kBq	rad.La140 p
208.	Radio. Mn54 p	kBq	rad.Mn54 p
209.	Radio. Nb95 p	kBq	rad.Nb95 p
210.	Radio. Np237 p	kBq	rad.Np237 p
211.	Radio. Pa234m p	kBq	rad.Pa234m p
212.	Radio. Pb210 s	kBq	rad.Pb210 s
213.	Radio. Pm147 p	kBq	rad.Pm147 p
214.	Radio. Po 210 s	kBq	rad.Po 210 s
215.	Radio. Pu alpha p	kBq	rad.Pu alpha p
216.	Radio. Pu241 Beta p	kBq	rad.Pu241 Beta p
217.	Radio. Ra226 p	kBq	rad.Ra226 p
218.	Radio. Ra226 s	kBq	rad.Ra226 s
219.	Radio. Ra228 s	kBq	rad.Ra228 s
220.	Radio. Rn220 s	kBq	rad.Rn220 s
221.	Radio. Rn222 p	kBq	rad.Rn222 p
222.	Radio. Rn222 s	kBq	rad.Rn222 s
223.	Radio. Ru103 p	kBq	rad.Ru103 p
224.	Radio. Ru106 p	kBq	rad.Ru106 p
225.	Radio. Sb124 p	kBq	rad.Sb124 p
226.	Radio. Sr90 p	kBq	rad.Sr90 p
227.	Radio. Tc99 p	kBq	rad.Tc99 p
228.	Radio. Th228 s	kBq	rad.Th228 s
229.	Radio. Th230 p	kBq	rad.Th230 p
230.	Radio. Th232 s	kBq	rad.Th232 s
231.	Radio. Th234 p	kBq	rad.Th234 p
232.	Radio. U alpha p	kBq	rad.U alpha p
233.	Radio. U234 p	kBq	rad.U234 p
234.	Radio. U235 p	kBq	rad.U235 p
235.	Radio. U238 p	kBq	rad.U238 p
236.	Radio. U238 s	kBq	rad.U238 s
237.	Radio. Xe133	kBq	rad.Xe133
238.	Radio. Xe135 p	kBq	rad.Xe135 p
239.	Radio. Xe135m p	kBq	rad.Xe135m p
240.	Radio. Xe138 p	kBq	rad.Xe138 p
241.	Radio. Zn65 p	kBq	rad.Zn65 p
242.	Radio. Zr95 p	kBq	rad.Zr95 p
243.	Sb Antimon p	kg	Sb antimony p
244.	Sb Antimon s	kg	Sb antimony s
245.	Sc Scandium p	kg	Sc scandium p
246.	Sc Scandium s	kg	Sc scandium s
247.	Se Selen p	kg	Se selenium p

248.	Se Selen s	kg	Se selenium s
249.	Si Silizium m	kg	Si silicon m
250.	Si Silizium p	kg	Si silicon p
251.	Si Silizium s	kg	Si silicon s
252.	Sn Zinn p	kg	Sn tin p
253.	Sn Zinn s	kg	Sn tin s
254.	SOx als SO2 m	kg	SOx sulphur oxides as SO2 m
255.	SOx als SO2 p	kg	SOx sulphur oxides as SO2 p
256.	SOx als SO2 s	kg	SOx sulphur oxides as SO2 s
257.	Sr Strontium p	kg	Sr strontium p
258.	Sr Strontium s	kg	Sr strontium s
259.	TCDD-Äquivalente	ng	TCDD equivalents (tetrachloride-dibenzo-dioxin)
260.	Th Thorium p	kg	Th thorium p
261.	Th Thorium s	kg	Th thorium s
262.	Ti Titan p	kg	Ti titanium p
263.	Ti Titan s	kg	Ti titanium s
264.	Tl Thallium p	kg	Tl thallium p
265.	Tl Thallium s	kg	Tl thallium s
266.	Toluol p	kg	toluene p (C6H5C H 3)
267.	Toluol s	kg	toluene s
268.	U Uran p *	kg	U uranium p
269.	U Uran s *	kg	U uranium s
270.	V Vanadium m	kg	V vanadium m
271.	V Vanadium p	kg	V vanadium p
272.	V Vanadium s	kg	V vanadium s
273.	Vinyl Chlorid	kg	vinyl chloride (C H 2=C H Cl)
274.	Xylole p	kg	xylene p (C6H4 (C H 3)2)
275.	Xylole s	kg	xylene s
276.	Zn Zink m	kg	Zn zinc m
277.	Zn Zink p	kg	Zn zinc p
278.	Zn Zink s	kg	Zn zinc s
279.	Zr Zirkonium p	kg	Zr zirconium p
	Emissions to Water		
280.	Abwärme in Wasser m	TJ	waste heat to water m
281.	Abwärme in Wasser s	TJ	waste heat to water s
282.	Aktivchlor p	kg	availible chlorine p (Cl2)
283.	Alkane in Wasser p	kg	alkanes various to water p
284.	Alkene in Wasser p	kg	alkenes various to water p
285.	Ammoniak als N p	kg	ammonia as N p (NH3 as N)
286.	AOX p	kg	AOX p
287.	Arom. KWe gesamt p	kg	aromatics various p
288.	Barit p	kg	barite p
289.	Basen gesamt p	kg	alkalines various p
290.	Benzol in Wasser p	kg	benzene in water p
291.	BSB5 p	kg	BOD5 p
292.	Chlor. Chlorbenzol p	kg	chlor. chlorobenzene p
293.	Chlor. Ethylen Dichlorid	kg	chlor. ethylene dichloride
294.	Chlor. HOCl p	kg	chlor. hypochlorous acid HOCl
295.	Chlor. Lösungsmittel gesamt p	kg	chlorinated solvents various p
296.	Chlor. Methylenchlorid p	kg	chlor. methylene chloride
297.	Chlor. OCl p	kg	chlor. hypochlorite OCl-
298.	Chlor. Trichlorethylen	kg	chlor. trichloroethylene (C2HCl3)
299.	Chloride p	kg	chloride Cl-
300.	COD p	kg	COD p
301.	Cyanide p	kg	cyanide CN- p
302.	Diamine gesamt p	kg	diamines various p
303.	DOC p	kg	DOC p

304.	Ethylbenzol in Wasser p	kg	ethylbenzene in water p
305.	Fette und Oele gesamt m	kg	fats and oils various m
306.	Fette und Oele gesamt p	kg	fats and oils various p
307.	Fettsäuren als C gesamt p	kg	fatty acids as C p
308.	Flüchtige organ. Verbindungen als C p	kg	VOC as C p (volatile organic compounds)
309.	Fluoride p	kg	fluorides various as F- p
310.	Formaldehyd in Wasser p	kg	formaldehyde in water p
311.	gelöste Stoffe p *	kg	dissolved substances p
312.	Glutaraldehyd in Wasser p	kg	glutaric aldehyde p
313.	Ion Aluminium p	kg	ion Al p
314.	Ion Antimon Sb p	kg	ion Sb p
315.	Ion Arsen p	kg	ion As p
316.	Ion Barium p	kg	ion Ba p
317.	Ion Berillium p	kg	ion Be p
318.	Ion Blei p	kg	ion Pb p
319.	Ion Bor p	kg	ion B p
320.	Ion Cadmium p	kg	ion Cd p
321.	Ion Calcium p	kg	ion Ca p
322.	Ion Cäsium p	kg	ion Cs p
323.	Ion Chrom-III p	kg	ion Cr3+ p
324.	Ion Chrom-VI p	kg	ion Cr6+ p
325.	Ion Eisen p	kg	ion Fe p
326.	Ion Iod p	kg	ion iodide I- p
327.	Ion Kalium p	kg	ion K p
328.	Ion Kobalt p	kg	ion Co p
329.	Ion Kupfer p	kg	ion Cu p
330.	Ion Magnesium p	kg	ion Mg p
331.	Ion Mangan p	kg	ion Mn p
332.	Ion Molybdän p	kg	ion Mo p
333.	Ion Natrium p	kg	ion Na p
334.	Ion Nickel p	kg	ion Ni p
335.	Ion Quecksilber p	kg	ion Hg p
336.	Ion Quecksilber s	kg	ion Hg p
337.	Ion Rubidium p	kg	ion Rb p
338.	Ion Selen p	kg	ion Se p
339.	Ion Silber p	kg	ion Ag p
340.	Ion Silizium p	kg	ion Si p
341.	Ion Strontium p	kg	ion Sr p
342.	Ion Titan p	kg	ion Ti p
343.	Ion Vanadium p	kg	ion V p
344.	Ion Wolfram p	kg	ion W p
345.	Ion Zink p	kg	ion Zn p
346.	Ion Zinn p	kg	ion Sn p
347.	Kohlenwasserstoffe gesamt p	kg	hydrocarbons various, CxHy p
348.	Metallionen gesamt p	kg	metal ions various p
349.	MTBE in Wasser p	kg	MTBE in water p
350.	Nitrate p	kg	nitrates various as NO3- p
351.	Nitrite p	kg	nitrites various as NO2- p
352.	PAH Polycyklische arom. KWe in Wasser p	kg	PAH various in water p (polyaromatic hydrocarbons)
353.	Phenole p	kg	phenols various p
354.	Phosphate p	kg	phosphates various as PO4- - -
355.	Phosphor Verb. p	kg	phosphorous compounds as P p
356.	Polyzykl. arom. KWe p	kg	PAH various p (polyaromatic hydrocarbons, redundant to No. 352)
357.	Rad. Aktinide p	kBq	rad.actinides various in water p
358.	Rad. Am241 p	kBq	rad.Am241 in water p
359.	Rad. C14 p	kBq	rad.C14 in water p
360.	Rad. Cr51 p	kBq	rad.Cr51 in water p

361.	Rad. Ce144 p	kBq	rad.Ce144 in water p
362.	Rad. Cm alpha p	kBq	rad.Cm alpha in water p
363.	Rad. Co58 p	kBq	rad.Co58 in water p
364.	Rad. Co60 p	kBq	rad.Co60 in water p
365.	Rad. Cs134 p	kBq	rad.Cs134 in water p
366.	Rad. Cs137 p	kBq	rad.Cs137 in water p
367.	Rad. H3 p	kBq	rad.H3 in water p
368.	Rad. I129 p	kBq	rad.I129 in water p
369.	Rad. I131 p	kBq	rad.I131 in water p
370.	Rad. K 40 p	kBq	rad.K40 in water p
371.	Rad. Mn54 p	kBq	rad.Mn54 in water p
372.	Rad. Mn55 p	kBq	rad.Mn55 in water p
373.	Rad. Nb95 p	kBq	rad.Nb95 in water p
374.	Rad. Np237 p	kBq	rad.Np237 in water p
375.	Rad. Nuklidgemisch p	kBq	rad.nuclides mix in water p
376.	Rad. Pa234m p	kBq	rad.Pa234m in water p
377.	Rad. Pb 210 p	kBq	rad.Pb210 in water p
378.	Rad. Po 210 p	kBq	rad.Po210 in water p
379.	Rad. Pu alpha p	kBq	rad.Pu alpha in water p
380.	Rad. Pu241 beta p	kBq	rad.Pu241 beta in water p
381.	Rad. Ra 224 p	kBq	rad.Ra224 in water p
382.	Rad. Ra 226 p	kBq	rad.Ra226 in water p
383.	Rad. Ra 228 p	kBq	rad.Ra228 in water p
384.	Rad. Ru103 p	kBq	rad.Ru103 in water p
385.	Rad. Ru106 p	kBq	rad.Ru106 in water p
386.	Rad. Sb124 p	kBq	rad.Sb124 in water p
387.	Rad. Sb125 p	kBq	rad.Sb125 in water p
388.	Rad. Sr90 p	kBq	rad.Sr90 in water p
389.	Rad. Tc99 p	kBq	rad.Tc99 in water p
390.	Rad. Th 228 p	kBq	rad.Th228 in water p
391.	Rad. Th 232 p	kBq	rad.Th232 in water p
392.	Rad. Th230 p	kBq	rad.Th230 in water p
393.	Rad. Th234 p	kBq	rad.Th234 in water p
394.	Rad. U 238 p	kBq	rad.U238 in water p
395.	Rad. U alpha p	kBq	rad.U alpha in water p
396.	Rad. U234 p	kBq	rad.U234 in water p
397.	Rad. U235 p	kBq	rad.U235 in water p
398.	Rad. Zn65 p	kBq	rad.Zn65 in water p
399.	Rad. Zr95 p	kBq	rad.Zr95 in water p
400.	Salze p	kg	salts various p
401.	Säuren gesamt p	kg	acids various p
402.	Schwebestoffe p	kg	suspended substances p
403.	Schwefelwasserstoff p	kg	hydrogen sulphide H2S p
404.	Stickstoff Gesamt p	kg	nitrogenous compounds various as N p
405.	Stickstoff organ. gebund. p	kg	organic bonded nitrogen p
406.	Sulfate p	kg	sulfates various as SO4- - p
407.	Sulfate s	kg	sulfates various as SO4- - s
408.	Sulfide p	kg	sulfides various as S-- p
409.	Sulfite p	kg	sulfites various as SO3- - p
410.	TOC p	kg	TOC p
411.	Toluol in Wasser p	kg	toluene in water (C6H5C H 3)
412.	Tributylzinn TBT p	kg	tributyl tin p (Sn (C4H9)3)
413.	Ungelöste Stoffe p	kg	unsolved substances p
414.	Xylol in Wasser p	kg	xylenes in water p (C6H4 (C H 3)2)
	Emissions to Soil		
415.	Abwärme in Boden p	TJ	waste heat to soil p
416.	Öl biol. p	kg	animal/vegetable oil p
417.	Öl p	kg	mineral oil p

A.4 Summarised Results

The translation of the summarised results categories from part XIII.

Ressourcen	Unit	Resources
Fläche II - III	m2a	land use II – III
Fläche II - IV	m2a	land use II – IV
Fläche III - IV	m2a	land use III – IV
Fläche IV - IV	m2a	land use IV – IV
Erdölgas	m3	gas from oil/gas fields
Rohgas	m3	natural gas
Grubengas	m3	mine gas
Rohöl	t	crude oil
Rohfördersteinkohle	kg	crude hard coal
Rohbraunkohle	kg	crude lignite
Uran ab Erz	kg	uranium in ore
Potentielle Energie Wasser	TJ	potential energy of water
Holz im Wald	t	wood in forests (dry matter)
Wasser total	kg	water total
Strom total	TJ	**Electricity total**
Materialien		**Materials**
Materialien total	kg	materials total
Betonkies	kg	concrete gravel
Kalkstein vor Abbau	kg	limestone
Stahl und Guss total	kg	steel and cast iron total
Kupfer	kg	copper
Transporte		**Transport**
Transport LKW	tkm	transport street
Transport Schiene	tkm	transport rail
Transport Schiff	tkm	transport ship
Abwärme total	TJ	**Waste Heat total**
Emissionen Luft		**Emissions in Air**
CO2 m	kg	CO2 from mobile sources
CO2 p	kg	CO2 from processing steps
CO2 s	kg	CO2 from stationary sources
SOx als SO2 total	kg	SOx as SO2 total
NOx als NO2 total	kg	NOx as NO2 total
C H 4 total	kg	C H 4 total
NMVOC total	kg	Non-Methane VOCs total
BTEX-Aromaten total	kg	BTEX aromatics total
Benzo(a)Pyren total	kg	benzo[*a*]pyrenes
HCl total	kg	HCl total
Hg Quecksilber total	kg	Hg mercury total
Vanadium total	kg	V vanadium total
Rn total (inkl. Ra total)	kBq	Rn & Ra, Radon and Radium total
Edelgase total	kBq	rad. noble gases total
Aerosole total	kBq	rad. aerosols total
Aktinide total	kBq	rad. actinides in air total
Emissionen Wasser		**Emissions in Water**
Chloride total	kg	chlorides total
Sulfate total	kg	sulphates total
Ammoniak als N total	kg	ammonia as N total
Fette und Öle gesamt	kg	fats and oils total
Arom. Kohlenwasserstoffe	kg	aromatics total
Zink	kg	zinc total
Ra total	kBq	Radon in water total
H3	kBq	H3
Nuklidgemisch total	kBq	Nuclides various
Aktinide total	kBq	rad. actinides in water total
Abfälle		**Wastes**
Inertstoffdeponie	kg	wastes to sanitary landfill
Reststoffdeponie	kg	wastes to low active chemical landfill
Reaktordeponie	kg	wastes to high active chemical landfill
KVA	kg	wastes to community incineration
Sonderabfälle	kg	industrial wastes
Landfarming	kg	wastes to landfarming
Schwachaktive Abfälle	m3	low active wastes (landfill)
Schwach und mittelaktive Abfälle	m3	low and medium active wastes (B)
Hochaktive Abfälle	m3	high active wastes (C)

Annex B: Figures of Process Chain Structures

B.1 General

The figures show the *principal* interconnections between the modules of each inventoried energy system. The delivered energy service is placed at the top of the sheet. The connected modules upstream through the process chain are displayed. Each module is represented by a box with its *name* and followed by its *output unit* .

The arrows indicate the «direction of request»; the given number is the direct linking factor (input data). E.g. an arrow from *«lignite dust TJ»* to *«crude lignite from mine t»* with factor 111.4 signifies that the production of one terajoule (TJ) of lignite dust has a *direct* input of (or requires) 111.4 tons of crude lignite. The *cumulated* crude lignite consumption is bigger due to higher order requests. The cumulated data is contained in the result files and is not displayed here.

Only the modules of one energy system are shown per panel. Other links to requested energy services, standard modules (materials, transport, disposal) or emission modules are *not* shown in the figure. The aim is to give a basic understanding of the structure of the inventoried process chain and not a complete representation of all links. The different energy system categories are explained in Annex C «How to use the data diskettes». Apart from the energy systems a figure of the applied electricity mixture are shown additionally.

Not all links of the displayed modules are shown. The given data is taken from the input files.
In case of inconsistencies the information of the software files on the data diskettes is valid.

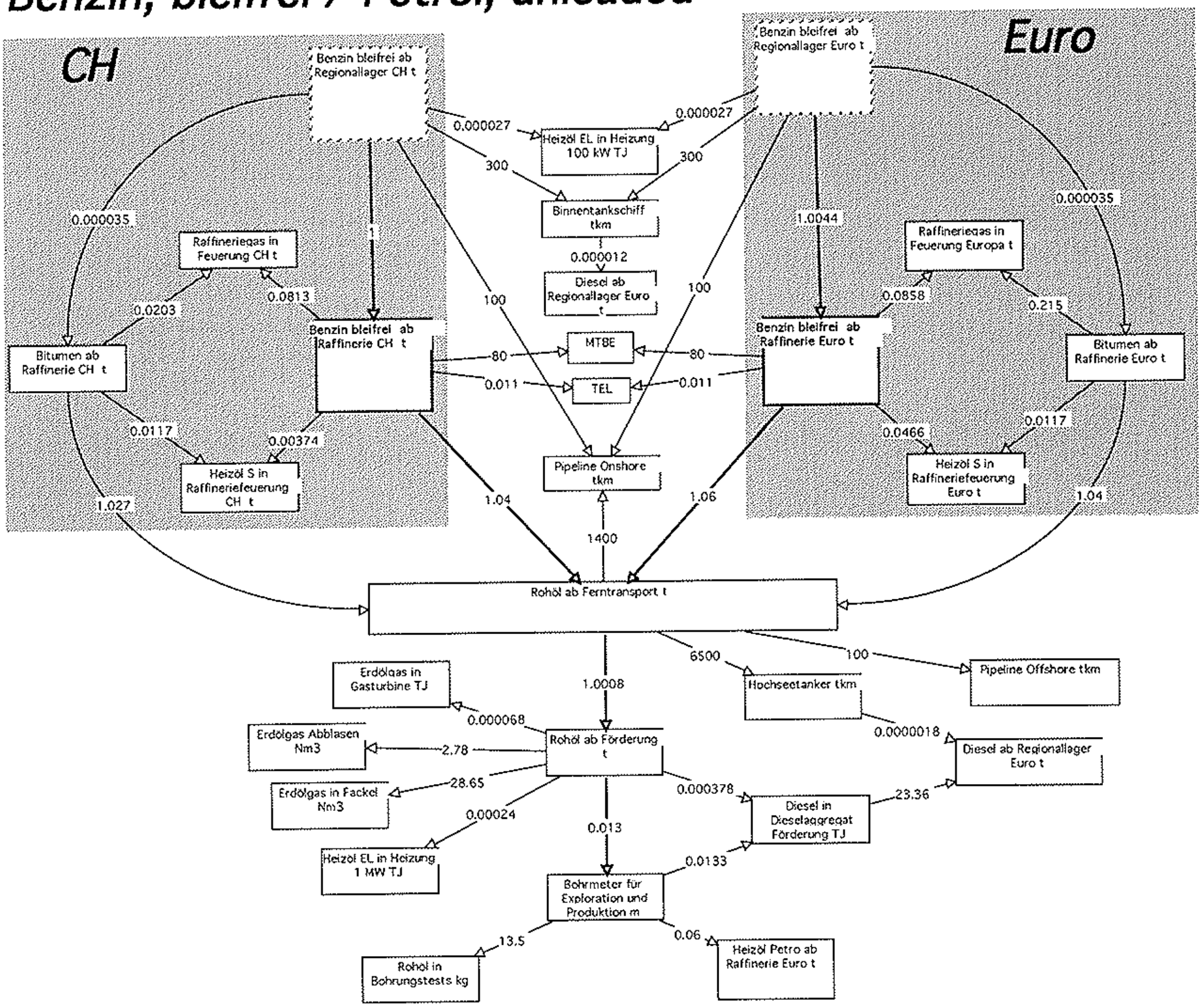
B.2 Layout rules

- As a rule each module is only displayed once, hence showing all links of that module within the energy system. Exceptions to this rule had to be made, when the resulting set of arrows became too tangled, e.g. the *«leakage...»*-modules in the natural gas chain and the modules of the waste disposal chain in the nuclear fuel cycle are repeated at different locations. For the UCPTE coal power plants and the complete natural gas precombustion only one example for one country is displayed in full length. The other contributors have a mostly analogous structure but different input data.
- The various energy services of one system are displayed at the top of the panel. Below that, the upstream processes are represented. Generally, the downward direction represents the upstream path of the process chain. Exceptions were made, e.g. in the solar thermal system.
- For better orientation modules of equal function within the process chain are clustered together or at least displayed at equal height, if possible.
- The main fuel path is indicated with bold arrows (⟶). In the photovoltaic process chain the upstream silicon path is indicated that way.
- There are some module boxes, that do not belong to the category of the presented energy system but are of certain importance for the process chain or give additional information. Those boxes are dimmed (). The data module categories applied here are explained in Annex C.2.

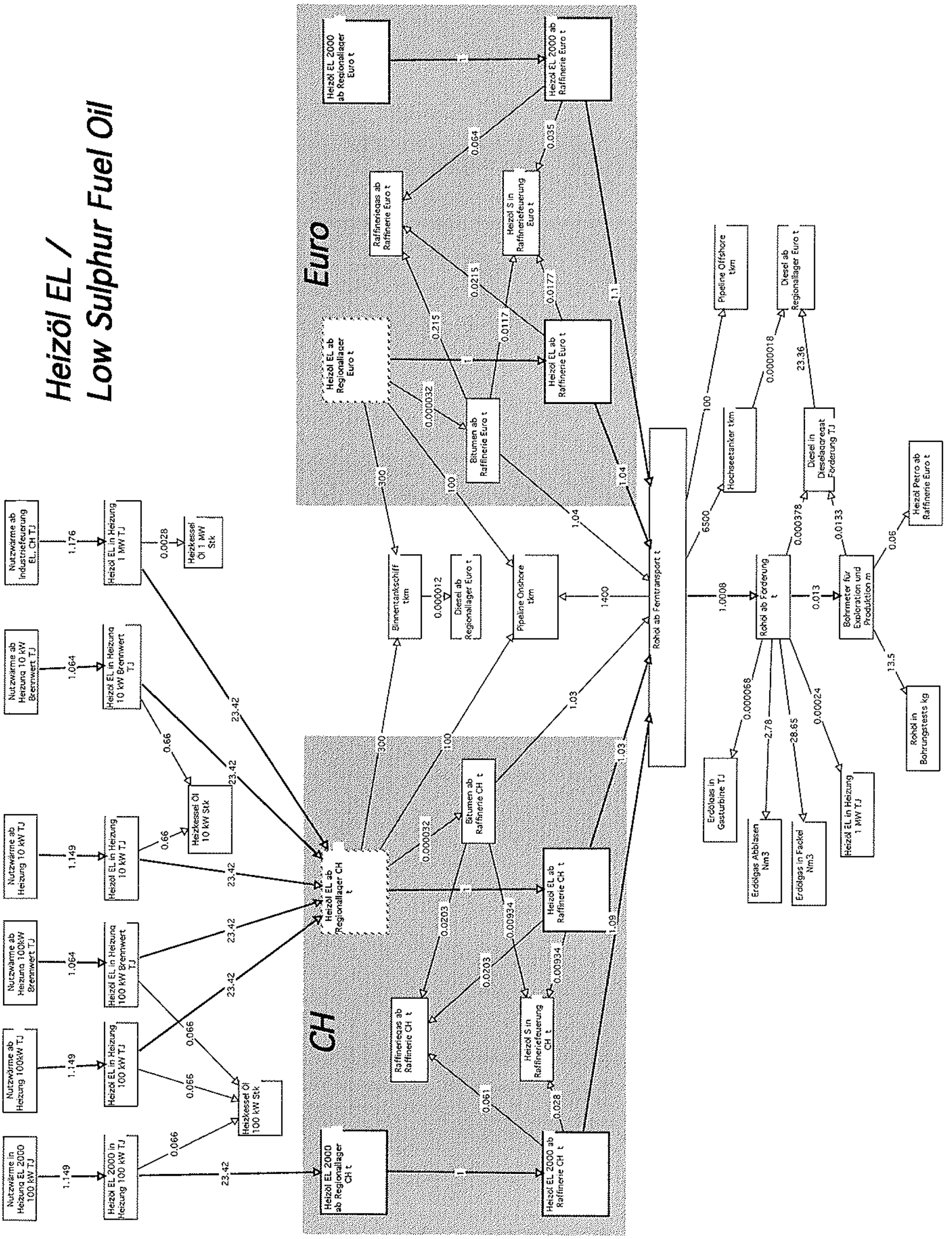
Diaplayed Figures

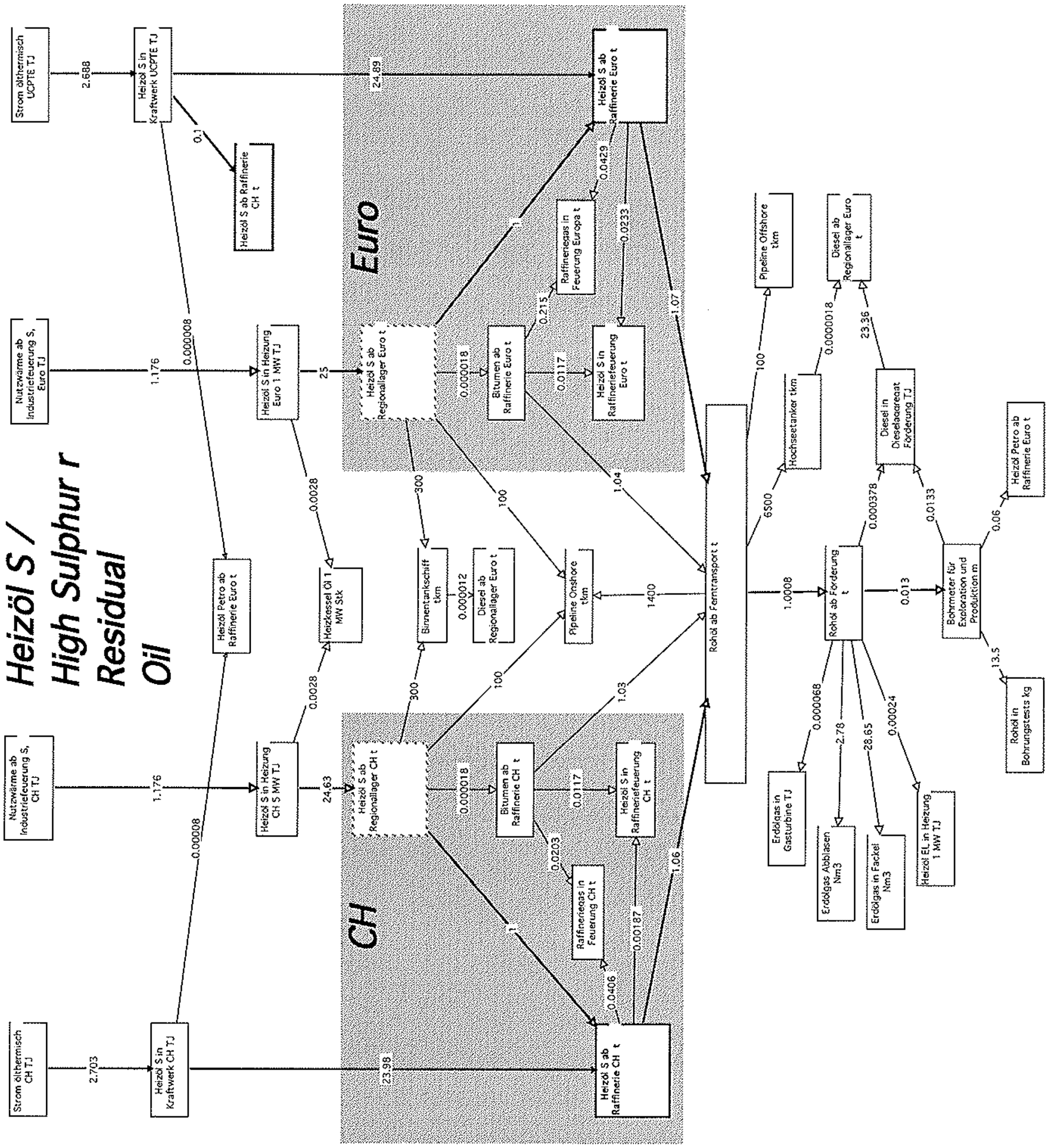
- Oil process chain for unleaded petrol
- Oil process chain for low sulphur fuel oil and corresponding energy services
- Oil process chain for high sulphur residual oil and corresponding energy services
- Natural gas process chain
- Coal process chain
- Nuclear process chain
- Hydroelectric process chain and applied electricity mixture in the Swiss and UCPTE grid
- Photovoltaics
- Solar thermal
- Wood thermal

Benzin, bleifrei / Petrol, unleaded



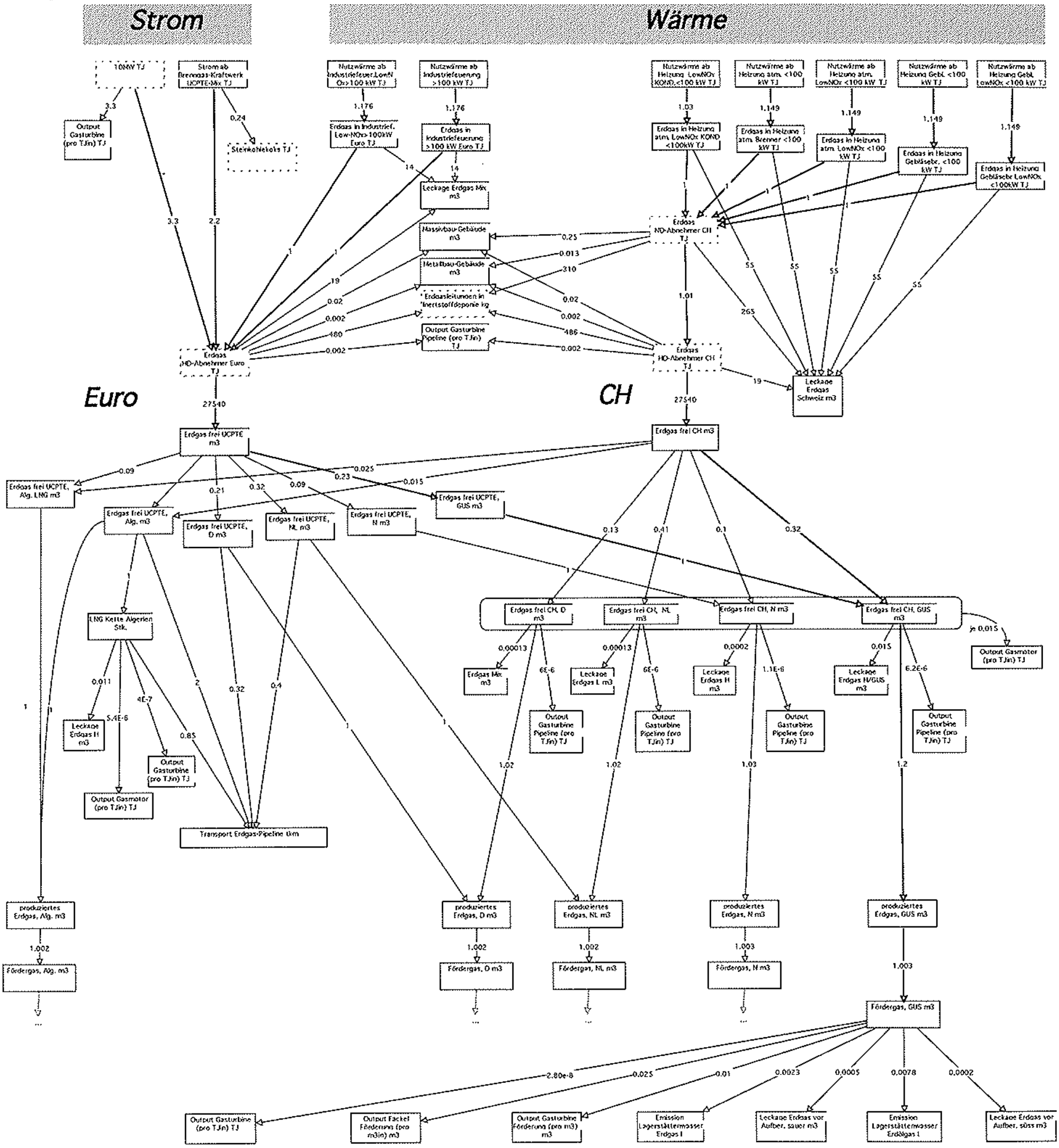
Heizöl EL / Low Sulphur Fuel Oil

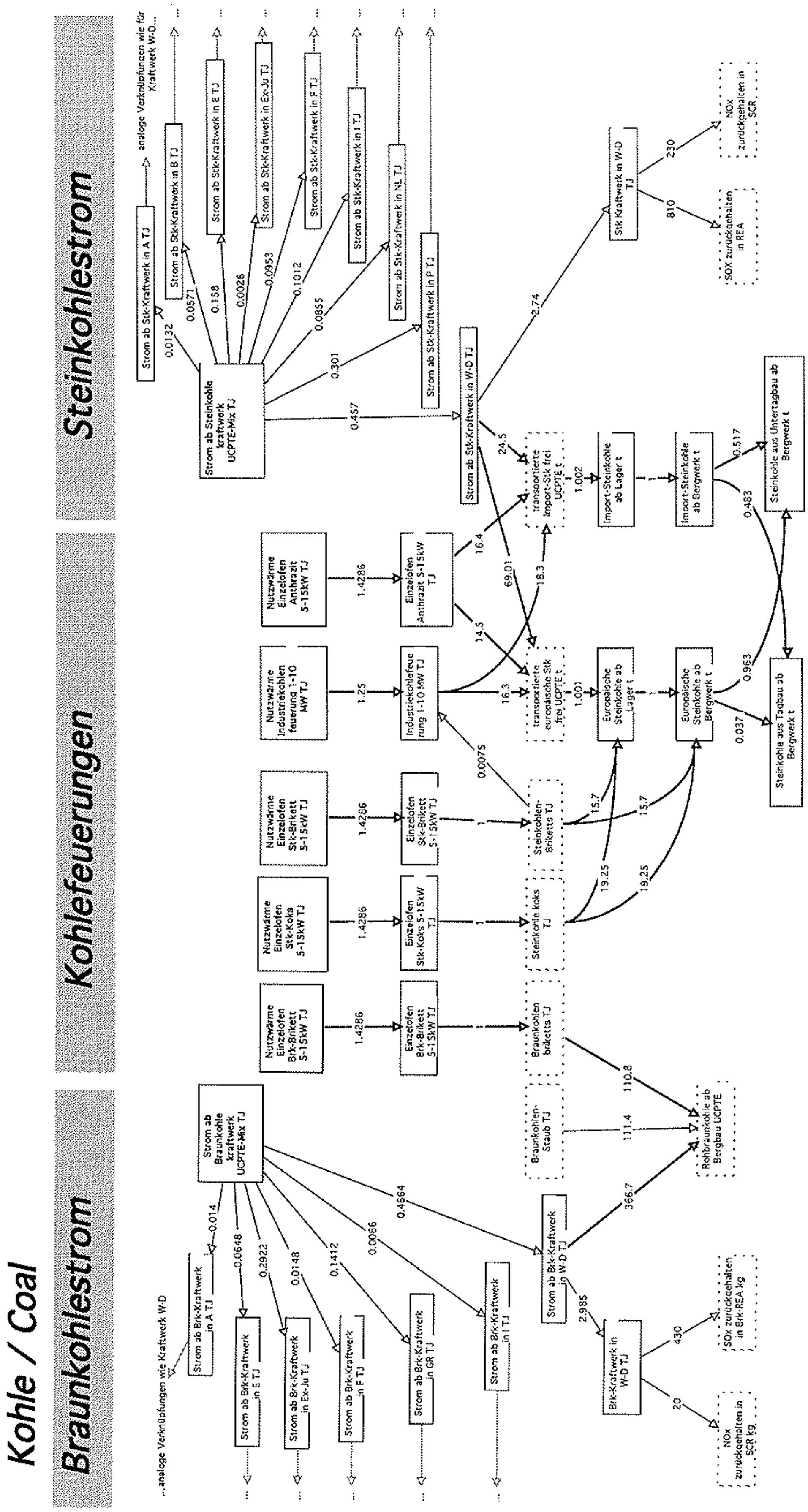




Heizöl S / High Sulphur Residual Oil
Euro
CH
Strom ölthermisch UCPTE TJ
2.688
Heizöl S in Kraftwerk UCPTE TJ
24.89
0.1
Heizöl S ab Raffinerie CH t
Heizöl S ab Raffinerie Euro t
0.0429
Raffineriegas in Feuerung Europa t
0.0233
1.07
Nutzwärme ab Industriefeuerung S, Euro TJ
1.176
0.000008
Heizöl S in Heizung Euro 1 MW TJ
25
Heizöl S ab Regionallager Euro t
0.000018
Bitumen ab Raffinerie Euro t
0.215
0.0117
Heizöl S in Raffineriefeuerung Euro t
1.04
0.0028
300
100
Heizöl Petro ab Raffinerie Euro t
Heizkessel Öl 1 MW Stk
Binnentankschiff tkm
0.000012
Diesel ab Regionallager Euro t
Pipeline Onshore tkm
1400
Rohöl ab Ferntransport t
Pipeline Offshore tkm
Hochseetanker tkm
6500
0.0000018
Diesel ab Regionallager Euro t
23.36
Diesel in Dieselaggregat Förderung TJ
0.000378
0.0133
1.0008
Rohöl ab Förderung t
0.013
Bohrmeter für Exploration und Produktion m
0.06
Heizöl Petro ab Raffinerie Euro t
13.5
Rohöl in Bohrungstests kg
0.000068
2.78
28.65
0.00024
Erdölgas in Gasturbine TJ
Erdölgas Abblasen Nm3
Erdölgas in Fackel Nm3
Heizöl EL in Heizung 1 MW TJ
Nutzwärme ab Industriefeuerung S, CH TJ
1.176
0.00008
Heizöl S in Heizung CH 5 MW TJ
24.63
Heizöl S ab Regionallager CH t
0.000018
Bitumen ab Raffinerie CH t
0.0117
Heizöl S in Raffineriefeuerung CH t
1.03
0.0203
Raffineriegas in Feuerung CH t
0.00187
1.06
0.0406
Strom ölthermisch CH TJ
2.703
Heizöl S in Kraftwerk CH TJ
23.98
Heizöl S ab Raffinerie CH t

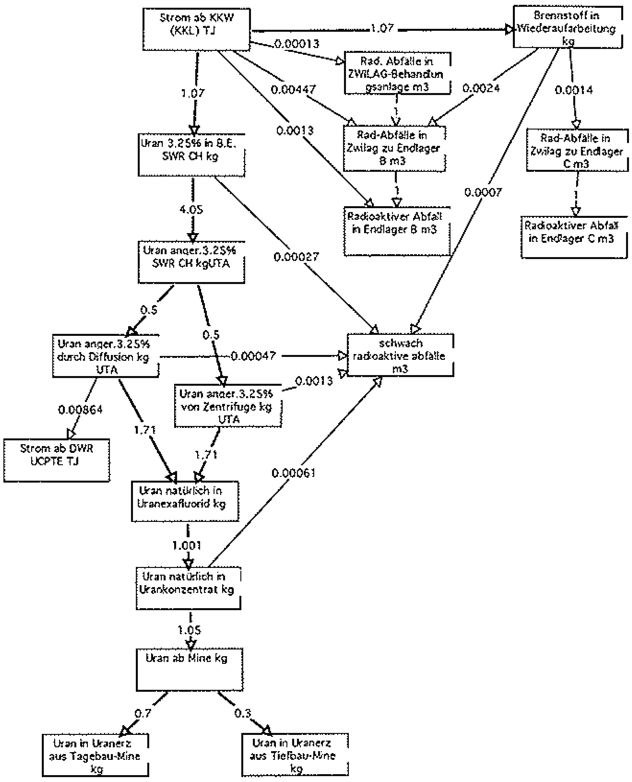
Erdgas / Natural Gas



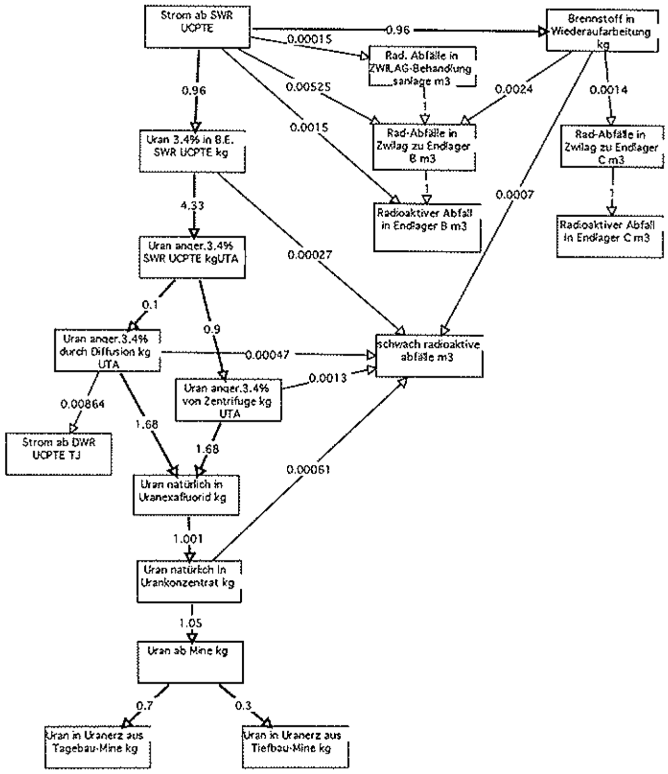

Kohle / Coal
Braunkohlestrom
Kohlefeuerungen
Steinkohlestrom

Kernkraft / Nuclear

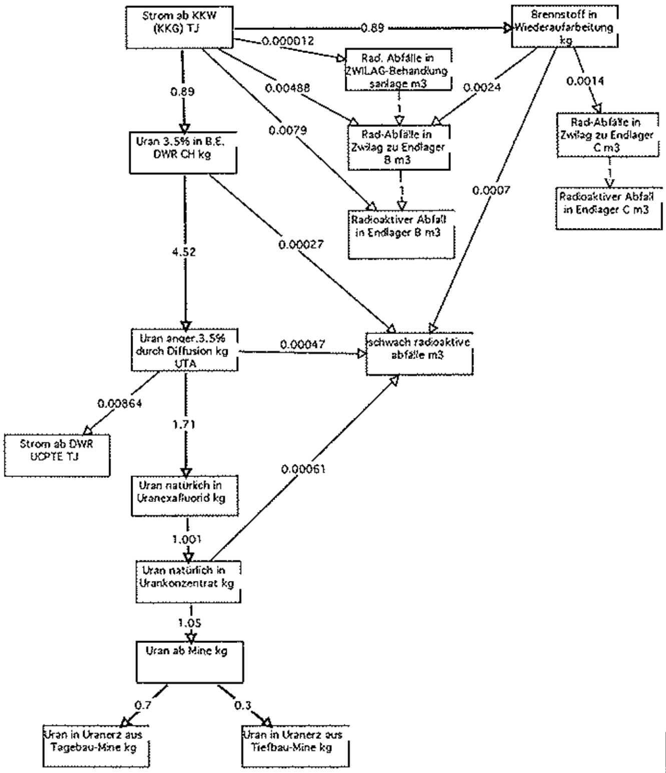
SWR CH (KKW Leibstadt)



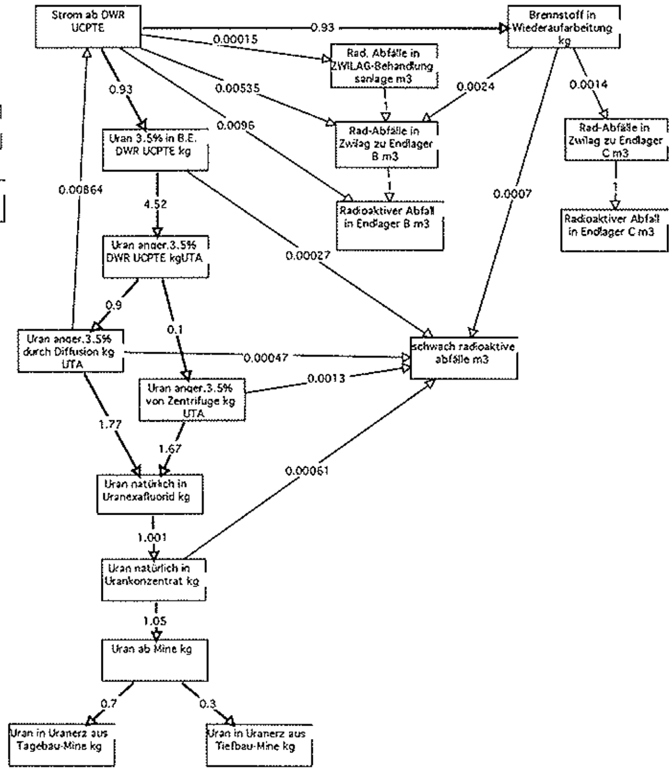
SWR UCPTE

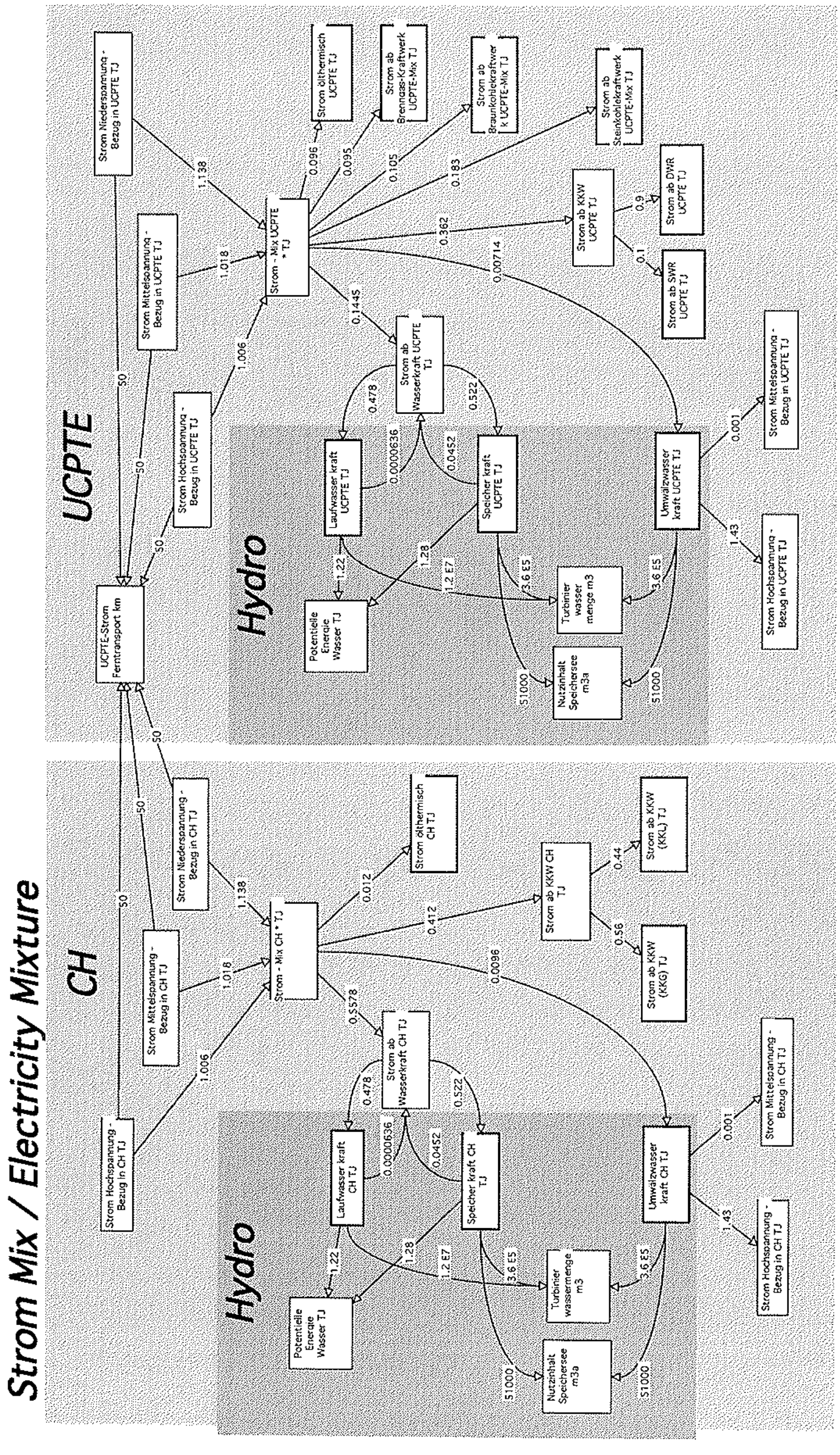


DWR CH (KKW Gösgen)

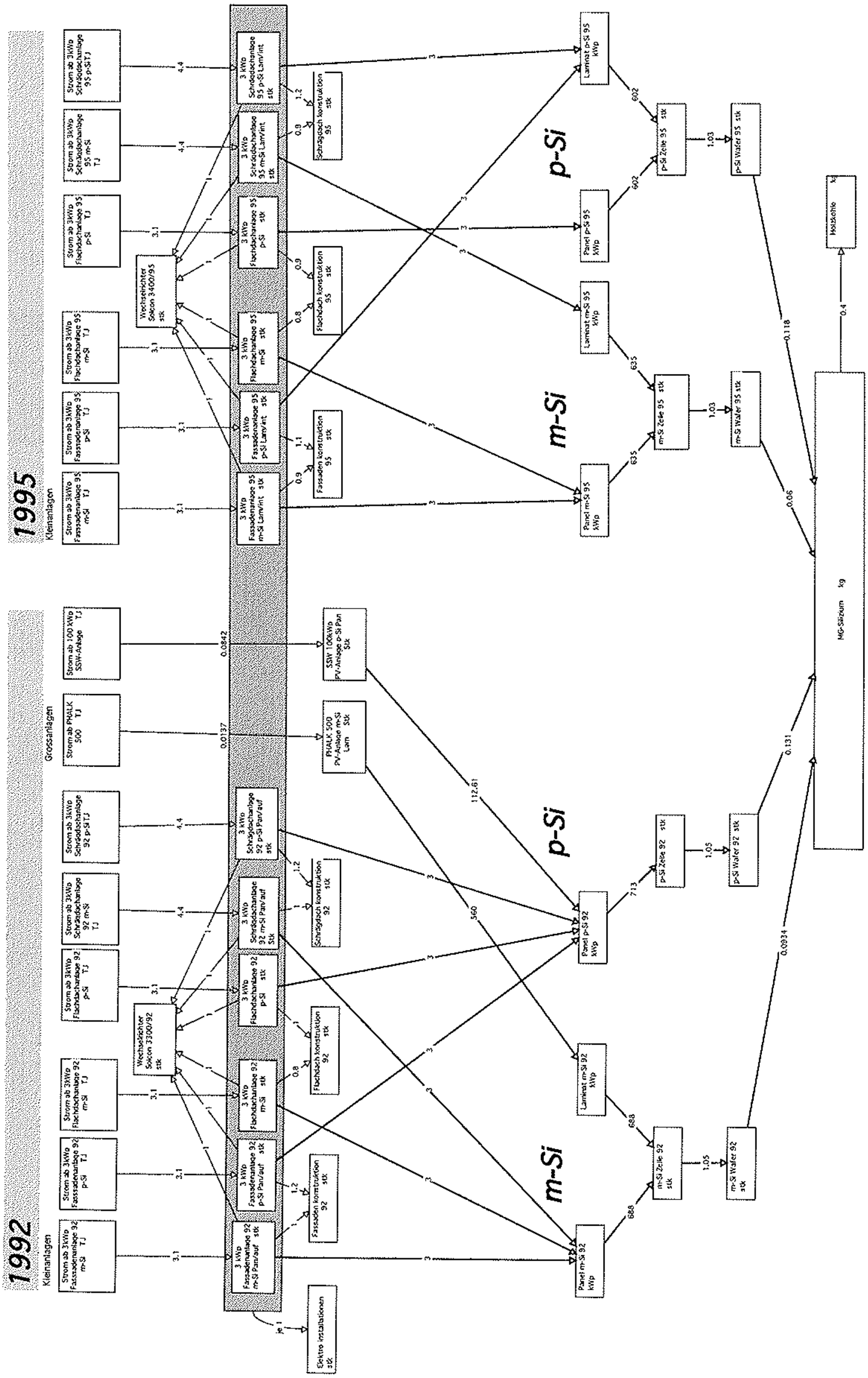


DWR UCPTE

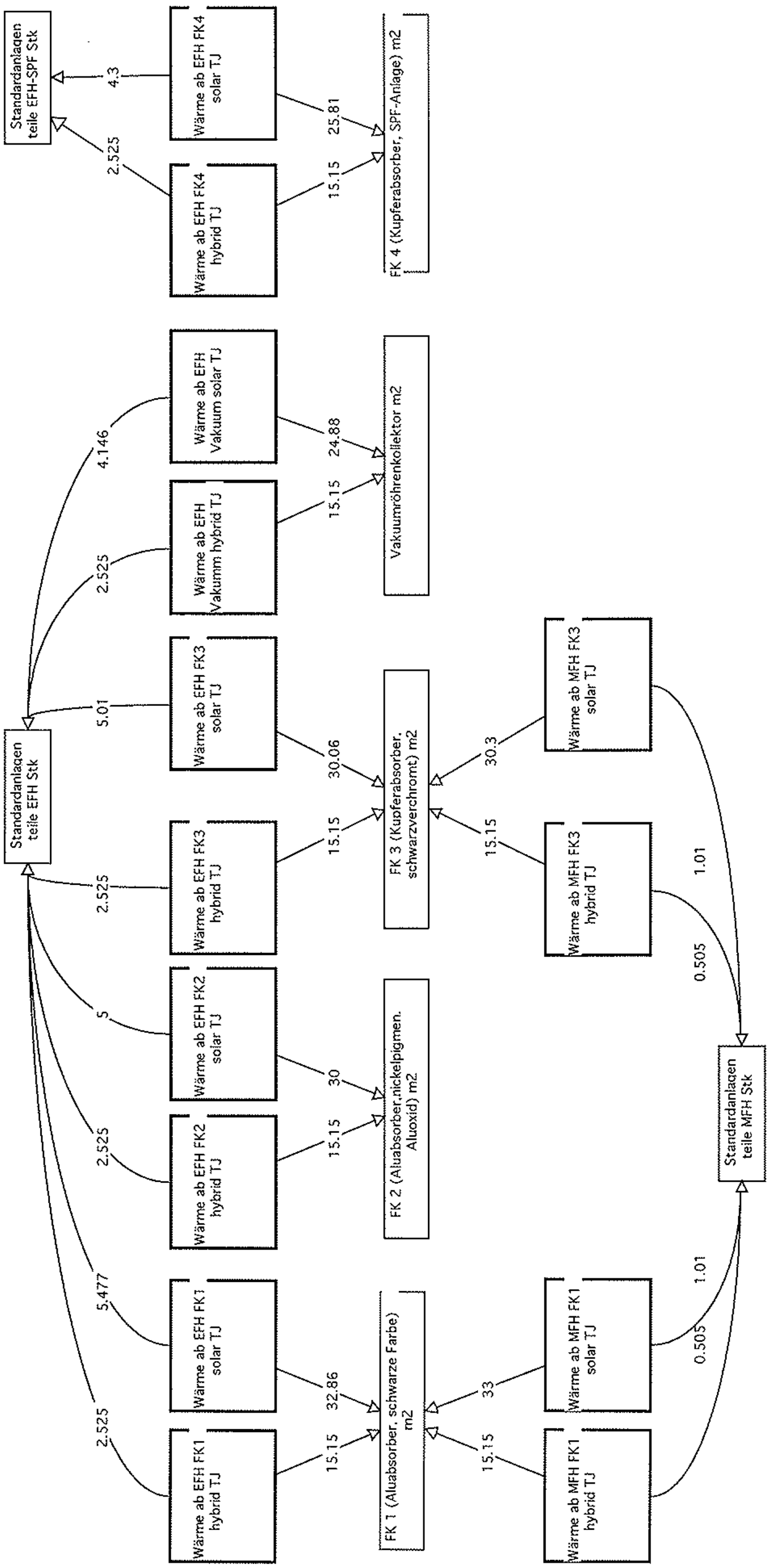



Strom Mix / Electricity Mixture
UCPTE
CH
Hydro
Hydro
Strom Niederspannung - Bezug in UCPTE TJ
Strom Mittelspannung - Bezug in UCPTE TJ
Strom Hochspannung - Bezug in UCPTE TJ
Strom - Mix UCPTE * TJ
Strom ölthermisch UCPTE TJ
Strom ab Brenngas-Kraftwerk UCPTE-Mix TJ
Strom ab Braunkohlekraftwerk UCPTE-Mix TJ
Strom ab Steinkohlekraftwerk UCPTE-Mix TJ
Strom ab KKW UCPTE TJ
Strom ab DWR UCPTE TJ
Strom ab SWR UCPTE TJ
Strom ab Wasserkraft UCPTE TJ
Laufwasser kraft UCPTE TJ
Speicher kraft UCPTE TJ
Umwälzwasser kraft UCPTE TJ
Potentielle Energie Wasser TJ
Turbinier wasser menge m3
Nutzinhalt Speichersee m3a
UCPTE-Strom Ferntransport km
Strom Niederspannung - Bezug in CH TJ
Strom Mittelspannung - Bezug in CH TJ
Strom Hochspannung - Bezug in CH TJ
Strom - Mix CH * TJ
Strom ölthermisch CH TJ
Strom ab KKW CH TJ
Strom ab KKW (KKL) TJ
Strom ab KKW (KKG) TJ
Strom ab Wasserkraft CH TJ
Laufwasser kraft CH TJ
Speicher kraft CH TJ
Umwälzwasser kraft CH TJ
Turbinier wassermenge m3
Nutzinhalt Speichersee m3a
1.138
1.018
1.006
50
0.096
0.095
0.105
0.183
0.362
0.9
0.1
0.00714
0.1445
0.478
0.522
0.0000636
0.0452
1.22
1.28
1.2 E7
3.6 E5
51000
0.001
1.43
0.012
0.412
0.44
0.56
0.0096
0.5578

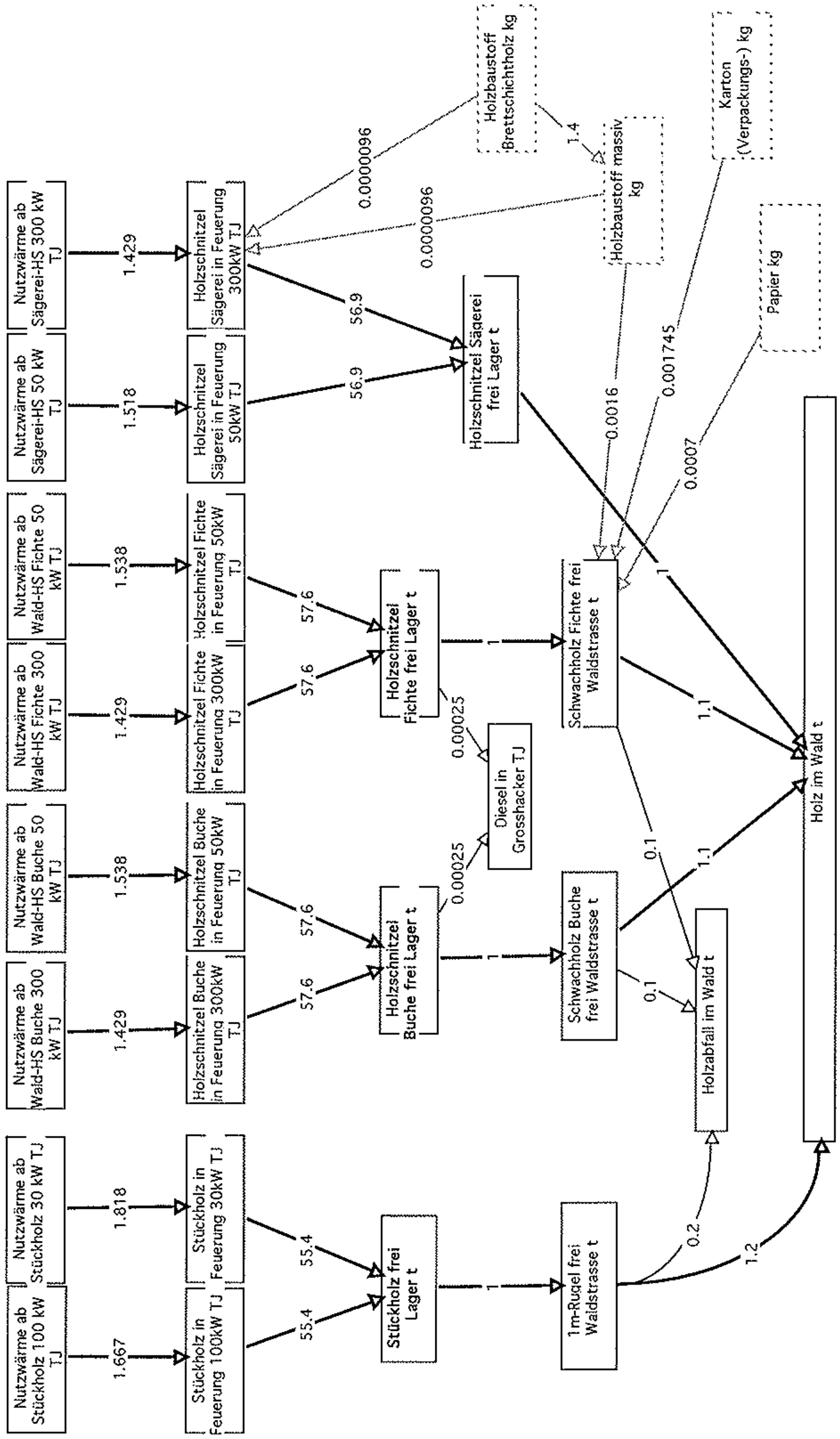
Photovoltaik/ Photovoltaics



Solar-Kollektor / Solar Thermal



Holz / Wood



Nutzwärme ab Stückholz 100 kW TJ
Nutzwärme ab Stückholz 30 kW TJ
Nutzwärme ab Wald-HS Buche 300 kW TJ
Nutzwärme ab Wald-HS Buche 50 kW TJ
Nutzwärme ab Wald-HS Fichte 300 kW TJ
Nutzwärme ab Wald-HS Fichte 50 kW TJ
Nutzwärme ab Sägerei-HS 50 kW TJ
Nutzwärme ab Sägerei-HS 300 kW TJ
1.667
1.818
1.429
1.538
1.429
1.538
1.518
1.429
Stückholz in Feuerung 100kW TJ
Stückholz in Feuerung 30kW TJ
Holzschnitzel Buche in Feuerung 300kW TJ
Holzschnitzel Buche in Feuerung 50kW TJ
Holzschnitzel Fichte in Feuerung 300kW TJ
Holzschnitzel Fichte in Feuerung 50kW TJ
Holzschnitzel Sägerei in Feuerung 50kW TJ
Holzschnitzel Sägerei in Feuerung 300kW TJ
55.4
55.4
57.6
57.6
57.6
57.6
56.9
56.9
0.0000096
0.0000096
Holzbaustoff Brettschichtholz kg
1.4
Holzbaustoff massiv kg
Karton (Verpackungs-) kg
Papier kg
Stückholz frei Lager t
Holzschnitzel Buche frei Lager t
Holzschnitzel Fichte frei Lager t
Holzschnitzel Sägerei frei Lager t
0.00025
0.00025
Diesel in Grosshacker TJ
1
1
1
1
1m-Rugel frei Waldstrasse t
Schwachholz Buche frei Waldstrasse t
Schwachholz Fichte frei Waldstrasse t
0.0016
0.001745
0.0007
0.1
0.1
0.2
1.1
1.1
1.2
Holzabfall im Wald t
Holz im Wald t

Annex C: How to use the Data Diskettes

C.1. Decompressing

The diskettes contain a) the input data (direct fluxes) used for the calculation with the EcoInvent program and b) the cumulated results of the recursive calculation with EcoInvent. The files are in a compressed format. Do the following to extract the files:

Mac Excel (Text) HD, DD.	MS-DOS Excel (Text) HD, DD	MS-DOS Lotus (WK3) HD
1. Create a new folder on the hard-disk.	1. Create a new folder on the hard-disk.	1. Create a new folder on the hard-disk.
2. Put the files named «MacComp ...» in the new folder.	2. Put the files named «DOSCOMP ...» in the new folder.	2. Put the files named «LOTUS ...» in the new folder.
3. Start «MacComp...» by double clicking.	3. Start «DOSCOMP...» by double clicking.	3. Start «LOTUS ...» by double clicking.
4. Choose command «Extract» to de-compress files.	4. The files decompress automatical-ly.	4. The files decompress automatical-ly.
Decompressed size: 4.2 MB	Decompressed size: 4.2 MB	Decompressed size: 12 MB

Please have enough memory available for the decompressing procedure. The Excel files have *Text* format. For calculations revert them to *Normal* format (*Save As / Option / Normal / Save*). The decimal point in DOS files may be represented with commas instead of points: Change the setting for the decimal point in your computer system.

C.2. Structure of data files

The input and result data are contained in two {491 by 908} matrices. The structure of matrices is similar. The column heads give the names and units of the contained data modules. One data module equals one column. The entries in the column are named in the row head. The input data with the direct flux entries are stored in files with*«Ein...»* in their name (for Ger. *«Eingabe»*=input). The names of the result files with the cumulated flux entries begin with *«Res...»*.

The Excel format only allows a maximum of 250 columns per worksheet. Since the number of the represented data modules is bigger than 250, all matrices are divided *vertically* in two parts numbered with 1 and 2. Files with *«...1...»* in their name contain data for processes 1 to 246; files with *«...2...»* processes 247 to 491.

The matrices are also *horizontally* separated into different files. The upper part contains all the rows with entries referring processes and has the suffix *«...Proz»* in the name. The other part contains all the rows with entries referring to resource depletion and emissions (final modules) and has the suffix *«...Emiss»* in the name.

File name	**Contents**
Ein1Emiss	Input data of emissions and resource depletion for processes 1 to 246
Ein2Emiss	Input data of emissions and resource depletion for processes 247 to 491
Ein1Proz	Input data for requested processes (or products) like «crude oil from transport», «steel, high-alloy», «transport rail», «wastes to sanitary landfill» etc. for processes 1 to 246
Ein2Proz	Input data for requested processes (or products) for processes 247 to 491
Res1Emiss	cumulated emissions and cumulated resource depletion for processes 1 to 246
Res2Emiss	cumulated emissions and cumulated resource depletion for processes 247 to 491
Res1Proz	cumulated requests of processes (or products) for processes 1 to 246
Res2Proz	cumulated requests of processes (or products) for processes 247 to 491

The processes are clustered into several categories. Within the categories the entries are listed alphabetically. Please note that the numbers below exclude the row/column heads with names and units.

Processes:

No.	Category
1 - 25	Energy carriers (consumed by e.g. industry, trade, households)
26 - 94	Standard materials
95 - 106	Standard transport services
107 - 109	Standard Construction services
110	Power saw
111 - 113	Standard Retention services (REA, DeNOx)
114	Sputtering (coating solar thermal collector)
115 - 184	Oil
185 - 239	Natural gas
240 - 289	Coal
290 - 321	Nuclear
322 - 325	Electricity mix and transport
326 - 333	Hydro power
334 - 387	Wastes to processing
388 - 441	Photovoltaics
442 - 463	Solar thermal
464 - 489	Wood thermal
490 - 491	Small scale geothermy and heat pump

Emissions and resources

No.	Category
1 - 28	Non-energetic resources
29 - 38	Energetic resources
39 - 279	Emissions Air
280 - 414	Emissions water
415 - 417	Direct loads to soil

Input data files

	Processes 1-246	Processes 247 - 491
Processes 1-491	Ein1Proz	Ein2Proz
Emissions & resources	Ein1Emiss	Ein2Emiss

Result files

	Processes 1-246	Processes 247 - 491
Processes 1-491	Res1Proz	Res2Proz
Emissions & resources	Res1Emiss	Res2Emiss

Fig.: Outline of the structure of the data files on the diskettes and names of the sub-files