Global Emission Model of Integrated Systems (GEMIS)

Manual

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CONTENTS

1 About This Manual

This manual consists of several parts:

- Chapter 2 gives an introduction to GEMIS and is about the limits of the program
- Chapter 3 deals with the most important innovations compared to former GEMIS-versions

The main part of this manual is formed by the chapters 4…8:

- Chapter 4 describes the program window (chapter 4.1), working with products (chapter 4.3), processes (chapter 4.4), and scenarios (chapter 4.5), as well as references (chapter 4.6) and standards (chapter 4.7)
- Chapter 5 explains how results of scenarios can be created and analysed in GEMIS
- Chapter 6 is about loading and saving and export of records/projects
- Chapter 7 informs you about further records influencing results
- Chapter 8 gives hints concerning units, settings, and the important global switches

The final part of the manual contains further information for users:

- Chapter 9 is the glossary – there you can find short explanations of important terms in GEMIS
- Chapter 10 is about the naming rules for products, processes, and scenarios
- Chapter 11 gives an overview on the most important color codes for record names and connected sources
- Chapter 12 is a list of abbreviations in GEMIS
- Chapter 13 explains data conversion at data entry in GEMIS with two examples
- Chapter 14 shows the systematics in GEMIS (location, NACE, SNAP97)

The Appendix consists of 6 so-called *GEMIS-tours* offering the possibility to learn more about working with GEMIS.

2 Introduction

GEMIS is the acronym for Global Emission Model for Integrated Systems.

The model can perform complete life-cycle computations for a variety of emissions, and can determine the resource use (CER, CEC, CMR, land use).

In addition, GEMIS analyzes costs - the corresponding data of the fuels as well as cost data for energy and transport processes are included in the database.

GEMIS allows also to assess the results of environmental and cost analyses: by aggregation of emissions into so-called CO2 equivalents, SO2 equivalents, and tropospheric ozone precursor potential (TOPP), and by a calculation of external costs.

In GEMIS 4.5, emission standards are included - you can easily check if combustion processes comply with national and international emission standards, and filter the database for suitable processes.

The GEMIS 4.5 database offers information on energy carriers (process chains, and fuel data) as well as different technologies for heat and electric power generation.

Besides fossil energy carriers (hard coal, lignite, oil, natural gas), also renewable energies, household waste, uranium, biomass (e.g. fast growing woods, rape) and hydrogen are covered in GEMIS.

Data on various material process chains (above all for construction materials), and processes for transport services, i.e. cars (gasoline, diesel, electricity, biofuels), public transport (bus, train) and airplanes as well as processes for freight transport (trucks, LDVs, train, ships and pipelines) are available in the database.

A novelty is the processes for waste treatment (disposal), and the monetary processes which represent aggregated data for the sectors of the economy.

The process data are given now for a variety of different countries, and a special set of data (called "generic") refer to the situation in developing countries.

Users can adjust each and every data item to their needs, or work with the core database which covers more than 8000 processes in over 20 countries.

The current GEMIS version 4.5 has some new features and extended data bases. We urge all users only to use this version, because of data update. You can append your own data to the 4.5-data base.

2.1 The background of GEMIS

Since decades the connection of energy and environment is subject of environmental research and discussion. The central question "What kind of environmental effects result from energy systems?" shows a considerable complexity, if the variety of energy technologies as well as the diversity of environmental impacts are considered.

2.1.1 From fuel to material flow

Studies from the early seventies predominantly investigated air pollutant emissions of different energy carriers (fuels) for electric power supply. In the eighties there was, besides nuclear specific environmental impacts, a focus of attention for above all SO2 and NOx. Also heating systems were investigated. Since the end of the eighties attention was turned to release of greenhouse gases, and traffic-sector is included. The early nineties are characterized of a further extension of the discussion: Up to now not only the direct environmental effects of energy systems have been regarded, but also the upstream processes. From now on the materials for construction of the processes are considered too under the term life cycle analysis (LCA). This integrated way of looking at energy- and material flows puts up high standards to database and computer modeling and it cancels the distinction between "energy referred" environmental assessments and such in other sectors (e.g. consumer goods, traffic).

2.1.2 Methodical questions at environmental analysis

LCAs should include all relevant physical-chemical activities, that are connected with the supply of an (energy)-service or a product. All relevant transports as well as the production of materials and auxiliary products should be considered, too. The environmental impacts of the supply of an energy-carrier or material result from all processes involved. As also auxiliary energies and the processes supplying them cause environmental effects - as indirect impacts resulting partially from loops and other process chains - LCAs can't be calculated simply linear. The same applies to the fact, that materials preliminary work is included in LCAs, which extends data and modeling questions considerably: Besides energy flows now also material flows are considered as well as connections between both. Extraction, transports, conversions etc. (with specific environmental impacts) have to be paid attention to in connection with material process chains, too.

2.2 Limits of GEMIS

We urge you to really consider the following facts when using the computer program:

Despite of all upgrades and extensions, GEMIS 4 still is what GEMIS 1.0 already was: a tool.

Computers allow to easily collect and change data , but the present hard- and software doesn't allow to supply useable "expert" systems on the level of a PC.

On the one hand, GEMIS 4 contains a lot of data links and algorithms, on the other hand they are kept simple and follow mostly linear functions. This is unproblematic when using the core data records, as these data was selected to be useful in a broad variety of applications.

The strength of the GEMIS model to allow user adaptations is also a danger: When adjusting data, GEMIS 4 only checks the formal correctness of process chain structures, the content of data adjustments cannot be checked by GEMIS (only exception: fuel changes).

Compared with previous versions GEMIS 4 can adjust automatically the data for the construction materials, land use and costs when a user adjusts the capacity data of processes. A linear scaling within given limits is used for this. The same applies for emissions control technologies which GEMIS 4 adapts automatically (capacity, costs).

Once you enter new data (i.e. not using the copy command), you are rather free - GEMIS is not "artificially intelligent", it knows neither rules for adaptation of complex data structures, nor support concerning the content of new data.

As far as user-defined data describe a situation correctly, GEMIS 4 will be a useful tool - it will determine emission balances in an adequate way, visualize results, and will help with the analysis of uncertain data etc..

But: The burden of consistent data adjustment is up to YOU: users have the final responsibility.

2.3 GEMIS-tours

The appendix of this manual consists of the so-called *tours* – i.e. step by step instructions for learning how to work with GEMIS. The tours are available as pdf-files on the GEMIS-website, also.

The tours deal with:

- The creation of own data (products, processes, and scenarios) in GEMIS (tour 1: From Processes to Scenarios);
- The creation of results – clarified by greenhouse gas balances etc. for the example scenarios created in tour 1 (tour 2: Results of Scenarios)
- Using GEMIS to calculate environmental impacts (Tour 3: Simple Calculation of Environmental Impacts of Processes)
- The extended options for scenarios and the analysis of results (Tour 4: Scenarios and Analysis of Results)
- Using the GEMIS global switches to select the system boundaries (Tour 5: Global Switches in GEMIS)
- Combined Heat and Power Processes and GEMIS (Tour 6: Combined Heat and Power (CHP) Processes)

If you have criticism or feedback concerning these tours, or ideas for further tours, feel free to contact us. Our email-addresses are: k.schmidt@oeko.de and u.fritsche@oeko.de.

3 What's new?

- **User interface:**
  - **Direct calculation** is an option since GEMIS version 4 to immediately calculate the balance of a life-cycle of a process - this is done in the local menu or by clicking on button "Calc" on card "Results" of the (marked) process. The direct calculation can be done for emissions, and resource requirements (CEC, CER, CMR, land use) using a **(right) mouse click**. All upstream processes - i.e. the total process chain - are included in the computation.
  - the location names (countries, regions) were completed and made consistent for all product and process names
  - the time reference is now possible for single years
  - The **Info card** of data records was adapted and supplemented. Info card details can be hidden/shown by clicking on "-" / "+". Clicking on blue hyperlinks shows the info card of a data record.
  - **Copying** of data records to EXCEL etc.: a selected text or data record can be copied to the so-called clipboard using the Windows®-function “copy”. From there, the function **Paste** inserts the content of the clipboard into a text, list or another Windows application (spreadsheet, text). The shortcut for Copy is CTRL+C, for Paste CTRL+V.
  - the model can be switched to a **Spanish** user interface
  - the model can be switched to a **French** user interface
  - direct input of search word on card Filter possible
- **Model features:**
  - the calculation for **pipeline emissions** was updated
  - the editing of product data for fuels was updated and extended, including now the fuel density
- **Database updates/extensions:**
  - Update of **photovoltaics**-data
  - complete update (with corrections) of the **upstream data** for natural gas, oil, and hard coal
  - updated data for German **electricity generation** after 2000 (base: EWI/Prognos Energiereport IV)
  - updated **cost data** for fossil fuels after 2000 (base: EWI/Prognos Energiereport IV and EEA)
  - updated and completed **energy data for all EU-25 countries** now up to 2030 available
  - extended data for **bioethanol** in large plants and new data for **BtL** (Fischer-Tropsch-Diesel)

- new data for biofuel **imports** (from Brazil, Poland, Romania) from the BMU-Bio-EU-Trade Project (see http://www.ie-leipzig.de/Biomassenutzung/Biomasse.htm)
- new data for biofuel **imports** (from Brazil, Poland, Romania) from the BMU-Bio-EU-Trade Project (see http://www.ie-leipzig.de/Biomassenutzung/Biomasse.htm)

- **Corrected Model Bugs**
  - GEMIS starts now even if no printer is installed
  - The user registration is now simplified
- **Soft- and Hardware Requirements**
  - When using Windows 95, the following components must be updated:

    - Internet Explorer to Version 4.0 or later, and
    - Fonts with Euro symbol.

(For more information on bugs, database extensions etc. please check the GEMIS website www.gemis.de)

3.1 New Product Types in GEMIS

3.1.1 User-defined Product: Emissions

You can enter your own emissions in GEMIS 4.5 as products. This will enlarge the scope of the environmental indicators available in GEMIS.

On card "data" of this type of product, you can

- enter external costs,
- enter a CAS number (chemical abstract system),
- enter a factor for the global warming potential (GWP) which allows to include your emission in the computation of CO_2 equivalents,
- enter a factor for the acidification potential (AP) which allows to include your emission in the computation of SO_2 equivalents, and
- enter a factor for the tropospheric ozone precursor potential (TOPP) which allows including your emission in the computation of ozone precursor equivalents.

3.1.2 User-defined Product: Solid Wastes

You can enter your own solid wastes as products in GEMIS 4.5 which enlarges the scope of environmental aspects covered by GEMIS.

On card "data" of this type of product, you can

- enter external costs,

- enter a CAS number (chemical abstract system).

3.1.3 User-defined Products: Liquid Effluents

You can enter your own liquid effluents as products in GEMIS 4.5 which enlarges the scope of environmental aspects covered by GEMIS.

On card "data" of this type of product, you can

- enter external costs,
- enter a CAS number (chemical abstract system).

3.2 New Process Types in GEMIS

3.2.1 Waste treatment

This is a new process type in GEMIS 4 which is used to handle solid wastes from other processes - it reflects the "back end" of a process chain: **a sink**. Waste treatment processes can - as all other processes - have direct emissions (and residues!), links to auxiliary inputs (energy, materials) and materials for construction, as well as costs. Waste treatment processes are - similar to emission control technologies - linked to other processes which generate residues (and to a transport process). GEMIS then computes the environmental effects from the waste treatment (or disposal) for this process.

3.2.2 Fuel mixers

Fuel mixers are new processes in GEMIS: similarly to mixers, they combine several processes to deliver a joint output. But they do also **actively mix** the fuels from these processes into a new "mixed" fuel which inherits the fuel characteristics according to the shares of fuels which are delivered by the mixed processes.

3.2.3 Monetary processes

Monetary processes are a novelty in GEMIS 4. They represent the environmental impacts of production values or expenditures for goods or services from statistical sectors of the economy. Their symbol is € . These processes are useful if no detailed information is available on the upstream processes, or the inputs to the product or service are a too complex combination of material, energy or transport services (e.g. banks, toys, hospitals). For these processes, one can determine the upstream impacts using an Input-Output-Table (IOT) which reflects the monetary links to the other economic sectors. In GEMIS 4, all economic sectors from German UGR have been implemented, i.e. there are now processes for the whole economy. The current database of the UGR is the year 1995, and covers air emissions, greenhouse gases and primary energy requirements (CER). Monetary processes can be used in scenarios to supply services and products for which a demand has been defined in monetary terms (money), i.e. *expenditures* for the services, or the production values of the economic sectors.

3.3 New data filters in GEMIS 4

3.3.1 Data Filter: Reference/Project

In order to see only those records that are associated to a certain reference or project, the data filter "Reference/Project" can be used.

Here, a project is a special kind of reference. The project has the same format as a normal reference. However, the project-icon is red (). The other types of references are: "Text", "Html", "Rich Text", "Tif picture", "PDF File", "URL", "Excel File", "Word File", "Jpg picture", and "Generic File". Unfortunately, document references (html, Tif, PDF, doc, xls,...) cannot be used yet. The URL type is available. If the URL type is used, you can click on links in card "Info" of file card windows.

The data filter list box contains all references.

If no records are displayed for a reference, the currently loaded GEMIS-project does not contain any records which match to the chosen setting.

If you want a complete list of all records for a given reference, don’t forget to set all other data filters to “All”.

3.3.2 Data Filter: reference year

In order to see only those processes that are associated to a certain reference year, this data filter can be used.

3.4 New possibilities for analysis in GEMIS 4.5

3.4.1 Quick calculation of employment effects for scenarios

GEMIS 4.5 offers the quick calculation of employment effects for scenarios. You'll find the details under "Employment effect" in the glossary (chapter 9).

3.4.2 Quick calculation of the cumulated energy consumption (CEC)

Besides the implementation of the quick calculation of the cumulated energy requirement (CER), GEMIS 4.5 offers the fast calculation of the cumulated energy consumption (CEC). Again, the details are in the glossary (chapter 9) under "CEC".

4 Explanation of the GEMIS-Program

4.1 The GEMIS program window and menu system

When GEMIS starts, the so-called program window appears. In this window, all work with GEMIS is done. If you start GEMIS for the first time, the size of this window is set to a default value - you can change its size (e.g. maximize it) or move it. At the top of the program window the name of the currently opened project is displayed in the title bar.

Below, you can activate commands in the menu: open a file with records, edit records, call products or processes from data base, calculate scenarios as well as adjust extras, arrange windows and call for help. You can click with the mouse on the menu to activate the corresponding commands.

Below the menu you find several buttons. Move the mouse over these buttons, and a short explanations of the corresponding function will appear at the bottom of the program window. The five buttons (Products , Processes , Scenarios, References, and Standards) are bigger because they are more important - they open so-called file card windows, a special type of window, that allows easy access to the data base. Every record in the GEMIS data base has its own name and saves information on so-called cards. In file card windows a list of all available records is displayed and you can edit the information on their cards by using the local menu (opened with right-click).

4.2 The GEMIS File Card Concept

In GEMIS, the information for all data records is stored in cards which can be accessed by clicking on the corresponding tabs. To edit cards, first a record must be marked (selected). This happens in so-called **file card windows** which all have the same structure:

There are data filters determining which records are shown in the file card window.

In the left part of the file card window, a list shows the name of all records that comply with the chosen filter criteria.

In the right part of the file card window is the data display, in which relevant information from the cards of the marked record are shown.

In order to edit the cards, you have to open the local menu. For this you have to mark the record to be edited and then - with the mouse-pointer positioned in the list area - press the right mouse-key shortly. In the appearing local menu you choose "edit".

4.3 File Card Window: Products

Assumed, you've opened the file card-window for products by clicking on button Products.

Then, in the left part of the file card window an alphabetically sorted list of products is shown. The icons before the names indicate to which group the product belongs. The colour of the name indicates for instance that the product belongs to the protected core data (see chapter 11).

When opening the products file card window, the data filters show all products of the currently loaded project in alphabetical order, and the first product is marked automatically - you can see that the product name is shown in a darker colour (colour depends on your Windows® adjustments).

In the right part of the window, a summary of relevant information of the marked product is shown in the info card (note that you cannot edit this card).

To mark another product, click on its name.

Using the local menu (right mouseclick !), a marked product can be renamed (if it does not belong to the protected core data), copied or deleted (if no other record has a link to it, i.e. if it is unused). Furthermore, the local menu offers the show links function which lists all processes which are linked to the marked product.

To get access to the file cards (e.g. the data card) of a product, double-click on its name in the list on the left part of the window.

The following chapters explain the data editing of selected products in GEMIS:

4.3.1 Edit Products: Card "Data" of Energy Carriers

If the marked product is an energy carrier, but no fuel, the data card has the following information:

- Energy content - (Energy per mass-unit)
- Costs - enter the variable costs of the energy carrier


These data of the product are "reported" to all processes using this product. Therefore you don't have to enter the costs at the process-level, once entered on the card "Data" of products - that's enough.

If the marked product is a fuel, the card "Data" is more complicated. (see the following chapters)

4.3.1.1 Edit Products: Card "Data" of solid/liquid fuels

In the upper part of the data card, you find the data entry fields for the ultimate analysis of the fuel.

In the left upper corner the "input as" box offers 3 switchpoints which determine how the ultimate analysis is displayed and entered in the weight share table. The default setting is "as received", that means the fuel contains water and ash. The switch "water free" allows entering of the ultimate analysis or the fuel without water (wf) and the switch "water- & ash free" allows entering the ultimate analysis without water and ash (waf).

If you have an ultimate analysis only in format "water free" or "water- & and ash free", choose the corresponding format with these switches before you enter data. Example: In order to adjust the water content, first click on "water free", then enter the new value of the water contents, and then click on the switch "as received". GEMIS will then re-compute the previous ultimate analysis data for the given water content, and displays the new ultimate analysis data.

In the right, upper part of the card you will find the weight share table for the ultimate analyses. If you adjust these data and the sum of all components doesn't equal 100%, GEMIS will remind you or adjust the C-content automatically. Please note that the automatic adjustment makes sense only for small deviations - e.g. if you change the sulfur content.

Below the Input as field is the data entry field for the heating value - the default setting here is for the lower heating value (LHV), but you can also use the higher heating value (HHV) instead: you can change the base for the heat value with a global switch (see Global Switch: Heat Value Base).

Furthermore, the density of liquid fuels can be entered.

In the lower left part of the card, you can enter costs of the fuel. GEMIS accepts only energy-based costs (e.g. €/MWh), but displays the mass-based costs (e.g. €/kg) as well below the costs data field.

When you switch to the HHV base (default setting: LHV), GEMIS will show the costs data entry field with a yellow background.

4.3.1.2 Edit Product: Card "Data" of Gaseous Fuels

On the left side, you can enter the costs of the fuel. GEMIS accepts only energy-based costs (e.g. €/TJ), but displays the volume-based costs also.

Below, GEMIS displays the calculated values which were derived from the ultimate analysis:

The higher heating value (HHV), and the lower heating value (LHV).

Note that you can change the base for the heat value with a global switch (see Global Switch: Heat Value Base).

When you switch to the HHV base (default setting: LHV), GEMIS will show this: costs data entry field is displayed with a yellow background.

On the right side of the data card, you can find the data entry fields for the ultimate analysis. If you adjust these data and the sum of all components doesn't equal 100% any more, the methane content is changed automatically so that the sum equals 100% again.

Please note that automatic adjustment only makes sense for small differences - e.g. if you change the H_2S content.

4.3.2 Edit Products: Card "Data" of Materials

The card "data" of materials has two fields for entering data:

- **Neutralization capacity** - if the material is able to fix harmful substances like sulphur or chlorine by chemical reaction, enter the value here - further info you can find in the model documentation
- **Costs** - enter the variable costs of the chosen material here

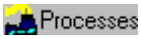
4.3.3 Edit Products: Card "Data" of Resources

In this card you can determine if the resource is renewable, non-renewable or secondary. This category is used by GEMIS to determine the resource balance, especially the CER.

4.3.4 Edit Card "Data" of User Defined Products: Airborne Emissions, Residuals, and Liquid Emissions

On card data of **user defined liquid emissions** and **user defined residuals** you may enter specific external costs and a Chemical Abstract System (CAS) code for the product.

Additionally, CO_2, SO_2, and TOPP equivalent values can be entered for **user defined airborne emissions**.

4.4 The File Card Window: 

In the file card window for processes, you can see the alphabetically sorted list of processes on the left side.

The process-names have different colors (see chapter 11). In the **Info card**, to the right, relevant information from the data cards of the marked process is summarized (please note that you cannot edit the data in the Info card!).

To restrict the list of shown processes, you can access the **Filter card** - just click on tab "Filter" on the right side. Here you can choose criteria for the data retrieval in several listboxes. Move the mouse over the different areas of the filter card, and a brief explanation is shown at the bottom of the window.

 You can also see the links of the marked process to others with local menu function *Show links* and display the links of a process to others graphically as a **process chain**.

Like in all file card windows you can access the data cards by a **double-click** on the name in the list.

The typical features of these data cards will be explained in the next chapters (predominantly for a combustion process, but also valid for most other GEMIS process types):

4.4.1 The Cards of Combustion Processes

You can find combustion processes in GEMIS easily by using data filter **Process type**.

The first card of combustion processes is the **metadata** card.

4.4.1.1 Card "Meta data"

The meta data card explains the data background of a process.

In the **upper left part** of the card, you can link references with the process to inform others about the origin of the process data. Simply do a right click on the listbox to add or delete references.

Below - in the frame "Data source and review" - you find information on the origin of the data - firstly the listbox Source where you can choose an organization or group that is responsible for the record. If you've copied a process, the original is kept - but you can choose another source in your copy. **Below** are the listboxes "Data entry by", "Review by" and "Review Status".

In the **upper right part** of the card you can choose the Data Quality Indicator that represents the record - click on one of the five points. Note that the chosen data quality is visible in the info card if the Meta data card is closed.

Below is the frame "Grouping" with the listboxes:

- Technology
- Tech. Status
- reference year
- NACE
- Location
- SNAP.

To the right of listbox "location" is a small, colored button. It is for creating new locations (e.g. sub-regions, cities...).

The next card to be explained is the comment card:

4.4.1.2 Card "Comment"

The comment card is for editing the German and English comment of the record being edited at the moment.

4.4.1.3 Card "Data" (combustion)

This card serves for laying down the energy and material data of the process.

In the upper left corner of the card you see the currently set link to the upstream process (its symbol of technology in front of it) as well as - under it - the name of the input-product, that is supplied by this process - here also the corresponding symbol is displayed. If you want to choose another upstream process, click on the button. Then GEMIS opens a window, where you can choose the input link to the upstream process. In this window the list of processes is in the right part of the window and to the left you can set several data filters in order to reduce the number of displayed processes. The data filters are power (size) as well as categories for input- and output-product, technology and location. You can choose an upstream process by clicking on its name in the list-area and then clicking on the "OK"-button - then the "Select process"-window is closed and the process name appears upside, to the left, together with its symbol.

Please note: combustion processes can be connected only with processes, that supply fuels. The choice of the upstream process regulates, which energy carrier is used by the combustion process - please note, that there are only products in the listbox, which belong to the same category as the product that is supplied by the upstream process.

Further down on the card the outputlist is displayed - for combustion processes outputs must be energy carriers. If you want to change the outputlist, right-click on the list.

Above the outputlist you see the symbol of the chosen energy carrier as well as a green arrow behind, whose width represents the effective energy-output of the combustion process. The width of the brown arrow represents quantitatively the energetic losses. The efficiency of the energy-conversion is shown above. You can adjust it on card "Design". This card is opened when you click on the corresponding button.

4.4.1.3.1 "Design“ Card

If you click on button "Design" on card "Data", GEMIS opens a new window, where you can edit the design data of the process.

To the left, on the top you find data-entry fields for the Operation time, the process is run normally. (Please note, that full load equivalent hours are meant here).

To the right you can enter the power (capacity) of the process - it is always output-based.


If the process was created by copying core data, there exist both for the operating time and the power limitations of validity: generic data are defined for a specific range only, within of which you can change values as you like it. If - by contrast - you create your own processes by activating the "New"-command in the local menu, you can set any power value you like.

Below the power values you can fix the share of power that is firm.

To the left, at the bottom of the window you can enter life time, area, and employment data. To the right, at the bottom of the window you find efficiency data of the process - for combustion processes you enter gross efficiency and - under it - GEMIS displays net efficiency that results from the inclusion of the energy demand of linked emissions control technology processes (if any). If no ECT is linked to the combustion process, gross equals net.

4.4.1.4 Card "Auxiliaries“

On this card you can see and change auxiliary links of the process in 3 tables:

- The **upper** table is for processes supplying auxiliary energy, i.e. amounts of energy needed in addition to the input product for operating the process (e.g. auxiliary electricity). Here, the name of the process delivering the auxiliary energy is given, then the name of the delivered energy carrier, and then the amount of energy that is required by the process in the next column. This amount of energy refers to the energy content of the output product that is delivered. Additionally a vehicle and transport distance can be entered for the auxiliary energy demand.
- The table in the **middle** is for processes supplying auxiliary materials (e.g. lubricants) - again, first the name of the auxiliary process is given, then the name of the delivered auxiliary material, and then the amount of material needed by the process, based on the output. Furthermore a transport vehicle and transport distance for the auxiliary material delivery can be entered.
- The **lowest** table is for processes delivering the materials needed for the construction of the process - this reflects the "cradle" stage of the process life-cycle. As before, first the name of the delivering process is given, then the name of the construction material, and finally the amount of material, now based on the capacity of the process. Here, also a vehicle and transport distance for the construction material can be specified.

As regards construction materials (lowest table), note that a global switch is available in GEMIS now, which can de-activate the inclusion of the construction materials in the life-cycle computations.

4.4.1.5 Card "Emissions" (combustion)

This card describes the details of air pollutant and greenhouse-gas emissions of combustion processes.

In the **upper left part** of the card, you can link up to 3 emissions control technologies (ECT) - one per listbox - just click on one of the listboxes and then on the name of the appropriate ECT processes. Note that GEMIS only lists ECT processes which "fit" the capacity of the combustion process - a "small" filter can't be linked to a "large" power station. GEMIS will report the resulting costs to the costs card of the process.

ECT processes often need auxiliary energy (electricity, steam). With the "Energy for flue gas treatment" listbox in the **upper right part** of the card you can decide where this energy comes from - the default setting is "Process output". In this case GEMIS calculates the net efficiency of the process.

Below is the box for "Flue gas condition": the O_2 content of the flue gas which represents the excess air of the combustion. Below this, GEMIS reports the corresponding CO_2 content and the calculated "Flue gas volume" (hourly). Next, there is the data entry field for the "Stack height".

Between the emission control listboxes and the "Flue-gas condition" frame is the button  . If you click on it, GEMIS checks which emission standards the process complies with, and shows a report in a new window.

The **lower half** of the card concerns the emissions in a table:

- The **1. column** renders the name of the "Emission into air"

- In the **2. column** you can enter the raw-gas concentration of emissions (in the white data entry fields). Some of these fields are gray, as they contain calculated values: SO_2, HCl, HF etc. are calculated from the ultimate analysis of the fuel. The other fields can be edited (NO_x, CO etc.).
- In the **3. column**, the internal reduction is shown which represents factors that either reduce or increase the theoretical raw gas emissions. Example: The theoretical SO_2 emissions, calculated from the sulfur content of the fuel, can be reduced by calcium in the fuel, as this component can bind SO_2 in the ash. Depending on the temperature of combustion, reductions of 5-35 % are possible. This internal reduction is a direct function of the combustion process, not a consequence of ECT.
- The **4. column** shows the abatement factors of linked ECT processes (if any). If there is more than one link, the cumulative (combined) control factors are shown. If there is an "internal reduction" (3. column), it is included in the 4. column also - GEMIS displays the effective control rate.
- The **5. column** displays the resulting pollutant concentrations in the flue gas ("clean gas") that finally reach the environment.

Please note that not all emissions might be displayed on the card simultaneously - there may be many emissions in GEMIS. In order to see the emissions sequentially, use the slide bar on the right side of the window. - Click on in order to move the table up or down - or left-click on the vertical gray slide bar and keep the mouse-button down while moving your mouse.

The table can be moved horizontally, too: in the lower right part at the bottom of the card you might find another slide - if you click on , GEMIS moves the columns to the left:

- In the **6. column** the clean gas emissions in ppm (parts per million) appear.
- The **7. column** shows the calculated emission factors based on the output of the process.
- The **8. column** shows the input-based emission factors.
- The **9. column** gives the hourly emission flow (mass of pollutant per hour).
- The **10. column** shows the annual emission flow (mass of pollutant per year).
- The **11. and 12. columns** show the immissions (increments of the ambient air concentrations) for average and peak levels.

Please note that the emissions comprise **only direct emissions** of the process, i.e. effects from auxiliary energies, materials, and from upstream processes and construction materials **are <u>not</u> included here** - but you can easily calculate them using “direct calculation” (see the glossary). Usually, the life-cycle impacts of processes are determined in scenarios.

In order to insert a **user-defined emission,** move the mouse into the air pollutants table on card emissions, and right-click with the mouse. Choose "Insert new element" and select your new emission in the window that has been opened.

In you have not yet defined the user-defined emission you want to insert, you first have to open the window Products and to define the new air pollutant. Then you open window Processes again, and proceed as described above.

As you can see, the card "Emissions" offers a detailed treatment of air pollutants and greenhouse gases, as well as their reduction. The concept of linking processes and products (fuels) helps to keep data consistent, and the links of combustion processes with ECT processes simplifies the treatment of the complex effects on energy demand, costs, and residues.

4.4.1.6 Card "Residues"

This card consists of several data entry fields for the solid and liquid residues (emissions) in form of emission factors that are always based on the output of the process.

- for extraction, conversion and transport processes it is the energy content (heating value) or the mass of the product delivered, e.g. in kg/TJ or kg/t, respectively
- for transports it is the transportation service, i.e. in kg/km or in kg/t*km or kg/P*km.

If you want to use another unit you can change it at once: Choose menu Extras\Units. Choose the right unit there and close the units-window. Then GEMIS will display the new unit at once and accept corresponding inputs.

In the upper left part of the card you find fields for ash, FGD residues, sewage sludge, production waste and overburden. In order to insert a new residue, you first have to open the card file window "products" by clicking on Products and to define the new residue as a product. Then you open file card window "processes" again (click on Processes), move the mouse-pointer into the upper table on card residues and click the right mouse-key. Please choose "Insert line" and select your new residue in the window that has just been opened.

The insertion of a new liquid effluent (into the lower table) takes place in the same way.

You can use emissions control technology processes only for reduction of emissions of air pollutants and greenhouse gases of combustion processes, not for residues!

Generally applies: Numbers on white background can be edited, numbers on grey background are calculated by GEMIS.

4.4.1.7 "Costs" Card

This card serves for laying down the economic data of the process.

All the data on card "Costs" are not editable directly. To edit them just click on the appropriate button.

In order to calculate the capital costs of the investment, the same interest rate is used in GEMIS for all processes. This interest rate is stored in the project database and can be changed (see menu Data: Economic factors).

Please note that you can see for instance the effects of a changed product price directly on this card - either you enter these costs in the corresponding field or you open the file card window "Products", mark the product and open its card "Data". There you enter the new product price and GEMIS will calculate the effect on the costs card of the process after closing and reopening of the process.

If you want to see the effect of a changed interest rate, open the corresponding card file window and mark the record - GEMIS will update the values on the costs card of the process after closing/reopening of the process.

If you want to see the economical effects of changing - for instance - efficiency, operating time or life time of the process, simply open the card "Design data" (a sub-card of card "Data") and enter the changes - then GEMIS will display the effects on the costs card after closing/reopening of the process. All this is made possible by the linking of the data cards.

As you can see, the costs card gives you a lot of information about the economy of a process - and you see the usefulness of linking cards as well as products and processes.

General rule to be remembered: Numbers on white background can be edited; numbers on gray background are calculated by GEMIS.

4.4.2 The Cards of Energy Conversion Processes

Energy converting processes in GEMIS are processes, that change one energy carrier product into another energy carrier product - but not by combustion (this is a process-type of its own).

Like all records, they have metadata and comment cards. Their **Data** cards look like those of combustion processes (see previous chapter), just as the internal **Design data** and the **Costs** card. The **Emissions** and **Residues** cards equal those of other processes.

4.5 File Card Window Scenarios

In the left part of the file card window for scenarios, you can see the alphabetically sorted list of scenarios. The scenario names have different colors (see chapter 11).

If you want to list only certain scenarios, click on tab "Filter". Here you can choose filter criteria. Move the mouse over the different areas of the filter card, and you will see a brief explanation at the bottom of the scenarios window.

To edit a scenario you have to double-click on its name in the list.

In GEMIS there are two types of scenarios:

- scenarios with the symbol (energy-only)
- scenarios with the symbol A/B (multiple options)

Furthermore, the cards "Results", "Graph", "Comparison", "Contribution" and "Trade off" are available to get results from scenario calculations. They are explained in chapter 5.

The next chapter is about the data card of a multiple options scenario:

4.5.1 Data Card of a Multiple Options Scenario

Card "Data" consists of 6 sub-cards for energy demands, material demands, persons transport demands, goods transport demands, waste treatment, and monetary service demands. By clicking on the corresponding tab they can be opened.

Move the mouse-pointer over the different areas of the data card. Then you'll get some hints in the lower part of the data card.

Here again, the right mouse-button is important for entering and changing data. After positioning of the mouse-pointer and pressing the right mouse-button the local menu is opened and you can enter new or cancel existing processes in the sub-card lists.

Moreover you can copy a table into clipboard or export a table to EXCEL.


Please note one important restriction of multiple options scenarios: If you choose an energy-process with combined heat and power (**CHP**), that has a bonus for its coupled product (heat or electricity), GEMIS can calculate this bonus correctly as far as environmental aspects are concerned, but not for the balance of **costs**! In order to calculate costs of CHP-processes (with or without bonus), you have to use "Energy only scenarios".

After you have defined the options of a scenario, GEMIS can calculate and display results (see chapter 5).

4.5.2 Data Card of an Energy Only Scenario

The data card of energy only scenarios consists of two sub-cards:

4.5.2.1 Tab "Generation"

In the upper table you enter data of your generating processes. Move the mouse-pointer into the table and press on the right mouse-key. Now you can enter new processes to your scenario, cancel existing ones, etc..

In the lower table you can enter processes for balancing supply.

4.5.2.2 Tab "Transport and Distribution"

In this card you can enter length, share, loss power and loss energy of electric or thermal energy distribution networks. Move the mouse pointer into the table and press the right mouse-key. Now you can enter new processes, delete existing ones, etc..

4.6 File Card Window References

To the left you see the alphabetically sorted total list of references. The names of the references have different colors (see chapter 11).

You can also determine links to references with a special function (Show links) in the local menu.

Like in any other file card window you can copy records in the list area, rename existing ones and enter new records. You can copy texts from one reference or Windows application to another reference by using the copy function.

4.7 File Card Window Standards

The file card window "Standards" shows on the left the list of all emission standards available in the currently opened project.

On the right you can select the cards "Info", "Comment" and "Filter":

- Card "Info" summarized data on the standard marked in the list on the left side. When you open the window, this is automatically the first one in the alphabetically sorted list. Note that it is not possible to edit data in this card.
- Card "Comment" contains textual information concerning the marked standard. Here, you also cannot edit.
- Card "Filter" allows to apply data filters for the standards to be shown in the list. For instance you can narrow the list of standards to a certain data quality, or standards from a certain source.

To work with standards (i.e. view/edit their data), you must either double-click on their name, or use the local menu: to open it, move the mouse-pointer into the list and right-click with the mouse.

4.7.1 Editing Standards

Standards have - as all records in GEMIS - a card for metadata. This card is opened automatically when you double-click on the name of a standard, or when you use the command "Edit" in the local menu.

A standard consists of regulations which are stored on the corresponding card - just click on the tab "Regulations".

The regulations specify the scope of the standard, while the details of the regulations are given in rules.

4.7.2 Editing Regulations and Rules

When you click on the tab "Regulations", GEMIS opens the respective card which gives the details of an emission standard - and you can enter new ones, or edit existing regulations:

In the left list you can mark a regulation - as with all data records, you can use the local menu to rename, copy, delete or insert new regulations.

For the marked regulation, you see in the listboxes on the right for which fuels, technologies and capacities the regulation is applicable - and you can also change the entries in the listboxes.

In the lower right part of the card the list of rules is shown which are part of the regulation:

A right mouseclick on the name of a rule allows to edit, delete, or insert a rule.

When you edit a rule or insert a new one, a new window is opened in which you can specify

- which emission the rule concerns - this is set in the upper right listbox
- how the emission limit is expressed, i.e. if it specifies a flue-gas concentration of a pollutant or the ambient air concentration (immission) is meant. For flue-gas rules, the corresponding O2 value (as a measure of the excess air) can be given also.
- whether the rule limits an emission factor, an emission rate or sets a minimum abatement rate.

To select the specifics of the rule, just mark the appropriate switch (click on it), and then enter the appropriate value in the data entry field below the listbox for the pollutant.

Once all details of a rule are given, click on the "OK" button.

Each regulation can consist of any number of rules , e.g. to specifically reflect different capacities, fuels, and technologies.

5 Results of Scenarios

5.1 File Card Window Scenarios: Card Results

If you have defined a scenario (i.e. its options), you can calculate results with this card.

At the top of the card, you can determine the scope for the calculation:

In the listboxes, a location and/or a NACE Code can be selected - GEMIS then shows in the tables

- all contributions from processes which have the selected location and/or NACE Code as a partial sum, and
- "all others" as a further partial sum, and
- the total.

If you accept the default settings in the listboxes (“all"), no partial sums will be shown - GEMIS then shows only the totals for all processes.

Below, you see several buttons for choosing a specific result:

- Greenhouse Gases - CO2, CH4, N2O, HCF, PCF, SF6
- Air Emissions - SO2, NOx, particulates, HCl, HF, CO, NMVOC, H2S, NH3
- Solid Wastes - ash, overburden etc.
- Liquid Effluents - AOX, BOD, COD etc.
- Resources Use: CEC, CER, and CMR
- Land Use - area affected by processes - Caution: since GEMIS 4, the annual land use is calculated, i.e. the life-time of process is not included !
- Costs - internal and external costs, and total costs (sum internal + external), for "Energy-only"-scenarios also investment- and average costs
- Employment effects
- Fuel Balance - the amounts of fuels used
- Process Turnover - detailed representation of the energy, material, and transport turnover for all processes in each scenario option

When you click on one of the buttons for the first time, GEMIS starts the life-cycle calculation for the chosen scenario. After a few seconds, a table will appear. If you click again on another button, the calculation is much faster, because the energy and material flows were established already.

Each time you change the scope (see above), a product, a process, a scenario option, or the global switches, GEMIS must re-calculate the flows - this takes a little time.

All result tables in GEMIS have the same structure:

First, the names of the scenario options are shown, followed by the results in columns. Each line represents a scenario option, each column a result.

Within the columns of the result table, you can click on any cell with the mouse, and then right-click: this activates the local menu where you can

- copy the result table: this will copy the result table into the Windows® clipboard so that you can paste it into any other Windows® application (e.g. spreadsheet program like Excel, or word processing program like Word)
- export the result table: this will open a new window in which you can select an existing Excel spreadsheet file as the export target. Once selected, you can specify into which worksheet the table is to be exported - if the worksheet does not yet exist, GEMIS will create it in the file. You can enter any name. Note that the export to Excel is possible only for Office versions 97 or higher.
- explain value: this will open a new window in which GEMIS lists the processes contributions to the result. In the first column, the quantitative contribution is shown, and in the second column, the share of each process as a percentage. In the bottom line, the sum of all contributions is given also.

If you select "explain value" in a column which shows results of emission equivalents (SO2 equivalents, CO2 equivalents, ozone precursor equivalents), GEMIS does not show the contributions of processes but

- the contributions of the respective emissions to the total equivalent,
- the respective equivalent factor,
- the contribution, expressed as the equivalent, and
- the share (percentage of the total).

5.1.1 Result Table: Resource Use (CER, CEC, and Raw materials)

Assumed, you see the result table for resources used in a scenario.

Then, above the table, you can choose in the box "level of detail" if the results should be displayed as aggregated data, or in detail. In the box "Resource type" on the right, you can switch between primary energies (expressed as CER or CEC), and raw materials (expressed as CMR).

The table first shows the names of the scenario options, followed by the results in columns. Each line represents a scenario option, each columns a result.

If you have set the "Level of detail" to aggregated, the first result column shows the total CER, CEC or CMR, and then the partial sums for the non-renewable CER, CEC, or CMR, the renewable CER, CEC, or CMR, and "other" CER, CEC, or CMR - the latter represents the use of secondary resources.

If you have set the "Level of detail" to detailed, the first result column shows the total CER, CEC, or CMR, and the following columns the various resources used in the scenario.

5.1.2 Result Table: Process turnover

Assumed, you see the result table for the turnover of the marked scenario.

The table first shows the alphabetically sorted names of the processes and their products used in the scenario, followed by a column with the respective units in which the process turnover is calculated. The other columns represent the scenario options.

Within the data columns of the table, you can click on **any cell** with the mouse, and then **right-click:** this activates the local menu where you can

copy the result table: this will copy the result table into the Windows® clipboard so that you can paste it into any other Windows® application (e.g. spreadsheet program like Excel, or text processing program like Word)

export the result table: this will open a new window in which you can select an **existing** Excel spreadsheet file as the export target. Once selected, you can specify into which worksheet the table is to be exported - if the worksheet does not yet exist, GEMIS will create it in the file. You can enter any name. Note that the export to Excel is possible only for Office versions 97 or higher.

explain value: this will open a new window in which GEMIS lists the processes contributions to the result. In the first column, the quantitative contribution is shown, and in the second column, the share of each process as a percentage. In the bottom line, the sum of all contributions is given also.

Sort: here you may select sorting by process name, product name, unit, or value.

Hide small values: this command refers to rows in which **all** values are "near" zero (more exact: between minus one and plus one). If there are rows with all values in this range, they can be hidden with this command altogether.

5.1.3 Result Table: Fuel Balance

Assumed, you see the result table for the fuel use of the marked scenario.

The table first shows the name of each fuel, followed by the results in each scenario option in the columns. Each line represents a fuel, each column the fuel use in the respective scenario option.

5.2 File Card Window Scenarios: Card "Graph"

With the graph card, you can create graphs for scenarios results.

It consists of a text input field (above) as well as under it four list boxes and two buttons.

On card "Graph" you can choose in four list boxes, which result shall be displayed. At the top of the card there is a text input field for the title of the graph - you can enter a text you like instead of the default text. Under it are four list boxes:

- Type of result - here you can choose, which category of result you want to see (airborne emissions, greenhouse gases, costs, etc.)
- Subtype - here you can choose, which subtype (e.g. single harmful substance) of the first chosen category of result you want to see
- Location - in the third list box you can determine, which processes are taken into account at calculating the graph. If you choose EU, the contribution of processes that are located in the European Union will be displayed.
- NACE - here also you can reduce the number of processes, that are taken into account at calculating the graph. If you choose "agriculture" here, the processes from the industrial sector "agriculture" are shown in one bar. In the complete graph you'll see the contribution of all other upstream processes in a bar of another colour on top of the agricultural processes bar.

After you've chosen the result to be displayed in the graph, click on button "Graph" and GEMIS will open a new window with the corresponding graph - you can change the size of this window with your mouse and maximize it, too. In order to create further graphs, choose the results you want and click again on "Graph".

Here a little tip: If you should not be able to read the x axis labels in the graph completely, it might be useful to deactivate the default-setting "horizontal x axis label". In order to accomplish this deactivation - i.e. vertical labelling, you only have to click on button "options" on card "graph", and then cancel the appropriate hook.

Please note, that changes in scenarios or processes do not influence graphs, that are already created, but have an effect only for new graphs !

5.3 File card window scenarios: card "Trade-off"

If you have defined a scenario (i.e. its options), you can determine and display the differences of two results at the same time for all options of a scenario against a reference option. All this is possible with card "trade-off".

It consists of nine listboxes for choosing results and the reference option and two buttons.

You see four listboxes in the upper part (frame Contribution 1):

- Type of result - in the first listbox you choose the first category of results, whose trade-off shall be determined (air pollutants, greenhouse gases, costs, etc.)
- Sub type - here you can choose the first subtype (e.g. single harmful substance), whose trade-off shall be determined
- Location #1 - in this listbox you can choose, whether you want to consider all upstream processes, that contribute to result-subtype #1, or only those of a certain location.
- NACE #1 - here you can set the economic sector of processes, that contributes to result-subtype #1

Under it you find four other listboxes (frame Contribution 2):

- Type of result - in the fifth listbox you choose the second category of results, whose trade-off shall be determined (air pollutants, greenhouse gases, costs, etc.)
- Subtype - here you can choose the second subtype (e.g. single harmful substance), whose trade-off shall be determined
- Location #2 - in this listbox you can choose, whether you want to consider all upstream processes, that contribute to result-subtype #2, or only those of a certain location.
- NACE #2 - here you can set the economic sector of processes, that contributes to result-subtype #2

Under it you find the "Reference option" listbox - here you choose your reference option from the marked scenario for trade-off calculation.

GEMIS subtracts the chosen results #1 and #2 of the reference option from the corresponding results #1 and #2 of all other options in the marked scenario, so that only the differences remain. These "deltas" are then divided.

After you've made your choices in the listboxes, you click on button "Table". GEMIS will open a new window with a trade-off table:

- In the first column are the names of all options the marked scenario contains (but without the reference option)

- In the second column is the numerical tradeoff, i.e. the result of the calculation (result #1 of the current option minus result #1 of the reference option divided through result #2 of the current option minus result #2 of the reference option)
- In the third column is the value of the delta for result 1 (result #1 of the current option minus result #1 of the reference option)
- In the fourth column is the value of the delta for result 2 (result #2 of the current option minus result #2 of the reference option)

In the trade-off graph - created by a click on button "Graph" - the deltas of all options against the reference option are displayed graphically. The X-axis represents result #1 and the Y-axis result #2. Please note, that the deltas can be negative (reduction as compared to the reference option).

Please note, that changes in the scenarios or processes do not influence already created tradeoff tables or tradeoff graphs, but have an effect only for new tradeoff calculations!

5.4 File card window scenarios: card "Comparison"

If you have defined a scenario (i.e. its options) you can compare the results of two options with card "comparison". To do this just click in file card window "scenarios" on tab "comparison". Now card "comparison" appears in the right part of the window. It consists of four listboxes for choosing the results as well as two listboxes for choosing the options that shall be compared.

You find four listboxes above:

- Type of result - in the first listbox you can choose the category of result you want to compare the options for (air pollutants, greenhouse gases, costs etc.)
- Subtype - in the second listbox you choose the subtype (e.g. single harmful substance)
- Location - in the third listbox you can determine whether all upstream processes shall be considered when comparing the options, or only those that are located in a certain country or group of countries.
- NACE - in GEMIS every process belongs to a certain economic sector - its "NACE". With the fourth listbox you can determine the economic sector the upstream processes have to belong to, in order to be considered. If you choose "All", upstream processes from all economic sectors, i.e. the whole economy are considered.

Below you find two further listboxes:

- Option #1 - here you choose the first option from the marked scenario, that shall be part of the comparison
- Option #2 - here you choose the second option from the marked scenario, that shall be compared with the first option.

After you've made your choice in the listboxes, you click on button "Table" and GEMIS will open a new window, where you can find the following data:

- In the first column are the names of all processes contributing to the chosen result, beginning with the sum of all processes - the sorting is chosen in a way, that the process with the highest contributions is at the top.

- In the second column is the contribution of the processes for Option #1
- In the third column is the contribution of the processes for Option #2
- In the fourth column is the location of the processes
- In the fifth column is the data quality indicator of the processes

With this arrangement of results you can see directly, which process takes part in which option with which share. Furthermore you can correlate the contributions with the locations and data quality.

Please note, that changes in the scenarios or the processes don't influence existing tables, but have an effect only for new comparisons!

5.5 Scenarios: Card "Contribution"

If you have defined a scenario (i.e. its options), you can put two results of a certain scenario-option opposite to one another and thus compare the contributions of upstream processes to the two results.

To do so click in file card window "scenarios" on tab "contributions" at the top of the window. Now card "contributions" appears in the right part of the file card window. It consists of nine listboxes for choosing the results and variant/option and a button. Above you find two times four listboxes:

- type of result - in the first and fifth listbox you choose the category of result, whose contribution to the option shall be determined (air pollutants, greenhouse gases, costs etc.)
- subtype - in these listboxes you choose the subtype (e.g. single harmful substance), whose contribution to the option shall be determined.
- location - in these listboxes you can narrow the number of regarded upstream processes. As an example: If you choose "USA", only processes native in the USA are taken into consideration.
- NACE - in these listboxes the number of considered upstream processes can be narrowed, too. As an example: the emissions from metal-processing industry for a scenario-process "gas-heating" can be determined; different economic sectors can be chosen here.

Further down you'll see the listbox "option #1" - here you choose the option/option from the marked scenario, for which the contributions of results shall be determined.

After you have made your choice in the listboxes, click on button "Table" and GEMIS will open a new window, where you can find the following data:

- in the first column are the names of all processes contributing to the chosen result #1 or #2, beginning with the sum of all processes - they are sorted so that the process with the highest contribution to result 1 is at the top
- in the second column is the contribution to result #1
- in the third column is the contribution to result #2

- in the fourth column is the corresponding location of the processes
- in the fifth column is the corresponding data quality indicator of the processes

With this arrangement of results you can see directly which process takes part in the option, and what is their contribution to result #1 or #2 - and at the same time you can see their location and data quality.

Please note that changes in scenarios or processes do not influence already existing contributions tables, but have an effect only for new calculations !

6 Menu File: Saving, Exporting, Appending

6.1 Menu File: Open Project

In order to work with GEMIS, a data base (so-called **project**) has to be opened. If you start GEMIS for the first time, you can only use the STANDARD database which comes with the setup.

To open a project click on button  or on Menu File: Open Project.

Then GEMIS shows the Windows® dialog for opening of files. Use the mouse to mark the name of the project you're interested in and **double-click** on it.

GEMIS then loads all project files with all records into the PC's memory.

If for some reason the project you want to open is not longer readable (i.e. GEMIS reports an error), you can try to open a backup (previously stored version) which can be created by GEMIS automatically (see Menu Extras: Settings - user interface).

To open a project backup, click on button  or on Menu File: Open Project: In the Windows® dialog, click on the lowest listbox called "object type", and choose "GEMIS Backup Project" instead of "GEMIS Project". Now the window shows all available backup project files. Select the one you want to use, and double-click on it.

6.2 Menu File: Save

With this button (or the command save in menu file) you cause GEMIS to save the currently loaded project on the storage medium (with pre-adjusted path). Here GEMIS uses name and path, under which the project was opened - this name is displayed in the title bar of the GEMIS-program-window. Please note, that the previously saved version of the project is super scribed by the current version.

For saving the current project under another name see: save as...

6.3 Menu File: Export

You can export GEMIS-records, too - as MS access-compatible data bases or as HTML-data structure.
Please note, that an import of data from other data bases is not possible at this time. Only the binary data field of the data base can be imported, i.e. no changed parts of the data base.

If you want to export to an existing data base, you have different update-possibilities, that determine, how the current content of the data base is treated. Choose menu file\export\export database.

You can

- if need be overwrite the existing data base,
- append data to the existing data base
- or take only newer objects.

Furthermore you can write binary data and/or a table with all results (on process-level). (The last option takes a lot of time). Finally click on button "Export". The "Select database"-window is opened. Here you can choose the type and filename of the data base to be used.

If several GEMIS-users work at a GEMIS-record, the independently updated GEMIS-record-versions can be merged to one current data base. Then exporting option "take only newer objects" must be selected.

6.4 Menu File: Append Project

You can also combine projects - this is done in Menu File - Append Project.

When you activate it, GEMIS shows the Windows® dialogue for opening files.

Use the mouse to mark the name of the project you want to append, and double-click on it. GEMIS then opens this project and loads all data records which are not yet part of the currently opened project (i.e. the one in the PC's memory).

This means that all data records in the currently opened project will be unchanged - only *additional* data records from the appended project will be inserted into the current project.

After appending, you should save the project under a new name (see Menu File: Save as...).

7 Menu Data: Further Options

Via menu *Data* you can access further records that influence the calculation of results in GEMIS:

7.1 Menu Data: Economic characteristics

These are on the one hand the interest rate and on the other hand the employment effect.

In GEMIS, the interest rate for capital (i.e. investment costs) is used to determine the cost balance of processes and scenarios.

To mark the interest rate you want to use, just click on its name in the list (left part of the window that is opened after menu Data\Economic characteristics). GEMIS will then use the corresponding value for all costs calculations in the currently loaded project, thus also in all scenarios. If you mark another interest rate, GEMIS uses this one to calculate cost results.

To edit a economic characteristics record, double-click on its name.

As all data records, it has metadata.

Its data card contains the value of the interest rate and the employment effect factor - just enter the appropriate percentage. Please note that in the STANDARD database, the interest rates are given in real (not nominal) terms.

7.2 Global Warming Potentials

In GEMIS you can convert emissions of greenhouse gases (GHG) by using their so-called global warming potentials (GWP) into the equivalent quantity of CO_2, so that the emissions of different greenhouse gases can be summed up into the total CO_2 equivalent.

The GWP factors are based on the relative radiative forcing of GHG compared to CO_2 with respective to their atmospheric residence time.

In the list area of the file card window "GHG factors" you can mark the record to be used for scenario calculations as well as edit available GWP data or enter new ones (of your own). Both happens by the local menu, that is opened by pressing on the right mouse-button. (The mouse has to be positioned in the list-area of the window).

The GEMIS core database contains GWP data for the direct greenhouse effect (zero for SO_2, NO_x, CO and NMVOC) for a time horizon of 100 years. For CH_4 and N_2O, as well as SF_6, HFC and PCF, the data are based on IPCC reports.

All GWP in GEMIS are mass-based, i.e. they give the relative greenhouse effect of 1 kg CO_2

7.3 External Costs

In addition to the interest rate for internal costs you can select also cost factors representing external costs of emissions and residues.

Based on these values GEMIS then calculates the external costs of scenarios.

To select the External Cost Record you want to use, mark its name in the list area of the window. GEMIS will use the corresponding values for all costs-calculations in the currently loaded project, thus also in all scenarios.

If you mark another record, GEMIS calculates the new results for the new cost factors.

To edit an External Cost record, just double-click on its name.

To copy existing or insert new records, right-click with the mouse, and choose the appropriate command in the local menu.

Please note, that the external cost factors in the STANDARD database are based on avoidance-costs, and that in GEMIS external costs always represent real (not nominal) costs.

The external costs of user-defined emissions and user-defined residuals are managed and saved on the corresponding product datacards.

7.4 Locations

Via menu *Data-Locations* you can open a window that displays a hierarchic tree structure for the locations. By clicking on symbol "+" in front of a location you can extend the display for a sub-regions/countries.

With a right mouseclick you can **delete**, **rename**, and **change**[1] locations. New locations can be entered only on card *metadata* of processes.

7.5 Source

Window **Sources** shows the list of sources of data records available in the currently loaded project.

As in all lists, you can use the local menu to rename sources (if they do not belong to the protected core data), delete unused sources, and insert new sources.

In addition, the local menu offers the show links function.

7.6 Menu file – User

Here you can see the GEMIS user list.

8 Menu Extras: Units, Settings, Global Switches

8.1 Menu Extras: Units

In the file card window for units, you can select various units which GEMIS uses for data inputs and results.

This file card window is accessible also with the button 

.

In the first 3 cards, several listboxes are available for a variety of items. Once you choose a certain unit, all windows with data are converted immediately into the new unit.

[1] The „Change" replaces one location by another. Please note, that this is possible for unprotected data records only – all protected data records can't be changed.

On the 4th card, you can select the currency to be used for costs. Here, you can also enter a new currency.

Note that the units do not influence the precision of data - GEMIS internally always computes with the metric (SI) units, and costs in € (Euro).

8.2 Menu Extras: Settings, Global Switches Card

Global switches are a novelty since GEMIS version 4 by which the system boundaries for life-cycle computations can be determined:

Inclusion of the construction requirement, transports, credits, CER-methods (efficiency of resource extraction, primary energies used as materials), and waste treatment.

The sensitivity of the GEMIS-calculations thus can be determined quickly by switching the global switches on/off (Results must be recalculated after every change of the settings.)

8.2.1 Global Switch "Construction"

If this global switch is active (indicated by ☑), *material requirements for the constructing of all processes* are included in the life-cycle calculation of GEMIS - this is the default setting.

If you de-activate the global switch by clicking on the checkbox, GEMIS will ignore any entry in the "Auxiliaries" cards of processes which concern construction materials, i.e. the construction phase and its material use will be excluded from the life-cycle computation.

This global switch is useful to determine the sensitivity of e.g. scenarios results regarding the inclusion of materials used for construction:

You can let GEMIS calculate your scenario with the activated global switch, and export the results into a worksheet of an Excel spreadsheet.

Then you can de-activate the switch, re-calculate the scenario, and again export the results - this time to another worksheet of the spreadsheet.

Now you can easily compare the results - if the impact of construction materials is significant, you must make sure that your data on material use is adequate.

8.2.2 Global Switch "mobile transport"

If this global switch is active (indicated by ☑), all *mobile freight transport processes* like LDVs, ships, tankers, trains, and trucks are included in the life-cycle calculations of GEMIS - this is the default setting.

If you de-activate this switch by clicking on the checkbox, mobile freight transports will not be included in the life-cycle calculation any more.

Note that this global switch has no effect on stationary transport processes (pipelines, transmission lines).

This global switch is useful to determine the sensitivity of e.g. scenarios results regarding the inclusion of freight transports:

You can let GEMIS calculate your scenario with the activated global switch, and export the results into a worksheet of an Excel spreadsheet.

Then you can de-activate the switch, re-calculate the scenario, and again export the results - this time to another worksheet of the spreadsheet.

Now you can easily compare the results - if the impact of excluding freight transports is significant, you must make sure that your data on transport (e.g., distances, modes) is adequate.

8.2.3 Global Switch "Efficiency of Resource Extraction"

If this global switch is active (indicated by ☑), the efficiency of all extraction processes is set to 100% by definition - disregarding any other entries on the "design data" card of these processes.

This setting is relevant for the calculation of the CER: GEMIS determines the primary energy use from the amount of resource input to extraction processes which is dependent on the efficiencies of the extractors. The "100%"-rule is implemented to reflect the methodological requirements of the CER as developed by Öko-Institut (see CER project website).

If you de-activate the global switch by clicking on it, GEMIS uses the data for efficiency as given on the data card of extraction processes - this represents the "traditional" accounting method for the CER as laid out in the VDI Directive 4600 (German version).

Note that this global switch influences only extraction processes - the efficiencies of all other processes are fully taken into account in the life-cycle calculation, whatever the setting of the global switch be.

The reason for the "100%-rule" (default setting) is that the VDI Directive 4600 creates an imbalance between fossil and renewable energy extraction: while for fossil fuels, the e.g. mining is considered to be 100% effective (all losses are allocated to the stock, or reservoir), the extraction of e.g. wind power is calculated with an efficiency of 20-35%, depending on the technology. Similarly, solar power extraction processes have efficiencies of 5-10 % (solar electricity from photovoltaics), and 25-40% (solar thermal processes).

The "new" CER methodology implemented in GEMIS equals this: all resource extraction is set to a 100% efficiency, which is also compatible with the international rules of energy statistics.

If users do not want to use the new methodology, they can reset GEMIS to the "traditional" methods of accounting for primary energies with the global switch.

8.2.4 Global Switch "treated/disposed solid wastes"

If this global switch is active (indicated by ☑), GEMIS excludes the solid wastes which are treated by a waste process from the results of life-cycle calculations.

If you de-activate the global switch by clicking on it, the life-cycle computation will include all solid wastes from processes whether they are treated by a waste process or not - i.e. any links to waste processes will be ignored.

This global switch is useful to determine the sensitivity of e.g. scenarios results regarding the inclusion of waste treatment processes:

You can let GEMIS calculate your scenario with the activated global switch, and export the results into a worksheet of an Excel spreadsheet.

Then you can de-activate the switch, re-calculate the scenario, and again export the results - this time to another worksheet of the spreadsheet.

Now you can easily compare the results - if the impact of excluding treated wastes is significant, you must make sure that your data on waste treatment is adequate.

8.2.5 Global Switch “Use saved turnover values”

This global switch is an experimental feature. Please don’t use it.

8.2.6 Global Switch "Base for Heating Value Related Data"

This global switch decides which base is used in GEMIS for data related to the heating value of fuels:

- the default setting is the lower heating value (LHV, also known as net calorific value), while
- the alternate setting is the higher heating value (HHV, also known as gross calorific value).

Because the setting of this global switch influences all fuel-related data entries and the display of data (e.g. efficiency, emission factors, cost data), its status is always shown in the status line (lowest part of the program window).

When you switch to the HHV base, GEMIS will also show this when you edit the "Design Data" card of combustion processes: The data entry box for efficiency on this card is shown with a yellow background.

Similarly, the costs data entry fields, and the heating value entry fields of fuels are also shown with a yellow background (see Edit Products: Card "Data" of gaseous fuels, and Edit Products: Card "Data" of solid/liquid fuels)

When you switch back to the LHV base, these hints will be deactivated, and the entry fields are shown again with the normal **white background**.

8.3 Menu Extras/Settings/Allocation

Here you can setup an allocation method. Tour 7 (about allocation) in the appendix might be helpful for you.

9 Glossary

Here you find a brief explanation of relevant terms used in GEMIS.

a (annum) is the acronym for year.

A&F (agriculture and food) is the acronym in GEMIS for a group of processes from the area of agriculture and food production. The base data came from GhK and are currently updated and extended (in cooperation with partners).

abatement factors represent the percentages by which the theoretical uncontrolled ("raw") emissions of a combustion process are reduced by an emissions control technology. Usually, the abatement factors are **positive**, i.e. emissions are reduced. But there are cases in which the reduction of one pollutant is possible only by increasing the emission of another pollutant (e.g. more CO for less NO_x). To model this, also **negative** abatement factors can be entered to **increase** the raw emissions by a certain percentage.

acidification potential (AP) is the result of aggregating acid air emissions, expressed in SO_2 equivalents. The AP is an important environmental indicator.

af is the acronym for **a**sh-**f**ree and is used to characterize the ultimate analysis.

AGEB (Arbeitsgemeinschaft Energiebilanzen) issues the annual energy balance for Germany which contains important basic data especially for the energy use of industry, electricity generation, and the primary energy use. AGEB has a website with more information.

air pollutants are products of the type emissions (especially SO_2, NO_x, HCl, HF, NH_3, H_2S) for which GEMIS determines the acidification potential, and CO, NMVOC, NO_x, for which GEMIS determines the ozone precursor potential. Users can extend the database with user-defined emissions.

allocation is the distribution of (environmental) burdens of processes to several outputs (products) of these processes. The allocation can be based on e.g. heat values, mass or costs, or by crediting.

AOX (absorbable organic halogens) is a measure for the load of liquid effluents with organo-halogenic compounds.

APME (Association of Plastics Manufacturers in Europe) offers LCA data for plastic on their website (APME data are also part of the GEMIS 4.5 database).

ar ("**a**s **r**eceived") refers to fuel data for which the ultimate analysis is given including the ash and water content. See also wf (water-free), and waf (water- and ash-free)

ash is in GEMIS part of the solid wastes. The amount of ash is automatically calculated in GEMIS for combustion processes, for which data on the ash content is used from the ultimate analysis of the used fuel.

ash-free refers to fuel data for which the ultimate analysis is given excluding the ash content. See also wf (water-free), waf (water- and ash-free), ar (as received)

ATB is the Institut for Agrartechnik Bornim e.V. in Potsdam, Germany, a GEMIS user and cooperating partner for A&F data. More information is given on the ATB-website.

ATC is the abbreviation of "Atlantic Central", a zone consisting of Belgium, Germany, France, and United Kingdom.

ATN is the abbreviation of "Atlantic North", a zone consisting of Finland, Sweden, Estonia, Lithuania, and Latvia.

BASiS (**B**edürfnisfeldorientierte **A**nalyse von **S**toffströmen **i**n scenarios) is a computer model for material flow analyses. BASiS models also the demand side, i.e. needs like buildings, housing, good consumption etc. It is also dynamic with time series for both the demand, and the supply side.

BaUm (Basisdaten Umweltmanagement) is an IT project of UBA which prepared a public database in the **internet** for environmental management, life-cycle analyses, and material flow analyses, offering e.g. GEMIS data. More information is given on the (German) ProBas-website.

BGR is the Bundesamt for Geowissenschaften and Rohstoffe in Hanover, compiling e.g. data for raw material extraction and processing.

biogas is a high energy gas mixture made by fermentation of biomass

biogenic is a characteristic of fuels, showing that the fuel stems from biomass.

biomass is a renewable resource which can be used both as a primary energy and a raw material (*biomass cultivation*). In GEMIS, biomass can also be a secondary resource (*biomass residues*) which is accounted for as "other CEC" and not as a primary energy according to the CEC methodology, because it is a recycled residue. Fuels and raw materials from biomass have the following icons:

-  for solid biomass (wood, straw)
-  for bio-gases (bio-, landfill-, wood- and sewage treatment gas)
-  for liquid bio energies (bio-ethanol, rape oil, RME)

BMBF is the German Federal Ministry for Education and Research (Bundesministerium for Bildung and Forschung). More Information is given on the BMBF-website. The BMBF sponsors a project of Öko-Institut where GEMIS is used as a tool for material flow analysis - see website Sustainable Cities.

BMU is the German Federal Ministry for Environment, Nature Protection, and Nuclear Safety (Bundesministerium for Umwelt, Naturschutz and Reaktorsicherheit). More information is given on the BMU-website.

BOD is the biological oxygen demand, a measure for the pollution of waste water with bio-degradable substances.

BP is the acronym for back-pressure turbine (for CHP processes).

BTU means British Thermal Unit, an Anglo-Saxon energy unit.

Building types are generalized structural shapes of houses for which the construction units describe the material requirement for building the house. Examples for building types are SFB and MFB.

BUIS (Betriebliche Umwelt-Informations-Systeme) are computerized tools for the environmental management in enterprises.

cards in GEMIS are the "pages" on which information for data records (products, processes, scenarios, references) are stored and displayed. Each data record can have several cards.

cars in GEMIS are processes of the type person-transport and are listed under name name element "car". GEMIS contains cars using various fuels (gasoline, diesel, natural gas, H_2, rape oil, RME, electricity), weight classes, driving cycles, and emission classes.

CAS is the Chemical Abstract System

CC are combined-cycles, i.e. combinations of gas turbines and steam turbines.

CDER (Centre de Développement des Energies Renouvelables) is a research institute in Marrakech which prepared within the EM-Project country data for Morocco (sponsored by GTZ). The Morocco data are integrated in the GEMIS core database.

CEC is the Cumulated Energy Consumption and is, similar as CER, a yardstick for the entire expenditure of energy resources (primary energies) for the supply of a product or a service. The CEC can be divided into the portion of renewable and not-renewable primary energies. Differently than the CER the energy portions in the CEC, which do arise with materially used sources of energy as heat value (e.g. wood as building material, plastics, paper) are not included, since these are available still for an energetic use. The CEC differs thus from the CER in the fact that it covers the necessary energetic expenditure for the supply of necessary materials without its heat value.

CEE is the country code for Central and Eastern Europe.

CER is the Cumulated Energy Requirement, a measure for the total amount of energy resources (primary energies) needed to deliver a product or a service. In GEMIS, a new methodology is implemented for the calculation of the CER - see CER Project - but this can be changed with a global switch back to the "old" methodology of the VDI Guideline 4600.

CEU is the Cumulative Energy Use, the same as the CEC

CFCs are chlorinated fluoro-carbons, chemically rather stable compounds with a very high global warming potential (GWP). In the higher atmosphere, they are decomposed by UV radiation and cause ozone depletion. This effect more than compensates their radiative forcing, because ozone itself is a strong GHG - the "net" GWP is therefore assumed to be zero. CFC were used as working fluids in heat pumps, and foaming agents for insulation materials, but are more and more substituted by H-CFC, butane etc.

CH_4 is the chemical formula for methane. Its effect as a greenhouse gas is included in the CO_2 equivalents, while its effect as an air pollutant is included in the ozone precursor equivalents.

chem-anorg is a name element in GEMIS for processes in the chemical industry which deliver inorganic base materials.

chem-org is a name element in GEMIS for processes in the chemical industry which deliver organic base materials.

CHP is the acronym for **combined heat & power,** i.e. the joint delivery of electricity (power) and heat - but also chilling, cooling etc. In GEMIS, CHP processes have the symbol  before their name which also contains the acronym cogen or ICE. The name element "th" refers to heat output of a CHP process, while *without* "th", the processes generally deliver electricity. In GEMIS, usually a credit for the coupled product is allocated so that the CHP process is modeled on a net base. In the names of CHP processes in GEMIS, this is shown by the "/", followed by the credited process. There are also CHP processes modeled without credit - this is indicated by the name element "gross" after the "/".

CIS is the country code for the Commonwealth of Independent States (former USSR).

city is the acronym for the driving cycle "in the city".

CityPlan is a consultancy in Prague which prepared - sponsored by UBA-Wien - the country database for the Czech Republic. These data are now integrated in the GEMIS core database

CMR is the Cumulated Material Requirement, a quantitative measure of the total amount of raw materials needed to deliver a product or a service. In GEMIS, the CMR is the material complement to the CER.

CNG (compressed natural gas) is a methane-rich fuel, especially for vehicles.

C_nH_m are hydrocarbons. In GEMIS they are divided into NMVOC and CH_4.

CO means

- either **carbon monoxide.** This gas is the result of incomplete combustion and part of the air emissions in GEMIS. Its effects are included in the ozone precursor equivalents,

- or the **commercial sector**.

CO_2 (carbon dioxide) is the quantitative most relevant greenhouse gas (GHG) emitted by human activities (especially combustion of fossil fuels).

CO_2 equivalents are the result of the aggregation of greenhouse gases (GHG) which takes into account their respective global warming potentials (GWP).

CO_2 neutral means in GEMIS that no net CO_2 emissions are charged to fuels, as the carbon of the fuel was taken from atmosphere when the fuel was produced. This "closed" carbon-cycle is characteristic for biomass from sustainable cultivation. Please note that also for CO_2 neutral fuels CO_2 emissions of upstream processes and other greenhouse gases are balanced.

coal is in GEMIS the name of the product group for solid fossil fuels. The fuels in this group carry the icon  before their names. In the core database, hard coal and lignite are part of this group.

COD is the chemical oxygen demand, a measure for the pollution of waste water with chemically degradable substances.

cogen is the acronym for combined heat & power. For small-scale cogen, see ICE.

combustion is the conversion of a fuel by oxidization. Based in the ultimate analysis, GEMIS can compute the amount of energy (heating value) and flue gas. From that, GEMIS computes the flue-gas concentrations and emission factors for emissions - these are SO_2, HCl, HF, CO_2 and ash.

combustion processes are processes in GEMIS in which fuels are converted into heat or electricity (or both) by means of oxidization (combustion). For these processes, GEMIS can compute the fuel-depending emissions (see Model Documentation), and they can be linked to emission control technologies, and their compliance with emission standards can be tested. Examples are heating systems, thermal powerplants (with FC, ST, GT or CC) and ICE, or systems for combined heat & power.

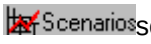
comment is part of a data record and usually offers a description of the record. It further offers some information on the data generation, restrictions, etc. In GEMIS 4.5, the comment is multilingual.

Comparison - card "Comparison" in file card window 

serves for comparing the results of two scenario-options.

CON is the abbreviation of "Continental", a zone consisting of Austria and Poland.

construction units - are GEMIS-processes representing typical elements of a building (e.g. roof, window, outer wall) and carrying the symbol  in front of their name. The construction unit processes contain the material masses for the production of 1 m² construction unit area and links to delivering processes. Building types can be modeled by construction units.

Contribution - card "Contribution" in file card window 

serves for putting two results of a certain scenario-option opposite to one another and thus compare the contributions of upstream processes to these two results.

copy is a Windows® function to copy a selected text or data record into the so-called clipboard. From there, the function **Paste** inserts the content of the clipboard into a text, list or another Windows application (spreadsheet, text). The shortcut for Copy is CTRL+C, for Paste CTRL+V.

core data are the data records of the project STANDARD which come with the GEMIS setup. The core data are protected against changes - to make this visible, the names of these records are shown in color, while the non-core (user-defined) data are shown in black. Core data records can be copied, thereby getting transformed into user-defined data.

costs are the monetary values of products and services delivered by processes. GEMIS offers a simplified calculation of costs for the delivery of a product by a process or in a scenario. For

that, investment costs, fixed annual costs, variable costs, and fuel costs are included in the calculation of the internal (private) costs, as well as total (societal) which include external costs also. The algorithms for the cost calculation are given in the Model Documentation.

country code in GEMIS is an acronym for nations (countries) and groups of nations (e.g. DE).

credits are a method of allocation for processes which deliver more than one product - see combined heat & power (CHP). CHP processes in GEMIS for which a credit was allocated have the name element "net".

d (diem) is the acronym for day.

data filters in GEMIS are **selection criteria** for the retrieval and display of records in the database: only those data records are shown in a file card window which comply with the chosen filter criteria. The data filters have their own card which offers - depending on the file card window - several filters. Always the filters for last change, source, owner and data quality are available.

data record is in GEMIS the smallest unit in which data is stored. Each data record has a unique name, an owner and a source. The totality of all data records is called project.

data quality indicator is a description for the respective origin and quality of a data record and is stored in the metadata card of products, processes and scenarios, as well as standards. The indicator is used in results to show for each part of a scenario result the data quality. The indicator highlights also the uncertainty of results, and has 5 levels. The meaning of these levels is as follows:

- *very good*: data come from a primary source (e.g. measurements, reports from on-site inspections etc.) and are validated, i.e. peer-reviewed. This data quality is shown with the **symbol "++"** in result tables
- *good*: Data come from a primary source, but are not peer-reviewed. This data quality is shown with the **symbol "+"** in result tables
- *medium*: Data come from secondary sources (e.g. literature) or are processed (e.g. averaged). This data quality is shown with the **symbol "+/-"** in result tables
- *simple estimate*: Data come from estimates. This is shown with the **symbol "-"** in result tables
- *preliminary*: Data are not (yet) suitable for comparisons, and need further refinement. This data quality is shown with the **symbol "?"** in result tables.

DeNOx is the acronym for NO_x removal, i.e. reduction of NO_x. In GEMIS, DeNOx processes belong to emission control technologies, and there are Low-NOx, SCR and SNCR.

Design: By clicking on 

on card Data of a Process, the Design data card is opened

direct calculation is an option since GEMIS version 4 to immediately calculate the balance of a life-cycle of a process - this is done in the local menu or by clicking on button "Calc" on card Results" of the (marked) process. The direct calculation can be done for emissions, and resource requirements (CEC, CER, CMR, land use) using a **(right) mouse click**. All upstream processes - i.e. the total process chain - is included in the computation.

direct emissions always derive from running a single process - without considering the upstream processes. So for example the direct CO_2-emissions of an electric car are zero, since when driving with it no CO_2 is emitted. Direct emissions are entered on card "emissions" of the processes and form a subset of the entire emissions which can be calculated by direct calculation.

DIW is the German Institute for Economic Research (Deutsches Institut for Wirtschaftsforschung) in Berlin. It operates as the central office for AGEB. More information is given on the DIW-website.

DLR (Deutsches Zentrum für Luft- und Raumfahrt) is a research center dealing with renewable energies and LCA for fuel cells. More information is given on the DLR-website. A division of DLR is working on solar-thermal systems (see PSA).

driving cycles are standardized routes which are traveled by vehicles with pre-determined speeds, and gears (incl. start-up, acceleration, etc.) to determine emission factors. In GEMIS, vehicle emissions refer to the driving cycles hiWay, rural and city.

DSI (dry sorbent injection) is a type of FGD which captures SO_2 and halogens using a dry sorbent like CaO which is directly added to the fuel, or introduced into the combustion area. The reaction product is then collected with the ash, and fly ash. Due to the low reactivity of most sorbents at high temperatures, the control efficiency of DSI is quite low, and the amount of additional waste generated quite high. Still, DSI is relatively inexpensive to install, so that it is used often to retrofit older (coal) plants.

DSM (Demand-Side Management) is the general term for energy efficiency programs (NegaWatt).

efficiency is the quantitative ratio of the output of a process to its input, but excluding auxiliary energy or material inputs (these are entered explicitly). Note that the efficiency of energy systems usually refers to the lower heating value, but in other countries also the higher heating value is used (especially USA).

el is the name element in GEMIS for electric.

EM (Environmental Manual for Power Development) is a computer program derived from GEMIS, made by the Öko-Institut for GTZ, KfW and World Bank and to be used in developing countries. More information about the EM is on its project-website.

EMAS (Environmental Management and Auditing Scheme) is the EU guideline for environmental auditing, which allows enterprises to certify their environmental management to obtain an EMAS label.

emissions are outputs (products) related to the operation of processes. In GEMIS, the emissions consist of air pollutants, greenhouse gases, solid wastes, and liquid effluents. Emissions can have external costs. For combustion processes, GEMIS can calculate some of the emissions from the ultimate analysis of fuels.

emission classes are legal classes of emission limits for vehicles, referring especially to driving cycles and several weight- and age classes. For trucks, GEMIS offers the emission classes EURO 1 to EURO 5 and for cars the emission classes EURO 1-4.

emission control technologies in GEMIS are special processes which can be linked to combustion processes to reduce their emissions (e.g. FGD). GEMIS determines then automatically the respective "clean gas" emissions, i.e. the effective emissions after the emission control technology. Furthermore, the effects on residues, the respective auxiliary energy (see net efficiency), and the cost impacts of the emission reduction are added to the data of the combustion process.

emission factors are the specific amount of emissions per unit of activity (usually: output). In general, this is the mass of emissions per unit of energy, material turnover, transport service, or economic value. All emission factors in GEMIS refer to the output of processes:

- for energy processes, e.g. kg per MWh of electricity or heat
- for transport systems, e.g. kg per tkm or per P.km
- for material processes, e.g. kg per kg of delivered material

- for monetary processes, e.g. in kg/Mio € value generated.

emission standards - see standards

Employment balance: GEMIS 4.5 makes the fast computation of the direct and indirect job-creating effects as well as the sum of both portions possible. The direct effects are given by jobs in energy systems and their upstream processes, the indirect ones by jobs in the industry producing capital goods (mechanical engineering). The computation can be made by the local menu on process level (see direct calculation), or on scenario level in card "Results". Details for the determination of the employment balance are located in the model documentation of GEMIS 4.5.

energy sources are fuels (e.g. gasoline, coal, H_2, wood) and electricity, heat (hot water etc.), as well as uranium.

Energy mixer is a process type in GEMIS 4.5 delivering fuel mixes. If the hook on card Data besides "Erzeugnis auswählen" is cancelled, a new product with the name "Fuel mix..." is created which equals the defined output product or the mixer.

environmental indicators are categories to describe quantitatively the environmental burdens. GEMIS encompasses the following environmental indicators

- acidification: SO_2, NO_x, HCl, HF, NH_3, H_2S
- ozone precursors: CO, CH_4, NMVOC, NO_x
- global warming: CO_2, CH_4, N_2O, SF_6, PFC, HFC
- eutrophication: N and P, COD
- solid wastes: overburden, ash, sewage treatment sludge, production wastes, FGD residues
- liquid effluents: AOX, BOD, COD, inorganic salts, N, P
- resources: land use, CEC, CER (primary energy) and CMR (raw materials)

environmental management is the active dealing with environmental issues on the level of organizations, especially enterprises (see BUIS) and public administrations (cities & towns), and concerns environmental reporting, environmental audits, development of an environmental policy etc. (see EMAS and ISO Standards 14040 ff) which govern environmental reporting, and life-cycle analyses.

EPS is expanded polystyrene, a plastic material (icon ).

ERM (Environmental Resources Management Ltd) is a consultancy which prepared within the EM Project the country database for Vietnam which is included now in the GEMIS core database. More information gives the ERM-website.

ESP is an electrostatic precipitator, an emission control technology to reduce particle emissions. It traps dust by charging the particles in a high-voltage electrostatic field, and precipitating the charged particles on an electrode.

ESU is the group energy-materials-environment at the Eidgenössische Technische Hochschule (ETH) in Zurich/Switzerland, which co-operated with the GEMIS project (especially Rolf Frischknecht) and offers with ECOINVENT a special database for life-cycle analyses in Switzerland. More information is given on the ESU-website.

€ (Euro) is the new European currency. In GEMIS, the currencies of countries from the Euro zone are automatically converted by the fixed exchange rates.

external costs in GEMIS are the monetarized environmental costs of emissions. These costs represent the monetary value of damages or the avoidance associated with emissions or residues.

External costs are not part of the usual economic calculation which factors in only private costs: the societal costs of emissions and residues are beyond the scope (external) of the private economic consideration. From the societal perspective, though, external costs should be included in decisions regarding investments or procurement. The GEMIS core data on external costs offer values for air pollutants and greenhouse gases which are derived from the cost to avoid (and control) these emissions. For nuclear risks, a "memory value" of 1.5 €cent/kWh nuclear electricity is used.

extraction processes are converting resources into primary energies, or raw materials. They usually have the name element Xtra at the beginning of their name. When resources are excavated, the icons  (energy) and  (materials) are used, for cultivation (biomass) the icon  is used, respectively. In GEMIS, many processes for the delivery of electricity or heat from renewable energies are also extraction processes, because they convert a renewable resource (e.g. hydropower, wind) directly into energy sources. These processes have their own icons:

-  for geothermal
- for solar energy systems,
-  for hydropower,
-  for wind power.

Note: Also processes for energy efficiency are extraction processes.

FBC (fluidized-bed combustion) is the combustion in a layer (bed) of inert material (e.g. sand) with a small share of combustibles (fuel). The upward flow of the combustion air in the bed maintains a state of suspension (fluidization) which is extremely turbulent. The result is a high burnout rate even at low temperatures (<900 °C), allowing low NO_x emissions (but relatively high N_2O formation). Furthermore, desulphurization is possible by injection of a sorbent (e.g. lime) into the combustion zone. FBC can be either stationary or circulating (CFBC), and can operate at atmospheric pressure (AFBC), or in a pressurized state (PFBC).

FC - see fuel cells

FEEC (Faculty of Electrical Engineering and Computing) is a research group at the University of Zagreb (Dep. of Power Systems) which used the EM model to create a country database for Croatia. This database is integrated now into the GEMIS core database. Contact: zeljko.tomsic@fer.hr

FfE (Forschungsstelle for Energiewirtschaft) is a private research institute in Munich and a GEMIS user especially for CER. More information is given on the FfE-website

FGD is the acronym for flue-gas-desulphurization (emission control technology). In GEMIS are several types of FGD: wet, semi-dry (SDA), dry (DSI).

FGD-residue is the solid waste from FGD which in GEMIS is calculated automatically. It is shown as a solid waste in result tables and graphs.

file card windows in GEMIS are special windows in which data records can be selected, created, edited, copied or renamed, and deleted, respectively. The data records are always shown in a list on the left side where they can be selected with a mouse click. For the selected data record, a summary of relevant data is shown in card "Info" on the right side of the *file card window*. Card "Comment" displays additional information. On card "Filter" you can select data filters so that only those data records are listed which comply with the retrieval criteria.

Filter see data filter

final energy is energy which is available to the consumer for conversion into useful energy. An example for final energy is electricity from the socket.

fixed annual costs are in GEMIS the costs to operate and maintain a process, expressed as costs per capacity unit per year, incl. costs for personal, annual costs for repairs, and spare parts. In the core database, expenditures for taxes and insurance are **not** included in the fixed annual costs. See also costs.

fob (free on board) is used to characterize fuel costs

fossil is an attribute of fuels which come from deposits of fossilized biomass. This group contains solid fuels (hard coal, lignite) and liquid fuels (petroleum products), as well as gaseous fuels (natural , LNG, LPG). When burnt, the carbon content of fossil fuels causes a net CO_2 burden of the atmosphere.

freight transport systems in GEMIS deliver the driving force for transport processes. In GEMIS 4.5, they can also be directly linked to the inputs of processes to reflect the transport needs of the input product. Freight transport systems in GEMIS are structured into the following technology groups:

-  truck
-  light-duty vehicles (LDV)
-  ship, tanker
-  train or railroad transport

For trucks and LDV the groups are further divided into the respective driving cycles.

fuels in GEMIS are records of the type product and are part of the energy sources. For fuels, GEMIS stores the ultimate analysis, based on which the heating value or higher heating value and emissions can be computed (see Model Documentation). Furthermore, the price of the fuel, and metadata are stored.

fuel cells (FC) convert hydrogen (H_2) or H_2-containing gases in electricity (and heat) using an electrochemical process which oxidizes H_2 with O_2 from the air ("cold combustion"). This conversion yields low noise and low emissions, and relatively high electric efficiencies (40-60%), but needs the pre-processing of the fuel (e.g. natural gas) which causes losses. Currently, phosphoric acid FC, molten carbonate FC, and solid oxide FC are developed for stationary applications, while PEM-FCs are developed especially for mobile applications (cars).

fuel costs are the monetary value to deliver a fuel to a process, and are specified in the product database. Users can specify also fuel costs on the process level.

fuel mixers are new processes in GEMIS: similarly to mixers, they combine several processes to deliver a joint output. But they do also **actively mix** the fuels from these processes into a new "mixed" fuel which inherits the fuel characteristics according to the shares of fuels which are delivered by the mixed processes. For using the fuel mixer process, see multi-fuel combustion.

Gases in GEMIS are gaseous fuels. Gases from fossil energy sources have the icon . In the core database, gases are natural gas, CNG, coke oven gas, coalgas, LNG, refinery gas and LPG .

Gases from biogenic energy sources (e.g. biogas, landfill gas, woodgas) carry the icon .

GEMIS is the Global Emission Model of Integrated Systems, a life-cycle model of Öko-Institut. Since version 3.0, the software and its database are public domain, and available at no cost. To access the homepage of the GEMIS website, click here.

GhK (University of Kassel) - Center for Environmental Analysis - was participating in the development of GEMIS, and contributed to GEMIS data on agriculture and food (A&F). More information is given on the GhK website.

global switches allow to change the system boundaries of life-cycles with one mouse click: inclusion of the construction materials, transports, credits, and methods for the CER (efficiency of resource extraction, treatment of heat values of materials), as well as waste treatment can be selected now. Using this on- an off-switching and sequential re-computation, the sensitivity of GEMIS results as regards system boundaries can be identified quickly.

global warming potential (**GWP**) is the mass-based equivalent of the radiative forcing of GHG, based on the specific forcing of CO_2 - therefore, it is expressed in CO_2 equivalents. Because GHG have different atmospheric residence times, the GWP is determined as an integral over a period of time. Usually, GWP data refer to a time horizon of 100 years.

greenhouse gases (**GHG**) are gaseous emissions contributing to global warming. GHG are relevant environmental indicators and can be aggregated to the global warming potential (GWP). GHG are CO_2, CH_4 and N_2O as well as SF_6, PFC and HFC (Kyoto gases).

gross is a name element in GEMIS of processes with combined heat & power (CHP) for which **no** credit for the cogenerated, coupled product is given, i.e. **no** allocation.

GT is the acronym for gas turbine.

GTZ is the Deutsche Gesellschaft for technische Zusammenarbeit (GTZ) GmbH (see GTZ-website)

GWP - see “global warming potential (GWP)”

H_2S is the chemical formula for hydrogen sulfide.

HCl is the chemical formula for hydrogen chlorine.

HDPE is high-density polyethylene, a plastic material (icon)

heat coefficient of CHP-processes is the ratio of the cogenerated heat to the cogenerated electricity. In GEMIS, this value is the quantitative expression of the credit which an electricity-delivering CHP process receives for the heat (net definition). The heat credit is entered into the output list, below on card "Data".

hessenENERGIE is the energy agency of the State of Hesse and is a GEMIS user. The hessenEnergie operates its own homepage.

HF is the chemical formula for hydrogen fluorine.

HFC (hydrofluorocarbons) are greenhouse gases and have a high global warming potential.

HHV - see higher heating value

higher heating value (HHV) is the amount of energy from the complete oxidization (combustion) of a fuel **including** the vaporization heat of the water vapor. In international institutions, and especially the USA, the efficiency, costs, and emission factors are often based on the HHV, while in Europe and various other countries, these values are mostly based on the lower heating value. The differences are, depending on the fuel type, 5-20%. In GEMIS 4.5, there is the option to switch between HHV and LHV.

hiWay is the acronym for the driving cycle "highway".

HMULF was the State Ministry for Environment, Agriculture, and Forestry of the German State of Hesse. It was the main sponsor of GEMIS.

H_o - see higher heating value

H_u - see lower heating value

ICE-cogen are internal combustion engines for cogeneration, i.e. they deliver both electricity and heat (combined heat & power). They are mostly fueled with natural gas, diesel or biogas.

immissions are concentrations of emissions in the ambient air. GEMIS offers a simplified immission estimate for air pollutants, which is based on a stack-height-dependent dilution term, and results in annual average additional immissions from a combustion process, as well as short-term peak changes in the ambient air due to the emission. Note that the unit for immissions is µg/m^3 ambient air, i.e. in 1/1000 milligrams (mg) per m^3 of air in the neighborhood of the combustion process.

IN is used in GEMIS as the acronym for industry.

info card is a card of data records which summarizes important information from the data cards of the record. Info card details can be hidden/shown by clicking on "-" / "+". Clicking on blue hyperlinks shows the info card of a data record. Note that the data in the info card cannot be edited - for that, you must access the data cards by a double-click on the record name.

interest rate is the borrowing rate for capital which is used by GEMIS to determine the annual costs from investment costs of processes, using the annuity formula (see Model Documentation). The input or selection of the interest rate is made in the Menu Data. Please note that the interest rate is the **same for all processes**.

investment costs in GEMIS are part of the costs - they concern the costs to buy and construct processes, and can include interest during construction, taxes, and planning costs. In the core database, investment costs are so-called overnight costs, i.e. they do **not** include interest during construction, and **no** taxes/insurances.

ISI (Fraunhofer-Institut für Systemtechnik und Innovationsforschung) is a GEMIS user and a partner in the CER project). In the GEMIS core data, some energy processes from ISI concerning CER are included.

IST (Institut Supérieur de Technologie) together with the Mouvement Ecologique compiled the GEMIS database for Luxemburg, which is integrated in the core data of GEMIS 4.5.

IZW is the Information Center on Heat pumps and Cooling technologies (Informationszentrum Wärmepumpen und Kältetechnik) which has created special data records for heat pumps in GEMIS-4.0. The IZW has its own website.

J (Joule) is a basic energy unit, mostly used in multiples (kilo = 10^3, Mega = 10^6, Giga = 10^9, Tera = 10^{12}), especially MJ, GJ and TJ. 3.6 MJ are equivalent to 1 kWh.

k is the electricity-to-heat ratio of a CHP process, i.e. the ratio of the cogenerated electricity to the cogenerated heat. In GEMIS, k is the quantitative expression of the credit which a heat-delivering CHP process receives for the cogenerated electricity (net definition). The electricity credit is entered into the output list, below on card "Data".

KfW (Kreditanstalt für Wiederaufbau) is the German bank for development in Frankfort. It is one of the users of the EM and maintains an own website.

kW is the acronym for kiloWatt, a unit for power

kWh is the acronym for kilo-Watt-hours (= 3.6 MJ).

landfill gas is a biogas from landfills

LCA is the acronym for life-cycle analysis.

LCI is the acronym for life-cycle inventory.

LDPE is the acronym for low-density polyethylene, a plastic material (icon )

LDV is the acronym for light-duty vehicles which belong to the freight transport systems in GEMIS. They carry the icon  before their names.

life-cycle is a concept used in life-cycle analyses and material flow analyses to determine the environmental burdens of products and services from "cradle-to-grave", i.e. from the source (raw material- or primary energy extraction) through the use phase to the "sink" (e.g. waste treatment, or recycling) and to include the materials needed for the construction, all transports and auxiliary inputs as well. The links of all processes which contribute to a life-cycle are called process chain.

life-cycle analysis (LCA) is an approach to identify, compare and value the environmental burdens of products and services based on the life-cycle concept. The LCA consists of the inventory and the valuation stages, and follows special rules given e.g. by ISO, or SETAC.

life-cycle inventory (LCI) is the part of a life-cycle analysis in which the data base for energy and material flows and all necessary transports are compiled and linked to emission factors. The inventory also comprises the system boundaries, allocation rules, and data quality.

links in GEMIS are the connections between data records. There are links between processes, between products and processes, between scenarios and processes, and between references and products, processes, scenarios and standards. Links establish process chains which can be displayed via the local menu (right mouse click!). If you rename a data record, all links in GEMIS are adjusted to the new name automatically. If you copy a data record, all existing links of the original record become also part of the copied data record.

LH_2 is liquid hydrogen.

LHV - see lower heating value

liquid effluents in GEMIS are the environmental indicators AOX, BOD, COD, as well as N, P, and inorganic salts.

LNG is liquefied natural gas.

local menu is a new feature since GEMIS 3.x/4.0 which is activated by clicking the **right** mouse button when a data record is selected. Local menus drastically simplify the user interface, because all relevant menu options and commands of the GEMIS program can be accessed directly.

location in GEMIS is an attribute of processes which reflects the geographical position. It can be used to filter the database, as well as to group results for a selected location.

lower heating value (LHV) is the amount of energy resulting from the complete oxidization (combustion) of a fuel **excluding** the vaporization heat for the water vapor. In international circles and especially the USA, data for efficiency, costs and emission factors often are based on the higher heating value, while in Europe and most other countries, these data refer to the LHV. The differences between LHV and HHV are, depending on the fuel, 5-20%. GEMIS 4.5 offers the possibility to **switch** between the basis, i.e. data entry and display can be switched between lower heating value (default) and higher heating value.

LowNOx is the acronym for so-called primary NO_x reduction using combustion modification, e.g. staged burning.

LPG is liquid petroleum gas.

material flow analysis (MFA) is a method based on life-cycle analyses to determine the environmental effects of life-cycles, but the data are more general and refer not only to a specific products or service, but to groups of products or goods, or need areas.

materials in GEMIS are products representing raw or auxiliary matter used in processes.

MC (molten carbonate) - see molten carbonate FC

MED is the abbreviation of "Mediterranean", a zone consisting of Spain, Greece, Italy, and Portugal.

MeOH is the acronym for **methanol**, a liquid energy source derived from hydrocarbons (natural gas, mineral oil, coal or biomass), and which can be used as a chemical or as a fuel (e.g. in FC vehicles).

metadata is *information on data*, e.g. data on the origin (source), on the owner, data quality or location or the grouping in nomenclatures. Furthermore, references are important elements of metadata.

MFB is the acronym of Multi Family Building, a building type in GEMIS.

mi is the acronym for mile, i.e. approx. 1.609 km.

Mixer is a type of process in GEMIS, that allows a combination of several other processes. A mixer specifies the **portions** (percentages or absolute values), processes have for the common product- or service-supply. Additionally mixers can contain freight transport systems and their transport distance for every linked process. Mixers are used in GEMIS typically to combine the following processes:

- the supply of a fuel from different extraction processes (e.g. mining and open-cast, import countries) or
- supply of a material from different production processes (e.g. steel from electro- and oxygen-steelworks)
- several power plants to an electric generation mix.

see also fuel-mixer!

MJ is the acronym for MegaJoule (= 10^6 Joule).

molten carbonate FC (MC-FC) are fuel cells which can achieve rather high electric efficiencies (> 40 %) and offer waste heat at 400 °C (or more) - therefore, MC-FC are well-suited for combined heat & power generation.

monetary processes are a new process type in GEMIS 4.0 which represent the environmental impacts of production values or expenditures for goods or services from statistical sectors of the economy. These processes are useful if no detailed information is available on the upstream processes, or the inputs to the product or service are a too complex combination of material, energy or transport services (e.g. banks, toys, hospitals). For these processes, one can determine the upstream impacts using an Input-Output-Table (IOT) which reflects the monetary links to the other economic sectors. In GEMIS 4.5, all economic sectors from German UGR have been implemented, i.e. there are now processes for the whole economy. The current database of the UGR is the year 1995, and covers air emissions, greenhouse gases and primary energy requirements (CER). Monetary processes can be used in scenarios to supply services and products for which a demand has been defined in monetary terms (money), i.e. *expenditures* for the services, or the production values of the economic sectors.

MtOE equals 10^6 * tOE

multi-fuel combustion is a new option for combustion processes in GEMIS: if the input link of a combustion process is the new process type "fuel mixer", you can specify the emissions for

each fuel separately in the emission card, and also specify the emission characteristics of the mixed fuel.

multilingual is a feature of GEMIS 4.5 which allows to switch both the user interface of the program as well as its database between a country language and the fixed system language (English).

MW is the acronym for MegaWatt, a unit for power (= 1 MJ/s).

MW_{el} is the acronym for electric MegaWatt

MWh is the acronym for MegaWatt-hours (10^3 kWh)

MW_{th} is the acronym for thermal MegaWatt, i.e. heating power

N = nitrogen

N_2O is the chemical formula for nitrous oxide, a greenhouse gas.

NACE (National Accounts in Europe) is a European system to structure the economy into statistical sectors, and has been implemented into GEMIS as a nomenclature.

names are the identifiers of data records. Because GEMIS 4.5 is multilingual, names are always entered in a country language (e.g. German) and the fixed system language (English). For GEMIS there are also special naming rules.

net is a name element of GEMIS processes for combined heat & power (CHP) for which a credit for the cogenerated couple product is given, i.e. allocated.

net efficiency is in GEMIS the efficiency of a processes, taking into account the energy use for linked emission reduction technologies.

NH_3 is the chemical formula for ammonia, an acidifying air emission which is included in SO_2-equivalents.

Nm^3 is the standard cubic meter, a volume unit referring to standard temperature and pressure (273,15 K; 101,3 kPa).

NMVOC are non-methane volatile organic compounds. Their effects as air emissions are included in the ozone precursor equivalents.

nomenclatures are systems of names which follow a structure. In GEMIS 4.5, the NACE (statistical sectors) and SNAP (emissions types) are implemented. Both can be used as a data filter to retrieve and list processes in the database, and to aggregate results from scenarios.

NO_x (nitrogen oxides, given as NO_2) are acidifying air emissions - this environmental effect is taken into account in SO_2 equivalents. NO_x also acts as a precursor for summer smog which is included in the ozone precursor equivalents.

nutrition potential (NP) is a measure for the potential over-supply of nutrients into water bodies (lakes, rivers), and soil. Nutrifying substances are N, P, phosphate (PO_4^{3-}), ammonium (NH_4^+), NO_x, nitrate (NO_3) and COD. Due to the rather bad data availability for P emissions, GEMIS calculates no NP values (so far).

O_2 is the chemical formula for oxygen.

O_3 is the chemical formula for ozone.

Occupancy is an important value for person transport services delivered by person transport processes

Öko-Institut (Institute for applied ecology) is an independent, private environmental research institution. It was founded in 1977 and is recognized by law as a non-profit organization, and a charity. Öko-Institut currently has five Divisions:

- Energy & Climate Protection
- Nuclear Engineering & Plant Safety
- Infrastructure & Enterprises
- Sustainable Products & Material Flows
- Environmental Law & Governance

The Öko-Institut carries out life-cycle and material flow analyses and offers with GEMIS a public database and model. More information is given on the Institute's website.

oil is in GEMIS the name of the group of liquid fossil fuels. This group has the icon  before the product names. In the core database, gasoline, diesel, light oil, heavy fuel oil, and Bunker C are part of the group.

OPEC (Organization of Oil-Exporting Countries) is the country code for the group of oil-exporting countries.

operating time is the amount of operating hours per year (h/a) during which a process is operating with **full** capacity. This is equivalent to the so-called **load factor** which is given in % (= 100 * operating time/8760). If a process is operated for e.g. 5000 h/a with only half (50%) of its capacity, this gives 5000 * 50% = 2500 h/a in full-load equivalents. From the operating time and the installed capacity, GEMIS calculated the annual output, from which the annual emissions and - using the life-time - the annual costs, land use, and material use for construction are derived.

ORC (Organic Rankine Cycle) thermodynamic process using an organic working fluid

organic means "from organic farming"

overburden is in GEMIS a part of the solid wastes, characterizing the wastes from extraction of primary energies and raw materials.

owner is in GEMIS the one who is responsible for a data record in the database, i.e. the owner can enter and edit (change) the record. See also source.

OxCat is the acronym for oxidizing catalyst, an emission control technology for CO and C_nH_m

ozone (O_3) is the reactive form of oxygen (O_2). In the higher atmosphere, ozone is a greenhouse gas, but also protects from UV radiation of the sun (ozone layer). The **depletion of stratospheric ozone** by e.g. CFCs is a global environmental problem, while near-ground (**tropospheric**) ozone directly damages human health, and crops, and contributes to summer smog.

ozone precursor equivalents are the quantitative expression of the tropospheric ozone precursor potential and are calculated from the relative ozone formation rates of the air emissions CO, NMVOC and NO_x and the greenhouse gas CH_4. The more ozone precursor equivalents, the higher is the possibility for summer smog.

P = phosphorus

PA - see phosphoric acid FC

PAN is the abbreviation of "Pannonic-Pontic", a zone consisting of Czech Republic, Hungary, Slovenia, and Slovakia.

PE (polyethylene), a plastic material (icon)

PEM (proton-exchange membrane) is a fuel cells which uses a polymer as an electrolyte. The electric efficiency for PEM-FC are around 40 %, with waste @ 70 - 90 °C, so that the process can be used for combined heat & power generation. When adding a reformer, PEM can also use other fuels than H_2 (e.g. natural gas, biogas, methanol).

person transports in GEMIS are processes which reflect the mobility of human beings (e.g. motorcycles, cars train). Depending on the technology they have specific icons.

PFC (perfluorocarbons) are greenhouse gases with a high global warming potential.

phosphoric acid FC (PA-FC) are fuel cells using phosphoric acid as an electrolyte, thereby achieving relatively high electric efficiencies (> 40 %), and waste heat of > 200 °C. PA-FC are suitable for combined heat & power.

P.km is the unit person-kilometre(s) for measuring person transport service. Example: If a bus transports 20 persons over a distance of 100 km this equals a transport service of 2,000 P.km.

PNL = Battelle Pacific Northwest Laboratory, an energy research institution of the US-DOE in Richland/Oregon. See also the PNL-website.

power is the Capacity of processes, by which they can supply products, i.e. the amount of products per time unit. Depending on the process the power (capacity) can concern energy (e.g. MW thermal or MW electric) or materials (tons per hour) or means of transportation (e.g. miles per year).

PP means in GEMIS-names either

- **polypropylene** , a plastic material (icon), or
- **power plant**. Power plants produce electricity from fossil or renewable energy sources by combustion or conversion of energy. Please note that, in GEMIS, nuclear power plants don't belong to technology group "power plants" with symbol but to technology group "nuclear-processes" with symbol .

ppb are parts per billion

ppm are parts per million

primary energies in GEMIS are energy resources, including fossil and nuclear energy sources (non-renewable), renewable energies (biomass, geothermal, hydro, solar, wind), but not wastes (these are secondary resources). The sum of all primary energies consumed to deliver a product or a service is the CEC.

process chains are generated from links between processes and represent a network whose nodes (processes) jointly deliver a certain benefit (product or service). In GEMIS, process chains are displayed graphically in the file card window "processes" on card "process chain". The "beginning" (source) of a process chain is always an extractor which converts a resource into primary energy or raw materials, while the "end" (sink) of a process chain is waste treatment.

processes in GEMIS are activities which convert, transport or emit a product. New types of processes in GEMIS 4 are multi-fuel combustion, monetary services, and waste treatment.

products in GEMIS are the in- and outputs linked to a process. They are - depending on the process type - energy sources (especially fuels), emissions, residues, resources or materials and services. The most relevant ones are air emissions, greenhouse gases, solid wastes, liquid effluents, and services (freight and person transport, monetary services) are **hard-wired** into GEMIS, all others can be adjusted or freely added as user-defined products.

projects in GEMIS are the total of all data records which are stored under a joint filename. A project consists of single files for products (*.PRD), processes (*.PRC), scenarios (*.SCN) and

references (*.REF) as well as standards (*.STD), interest rate (*.CST), external costs (*.EXT), global warming potentials (*.GHG) and categories (*.CAT), groups (*.GGR) and sources (*.G4S).

PS = polystyrene, a plastic material (icon)

PSA (Plataforma Solar de Almeria) is a Spanish-German solar research facility of which the German part is managed by DLR. The PSA has contributed data on solar-thermal power plants (icon) within the EM Project, which are now integrated in the GEMIS core database. The PSA offers its own website.

PU = polyurethane, a plastic material (icon)

PV = photovoltaics (solar cells), in GEMIS an extraction process with the icon

PVC = polyvinyl chloride, a plastic material (icon)

raw materials in GEMIS are resources which are converted into useful primary materials. Examples are ores (for metals), minerals (e.g. chalk, gravel, sand, stones), air and water, but also oil, natural gas, coal and biomass if they are used as matter (e.g. construction materials, lubricants).

RE is the acronym for the residential sector (households).

RE/CO is the acronym for the residential and commercial sectors.

recycled material is in GEMIS a secondary resource, i.e. a residue that is potentially useable for energy or raw material purposes. At CEC, CER and CMR calculation they are balanced in category "other". The symbol for recycled material in GEMIS is .

reference in GEMIS is a data record which contains information on a data source (report, study, measurement, personal communication etc.). A reference consists of a name (e.g. author + year) and a text which describes the reference in detail, e.g. the full title (literature citation), or details for the reports etc. References can be linked to all data records in GEMIS (products, processes, scenarios, standards, costs, global warming potentials, external costs). On card "Metadata" of data records, the references may be entered. Normally, these references are referred to (in the GEMIS-comments) by the abbreviations "#1", "#2", "#3",....

reference year is a data filter for processes in GEMIS 4.5. On process level, single years can be chosen.

regulations are the elements of emission standards. They define for which fuels, technologies, and capacities an emission control requirement applies, and offer details in rules.

renewable energies are resources which are continuously replenished (biomass, geothermal heat, solar energy, hydropower, wind), i.e. they are **non-depletable** - in contrast to fossil energies and uranium. In GEMIS, renewables are usually extraction processes.

residues are either solid wastes (ash, FGD residual, sewage sludge, production waste, or overburden), or liquid effluents (P, N, AOX, COD, BOD5, inorganic salt). They are important environmental indicators.

resources in GEMIS are products representing **the stock** of primary energies and raw materials. Resources are the inputs for extractor processes, and therefore the "beginning" of process chains.

rules are the details of regulations in an emission standard. They describe for which emissions the regulation concerns, how the emission requirement is defined, i.e. if it refers to flue gas

concentrations, emission factors, an emission rate or a control factor, or if it refers to ambient air concentrations (immissions). For flue gas concentrations, the corresponding O_2 value (as a measure of the excess air) can be specified as well.

rural is a driving cycle (outside of cities, but not on highways).

SAPP (Southern Africa Power Pool) is the cross-country cooperation in the Southern African electricity sector, where Angola, Botswana, Dem. Republic Congo, Lesotho, Mozambique, Zambia, Zimbabwe, South Africa and Tanzania participate. Within the EM-Project, the Southern Centre prepared a database for several countries which is integrated in GEMIS now.

scenarios in GEMIS are the combination of demands (e.g. for heat, electricity, transports) with supply processes (e.g. heating system, power plant, car). For scenarios, GEMIS calculates emissions, residues, resource use, costs etc. for life-cycles.

- Scenarios of the **type energy** (icon ) can model only energy demand and supply, but for these, the amount of energy and the required load (power) can be specified, as well as transmission and distribution losses. Furthermore, this scenario type can modify the operating time of processes, and explicitly model credits (for CHP processes).

- Scenarios of the **type option comparison** (icon ) can model only energy demands (no loads/power), but can model also demands for materials (e.g. paper, food), person- or freight transport, waste treatment and monetary services, and link them to a combination of supplying processes.

SCR (selective catalytic reduction) is an emission reduction technology for NO which converts nitrogen oxides in a catalyst with NH_3 addition into N_2 and water.

SDA (spray-dryer absorption) is a form of FGD which adds a liquid additive in a spray-dryer into the flue-gas to capture SO_2 and halogens. The reaction product is collected in a post-SDA fabric filter or ESP.

SE is the acronym for either steam extraction turbine (for CHP processes) or steam engine.

secondary resources in GEMIS are wastes (residues) with the potential for energy- or material re-use. In the GEMIS calculation for CER and CMR, they are shown in the category "other".

SETAC (Society of Environmental Toxicology and Chemistry) is a non-profit scientific organization dealing especially with methodological issues of life-cycle analyses. More information is given on the SETAC website.

SF_6 is the chemical formula for sulfur hexafluoride, a greenhouse gas with a high global warming potential.

SFB is the acronym of Single Family Building, a building type in GEMIS.

SNAP is the European system for emissions CORINAIR which structures processes based on emission types. In GEMIS 4.5, the SNAP-97 code is implemented as a nomenclature.

SNCR (selective noncatalytic reduction) is an emission reduction technology for NO_x which converts nitrogen oxides without a catalyst, but with NH_3 addition in the hot flue-gas into N_2 and water.

SO_2 is the air pollutant sulfur dioxide, an acidifying gas which also causes respiratory health damages, and surface corrosion.

SO_2 equivalents are the quantitative expression of the acidification potential, based on the relative acidity of SO_2. In SO_2 equivalents, also the air emissions NO_x, HCl, HF, NH_3 and H_2S are included.

solid oxide FC are fuel cells which use solid oxides as their electrolyte - this achieves very high electric efficiencies (> 55 %) and waste heat @ > 500 °C. Furthermore, SO-FC can use fuels like natural gas and biogas directly (i.e. no pre-processing reformer), because the high operating temperatures cause H_2 to separate from the hydrocarbon fuel. Therefore, SO-FC are well-suited for combined heat & power generation. When adding a CC, the SO-FC yield electric efficiencies of 65 %

solid wastes are in GEMIS the emissions of solid residues, and are part of the relevant environmental indicators. Solid wastes encompass overburden, ash, sewage treatment sludge, FGD-residues, and production wastes.

sorbent is a substance which is sorbing other substances; in GEMIS: the substance that filters harmful substances from flue gases.

source is in GEMIS a special text referring to an institution or group which has entered several data records into the database. In file card windows, the source can be used as a data filter.

Southern Centre (for Energy and Environment) is a research institute in Harare/Zimbabwe which prepared within the EM-Project a database for most SAPP countries which is integrated in GEMIS now. Contact: scentr@harare.iafrica.com

SPOLD (Society for Promotion of Life-Cycle Analysis Development) is a non-profit business dealing with the development and sponsoring of life-cycle analysis. More information is given on the SPOLD website.

standards in GEMIS 4.5 are rules for legal emission limits for which the program can check if combustion processes comply with the standard. The standards can also be used as a filter in file card windows.

StBA is the Federal Statistical Office Germany. More information is given on the StBA website.

ST is the acronym for steam turbine.

Synopsis (Synopsis Institute) is a research institute in Lodève (France) which prepared within the EM Project for GTZ data records for solar cookers (stoves) which are now integrated into the GEMIS core database.

tCE is tonne coal equivalent, an energy unit (= 29300 MJ)

technologies in GEMIS are groups of processes which determine the icon before process names. They allow also to filter the database.

TEMIS is the English version of the GEMIS program (until version 3.1).

"**th**" (thermal) indicates heat as output (product).

thinning material results when forests are thinned

tkm is the unit ton-kilometer(s) for measuring freight transport service. Example: If a truck transports 30 tons over a distance of 1000 km this equals a transport service of 30,000 tkm.

tOE is tonne oil equivalent, a energy unit (= 43000 MJ)

TOPP (tropospheric ozone precursor potential) - see ozone precursor potential.

Trade-Off is a method for analyzing results, i.e. the determination of win-win-options in GEMIS. The Trade-Off is the quotient of two parameters for scenario options (e.g. CO_2 emissions and costs). Being the continuation of GEMIS tour "From Processes to Scenarios", GEMIS tour "Results of Scenarios" introduces the Trade-Off method.

train is in GEMIS a freight transport system or persons transport system and carries the symbol  .

transport processes in GEMIS represent e.g. the activity to **move a product** along a certain distance, using a freight transport system. Transport processes can move both energy sources, and materials, and can include losses from transport. The emissions of the transport are not calculated from the transport process itself, but from the freight transport system which delivers the driving force.

tropospheric ozone precursor potential (TOPP) is the mass-based equivalent of the ozone formation rate from precursors, measured ozone precursor equivalents. The TOPP represents the potentially formation of near-ground (tropospheric) O_3 which can cause summer smog.

trucks belong in GEMIS to freight transport systems. They carry the symbol  in front of their names.

tSKE is tonne coal equivalent, an energy unit (= 29300 MJ)

turnover is the amount of energy, materials, or transports which is delivered by processes in a scenario.

UBA (Umweltbundesamt) is the administrative body of the BMU in Berlin, offering more information on their website.

UGR is the environmental-economic total accounting of the StBA. It included the so-called emitter structure derived from Input-Output-Tables and their linkages to emission factors. The UGR data are integrated into GEMIS 4.5 as process type "monetary".

ultimate analysis is the quantitative description of the chemical composition of fuels from which GEMIS determines the heating value and - via a combustion calculation - the flue-gas volume and emission factors (see Model Documentation for details). The ultimate analysis reflects also the water (w) and ash (a) content and refers either on the "as delivered" status of fuels (incl. w + a) or assumes the fuels to be ash-free (af), water-free (wf) or water- and ash-free (waf).

upstream processes have to take place, before a product (energy source, material) can be used by a process. Typical upstream processes are e.g. mining (extraction), shipment (transport), refine (conversion) but also processes for auxiliary products (e.g. electricity or process heat supply) and supply processes for construction materials for building processes (e.g. power plants).

US-DOE (Department of Energy) is a GEMIS user and sponsor (see TEMIS). More information is given on the DOE-website.

useful energy is energy which is drawn by consumers appliances after its final conversion. An example is space heat.

user-defined in GEMIS means that data records are added to extend the environmental indicators, or the other parts of the database. User-defined entries are especially possible regarding air emissions, residues or liquid effluents. For example, users can add the heavy metal "lead" as an air emission in the product database, and then insert this emission in processes which emit lead, and add lead emission data. In the result tables, the user-defined emissions and residuals are shown as well.

variable costs in GEMIS are current expenses, that are connected directly with running a process as for instance cleaning materials and waste treatment. See also costs.

Vol.% O_2 is in GEMIS a measure of the dilution of the flue-gas from combustion processes causes by excess air. The combustion equation (see Model Documentation) determines only the **theoretical** amount of air needed to completely oxidize the combustibles of a fuel - the residual O_2 content of the flue gas is therefore zero. This **theoretical** flue gas must be corrected for processes: In **real** combustion, the flue gas is diluted by additional ("excess") air. To take that into account, the respective O_2 concentration in the flue gas (in volume% O_2) us used to determine the actual flue gas volume, and to relate this to the measured or computed

concentrations of pollutants in the flue gas. In the core database, the O_2 values are taken from emission standards (see standards) in Europe.

W see Watt

waf is the acronym for water- and ash-free and is used to characterize an ultimate analysis.

waste treatment is a new process type in GEMIS 4.0 which is used to handle solid wastes from other processes - it reflects the "back end" of process chain: **a sink**. Waste treatment processes can - as all other processes - have direct emissions (and residues !), links to auxiliary inputs (energy, materials) and materials for construction, as well as costs. Waste treatment processes are - similar to emission control technologies - linked to other processes which generate residues (and to a transport process). GEMIS then computes the environmental effects from the waste treatment (or disposal) for this process.

Watt is the basic unit for power (= 1 J/s)

wf is the acronym for water-free and is used in the ultimate analysis.

whole means "the whole plant"

XPS is extruded polystyrene, a plastic material (icon )

Xtra is in GEMIS a name element of extraction processes, i.e. processes which convert resources into either primary energies or raw materials.

10 Naming Rules in GEMIS

For the names of data records in GEMIS, a set of rules is used for easier identification and access in the rather long lists.

These naming rules have been used strictly for the core data of Öko-Institut (marked in **red)**, but they - regrettably - were not used strictly for some of the core data from other sources.

When entering your own data or copying records, we recommend to use the rules given below.

Helpful for data retrieval are also the **icons** shown before the names (referring to the group of products or processes, or scenario types), and the possibility to use filters for the lists in file card windows.

10.1 Naming rules for products

Product names in GEMIS are constructed so that

- “/en” is a name element of energy processes
- for **energy sources,** the type is always at the beginning (e.g. lignite, oil, wood, uranium).
- for **materials,** usually the general name is used (e.g. concrete, steel, water) which can also be an acronym (e.g. HDPE, PET) or a chemical formula (e.g. $Ca(OH)_2$).
- the name is often followed by a country code (e.g. AU, DE, US). After the country code, a hint for the use of the product can be given (e.g. RE/CO for residential/commercial sector) or a more detailed location (e.g. a region or city). The name element ***generic*** indicates products

which are not specific to any country, but especially reflect the conditions in developing countries.

10.2 Naming rules for processes

Process names in GEMIS are constructed so that

- for **energy processes,** the type of the energy source is always at the beginning (e.g. lignite, oil, wood, uranium), often followed by a technical acronym (e.g. ST for steam turbine) or a hint regarding the process type (e.g. "mix" for mixer, DH (district heating) for heat plants etc.). In the case of primary energy extractors or energy conversion processes, the name of the delivered energy source is given after the slash "\".
- for **combined heat & power** (CHP) there might be the element "th", indicating that the process delivers heat (otherwise electricity). Furthermore, there is a slash "/" at the end, followed by a hint regarding the allocation of a credit (e.g. "gross" for no crediting, "oil" if an oil-heating system is replaced etc.)
- for **material processes,** usually the production sector is given (e.g. chemicals, plastics, metal), then a hint regarding the process type (e.g. "mix" for mixer). In the case of primary material extractors or material conversion processes, the name of the delivered material is given after the slash "\".
- for **transport processes** the name usually offers a technology acronym (bus, car, pipeline, ship, train, truck), followed by the used fuel (gasoline, diesel, "el" for electric, H_2 etc.). After that, a driving cycle can be given and then an emission class (age or EURO).
- **extraction processes** for energy sources and materials have the acronym "Xtra-" (for extraction) at the beginning, followed by a technology hint (e.g. mix, off- or onshore, surface or deep mining), and, after the slash "\", the delivered product. *Exceptions* from this rule are
    - renewable energies for which the resource type (e.g. geothermal, hydro, solar, wind) is the first name element
    - the farming/cultivation of energy crops
    - animal husbandry.

The process name is often followed by a country code (e.g. AU, DE, US). After the country code, a hint for the application of the process can be given (e.g. RE/CO for residential/commercial sector) or a more detailed location (e.g. a region or city). The name element ***generic*** indicates processes which are not specific to any country, but especially reflect the conditions in developing countries.

10.3 Naming rules for scenarios

The names of scenarios are constructed so that first, the application area is indicated (energy, materials, transport) or a country reference (e.g. CN, MA). There are no other rules, because the comment of the scenarios usually explains the details.

11 Colors of GEMIS Record Names

In general, data records with colored names are protected against changes, while names of records shown in black can be changed if you are the owner - i.e. you have entered the data.

More specific, the following color code represents the respective data sources:

- dark brown APME, data for plastics
- lila: CDER, database for Morocco
- light red: CityPlan, database for the Czech Republic
- gray: ERM, database for Vietnam
- magenta: EWK Rüsselsheim, database CNG busses
- gray blue FEEC, database for Croatia
- dark blue FhG-ISI, database for CER of plastics
- light blue Forum Secretariat, database for Fiji
- brown-green: GhK, database for agriculture and food
- orange: GTZ, database for generic developing countries
- middleblue HMULF, database for biomass projects in Hesse
- blue: IKARUS-Projekt (Instruments for Climate-gas Reduction Strategies)
- dark green IST/Mouvement Ecologique, database for Luxemburg
- baby blue IZW, database for heat pumps
- red: Öko-Institut, core database
- magenta Phil-DOE, database for the Philippines
- magenta Phil-NPC, database for the Philippines
- light green: PSA, database for solar thermal powerplants
- dark grey Southern Centre, database for southern Africa
- light blue StBA, database for monetary services
- grey Synopsis, database for solar cookers
- middleblue Tsinghua-Universität, database for China

12 Abbreviations in GEMIS

A

a = year

aCFB = atmospheric circulating fluidized-bed

AFBC = Atmospheric Fluidized-Bed Combustion

ALG = country code for Algeria

AME = animal fat methylester

APME = Association of Plastics Manufacturers in Europe

AUS = country code for Australia

B

B&L = biowaste and landscape trimming

B+L = biowaste and landscape trimming

BGR = Bundesamt for Geowissenschaften und Rohstoffe

BMU = Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit

BMWi = Bundesministerium für Wirtschaft und Technologie

BOD = biological oxygen demand

BP = backpressure (in CHP processes)

briq = briquette(s)

BtL = Biomass to Liquid

BTU = British Thermal Unit

BUWAL = Bundesamt for Umwelt, Waldwirtschaft, Agrarwesen und Landwirtschaft (Switzerland)

C

C = carbon

C+M = cattle (liquid manure) + maize

C+P = cattle + pigs (liquid manure) or cattle manure + potato leaves

C&M = cattle (liquid manure) + maize

C&P = cattle manure + potato leaves

C&PT = cattle manure + potato tops

C+P+P = chicks + pigs (liquid manure) + potato leaves

Ca = calcium

CAN = country code for Canada

cat = 3-way-catalyst (catalytic converter)

CC = combined-cycle

CCS = chicken, cattle manure plus sugar beet leaves

CEC = Commission of the European Communities or Cumulative Energy Consumption

CEE = country code for Central and Eastern Europe

CEES = Center for Energy and Environmental Studies, Princeton University, Princeton NJ

CER = Cumulated Energy Requirement

CEU = Cumulative Energy Use

CFBC = Circulating Fluidized-Bed Combustion

CFC = chlorofluorocarbons

CH4 = methane

CnHm = carbohydrate compound

chem-inorg = processes in the area of inorganic chemistry

chem-org = processes in the area of organic chemistry

CHP = combined heat and power generation (cogeneration)

CIS = Commonwealth of Independent States (former USSR)

CMR = cumulated material requirement

CO = carbon monoxide (also acronym for commercial sector)

CO2 = carbon dioxide

COD = chemical oxygen demand

cogen = cogeneration (combined heat and power generation)

CP = cattle + pig manure

CPP = chicken, pig (manure) plus potato leaves

CPPL = chicken, pig (manure) plus potato leaves

D

d = day

D = country code for Germany

DeNOx = nitrogen oxide reduction

DGMK = Deutsche Wissenschaftliche Gesellschaft for Erdöl, Erdgas und Kohle e.V.

DH = district heating

DLR = Deutsche Forschungs- und Versuchsanstalt for Luft und Raumfahrt

DME = direct micro expelling

DOE = US Department of Energy

DS = Dry Substance

DSI = Dry Sorbent Injection

DSM = Demand-Side Management (energy-saving programmes)

E

E5-mix = transport fuel mix with 5 % Ethanol

EF+FT = Entrained-Flow + Fischer-Tropsch

el = electric/electricity

EM = Environmental Manual for Power Development, now integrated into GEMIS

EMPA = Eidgenössische Materialprüfungsanstalt (Switzerland)

EPA = US Environmental Protection Agency

EPRI = Electric Power Research Institute

eta = efficiency

ETH = Eidgenössische Technische Hochschule (Zurich, Switzerland)

EU = country code for the European Union

F

F = fluorine

FB = fixed bed (gasification)

FBC = Fluidized-Bed Combustion

FC = fuel cell

Fe = iron

FfE = Forschungsstelle für Energiewirtschaft

G

G+M = grease, food wastes, beer brewing residues, melasse

GEMIS = Global Emission Model of Integrated Systems

GH2 = gaseous hydrogen

GHG = greenhouse gases

GhK = University (Gesamthochschule) of Kassel

GWP = global warming potential (in GEMIS also: greenhouse gas factor)

gross = cogeneration processes modeled without credit

GT = gas turbine

GWh = GigaWatt-hours (106 kWh)

H

h = hour

H = hydrogen (also H2)

ha = hectare (104 m2)

HCl = hydrogen chloride

HDPE = high-density polyethylene

HF = hydrogen fluoride

HHV = higher heating value, i.e. energy contained in a fuel incl. evaporation heat for water

hiS = high sulphur content

hiway = highway driving cycle

HMULF = Hessisches Ministerium for Umwelt, Landwirtschaft und Forsten

HP = heat plant

H2S = hydrogen sulfide

HV = High Voltage (>1 kV)

I

IAEA = International Atomic Energy Agency (UN)

ICE = internal combustion engine

IEA = International Energy-Agency (of the OECD)

IER = Institut für Energiewirtschaft und Rationelle Energieanwendung

IfE = Institut für Energetik

IFEU = Institut für Energie- und Umweltforschung

IIASA = International Institute for Applied Systems Analysis

IKARUS= Instrumente für Klimagas-Reduktions-Strategien, research project of the BMBF (Germany)

imp = import

in = input

IN = industry sector

IOT = Input Output Table

IPCC = Intergovernmental Panel on Climate Change

ISI = Fraunhofer-Institut für Systemtechnik und Innovantionsforschung (Germany)

ISCCS= Integrated Solar Combined-Cycle System

J

J = Joule

K

km = kilometer (103 meter)

KTBL = Kuratorium für Technik und Bauwesen in der Landwirtschaft

kW = kiloWatt (103 Watt)

kWel = kiloWatt electric

kWh = kiloWatt-hour (103 Watt-hours)

kWth = kiloWatt thermal

KWU = Siemens AG - Kraftwerksunion (Germany)

L

LBS = Ludwig-Bölkow-Systemtechnik (Germany)

LDPE = low-density polyethylene

Lau = (Nieder)Lausitz

Lei = Leipzig

lig = lignite (brown coal)

LH2 = liquid hydrogen

LHV = lower heating value, i.e. energy contained in a fuel without evaporation heat

LNG = liquefied natural gas

loS = low sulphur content

LowNOx = NOx reduction by e.g. staged combustion, flue gas circulation

LV = Low Voltage (< 1 kV)

LPG = liquid petroleum gas

M

m = meter

m2 = square meter

m3 = cubic meter

MFB = multi-family building

mg = milligram (10-3 gram)

mi = mile

MBTU = Million British Thermal Units

MW = MegaWatt (106 Watt)

MWel = MegaWatt electric

MWh = MegaWatt-hour (103 kWh)

MWth = MegaWatt thermal

N

N = nitrogen (also N2)

NH3 = ammonia

NL = country code for the Netherlands (Holland)

NMVOC = non-methane volatile organic compounds

noCost= processes modeled without cost data

NOR = country code for Norway

NOx = nitrogen oxides (given as NO2)

N2O = nitrous oxide

O

O = oxygen (also O2)

OECD = Organization for Economic Cooperation and Development

OEKO = Öko-Institut (Institute for applied ecology e.V.)

OxCat = oxidizing catalyst

OPEC = Organization of Petrol Exporting Countries

ORNL = Oak Ridge National Laboratory

out = output

P

P = phoshorus

P&ST = pig manure + sugar beet tops

P+C = pig + cattle manure

P+ST = pig manure + sugar beet tops

pCFB = pressurized circulating fluidized-bed (gasification)

pFBC = Pressurized Fluidized-Bed Combustion

PFC = perfluorocarbons

PGM = Platin Group Metals

PL = country code for Poland

PP = polypropylene

PP/IN = powerplants and industry

ppb = parts per billion

ppm = parts per million

prim = primary extraction/processing technologies

PS = polystyrene

PV = photovoltaics (solar cells)

PVC = polyvinyl chloride

PWR = pressurized water reactor (nuclear power plant)

Q

R

raf = refinery

RE = residential sector (households)

RE/CO= residential and commercial sectors

RME = rape oil methylester

RSA = country code of the Republic of South Africa

ru = rural driving cycle

S

S = sulfur (also country code for Sweden)

SB = sugar beet

SCR = selective catalytic reduction, NOx is reduced in a catalytic converter with ammonia

SDA = spray-dryer absorption (emission control technology)

SE = steam extraction (for CHP processes)

sec = secondary extraction/processing technologies

SEGS = Solar-electric Generation System (solar thermal power plant, parabolic through)

SG = steam gasification

SI = Sisak (Croatia)

SNCR = selective non-catalytic reduction, NOx is reduced directly by adding ammonia to the hot flue gas

SO2 = sulfur dioxide

SRM = specified risk material

ST = steam turbine

StBA = Statistisches Bundesamt, Germany

T

tert = tertiary extraction/processing technologies

th = thermal

tCE = tonne of coal equivalent

TJ = TeraJoule (1012 = trillion Joule)

tOE = tonne of oil equivalent

TWh = TeraWatt-hours (109 = billion kWh)

U

U = uranium

UBA = Umweltbundesamt, Germany

UF6 = uranium hexafluoride

urb = urban driving cycle

USA = country code for United States of America

V

W

W = Watt (1 J*s)

WIKUE = Wuppertal Institut für Klima, Umwelt und Energie

X

Xtra = extraction

13 Hints for Data Entries into GEMIS

This page offers some hints to convert data into the specific formats needed for some of the data entry fields of products and of processes.

13.1 Data Entries for Products

When you enter new products or adjust data of copied products, some specific entry formats are required by GEMIS.

13.1.1 Costs of energy sources

GEMIS requires the energy-specific entry of energy costs (e.g. for fuels or electricity) - e.g. €/MJ.

If your have costs or prices in another currency, you can easily adjust the currency used by GEMIS to your own (see menu Extras: Units - Currency).

If your cost data or prices are based on **mass, weight,** or **volume**, you must convert the values before entering the data into GEMIS - in Example 1 your fuel cost be 100 €/Nm^3 of your gaseous fuel:

First look up the heating value of your product - this can be found in the info card which appears when you click on a product (e.g. natural-gas-DE) in the file card window Products on **the right side**. Example: There you can see 33.8 MJ/Nm^3. Note that the energy content of fuels can be expressed as a lower heating value or as the higher heating value - usually, GEMIS uses the lower heating value, but this can be changed (see Global Switch: Heating Value)

Now divide the cost value of your gas by its heating value - in the example 100 €/Nm^3 divided by 33.8 MJ/Nm^3 = 2.96 €/MJ - or converted to €/MWh: 2.96*3,600 €/MWh = 10,651 €/MWh.

Now you can enter the energy-based cost value into GEMIS

For the 2nd example, assume you know a coal price of 30 €/t:

First, check the heating value of your product - this can be found in the info card which appears when you click on a product (e.g. coal-DE) in the file card window Products on **the right side**. Example: There you can see 29.4 MJ/kg.

Divide the cost value of your coal by its heating value - in the example 30 €/t divided by 29.4 MJ/kg = 30 €/t divided by 29.4 GJ/t = 1.02 €/GJ.

Now you can enter the energy-based cost value into GEMIS

13.2 Data Entries for Processes: Pipelines

Transport processes of the type pipeline require in their card "Design Data" the entry of the transport energy as a specific value in terms of "energy per ton and kilometer" (e.g. MJ/t*km or kWh/t*km). When converting data, take care that you use only **suitable units** - for example, if one of your values is in kWh and another one in MJ, you must convert one of them into the unit of the other before you can perform any calculation with the data (1 kWh = 3.6 MJ). In GEMIS, you can also select another unit for the data entry (see Menu Extras - Units or click on the button kg/kJ).

If your data is available only for the **absolute transport energy** (e.g. X MWh per year), you must convert this:

The annual output of the Pipeline results from multiplying the capacity with the operating time - e.g. 100 MW * 2400 h/a = 240,000 MWh/a.

Then you must look up the energy content of your product - this can be found in the info card which appears when you click on a product (e.g. warm water) in the file card window Products on **the right side**. Example: There you can see 0.058 MWh/t, i.e. 1 ton (metric!) of warm water transports the energy content of 0.058 MWh.

Now you must divide the energy output of the pipeline by the energy content of 0.058 MWh/t, this gives the annual mass turnover (or flow): 240,000 MWh/a divided by 0.058 MWh/t = 4,137,931 t/a.

Next, you multiply the annual flow with the pipeline length (example: 100 km), this gives 4,137,931 t/a * 100 km = 413,793,100 t*km/a - this is the annual transport power.

Now you only have to divide your value for the absolute transport need by the annual transport power, and you have found the **specific transport energy**.

If you have data only for the **relative transport energy** (e.g. 1 % of the energy content of the delivered warm water), you must convert this as well:

First, check the specific weight of the transported product - this can be found in the info card which appears when you click on a product (e.g. warm water) in the file card window Products on **the right side**. Example: There you can see 17.2 t/MWh, i.e. 17.2 tons of warm water must be transported to deliver 1 MWh.

Now multiply this value with the pipeline length (example: 100 km), this gives 1,720 t*km/MWh.

Invert this value, i.e. compute 1/(1,720 t*km/MWh), this gives 0.000,581 MWh/t*km, i.e. 0.581 kWh/t*km.

Now you must multiply this result with the relative transport energy need you know - for this, use the percentage as decimals (1 % = 0.01): 0.581 kWh/t*km * 0.01 = 0.005,81 kWh/t*km. This is the **specific transport energy**.

14 Systematics in GEMIS

14.1 Country Codes in GEMIS

In GEMIS-names the ISO 3166-1 2-letter-acronyms are used for countries. So, for example, the acronym for Germany is DE.

The country code appears in GEMIS only if the country is registered by the UN, or that we suppose, it will be registered in the future (e.g. Palestine).

14.2 The NACE Nomenclature

The NACE (National Accounts in Europe) nomenclature (statistical structure of the economic sectors) of the Federal Statistical Agency and the EU is as follows:

Code	English Name
01	**Agriculture, hunting + related service activities**
01.1	*Growing of crops; market gardening; horticulture*
01.2	*Farming of animals*
01.5	*Hunting, trapping + game propagation, incl. related services*
02	**Forestry, logging + related service activities**
05	**Fishing, operation of fish hatcheries + fish farms**
10	**Mining of coal + lignite; extraction of peat**
10.1	*Mining + agglomeration of hard coal*
10.2	*Mining + agglomeration of lignite*
10.3	*Extraction + agglomeration of peat*
11	**Extraction of crude petroleum + natural gas**
12	**Mining of uranium + thorium ores**
13	**Mining of metal ores**
13.1	*Mining of iron ores*
13.2	*Mining of non-ferrous metal ores, except U + Th*
14	**Other mining + quarrying**
14.1	*Quarrying of stone*
14.11	Quarrying of stone for construction
14.12	Quarrying of limestone, gypsum + chalk
14.13	Quarrying of slate
14.2	*Quarrying of sand + clay*
14.21	Operation of gravel + sand pits
14.22	Mining of clays + kaolin
14.3	*Mining of chemical + fertilizer minerals*
14.4	*Production of salt*
14.5	*Other mining + quarrying n.e.c.*

15	**Manuf. of food prod. + beverages**
15.1	*Production, processing + preserving of meat + meat prod.*
15.11	Production + preserving of meat
15.12	Production + preserving of poultrymeat
15.13	Production of meat + poultrymeat prod.
15.2	*Processing + preserving of fish + fish prod.*
15.3	*Processing + preserving of fruit + vegetables*
15.31	Processing + preserving of potatoes
15.32	Manuf. of fruit + vegetable juice
15.33	Processing + preserving of fruit + vegetables n.e.c.
15.4	*Manuf. of vegetable + animal oils + fats*
15.5	*Manuf. of dairy prod.*
15.6	*Manuf. of grain mill prod., starches + starch prod.*
15.7	*Manuf. of prepared animal feeds*
15.8	*Manuf. of other food prod.*
15.9	*Manuf. of beverages*
16	**Manuf. of tobacco prod.**
17	**Manuf. of textiles**
18	**Manuf. of wearing apparel; dressing + dyeing of fur**
19	**Tanning + dressing of leather; Manuf. of leather goods**
20	**Manuf. of wood + of prod. of wood+cork, exc. furniture**
21	**Manuf. of pulp, paper + paper prod.**
21.1	*Manuf. of pulp, paper + paperboard*
21.2	*Manuf. of articles of paper + paperboard*
22	**Publishing, printing + reproduction of recorded media**
23	**Manuf. of coke, refined petroleum prod. + nuclear fuel**
23.1	*Manuf. of coke oven prod.*

23.2	*Manuf. of refined petroleum prod.*
23.3	*Processing of nuclear fuel*
24	**Manuf. of chemicals + chemical prod.**
24.1	*Manuf. of basic chemicals*
24.2	*Manuf. of pesticides + other agro-chemical prod.*
24.3	*Manuf. of paints, coatings, printing ink + mastics*
24.4	*Manuf. of pharmaceuticals, medical chem. + botanical prod.*
24.5	*Manuf. of soap + detergents, cleaning + polishing preparations, perfumes*
24.6	*Manuf. of other chemical prod.*
24.7	*Manuf. of man-made fibres*
25	**Manuf. of rubber + plastic prod.**
25.1	*Manuf. of rubber prod.*
25.2	*Manuf. of plastic prod.*
26	**Manuf. of other non-metallic mineral prod.**
26.1	*Manuf. of glass + glass prod.*
26.2	*Manuf. of non-refractory ceramics not for construction; refractory ceramics*
26.3	*Manuf. of ceramic tiles + flags*
26.4	*Manuf. of bricks, tiles + construction prod., in baked clay*
26.5	*Manuf. of cement, lime + plaster*
26.6	*Manuf. of articles of concrete, plaster + cement*
26.7	*Cutting, shaping + finishing of stone*
26.8	*Manuf. of other non-metallic mineral prod.*
27	**Manuf. of basic metals**
27.1	*Manuf. of basic iron + steel + of ferro-alloys*
27.2	*Manuf. of tubes*
27.4	*Manuf. of basic precious + non-ferrous metals*
27.5	*Casting of metals*

27.51	Casting of iron
27.52	Casting of steel
27.53	Casting of light metals
27.54	Casting of other non-ferrous metals
28	**Manuf. of fabricated metal prod., except machin. + equip.**
29	**Manuf. of machinery + equipment n.e.c.**
30	**Manuf. of office machinery + computers**
31	**Manuf. of electrical machinery + apparatus n.e.c.**
32	**Manuf. of radio, TV + communication equipment + apparatus**
33	**Manuf. of medical, precision + optical instruments, watches + clocks**
34	**Manuf. of motor vehicles, trailers + semi-trailers**
35	**Manuf. of other transport equipment**
36	**Manuf. of furniture; manufacturing n.e.c.**
37	**Recycling**
37.1	*Recycling of metal waste + scrap*
37.2	*Recycling of non-metal waste + scrap*
40	**Electricity, gas, steam + hot water supply**
40.1	*Production + distribution of electricity*
40.2	*Manuf. of gas; distribution of gaseous fuels through mains*
40.3	*Steam + hot water supply*
41	**Collection, purification + distribution of water**
45	**Construction**
45.1	*Site preparation*
45.2	*Building of complete constructions or parts thereof; civil eng.*
45.3	*Building installation*
45.4	*Building completion*

50	**Sale, maintenance+repair of cars+motorcycles; retail sale of automotive fuel**
50.5	*Retail sale of automotive fuel*
51	**Wholesale trade + commission, except of cars+ motorcycles**
52	**Retail trade, exc. cars + motorcycles; repair of personal + household goods**
55	**Hotels + restaurants**
60	**Land transport; transport via pipelines**
60.1	*Transport via railways*
60.2	*Other land transport*
60.3	*Transport via pipelines*
61	**Water transport**
61.1	*Sea + coastal water transport*
61.2	*Inland water transport*
62	**Air transport**
63	**Supporting + auxiliary transport activities; activities of travel agencies**
64	**Post + telecommunications**
65	**Financial intermediation, except insurance + pension funding**
66	**Insurance + pension funding, except compulsory social security**
67	**Activities auxiliary to financial intermediation**
70	**Real estate activities**
71	**Renting of machinery+equip. without operator+personal/household goods**
72	**Computer + related activities**
73	**Research + development**
74	**Other business activities**
75	**Public administration + defence; compulsory social security**
75.1	*public administration*
75.2	*foreign aff., military, public security*

75.3	*Compulsory social security activities*
80	**Education**
85	**Health + social work**
90	**Sewage + refuse disposal, sanitation + similar activities**
91	**Activities of membership organizations n.e.c.**
92	**Recreational, cultural + sporting activities**
93	**Other service activities**
95	**Private households with employed persons**
99	**Extra-territorial organizations + bodies**

14.3 The SNAP97 Nomenclature

The SNAP97 (Selected Nomenclature for Sources of Air Pollution) nomenclature (emission-oriented system of the European CORINAIR project) is shown in the following table for the SNAP97-ID (Codes) and the corresponding activities.

snap_id	snap_name
01	COMBUSTION IN ENERGY AND TRANSFORMATION INDUSTRIES
0101	Public power
010101	Combustion plants >= 300 MW (boilers)
010102	Combustion plants >= 50 and < 300 MW (boilers)
010103	Combustion plants < 50 MW (boilers)
010104	Gas turbines
010105	Stationary engines
0102	District heating plants
010201	Combustion plants >= 300 MW (boilers)
010202	Combustion plants >= 50 and < 300 MW (boilers)
010203	Combustion plants < 50 MW (boilers)
010204	Gas turbines
010205	Stationary engines
0103	Petroleum refining plants
010301	Combustion plants >= 300 MW (boilers)
010302	Combustion plants >= 50 and < 300 MW (boilers)
010303	Combustion plants < 50 MW (boilers)
010304	Gas turbines
010305	Stationary engines
010306	Process furnaces
0104	Solid fuel transformation plants
010401	Combustion plants >= 300 MW (boilers)

010402	Combustion plants >= 50 and < 300 MW (boilers)
010403	Combustion plants < 50 MW (boilers)
010404	Gas turbines
010405	Stationary engines
010406	Coke oven furnaces
010407	Other (coal gasification, liquefaction, ...)
0105	Coal mining, oil / gas extraction, pipeline compressors
010501	Combustion plants >= 300 MW (boilers)
010502	Combustion plants >= 50 and < 300 MW (boilers)
010503	Combustion plants < 50 MW (boilers)
010504	Gas turbines
010505	Stationary engines
010506	Pipeline compressors
02	NON-INDUSTRIAL COMBUSTION PLANTS
0201	Commercial and institutional plants (t)
020101	Combustion plants >= 300 MW (boilers)
020102	Combustion plants >= 50 and < 300 MW (boilers)
020103	Combustion plants < 50 MW (boilers)
020104	Stationary gas turbines
020105	Stationary engines
020106	Other stationary equipments (n)
0202	Residential plants
020201	Combustion plants >= 50 MW (boilers)
020202	Combustion plants < 50 MW (boilers)
020203	Gas turbines
020204	Stationary engines
020205	Other equipments (stoves, fireplaces, cooking,...)

0203	Plants in agriculture, forestry and aquaculture
020301	Combustion plants >= 50 MW (boilers)
020302	Combustion plants < 50 MW (boilers)
020303	Stationary gas turbines
020304	Stationary engines
020305	Other stationary equipments (n)
03	COMBUSTION IN MANUFACTURING INDUSTRY
0301	Comb. in boilers, gas turbines and stationary engines
030101	Combustion plants >= 300 MW (boilers)
030102	Combustion plants >= 50 and < 300 MW (boilers)
030103	Combustion plants < 50 MW (boilers)
030104	Gas turbines
030105	Stationary engines
030106	Other stationary equipments (n)
0302	Process furnaces without contact (a)
030203	Blast furnace cowpers
030204	Plaster furnaces
030205	Other furnaces
0303	Processes with contact
030301	Sinter and pelletizing plants
030302	Reheating furnaces steel and iron
030303	Gray iron foundries
030304	Primary lead production
030305	Primary zinc production
030306	Primary copper production
030307	Secondary lead production

030308	Secondary zinc production
030309	Secondary copper production
030310	Secondary aluminium production
030311	Cement (f)
030312	Lime (includ. iron and steel and paper pulp industr.)(f)
030313	Asphalt concrete plants
030314	Flat glass (f)
030315	Container glass (f)
030316	Glass wool (except binding) (f)
030317	Other glass (f)
030318	Mineral wool (except binding)
030319	Bricks and tiles
030320	Fine ceramic materials
030321	Paper-mill industry (drying processes)
030322	Alumina production
030323	Magnesium production (dolomite treatment)
030324	Nickel production (thermal process)
030325	Enamel production
030326	Other
04	PRODUCTION PROCESSES
0401	Processes in petroleum industries
040101	Petroleum products processing
040102	Fluid catalytic cracking - CO boiler
040103	Sulphur recovery plants
040104	Storage and handling of petroleum produc. in refinery
040105	Other
0402	Processes in iron and steel industries and collieries

040201	Coke oven (door leakage and extinction)
040202	Blast furnace charging
040203	Pig iron tapping
040204	Solid smokeless fuel
040205	Open hearth furnace steel plant
040206	Basic oxygen furnace steel plant
040207	Electric furnace steel plant
040208	Rolling mills
040209	Sinter and pelletizing plant (except comb. 03.03.01)
040210	Other
0403	Processes in non-ferrous metal industries
040301	Aluminium production (electrolysis)
040302	Ferro alloys
040303	Silicium production
040304	Magnesium production (except 03.03.23)
040305	Nickel production (except 03.03.24)
040306	Allied metal manufacturing
040307	Galvanizing
040308	Electroplating
040309	Other
0404	Processes in inorganic chemical industries
040401	Sulfuric acid
040402	Nitric acid
040403	Ammonia
040404	Ammonium sulphate
040405	Ammonium nitrate

040406	Ammonium phosphate
040407	NPK fertilisers
040408	Urea
040409	Carbon black
040410	Titanium dioxide
040411	Graphite
040412	Calcium carbide production
040413	Chlorine production
040414	Phosphate fertilizers
040415	Storage and handling of inorganic chemical prod. (o)
040416	Other
0405	Proc. in organic chemical industr. (bulk production)
040501	Ethylene
040502	Propylene
040503	1,2 dichloroethane (except 04.05.05)
040504	Vinylchloride (except 04.05.05)
040505	1,2 dichloroethane + vinylchloride (balanced process)
040506	Polyethylene Low Density
040507	Polyethylene High Density
040508	Polyvinylchloride
040509	Polypropylene
040510	Styrene
040511	Polystyrene
040512	Styrene butadiene
040513	Styrene-butadiene latex
040514	Styrene-butadiene rubber (SBR)
040515	Acrylonitrile Butadiene Styrene (ABS) resins

040516	Ethylene oxide
040517	Formaldehyde
040518	Ethylbenzene
040519	Phtalic anhydride
040520	Acrylonitrile
040521	Adipic acid
040522	Storage and handling of organic chemical products (o)
040523	Glyoxylic acid
040525	Pesticide production
040526	Production of persistent organic compounds
040527	Other (phytosanitary,...)
0406	Processes in wood, paper pulp, food, drink and
040601	Chipboard
040602	Paper pulp (kraft process)
040603	Paper pulp (acid sulfite process)
040604	Paper pulp (Neutral Sulphite Semi-Chemical process)
040605	Bread
040606	Wine
040607	Beer
040608	Spirits
040610	Roof covering with asphalt materials
040611	Road paving with asphalt
040612	Cement (decarbonizing)
040613	Glass (decarbonizing)
040614	Lime (decarbonizing)
040615	Batteries manufacturing

040616	Extraction of mineral ores
040617	Other (including asbestos products manufacturing)
040618	Limestone and dolomite use
040619	Soda ash production and use
0408	Production of halocarbons and sulphur hexafluoride
040801	Halogenated hydrocarbons production - By-products
040802	Halogenated hydrocarbons production - Fugitive
040803	Halogenated hydrocarbons production - Other
040804	Sulphur hexafluoride production - By-products
040805	Sulphur hexafluoride production - Fugitive
040806	Sulphur hexafluoride production - Other
05	EXTRACTION AND DISTRIBUTION OF FOSSIL FUELS AND GEOTHERMAL ENERGY
0501	Extraction and 1st treatment of solid fossil fuels (g)
050101	Open cast mining
050102	Underground mining
050103	Storage of solid fuel
0502	Extraction, 1st treatment and loading of liquid
050201	Land-based activities
050202	Off-shore activities
0503	Extraction, 1st treatment and loading of gaseous
050301	Land-based desulfuration
050302	Land-based activities (other than desulfuration)
050303	Off-shore activities
0504	Liquid fuel distribution (except gasoline distribution)
050401	Marine terminals (tankers, handling and storage)
050402	Other handling and storage (including pipeline) (q)

0505	Gasoline distribution
050501	Refinery dispatch station
050502	Transport and depots (except 05.05.03)
050503	Service stations (including refuelling of cars)
0506	Gas distribution networks
050601	Pipelines (q)
050603	Distribution networks
0507	Geothermal energy extraction
06	SOLVENT AND OTHER PRODUCT USE
0601	Paint application
060101	Paint application : manufacture of automobiles
060102	Paint application : car repairing
060103	Paint application : construction and buildings
060104	Paint application : domestic use (except 06.01.07)
060105	Paint application : coil coating
060106	Paint application : boat building
060107	Paint application : wood
060108	Other industrial paint application
060109	Other non industrial paint application
0602	Degreasing, dry cleaning and electronics
060201	Metal degreasing
060202	Dry cleaning
060203	Electronic components manufacturing
060204	Other industrial cleaning
0603	Chemical products manufacturing or processing
060301	Polyester processing

060302	Polyvinylchloride processing
060303	Polyurethane processing
060304	Polystyrene foam processing (c)
060305	Rubber processing
060306	Pharmaceutical products manufacturing
060307	Paints manufacturing
060308	Inks manufacturing
060309	Glues manufacturing
060310	Asphalt blowing
060311	Adhesive, magnetic tapes, films and photographs
060312	Textile finishing
060313	Leather tanning
060314	Other
0604	Other use of solvents and related activities
060401	Glass wool enduction
060402	Mineral wool enduction
060403	Printing industry
060404	Fat, edible and non edible oil extraction
060405	Application of glues and adhesives
060406	Preservation of wood
060407	Underseal treatment and conservation of vehicles
060408	Domestic solvent use (other than paint application)(k)
060409	Vehicles dewaxing
060411	Domestic use of pharmaceutical products (k)
060412	Other (preservation of seeds,...)
0605	Use of HFC, N2O, NH3, PFC and SF6
060501	Anaesthesia

060502	Refrigeration and air conditioning equipments
060503	Refrigeration and air conditioning equipments
060504	Foam blowing (except 060304)
060505	Fire extinguishers
060506	Aerosol cans
060507	Electrical equipments
060508	Other
07	ROAD TRANSPORT
0701	Passenger cars (r)
070101	Highway driving
070102	Rural driving
070103	Urban driving
0702	Light duty vehicles < 3.5 t (r)
070201	Highway driving
070202	Rural driving
070203	Urban driving
0703	Heavy duty vehicles > 3.5 t and buses (r)
070301	Highway driving
070302	Rural driving
070303	Urban driving
0704	Mopeds and Motorcycles < 50 cm3
0705	Motorcycles > 50 cm3
070501	Highway driving
070502	Rural driving
070503	Urban driving
0706	Gasoline evaporation from vehicles

0707	Automobile tyre and brake wear
08	OTHER MOBILE SOURCES AND MACHINERY
0801	Military
0802	Railways
080201	Shunting locs
080202	Rail-cars
080203	Locomotives
0803	Inland waterways
080301	Sailing boats with auxilliary engines
080302	Motorboats / workboats
080303	Personal watercraft
080304	Inland goods carrying vessels
0804	Maritime activities
080402	National sea traffic within EMEP area
080403	National fishing
080404	International sea traffic (international bunkers)(h)
0805	Air traffic
080501	Domestic airport traffic (LTO cycles - <1000 m)
080502	International airport traffic (LTO cycles - <1000 m)
080503	Domestic cruise traffic (>1000 m)
080504	International cruise traffic (>1000 m)(i)
0806	Agriculture
0807	Forestry
0808	Industry
0809	Household and gardening
0810	Other off-road
09	WASTE TREATMENT AND DISPOSAL

0902	Waste incineration
090201	Incineration of domestic or municipal wastes
090202	Incineration of industrial wastes (except flaring)
090203	Flaring in oil refinery
090204	Flaring in chemical industries
090205	Incineration of sludges from waste water treatment
090206	Flaring in gas and oil extraction
090207	Incineration of hospital wastes
090208	Incineration of waste oil
0904	Solid Waste Disposal on Land
090401	Managed Waste Disposal on Land
090402	Unmanaged Waste Disposal Sites
090403	Other
0907	Open burning of agricultural wastes (except 10.03)
0909	Cremation
090901	Incineration of corpses
090902	Incineration of carcasses
0910	Other waste treatment
091001	Waste water treatment in industry
091002	Waste water treatment in residential/commercial sect.
091003	Sludge spreading
091005	Compost production
091006	Biogas production
091007	Latrines
091008	Other production of fuel (refuse derived fuel,...)
10	AGRICULTURE

1001	Cultures with fertilizers
100101	Permanent crops
100102	Arable land crops
100103	Rice field
100104	Market gardening
100105	Grassland
100106	Fallows
1002	Cultures without fertilizers
100201	Permanent crops
100202	Arable land crops
100203	Rice field
100204	Market gardening
100205	Grassland
100206	Fallows
1003	On-field burning of stubble, straw,...
100301	Cereals
100302	Pulse
100303	Tuber and Root
100304	Sugar Cane
100305	Other
1004	Enteric fermentation
100401	Dairy cows
100402	Other cattle
100403	Ovines
100404	Fattening pigs
100405	Horses
100406	Mules and asses

100407	Goats
100408	Laying hens
100409	Broilers
100410	Other poultry (ducks,gooses,etc.)
100411	Fur animals
100412	Sows
100413	Camels
100414	Buffalo
100415	Other
1005	Manure management regarding organic compounds
100501	Dairy cows
100502	Other cattle
100503	Fattening pigs
100504	Sows
100505	Ovines
100506	Horses
100507	Laying hens
100508	Broilers
100509	Other poultry (ducks,gooses,etc.)
100510	Fur animals
100511	Goats
100512	Mules and asses
100513	Camels
100514	Buffalo
100515	Other
1006	Use of pesticides and limestone

100601	Agriculture
100602	Forestry
100603	Market gardening
100604	Lakes
1009	Manure management regarding nitrogen compounds
100901	Anaerobic
100902	Liquid systems
100903	Solid storage and dry lot
100904	Other
11	OTHER SOURCES AND SINKS
1101	Non-managed broadleaf forests
110104	European oak
110105	Sessile oak
110106	Other deciduous oaks
110107	Holm oak
110108	Cork oak
110109	Other evergreen oaks
110110	Beech
110111	Birch
110115	Other deciduous broadleaf species
110116	Other evergreen broadleaf species
110117	Soils (excluding CO2)
1102	Non-managed coniferous forests
110204	Norway spruce
110205	Sitca spruce
110206	Other spruce
110207	Scots pine

110208	Maritime pine
110209	Aleppo pine
110210	Other pines
110211	Fir
110212	Larch
110215	Other conifers
110216	Soils (excluding CO2)
1103	Forest and other vegetation fires
110301	Man-induced
110302	Other
1104	Natural grassland and other vegetation
110401	Grassland
110402	Tundra
110403	Other low vegetation
110404	Other vegetation (Mediterranean scrub,...)
110405	Soils (excluding CO2)
1105	Wetlands (marshes - swamps)
110501	Undrained and brackish marshes
110502	Drained marshes
110503	Bogs
110504	Fens
110505	Swamps
110506	Floodplains
1106	Waters
110601	Lakes
110602	Shallow saltwaters (<6m)

110603	Ground waters
110604	Drainage waters
110605	Rivers
110606	Ditches and canals
110607	Coastal waters (> 6m)
1107	Animals
110701	Termites
110702	Mammals
110703	Other animals
1108	Volcanoes
1109	Gas seeps
1110	Lightning
1111	Managed broadleaf forests
111104	European oak
111105	Sessile oak
111106	Other deciduous oaks
111107	Holm oak
111108	Cork oak
111109	Other evergreen oaks
111110	Beech
111111	Birch
111115	Other deciduous broadleaf species
111116	Other evergreen broadleaf species
111117	Soils (excluding CO2)
1112	Managed coniferous forests
111204	Norway spruce
111205	Sitca spruce

111206	Other spruce
111207	Scots pine
111208	Maritime pine
111209	Aleppo pine
111210	Other pines
111211	Fir
111212	Larch
111215	Other conifers
111216	Soils (excluding CO2)
1121	Changes in forest and other woody biomass stocks
112101	Tropical forests
112102	Temperate forests
112103	Boreal forests
112104	Grassland / tundra
112105	Other
1122	Forest and grassland conversion
112201	Tropical forests
112202	Temperate forests
112203	Boreal forests
112204	Grassland / tundra
112205	Other
1123	Abandonment of managed lands
112301	Tropical forests
112302	Temperate forests
112303	Boreal forests
112304	Grassland / tundra

112305	Other
1124	CO2 emissions from / or removals into soils
1125	Other

Appendix: GEMIS-Tours

Tour 1: From Processes to Scenarios, Darmstadt, September 2006

Tour 2: Results of Scenarios, Darmstadt, September 2006

Tour 3: Simple Calculation of Environmental Impacts of Processes, Darmstadt, September 2006

Tour 4: Scenarios and Analysis of Results, Darmstadt, September 2006

Tour 5: Global Switches in GEMIS, Darmstadt, September 2006

Tour 6: Combined Heat and Power (CHP) Processes, Darmstadt, September 2006

Tour 7: Allocations

Tour 1: From Processes to Scenarios

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Darmstadt, September 2006

1 Objectives of This Tour

In this step by step instruction (tour) you will create **your own data** (products, processes and scenarios) in GEMIS, and then compare them.

The example to demonstrate this is the **heating system of a one-family house** (OFH). An oil or a gas heating system will be used, as well as combinations of these two with a solar collector for hot water. Thus there are 4 options:

1. only oil heating system
2. only gas heating system
3. oil heating system + solar collector
4. gas heating system + solar collector

You will learn how to copy certain processes from the GEMIS database to create your own data. Additionally you will enter scenarios to calculate comparisons between different processes.

There are the following assumptions concerning the heating process of the house:

- 100 m² area to be heated
- 100 kWh/m²a, i.e. 10000 kWh heating system energy demand per year
- hot-water 10% of the heating process energy, i.e. 1000 kWh useful heat
- solar collector renders 75% of it, the rest is covered by the heating plant.

First of all, read the following definition of important terms in GEMIS:

What are **products** in GEMIS?

Products represent in GEMIS the inputs and outputs of *processes*. Important products are energy carriers and materials serving to link processes.

An important sub-type of energy carriers are *fuels* (e.g. coal, oil, biogas). Products have data that are needed to calculate costs and emissions:

- energy carriers and materials can have specific costs (e.g. prices)
- fuels have an inventory of if need be harmful substances (ultimate analysis)

What are **processes** in GEMIS?

A *process* in GEMIS is a certain activity to convert a given energy or material input into another energy or material output or an activity of transport.

Examples for these types of processes are:

- power plants converting fuels (input) to electricity (output),
- refineries converting one fuel into another,
- steel works converting pig-iron (input) to steel (output), and
- cars rendering person transport service.

A process can have secondary outputs like emissions, residues etc.. Furthermore, additional inputs may be necessary (auxiliary energies, auxiliary materials) as well as materials to build the process itself.

In GEMIS also several processes can be linked by a so-called *mixer* to supply an output (product) jointly – the mixer fixes the respective portions.

What are **scenarios** in GEMIS?

A scenario in GEMIS is a selection of processes (at least 1) that supply a certain demand for energy, material, as well as transport services (persons, freight), and if need be waste treatment. Every single combination of processes represents one scenario option.

If a scenario was implemented, GEMIS will calculate the environmental and cost aspects of the different scenario options, display results in tables and graphs, compare, as well as disaggregate them.

In case of pure *energy-scenarios* the demand can comprise also the needed power (electric as well as thermal), the supplying processes can be added, and their operating time can be determined independently. Additionally, *distribution systems* (electric power or district heat grid) may be included in energy-scenarios. The demand is automatically increased by the transport losses, if the transport lengths are given.

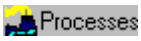
2 How to Create Your Own Processes ?

Proceed as follows:

Step 1: Start GEMIS and open project STANDARD with command File\Open project. If you don't have a GEMIS-registration, you should read and confirm the licensing conditions. Then you can continue working with a guest registration. After this, you should enter your name in the list of sources. Thus execute menu command **data\source**, position the mouse pointer in the list to the left, and click the **right mouse key**. In the appearing local menu choose option **New** and enter your name into the two white fields.

Finally, click on 

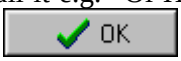
and close the window "sources".

Step 2: Click on 

and then on tab „filter" for opening card filter. Choose the following selection criteria:

- *Input Product Group*: fuels-fossil-oil
- *Technology Group*: heat-central-heating

Mark the most similar process to the one, that shall be created (here "oil-heating-DE-2000"). Paste a copy into the process list by executing **edit\copy** and then **edit\paste**.

Step 3: Give your new process a new german and english name. Call it e.g. "Öl-Heizung-DE-2000-1", or "oil-heating-DE-2000-1", respectively. Click on 

or press the <**Enter**>-key. The color of the process name has changed from red to black. This means that the data of your new process are no longer protected, i.e. you can change/edit data.

Step 4: Double click on your new process to edit it. The card **metadata** of it is opened automatically.

Enter your name instead of "Öko-Institut" as source. (So you can find your processes easier later on.) To do so, you have to click on the text "Öko-Institut" in field "source" and then choose your name in the listbox.

Step 5: Close card **metadata** by clicking on the <x>-button on the top, to the right in the window.

You've just created a new process "oil-heating-DE-2000-1" in GEMIS. In the following steps you will do the same for the gas heating system and the solar collector.

Have a short break!

Step 6: Choose the following selection criteria:

- *Input Product Group*: fuels-fossil-gases
- *Technology Group*: heat-central-heating

Click on process "gas-heating-DE-2000" and copy it with the command sequence **edit\copy** and then **edit\paste**. Give your new process the new names „Gas-Heizung-DE-2000-1" and „gas-heating-DE-2000-1". Click on 

.

Step 7: Double click on your new process again and enter your name as source. Close the window „process gas-heating-DE-2000-1" afterwards.

Step 8: Choose the following selection criteria:

- *Process Type*: Extraction
- *Input Product Group*: All
- *Technology Group:* All

Now click on process “solar-collector-Cu” (You can find it quicker, if you click on any process in the list and then press your <**S**>-key.) Copy this process with <**Ctrl+C**>, <**Ctrl+V**>. Give it the new names „SolarKollektor-Cu-1“ and „solar-collector-Cu-1“. Finally, don’t forget to click on 

.

Step 9: Double click on your new process again and enter your name as source. Close the window „process solar-collector-Cu-1“. Close the window „list of processes“.

Step 10: Save your data! To do so, use the menu-command **File\Save as...**. Enter a new name for your project, e.g. “myproject”, and save it on your computer.

3 How to Create New Scenarios ?

Step 1: Close all windows in GEMIS and click on 

.

Step 2: Position the mouse pointer in the list to the left and click on the **right mouse key**. Choose command **New** in the local menu (to create a new scenario).

The names should be: *Heizen+WW-Öl-Gas-Solar* and *heat+hw-oil-gas-solar*. The scenario ought to be of the type **Multiple options**. (This is the default setting.)

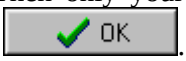
Step 3: Press your <**Enter**>-key or click on 

.

Step 4: Double click on your new scenario to edit it. Card **Meta data** is opened automatically. Enter your name as source. (So you can find your scenario easier later on.)

Step 5: Click on tab “options”. Create 4 options; i.e. choose 3 times menu command **New option** in the local menu that is opened by pressing the **right mouse key**. Write in the 4 white fields the 4 texts: “oil”, “gas”, “oil+solar”, and “gas+solar”.

Step 6: Now select your first option and click on tab **Data**.

Step 7: Select command **New** in the local menu (right mouse key!). The “select process” window is opened. Choose your name as **source**. Then only your “own” processes appear. Choose “oil-heating-DE-2000-1” and click on 

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Step 8: Enter the value 11000 kWh at option 1 and click into the sum row to bring your computer to take the value. If another energy unit is set, it can be changed to kWh with menu command **Extras\Units**.

Step 9: Return to card **options** by clicking on the appropriate tab.

You’ve just assigned an energy supplying process to option 1. Now, you’re going to do that for the other options:

Step 10: Select your second option and click on tab **data**.

Step 11: Execute local menu command **New,** select “gas-heating-DE-2000-1”, and click on 

.

Step 12: Enter the value 11000 kWh at option 2 and click into the sum row to bring your computer to take the value.

Step 13: Return to card **options** and control your input for option 2.

Now, it's the turn of the third option.

Step 14: Select the third option with your <**arrow-keys**> and click on tab **data**.

Step 15: Execute local menu command **New,** select "oil-heating-DE-2000-1", and click on OK.

Step 16: Execute once again local menu command **New,** select "solar-collector-Cu-1", and click on OK.

Step 17: Enter a value of 10250 kWh for the oil heating system and 750 kWh for the solar collector and click into the sum row to bring your computer to take the values.

Step 18: Return to card **options** and control your input for option 3.

Finally, the last option:

Step 19: Select the fourth option with your mouse and click on tab **data**.

Step 20: Execute local menu command **New,** select "gas-heating-DE-2000-1", and click on OK.

Step 21: Execute once again local menu command **New,** select "solar-collector-Cu-1", and click on OK.

Step 22: Enter a value of 10250 kWh for the gas heating system and 750 kWh for the solar collector and click into the sum row to bring your computer to take the values.

Step 23: Return to card **options** and control your input for option 4.

Step 24: Close the window "scenario heat+hw-oil-gas-solar" and save your project (with your new scenario) by executing menu command **File\Save**.

If you like, you can calculate the CO_2 or costs balance of your scenario to see results of your work.

Step 25: Click on tab **Results** and then on the button **Greenhouse gases** or the button **Costs**.

After a few seconds the results appear. An introduction about creating results offers GEMIS 4 tour 2 which is entitled "results of scenarios".

4 How to Adjust Cost Data ?

After the input of the scenario "heat+hw-oil-gas-solar" with the GEMIS data for product and investment costs, these data will be modified now.

4.1 Changing Product Costs (Oil and Gas Prices)

Assume the OPEC advances prices. The consequence be that oil and gas price raises for 10 %. Thus the oil price advances to 48.312 €/MWh[2], the gas price to 42.735 €/MWh.

We show in the following passage how these new data can be input in GEMIS: At first, it is important to know which products are used by the processes *oil-heating-DE-2000-1* and *gas-heating-DE-2000-1*.

Step 1: Click on Processes and take your name as data filter **Source.** Double click on process *oil-heating-DE-2000-1*, and then open card **Data**.

Here you can see that **oil-lite-DE-RE/CO-2000** is used as input product. The price of this product is to be changed. As you cannot change generic data in GEMIS and thus this product directly you should make a copy of this product record and change cost data there.

The created product (with a new name and higher costs) will be used by a new process **oil-heating-DE-2000-2** that is a changed copy of **oil-heating-DE-2000-1**.

Step 2: Close the processes window and open the products window by pressing on button Products in your toolbar. Copy product **oil-lite-DE-RE/CO-2000** to clipboard and paste it into the list under the new name **oil-lite-DE-RE/CO-2000-2**. (Both commands are in menu **Edit**.)

Step 3: Double click on your new product. Select your name as source.

Step 4: Click on tab **Data**. Change costs to 48.312 €/MWh. Close the window “product oil-lite-DE-RE/CO-2000-2”.

You’ve just advanced the oil price for 10%.

Now, change the gas price:

Step 5: Copy the product **natural gas-DE-RE/CO-2000** to clipboard, and paste it into the list under the new name **natural gas-DE-RE/CO-2000-2**. (For both commands see menu **Edit**.**)**

Step 6: Double click on your new product to edit it. Take your name as source.

Step 7: Click on tab **Data** and change the costs to 42.735 €/MWh. Close the window “product natural gas-DE-RE/CO-2000-2” and the products window.

The prices for oil and gas have been changed. Now, two new processes which use the new products as input have to be created.

Therefore results:

Step 8: Click on Processes. Copy process **oil-heating-DE-2000-1** to clipboard and paste it into the list under the new name **oil-heating-DE-2000-2** (- both commands are in menu **Edit**).

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2 The preset unit of energy for cost declarations is the TeraJoule (TJ). With the menu **Extras/units** and under tab “units 2” the MWh can be chosen.

Step 9: Double click on your new process to edit it. Open card **Data**. Click on the upper button on which is written "refinery\oil-lite-DE-2000". Change the output product (in the window "Select process") to **oil-lite-DE-RE/CO-2000-2** – your more expensive oil. Don't forget to click on 

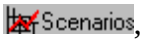
afterwards. Close the window "process oil-heating-DE-2000-2".

Step 10: Copy process **gas-heating-DE-2000-1** to clipboard and paste it into the list under the new name **gas-heating-DE-2000-2** (- both commands are in menu **Edit**).

Step 11: Double click on your new process to edit it. Open card **Data**. Click on the upper button on which is written "pipeline\gas-DE-mix-local". Change the output product (in the window "Select process") to **natural gas-DE-RE/CO-2000-2** - your more expensive gas. Don't forget to click on 

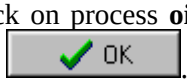
afterwards. Close the window "process gas-heating-DE-2000-2".

Now, you've used the more expensive products in new processes.

To get further results, open the scenarios window again by clicking on 

, copy your old scenario "heat+hw-oil-gas-solar" to clipboard, and paste it into the list of scenarios under the new name "heat+hw-oil-gas-solar-2" (- both commands are in menu **Edit**).

In the following passage the new scenario is changed so that the processes with the more expensive products are used.

Step 12: Double click on your new scenario to edit it. Open its card **Data**. Execute command **Edit** in the local menu (right mouse click!). Click on process **oil-heating-DE-2000-2** (the one with the more expensive oil), and then on 

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Step 13: Change to option 2 (gas) by clicking on the red arrow on card data (). (Don't mistake it for the red arrows on the tabs.)

Step 14: Execute again command **Edit** in the local menu (right mouse click!). Click on process **gas-heating-DE-2000-2** (the one with the more expensive gas) and then on 

.

Step 15: Change options 3 and 4 in the same manner.

Step 16: Check your scenario (with the **arrow-keys**). In all four options oil and gas heating systems have to be of the type "-2".

Step 18: Close the window "scenario heat+hw-oil-gas-solar-2", and save your scenario with the menu command **File\Save.**

Now, you can compare the scenarios with regard to the internal costs.

Step 19: Mark one of the two scenarios by clicking on its name in the list of scenarios. Then open card **Results** by clicking on the appropriate tab and click on button "**Costs"**.

After a few seconds the cost values that were calculated by GEMIS appear for the previously marked scenario.

4.2 Changing Investment Costs

The investment costs entered on process level in GEMIS are generally usual data but can differ from these values in individual cases (e.g. in concrete offers of manufacturers or suppliers).

Therefore, investment costs will be changed in the following passage: the oil heating system will be 10% cheaper, the gas heating system 10% more expensive, and the solar collector – for the reason of do-it-yourself at mounting – will be 15% cheaper.

Step 1: Start GEMIS and click on Processes. Open card **Filter** by clicking on the appropriate tab. Select your name as data filter *source*.

Step 2: Copy process **oil-heating-DE-2000-2** (to the clipboard), and paste it under the new name **oil-heating-DE-2000-3** into the list. (Both commands are in menu **Edit**.)

Step 3: Double click on the new process to edit it. Click on tab **Costs** to open card costs. Lower the investment costs for 10 % to 531.486 €/kW[3]. Then first click on Accept and finally on OK. Close the window "process oil-heating-DE-2000-3".

Step 4: Copy process **gas-heating-DE-2000-2** (to the clipboard), and paste it under the new name **gas-heating-DE-2000-3** into the list. (Both commands are in menu **Edit**.)

Step 5: Double click on the new process to edit it. Click on tab **Costs** to open card costs. Advance the investment costs for 10 % to 531.487 €/kW. Close the window "process gas-heating-DE-2000-3".

Step 6: Copy process **solar-collector-Cu-1** (to the clipboard) and paste it under the name **solar-collector-Cu-3** into the list. (Both commands are in menu **Edit**.)

Step 7: Double click on the new process to edit it. Click on tab **Costs** in order to open card costs. Lower the investment costs for 15 % to 3422.457 €/kW. Close the window "process solar-collector-Cu-3".

Now, a scenario "heat+hw-oil-gas-solar-3" has to be created to examine the cost changes of the processes.

Step 8: Close the **processes** window and open the **scenarios** window by clicking on button Scenarios in your toolbar. Click on tab **Filter** and select your name as data filter **source**. Copy the scenario "heat+hw-oil-gas-solar-2" to the clipboard and paste it into the list under the new name "heat+hw-oil-gas-solar-3".

Step 9: Double click on your new scenario "heat+hw-oil-gas-solar-3". Open its card **Data**.

Step 10: Execute the command **Edit** in the local menu that is opened by clicking on the right mouse key. Take your name as selection criterion **Source** in the window "Select Process". Mark the cheaper **oil-heating-DE-2000-3** and click on OK.

Step 11: Change to option 2 (gas) by clicking on the red arrow on card **Data** ( ). (Don't mistake it for the red arrows on the tabs.)

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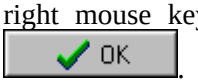
3 The preset unit of power for cost declarations is the MW. The unit can be changed with menu **Extras\units** under tab „units 2" to kW.

Step 12: Execute again the command **Edit** in the local menu that is opened by clicking on the right mouse key. Mark the more expensive **gas-heating-DE-2000-3** and click on 

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Step 13: Change options 3 and 4 in the same manner (instead of solar-collector-Cu-1: solar-collector-Cu-3; instead of oil...-2: oil...-3; instead of gas...-2: gas...-3).

Step 14: Check your scenario with the arrows. Only processes of the type "...-3" should appear as energy suppliers.

Step 15: Close the window "scenario heat+hw-oil-gas-solar-3" and save your scenario by executing the menu command "**File\Save**".

Now, you've created a third scenario – if you like, you may continue with Tour 2 where you will learn how to display results of scenarios graphically and in tables.

Tour 1 is completed – we hope that working with products, processes, and scenarios is a bit clearer now.

Tour 2: Results of Scenarios

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1 Objectives of This Tour

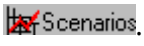
In this tour you will learn how to consider scenarios concerning the heating system of a single family house more closely. These scenarios were created in another tour[4]. They consisted of the four options:

- oil heating system
- gas heating system
- oil heating system + solar collector
- gas heating system + solar collector.

Thereby, the environmental impacts of the four options become visible.

2 How to Get Simple Results?

First of all, simple results – as tables or graphs – will be created:

Step 1: Start GEMIS, open your own project that has been changed in the preceding tour „From Processes to Scenarios“, and click on 

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Step 2: Open card **Filter** by clicking on the appropriate tab. Take your name as data filter **Source**. Then only your “own” scenarios are displayed.

Step 3: Mark for example „heat+hw-oil-gas-solar“. Click on tab *Results.*

Step 4: Execute menu command **Extras\units** in order to see the window „units“. Take the “kg” as mass-unit.

Step 5: Close the units-window by clicking on the <x>-buttons in the upper right corner of this window.

Step 6: Click on button “Table Greenhouse gases”. After a few seconds the table with the GHG emissions for the four options will appear.

Interpretation of the result:

As you can see the heat from a gas heating system causes a less amount of CO_2 equivalents than the heat from an oil heating process. The solar collector abates CO_2 emissions. This result can be displayed graphically, too:

Step 7: Close the „Results“ window and click on tab „Graph“. Take “Greenhouse gases” as type of result. GEMIS automatically selects “CO_2 equivalents” as sub type. Now click on button 

. A graph „GEMIS-results“ appears where the sums of the annual CO_2 equivalent emissions of the four options are displayed.

Step 8: Now, you can do for the internal costs what you did for the CO_2 equivalents. Here the internal costs comprise mostly the pure investment and fuel costs of the single options. So close the results window and click again on the tab *Graph*. Take “costs” as type of result, “internal costs” as sub type, and “Germany” as location.

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4 „How to Work with GEMIS 4.5? – Step by Step Instruction – Tour 1: From Processes to Scenarios“, U.R.Fritsche/K.Schmidt, Öko-Institut, Darmstadt 2008

Step 9: Repeat step 8 for the two other scenarios *heat+hw-oil-gas-solar-2* and *heat+hw-oil-gas-solar-3*.

Interpretation of the result:

As you can see for scenario *heat+hw-oil-gas-solar*, the oil heating system is more expensive than the gas heating process as far as the internal costs are concerned. Here the option with the highest internal costs is „oil+solar“.

3 How to Analyze Contributions of Different Processes?

GEMIS not only balances and displays the direct emissions of the oil and gas heating systems, and solar collectors. It also balances the emissions of the corresponding upstream process chain, i.e. transport processes, manufacturing processes, or fuel extraction processes.

This **upstream process chain** also has environmental impacts. Often it’s interesting to know the contributions of the single processes:

Step 1: Close the results window, if it is still opened. Click on tab *Contribution*.

Step 2: Take “Greenhouse gases” as type of result #1; sub type #1: CO_2; type of result #2: “Air emissions”; sub type #2: SO2.

Take “All” for the Location and NACE listboxes and in the Option listbox: “oil”.

Step 3: Click on button 

to display results.

Now you can see a list of CO_2 and SO_2 emissions of **all** processes for option „oil“. Their names are in the first column, in the second and third column there are the corresponding contributions to the total CO_2, or total SO_2 emission, respectively, of option „oil“. The fourth column is for the location of the process, and the fifth column is for the data quality indicator.

4 How to Compare Two Options Relative to One Result?

GEMIS gives you the opportunity to compare two options relative to one result. Proceed in the following manner:

Step 1: Close the results window, if it is still opened. Click on tab *Comparison*.

Step 2: Take “Greenhouse gases” as type of result. “CO_2” as sub type. „oil“ as option #1; „oil+solar“ as option #2. Please leave the default settings “all” in the location and NACE listboxes unchanged.

Step 3: Click on button 

.

Interpretation of the result:

You can see a table in which the options „oil“ and „oil+solar“ are compared with regard to the CO_2 emissions of the single processes that contribute to the total emission. Here upstream processes appear. You can see the names of the processes in the first column, in the second and third column the emissions in kg that the processes cause in the corresponding option, in the fourth column the location of the process concerned, and in the last column the data quality indicator.

A summarized consideration concerning **two** results of all options is given by the Trade-off presentation. You can learn more about it in the next part of this tour:

5 The Trade-Off

The Trade-off presentation stresses the differences in the results. One option is taken as reference (here: oil). The Trade-Off shows the differences of all other options for two results (here: CO_2 equivalents + internal costs). Proceed in the following manner:

Step 1: Close the results window, if it is still opened. Click on tab „Trade-Off“ of any scenario you like. Take the “Greenhouse gases” in the upper listbox, „CO_2 Equivalent“ as sub type. And as result #2: “Costs”, sub type #2: “Internal costs”. Take option “oil” as reference option. Leave the default settings “all” for the location and NACE listboxes.

Step 2: Click on Graph.

A 2-dimensional graph that shows the differences in the results for all options relative to the reference option appears. The reference option is situated in the crossing of the axes.

Step 3: Repeat steps 1 and 2 for your two other scenarios.

Step 4: Close the graph-window, mark the scenario „heat+hw-oil-gas-solar“ and click on button Table. After a few seconds you can see the trade-off data as a table. Additionally, – in the second column of the table – the quotient of the differences is shown.

Insertion: The sign of the quotient is less significant. If this sign is positive, you can’t determine whether numerator and denominator were both positive or both negative. If the sign of the quotient is negative, you only can conclude that numerator and denominator had different signs.

Interpretation of the results: Options “gas” and “gas+solar” seem to be win win options. Here a reduction of CO_2 equivalent emissions coincides with lower internal costs (- both relative to option oil).

In option “oil+solar” about 78.59 € more than in option “oil” have to be spent for a CO_2 equivalent reduction of about 249.3 kg relative to option “oil”. This equals an efficiency of 3.17 kg/€. That’s the absolute value of the ratio in the trade-off table.

You can calculate the additional expenses per kg CO_2 equivalent by exchanging results. Proceed in the following manner:

Step 1: Close the results window and click on tab „Trade-Off“.

Step 2: Enter the internal costs first and then the greenhouse gases (CO_2 equivalents). Then click on button Table again.

Interpretation of the results:

Now the absolute values of the ratios are a measure for the additional costs of the corresponding option concerning reduction of CO_2 equivalents. (about 31.5 €ct/kg CO_2 equivalent in „oil+solar“; 6.06 €ct/kg CO_2 equivalent in „gas+solar“).

Finally, you should calculate the Trade-Off of the air emissions NO_x and SO_2:

Step 1: Select **Air emissions** as *type of result* for both contributions, as the first *sub type*: **SO_2**, and the second: **NO_X.**

Step 2: Now click on button Graph (– not on tab "Graph").

Interpretation of the result:

Here "gas" and "gas+solar" are strong win win options. A saving of SO_2 **and** NO_x referring to option "oil" is possible.

6 Combination of Several Scenarios to a Total Scenario

Up to now, you always considered results of the three single scenarios that have been created by you. If you want to compare results of different scenarios, you have two possibilities:

- Either you export the tables in an (already existing) EXCEL™ file, by using the command "Export table" in the local menu that is opened by a right mouse click – then you can compare results in EXCEL™, create graphs, etc..
- Or – and this possibility will be explained here – you combine the single scenarios to a total scenario and create the results table or graph for the total scenario. So, you can continue working in GEMIS. The creation of the total scenario can happen quickly, if the window concept of GEMIS 4.5, the WINDOWS™-clipboard, and some commands from the local menu (rename, copy, paste, move up) are used.

Step 1: Close the results window, if one is opened.

Step 2: Double click on your scenario „heat+hw-oil-gas-solar-2" – your „type 2" scenario – and open its card **Options**. Append a 2 at the end of the four option names to be able to identify the options in the total scenario. Use the right mouse key to open the local menu and then the command "Rename".

Step 3: Please do the same with your "type 3" scenario. (Append a 3 at the end of the four option names.)

Step 4: Copy the scenario „heat+hw-oil-gas-solar" with which you started to clipboard and paste it with the new name „heat+hw-oil-gas-solar-total" into the list of scenarios. (Both commands are in the local menu!) This scenario forms your total scenario later on.

Now, the single options of the "type 2" and "type 3" scenario have to be copied into the total scenario.

Step 5: Double click on your (not yet ready) total scenario and after this on your "type 2" scenario. Position the windows in a way that you can easily change between the total and the "type 2" scenario. (The windows shouldn't be maximized.)

Step 6: Open card **Options** of the "type 2" scenario and copy option „oil 2" to clipboard. To do this, use the local menu that is opened by a right mouse click.

Step 7: Change to the total scenario window and open its card **Options** and select option „gas+solar". Press the right mouse key and execute the paste command.

Option „oil 2" with all its data is pasted before the last option.

Step 8: To correct the order of options, select the option at the bottom (gas+solar), open the local menu, and execute "Move up". Thereby, the order is correct again. („gas+solar" in front of „oil 2")

Step 9: Please do the same for the remaining options of the “type 2” scenario. Append them at the end of the options list of the total scenario.

Step 10: Close the “type 2” scenario window. Double click on your “type 3” scenario and append the “type 3” options to card **Options** of the total scenario.

After all, the list on card **Options** of the total scenario should contain the following options:

- oil
- gas
- oil+solar
- gas+solar
- oil 2
- gas 2
- oil+solar 2
- gas+solar 2
- oil 3
- gas 3
- oil+solar 3
- gas+solar 3

Now you can compare e.g. the internal costs of option „oil 2“ with those of option „oil“ in one table (or graph). You only have to mark your total scenario, open card **Results** and click on button 

.

We’ve reached the end of this 2nd tour and wish you will succeed when working with GEMIS.

Tour 3: Simple Calculation of Environmental Impacts of Processes

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1 Objectives of this Tour

„Tours“ are step by step instructions introducing users to working with GEMIS. This introduction is based on selected examples.

In this tour you will learn how the cumulated energy requirement (CER) can be calculated for processes of the GEMIS data base. Besides, you will determine the corresponding acidification potential (in SO_2 equivalents) and global warming potential (in CO_2 equivalents).

You will see that this is possible with a few keystrokes, or mouse clicks, respectively, and that you can get quickly to the processes you’re interested in by using data filters or a new search function.

A new function in GEMIS 4 enables you to calculate important energy and environmental data quickly, and a graphic tool visualizes process links in life cycles.

This tour enables you to become familiar with the - relative to older GEMIS versions -changed user interface and new GEMIS functions.

Please note that in GEMIS Version 4.5 there is an online-help answering further questions.

In further tours you will learn how to calculate results for more than one process (i.e. a **combination** of several processes) by using example scenarios. Furthermore, you will learn how to display results in graphs and how to export result tables from GEMIS.

We hope you’ll succeed testing this tour !

Your GEMIS developers team

2 How to Calculate Environmental Aspects of Processes that Supply Energy, Transport Service, or Materials?

On the following pages you will learn how to calculate quickly (with GEMIS) the cumulated energy requirement (CER), as well as the acidification potentials (in SO_2 equivalents), and global warming potentials (in CO_2 equivalents) for an oil heating system, first, then for a car, and finally for beer.

2.1 Preparation: Starting GEMIS and Loading The Data Base

Some steps of preparation are necessary to work with GEMIS:

Step 1: Start GEMIS 4.5. Then click on "*File"* in the menu bar and select the second option *"Open project"*.

In the selection window you see at least one project with the name „Standard.prd" that is offered as default in the box „*object name*". Click on button „*Open*".

Now GEMIS shows the progress bar in the middle of your screen indicating that your computer is busy opening the project.

In the title bar (at the top of the GEMIS program window) the name of the loaded project is shown inclusively its path.

Step 2: Click on button 

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GEMIS opens a window in which a list of processes appears to the left. These processes are saved in the project. They are in alphabetical order. To the right of the list, on card "Info" you can see a short description of the record chosen in the list – this is automatically the entry at the top of the list. In the right part of the window you can see four further tabs: "Comment", "Filter", "Process chain", and "Results".

Step 3: Click on tab „*Filter"*, and GEMIS shows a variety of selection boxes serving to filter the list displayed to the left.
These filter options will help you to find those processes you are interested in even if you don't know their "GEMIS-name". Don't worry about the variety of filters – you will get to know the most important ones (and there still is the online-help in GEMIS).

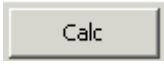
2.2 Calculation of the CER for an Oil Heating System

Step 4: At first, an **oil heating system** is to be found – to find it in the processes list, click on the selection box "*Input Product Group"*. Then, use the scrollbar to search for the entry "*fuels-fossil-oil"* and click on it.

Now the processes list only contains processes using fossil fuels of the type "oil" – but there still is no oil heating system displayed.

Step 5: Select an additional data filter: click on selection box „Technology Group“ and move the scroll bar to the bottom. Now you can see the entry “heat-central heating” among others – click on it.

The processes list to the left now displays all the processes from the GEMIS data base fitting into these two filter criteria – and nearly at the top of the list is: „oil-heating-DE-2000“: That’s the heating you’ve been looking for.

Step 6: Click on that process name and it is marked in dark blue. To calculate results for space heat from this oil heating process, open card Results and click on 

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Card Results now offers you beside other data the CER for the process „oil-heating-DE-2000“ – you only have to use the scroll bar! You can see the single CER components, first, as well as the CER sum. Further down the contributions of the single primary energies for the CER are listed.

If you’ve started GEMIS for the first time, the program has used the default units for energy, mass, etc. – these are TJ for energy and kg for mass. GEMIS calculates the CER always for the set unit i.e. in this case for 1 TJ space heat.

That’s a rather unsuitable unit for an oil heating system – but you can setup the units in GEMIS yourself:

Step 7: Click on symbol 

in the GEMIS symbol bar. Now GEMIS opens a window where you click on the first selection box and choose the fifth entry with the ending „*kWh*“. Close the window “units” afterwards.

Step 8: Calculate results for „*oil-heating-DE-2000*“ once again.

The result shows that an oil heating system needs about 1.39 kWh of primary energy to deliver 1 kWh of space heat – extraction, transport, and refine of the oil, as well as auxiliary electricity for the heating pump, and even the manufacturing of the heating system (and the refinery, the oil tanker etc.) are considered.

2.3 CER of a Car

Next, we explain how to calculate the CER for a car with GEMIS.

Step 9: Open card Filter and click on button 

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Now GEMIS shows the list of all stored processes – the unfiltered list appears in which the oil heating process is still marked (– GEMIS remembers that). You will see it, if you maximize the process window.

Step 10: We're interested in "car processes" – enter car as search word.

The processes list now only consists of processes with the word "car" in their name.

Step 11: Calculate results for process "car" in the list.

As you can see very soon, it takes about 0.617 kWh of primary energy for one person kilometer transport service. Again, oil extraction, transport, and gasoline production in a refinery, as well as the manufacturing of the car are included.

2.4 Calculating Emissions of a Car

As the calculation of the CER for the car was made rather quickly, have a look at the emissions of this car – here is the instruction:

Step 12: Move the scroll bar to the top.

Under the headline "Emissions into air" emissions of 1 P*km driving performance of the car appear – at the top of the list is the acidification potential given as SO_2 equivalent, then the TOPP equivalent followed by the single harmful (acid) substances.

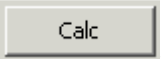
Furthermore, the global warming potential is given (as CO_2 equivalent) and below the single greenhouse gases. As it was with the CER, here also oil extraction, gasoline production, etc., and combustion of the gasoline in the car engine, as well as the production of the car are included in these results.

2.5 Environmental Balance for Beer

As you have seen, the balancing of emissions for a process in the data base can be executed very quickly – you will do this for another process: the production of **beer**.

Step 13: At first, open card Filter. Simply enter "beer" as search word.

In the list displayed to the left of card "Filter" the first process name with the search word "beer" is "food\beer". This process represents the production of beer in a brewery – and for this you can calculate results now:

Step 14: Mark process "food\beer", open card "Results" and click on 

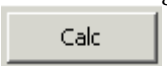
.

GEMIS shows in the result window that producing 1 kg of beer by the process „food\beer“ requires about 1.24 kWh of primary energy. Predominantly, natural gas and mineral oil are used here. As 1 kg beer equals about 1 liter (1000 ccm) beer, there are about 1.2 kWh primary energy per liter – or in other words: 0.12 liter of mineral oil is used per liter beer.

For the emissions you have to scroll upwards. The result means – referring to 1 liter beer – a global warming potential of 0.33 kg.

2.6 Comparing the CER of Two Processes

Finally, you will calculate a short comparison between a “conventional” beer and an “ecological” beer:

Step 15: You’ve already calculated the CER for „normal“ beer. The Results card still is on your screen. Leave the Results card opened and click with your mouse on process name “food\beer-organic“ under the normal brewery in the list of processes. Then click on 

again.

The new Results card shows you the cumulated energy requirement for brewing beer with barley from ecological cultivation – this requires about 1.18 kWh of primary energy per kg ecological beer. Why is the CER of ecological beer a bit smaller than the CER of normal beer?

2.7 Simple Analyses: The Process Chain Graph

To get a first answer to this question, just try another option of GEMIS: the **process chain graph**. Proceed as follows to activate it:

Step 16: Click with your right mouse key on process name “food\beer-organic” and select option *Process chain graph* in the local menu. Now you can see the upstream processes of ecological brewing in a new graph window – the malthouse directly above the brewery and above the malthouse the process for cultivating summer barley.

You will notice that there are further processes displayed in the graph – to the right with **red** links energy supplying processes (electric power grid, process heat, dieselmotor) and to the left with **blue** links materials supplying processes (e.g. “chem-inorg\fertilizer-Ca”). (The three processes supplying fertilizers are to the left of the process for cultivating summer barley.)

This “tree graph” shows the links constituting the life cycle of beer in the GEMIS process data base. The brewery needs the malthouse, and the malthouse needs the cultivation of barley. Every process needs more or less auxiliary energy, and partially material inputs.

How to compare the life cycle of “eco” beer with the life cycle of conventional beer? To see this, create another process chain graph, but this time for the conventional brewery:

Step 17: Leave the process chain graph for “food\beer-ecological” opened and click again on process “food\beer” in the list of processes. Then click with the right mouse key and select option *Process chain graph* in the local menu again. Now you can see the upstream processes of the “normal” brewery – again the malthouse and above the process for cultivating summer barley.

At the top, to the left in the graph you can see five processes supplying biocides and fertilizers linked with the cultivation of summer barley: chem-org\biocides, chem-inorg\fertilizer-Ca, chem-inorg\fertilizer-K, chem-inorg\fertilizer-P, and chem-inorg\fertilizer-N. Compared with the process chain graph of the ecological brewery there is an additional fertilizer (chem-inorg\fertilizer-N) and biocides used – **and this effects the CER**.

To see what is “behind” the process *chem-org\biocides*, click with your mouse on that name in the process chain graph. GEMIS shows the upstream processes of **this** process: with several steps biocides are made from natural gas[5]. The ecological cultivation of summer barley doesn’t need the biocides and thus saves energy.

The process chain display gives you a general impression of the life cycle that possibly consists of different processes to supply a product.

3 Outlook: Scenarios Can Do More

This graphic tool can’t help you, if you’re interested in the energy requirement or emissions “hidden” in upstream processes – in order to get this information you need **quantitatively** analyzing tools. GEMIS has them.

To do such analyses the simple calculation of results in the process data base of GEMIS is not enough – here it is necessary to calculate so-called **scenarios**. Tour #4 will show you how to do this. There you will also learn, how to calculate a combination of **more than one** process **at the same time**.

Tour #3 is finished now. You know how to find processes in the data base by using data filters. The calculation of the results only requires some mouse clicks.

Thank you for your attention and we hope you’ll succeed working with GEMIS in the future.

5 If you want to see the last process chain graph, you can use the command „Back“ in the local menu that is opened by clicking on your right mouse key.

Tour 4: Scenarios and Analysis of Results

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1 Objectives of This Tour

With this step by step instruction (tour) you'll learn how to calculate the cumulated energy consumption (CEC) as well as emission balances for **example scenarios** from the GEMIS data base – and after this the tour shows how to display, analyze, and export results for your own scenarios.

You'll see that this is possible with only a few keystrokes, or mouse entries, respectively – but some more activity is required than for the simple calculations[6].

The new CER/CEC-functions are integrated into scenarios. This allows an exact analysis of energy and environment data considering all process links even in complicated life cycles.

This tour was written to explain these extended options – the basic functions were described in the first CER-tour[1].

GEMIS Version 4.5 has an online-help which you can use.

In this tour you will learn how - by using **scenarios -** to calculate the CEC for a combination of several processes, how to display results in graphs, and how to export result tables from GEMIS.

Now we hope you'll succeed testing this tour!

Your GEMIS developers team

6 see „How to work with GEMIS 4.5?" – step-by-step-instruction – tour 3: Simple calculation of environmental impacts of processes, U.R.Fritsche/K.Schmidt, Öko-Institut, Darmstadt 2008

2 How to Calculate Scenarios that Demand Energy, Transport Services, or Materials ?

On the following pages you'll learn how to calculate CEC and emissions for a couple of example scenarios quickly. These example scenarios are part of the GEMIS data base. The first scenarios that you will calculate represent the energy and transport service demand of typical households. Then you will work with scenarios for different means of transportation and finally scenarios for food.

2.1 Preparation: Getting Started and Loading the Data Base

To be able to work with GEMIS, some steps of preparation are necessary:

Step 1: Start GEMIS 4.5.

Now the GEMIS program window is empty – for working you have to load a "project", i.e. a set of files, in which the GEMIS data base is saved. To do this, proceed as follows:

Step 2: Mouse click on *"File"* in your menu bar and then on *menu option "Open project"*.

In the selection window you'll see one project that is chosen in the box "*object name*" as default.

Step 3: Click on button "*Open*" to the right, at the bottom of the selection window.

Now GEMIS shows the progress bar in the middle of your screen, indicating that your computer is busy opening the project.

In the title bar (at the top of the GEMIS program window) the name of the loaded project is shown inclusively its path.

Step 4: Click on button 

, and GEMIS opens a window in which a list of all scenarios of the loaded project appears. This list is in alphabetical order. On the right side you can see a short description of the scenario record chosen in the list. When the window is opened, it is automatically the entry at the top of the list.

Furthermore there are *eight tabs* in the right part of the window. They have the names *„Info"*, *„Comment"*, *„Filter"*, and further tabs that will be explained later on.

2.2 CEC Calculation for Example Households

First the energy balance of typical **households** should be calculated:

Step 1: To find a fitting scenario in the list, open card Filter and enter *household* as search word.

The list shows scenarios, whose name contain the search word – the second scenario is *„demand-mix: household 2000*".

In the right part of the scenario-window a short description of this scenario is displayed. The calculation of results happens in the following manner:

Step 2: Mark the second scenario.

Step 3: To calculate the CEC for that scenario, click on tab "*Results*" and then on button Resources Use – now the progress bar window is opened again, indicating that your computer is busy calculating a balance. After the calculation, a new window entitled "Cumulated energy and material requirement" is opened, where you can see the results in a table.

You've just calculated the CEC for the scenario - that's all ! In the result window you can see the CEC sum and the single CEC components in the columns.

Step 4: In order to see the contributions of the single primary energies to the CEC, click in the upper part of the window on „*detailed*". Now you can use the scroll-bar at the lower edge of the window to display all columns little by little.

If you've started GEMIS for the first time, the program has used the default units for energy, mass, etc. – these are TJ for energy and kg for mass. That's a rather unclear unit for a household scenario, but you can setup the units in GEMIS yourself – read this:

Step 5: Click on symbol  in the GEMIS symbol bar. Now GEMIS opens a window, where you click on the first selection box and choose the fifth entry with the ending „*kWh*". Close the window "units" afterwards.

Now the CEC is shown in the unit "kWh".

What about other results for this scenario – for instance greenhouse gases? This also is very simple:

Step 6: First close the result window and then click in the upper right part of the scenario window on tab "*Graph*". Select "Greenhouse gases" as type of result, and "Germany" as location. Then click on button Graph (- don't mix it up with the tab "Graph" at the top of the window). After a few seconds GEMIS opens a new window, in which the greenhouse gas balance of the different households is shown.

The result graph shows the share of greenhouse gases that is emitted in Germany in green color. The amounts that are emitted in all other countries (and are caused by the demand of the households) are displayed in red – this graph helps to recognize the "homemade" share of greenhouse gases.

2.3 CER of Different Means of Transportation

Later on in this tour will be explained how this result was made – we now go on with the calculation of the CER for a scenario of different means of transportation.

Step 1: Close the graph window by clicking on button „X" in its upper right corner. To find the example scenario dealing with transport open card Filter and enter *transport* as search word.

Scenarios containing the word "transport" appear in the list to the left.

Step 2: Mark scenario "*transport: car driving systems (excluding biofuels)"* and open its card *Info*.

In the right part of the scenario window a short description of this scenario is shown now. We continue with the calculation of results of this scenario:

Step 3: To calculate the CER for that scenario, click on tab "*Results*", and then on button Resources Use – now the progress bar window is opened again, indicating that your computer is busy calculating a balance. After the calculation a new window entitled "Cumulated energy and material requirement" is opened, where you can see the results in a table.

You've just calculated the CEC and CER for the scenario - that's all ! After choosing "Primary energies (CER)" in field *Resource type*, you can see the CER sum and the single CER components in the columns.

Step 4: To see the contributions of the single primary energies to the CER, click in the upper part of the window on „*detailed*". Now you can use the scroll-bar at the lower edge of the window to display all columns little by little.

As the CER for the scenario was calculated rather quickly, use GEMIS now again to calculate – without ceremony – emissions of harmful substances! Here's the instruction:

2.4 Calculation of Emissions for Different Means of Transportation

Step 1: Close the CER result window and mouse click on button "Air emissions".

Again, GEMIS opens a result window. First the ozone precursor potential and the acidification potential in SO_2 equivalents is listed – followed by the single air emissions.

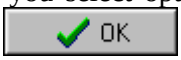
As it was for the CER, here also oil extraction, gasoline production, etc., the combustion in the motor, and the manufacturing of the car are included.

3 Scenarios Can Do More: Graph and Comparison Analyses

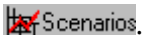
The result tables and the graph don't inform you, how much energy requirement or emissions are "hidden" in the upstream processes – they only show the total effect of all processes. The contributions of the single processes can only be determined by **quantitatively** analyzing options. GEMIS 4.5 offers these options, too.

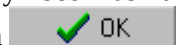
To execute such analyses, you have to calculate **scenarios** as above. Now we're going to create an own scenario:

As an example the scenario „beer“ with the two options „conventional“ and „ecological“ will be entered.

Step 1: Did you already enter your name in the GEMIS list of sources? If you did it you can continue with step 2. If you didn't do it, you should execute menu command **Data\Source**, position the mouse pointer in the list, and click on your right mouse key. In the appearing local menu you select option **New** and enter your name in the two white fields. Finally, click on 

and close the window "Sources".

Step 2: Now click on 

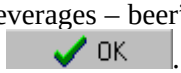
. Open the local menu by positioning the mouse pointer in the list of scenarios and clicking on the right mouse-key. Select option "New...". Enter "Bier" respectively "beer" as names and leave "Multiple options" as type of your new scenario. Click on 

in the dialog window.

The dialog window vanishes and scenario "beer" appears in the list(, if it isn't filtered out by the last filter settings). It is marked.

Step 3: Double click on the scenario name "beer", to edit this scenario. Enter your name as *source* (in the fourth white field from above). (So the scenario can be found much easier later on.) Then click on tab „Options“. Move the mouse pointer into the options table that is still empty, and click on the right mouse key to open the local menu.

Step 4: Select „New option“. You'll need two options in this scenario. Overwrite the two dummy-texts „Option 1“ with „conventional“ (above) and „ecological“ (below). Use your mouse to change from one row to another. Eventually, select option „conventional“ and click on tab „Data“.

Step 5: Click on tab "Materials“ and open the local menu[7]. Select „New“(, for a new process has to be inserted). The "Select Process"-window appears. Select "beverages – beer" as data filter *Technology Group*. Mark process „food\beer“ and click on 

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Now this process appears in the material source table.

Step 6: Change the demanded amount from 0 to 1 kg and select the field below (in the "Sum row"). (For saving data here, it's not enough to press your "Enter"-key. You have to take your mouse or the arrow-keys.)

There have to be two ones in the table now – one in the "process row" and one in the "Sum row".

Step 7: Select the second option ("ecological") now by clicking on the red arrow besides "Selected option". Open the local menu[2] and execute command "New".

[7] You have to position the mouse pointer in the empty table and click on the right mouse-key.

Step 8: Take again “beverages – beer” as data filter *Technology Group* in the “Select Process”-window and mark process “food\beer-organic”. After clicking on OK you should change the demanded amount from 0 to 1 kg and pay attention to the “Sum row”. Only if there is the correct value of 1 kg in the “Sum row”, your entry has been taken from your computer.

Step 9: Finally, you can click on tab “Options” again, to control the materials demand of the two options “conventional” and “ecological” (1 kg both).

Now your scenario is complete.

Step 10: Please close the window “Scenario ´beer´” and click on tab “Graph” in the scenarios window. Select as *Type of result*: **Greenhouse gases** and leave the *Sub type*: **CO_2-equivalents**. Click on button Graph.

A few seconds later the graph with the chosen result is shown.

Step 11: Close the graph window and click on tab “Comparison” afterwards. Select as *Type of result*: **Greenhouse gases** and click on button Table.

A comparison analysis table appears. It contains the disaggregated values for CO_2 equivalents of the upstream processes for both ways of brewing beer.

4 Beyond GEMIS: Export of Data and Results

If you have created result tables in window Scenarios (card “Results”), you can copy them (with command **Copy table** from the local menu) to clipboard.

In order to open the local menu, you have to position the mouse pointer in the corresponding table and click on the right mouse-key.

Afterwards, you can paste the contents of the clipboard – the table – in WORD® for example.

A more direct method, to export result tables in EXCEL®-files offers command **Export table** in the local menu.

This tour is over now. You know how to calculate the CER of processes and scenarios in GEMIS. Furthermore you can display results as a graph, analyze, and export them.

Calculation of the CER and emissions as well as their analysis and documentation only require some mouse clicks.

Thanks for your attention. We hope you’ll succeed working with GEMIS in the future.

Tour 5: Global Switches in GEMIS

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1 Objectives of this Tour

With this step by step instruction you'll learn how to work with the global switches in GEMIS 4.5. So you can better check the sensitivity of your results regarding system boundaries (scope of the life-cycle computation).

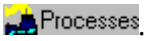
In GEMIS 4.5 there are five global switches, which can be set via menu **Extras\Settings**:

- Construction
- Mobile transport
- Efficiency of resource extraction
- Treated/disposed solid wastes are not included in results
- Base for heating value related data.

In the following chapters the use of these switches is explained.

2 Global Switch „Construction"

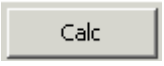
If this switch is activated, GEMIS will consider perhaps existing construction materials for **all** processes in its computations. The influence of this switch will be demonstrated for an example gas heating system.

Step 1: Start GEMIS, load project STANDARD, and click on 

.

Step 2: Open card Filter.

Step 3: Enter "gas-heating" as Search word.

Step 4: Mark process *gas-heating-DE-2000*. This process will serve as example. Select the kWh as energy unit via menu Extras\Units. Then open card Results and click on button 

to calculate the results.

After a few seconds, you can see under headline *Green house gases* that for 1 kWh[8] delivered space heat there are emissions of for instance about 0.264 kg CO_2. In this value the CO_2 emissions of the **construction** processes for the gas heating system, the gas pipeline, the gas processing, the gas extraction etc. are considered.

Now you will cause GEMIS 4.5 to ignore the emissions resulting from construction processes – proceed as follows:

8 Please note that you can change the units by clicking on icon in the toolbar.

Step 5: Open menu **Extras** and select option **Settings** and cancel the hook at global switch "Construction" – simply click at it once and the hook vanishes. Don't forget to click on  afterwards – your computer uses your new settings only if you click on  .

Step 6: Start a new calculation of the emissions balance for process *gas-heating-DE-2000* by positioning the mouse pointer in the list, clicking on your **right** mouse key, and then selecting option Results.

Now there are about 0.261 kg CO_2. This value is a bit smaller than the one with global switch "Construction" set (about 0.264 kg).

So you've determined the relevance of construction processes for a gas heating system – about 1% for CO_2.

Naturally, there are processes for which construction is much more relevant – e.g. solar cells (in GEMIS: solar-PV-...) or nuclear powerplants (in GEMIS: nuclear-powerplant-…). Now you're able to examine it yourself – and please note: global switch „Construction" functions for scenarios, too!

3 Global Switch „mobile transport"

If this switch is set, all upstream transport processes are considered at emissions computation with GEMIS. The global switch "mobile transport" determines, whether **non stationary** transport processes are included in this set of upstream transport processes.

Non stationary transport processes are transports by ship, truck, or train etc., whereas **stationary** transports are for instance transmission lines and pipelines.

To see the effect of this global switch for an example biogas cogeneration system, proceed as follows:

Step 1: Close the results window and activate again all global switches by menu **Extras\Settings**. Don't forget to click on  afterwards. Open card Filter and then enter "biogas-ICE" as Search word. Then mark process *biogas-ICE-cogen-central-intern-000-km*.

Step 2: Calculate results for this process.

After a few seconds, the emissions table appears. You can see that the whole process chain emits 3.02 g CO2, if one kWh of electric energy is generated by the marked biogas cogeneration system.

The CO_2 emissions of the truck, which transports the liquid manure from the farm to the biogas production plant, are included in the 3.02 g.

Now the same calculation will be made without considering the transports:

Step 3: Select menu **Extras\Settings** and **de**activate global switch "mobile transport", i.e. cancel the corresponding hook. Leave all other global switches set, and then click on 

.

Step 4: Calculate results for process *biogas-ICE-cogen-central-intern-000-km* once again (see step 2).

The new value amounts to 2.95 g CO_2 and is a bit smaller than the 3.02 g above.

The difference of 0.07 g CO_2 represents the contribution of the mobile transport – in this case it is negligible.

For other processes (e.g. mineral coal import, oil tanker, etc.) transports are of greater importance – now you know how to find out.

4 Global Switch „Efficiency of resource extraction = 100%"

If this global switch is set, the efficiency of primary energy or resource **extraction** processes (and these only) is set to 100% when the CER is calculated[9] and thus other efficiencies set on process level are ignored[10]. Let's take a monocrystal PV module without frame and without rack, to show the effect of this global switch. In GEMIS this process is called *solar-PV-mono-noFrame-noRack-DE*.

Step 1: Reset again all global switches with menu **Extras\Settings** and then close the selection window by clicking on 

.

To find process *solar-PV-mono-noFrame-noRack-DE* quicker in the list of processes, click on tab *Filter* and take the following data filters:

- Location: *Germany* and
- Technology Group: *renewable-solar*.

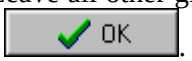
Step 2: Mark process *solar-PV-mono-noFrame-noRack-DE* and calculate the CER with card "Results".

9 CER = Cumulated Energy Requirement

10 Concerning the background of this rule a German paper exists, which explains the CER method in GEMIS 4.5. You can find it on the German KEA website http://www.oeko.de/service/kea under „download – Dokumente" and there "Arbeitspapier Methodik", or directly under http://www.oeko.de/service/kea/files/kea-methodik.pdf

The CER table shows approximately 0.4 kWh as CER-non renewable, about 1.02 kWh as CER-renewable, and 1.47 kWh as CER-sum. Further down in the result table, you will see a more detailed split of the CER into single primary energies[11] – under „sun“ there are 1.000 kWh. This corresponds to the fact that GEMIS supposes an efficiency of 100 % for extraction processes (and that's the type of the PV module[12]) – for 1.000 kWh of generated electric energy (output of the PV module), 1000 kWh of solar energy are necessary as input.

What happens, if you don't set the global switch? Find it out:

Step 3: Select menu command **Extras\Settings** and cancel the hook for global switch "Efficiency of resource extraction = 100%". Leave all other global switches unchanged and close the selection window by clicking on 

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Step 4: Please calculate the CER for process *solar-PV-mono-noFrame-noRack-DE* once again.

This time, the CER-sum amounts to approximately 9.12 kWh. That's much more than previously calculated. CER-non renewable hasn't changed much: about 0.41 kWh instead of 0.4 kWh that were calculated before. That's a difference of about 2 %. But the CER-renewable has increased enormously to 8.67 kWh (1.02 kWh before) and further down you'll find 8.651 kWh of "sun" (in the split of the CER to primary energies) instead of 1.000 kWh before!

How to explain such an increase for CER-renewable?

By the deactivation of the global switch GEMIS has inspected all extractors (extraction processes for primary energy or raw materials) for their efficiency – and used it.

Process *solar-PV-mono-noFrame-noRack-DE* has an efficiency of 11.56 % (see card „General data“), i.e. this process needs 8.65 kWh input per kWh output – for extraction processes, the input is a resource, for a solar cell: „sun“.

If 1.000 kWh primary energy „sun“ or 8.651 kWh are „consumed“ by the generation of 1.000 kWh solar electricity, is only a question of definitions: the sunlight reaches the earth in every case, no matter if the solar cell generates electricity, or not[13].

However, it is important that the values for CER-non renewable hardly change – so, the global switch has an effect especially for renewable energies.

---

11 If you don't see any detailed CER-information here, you

- either can enter a multiple options scenario with 1000 kWh energy demand delivered by the PV process, open card *Results* and then click on button "Table Resource Use" to calculate the detailed CER,
- or upgrade your GEMIS 4.0 version.

12 Most of the processes for using renewable energy sources in GEMIS are extraction processes, as they directly supply electricity or heat from a resource (geothermal, sun, hydropower, wind). A different case is biomass: The extraction processes here are either areas for cultivating renewable raw materials (forests, fields) or systems using residual materials (e.g. for liquid manure, residual straw, residual wood from forests). The resulting biomass then can be used like other fuels in heating systems, power stations, or vehicles.

13 An exacter argument, why the „100%“-rule is more sensible than others, you'll find in the paper mentioned in footnote 4.

5 Global Switch „treated/disposed solid wastes are not included in results“

If this global switch is set (i.e. if there is a hook), treated or disposed solid wastes are not considered when results are calculated: they are no longer balanced as ash or else, as they are disposed/treated[14].

Instead of executing example calculations with the right mouse key concerning the effect of the global switch in the processes data base, an example **scenario** will be used this time – it is called „*Energy: Effects of Waste Treatment (Landfill)*“ and is in the GEMIS 4.5 generic database.

Step 1: Reset all global switches except “Use saved turnover values” with menu **Extras\Settings**, close all windows, and then click on Scenarios.

Step 2: Mark scenario „*Energy: Effects of Waste Treatment (Landfill)*“ and click on tab „Graph“. Take „solid wastes“ as „Type of result“ and „Sub type“„Ash“ will be selected automatically. Then click on button Graph.

Now, GEMIS calculates the turnovers and environmental impacts of the scenario options and displays the result in a graph. There you can see that approximately 14000 kg ash result in the first option (coal-powerplant REF), whereas less than 2000 kg ash result in the second option (coal-powerplant + waste treatment) [15].

In the third option (lignite-briquette heating REF) about 6000 kg ash result, whereas in the fourth option the result is about 500 kg.

REF (= Reference) means that the process was modeled *without* ash disposal, while „ + waste treatment“ points out that in the scenario option a waste treatment facility for ash has been linked to the process – so the resulting ash is disposed of and no longer balanced in the result graph.

However, the waste treatment is of effect on environment, too – to see this, close the window “Graph: Ash”, take “Greenhouse gases” as “Type of result” on card *Graph*, and click once again on button Graph.

Now, you can see that scenario options with processes, which consider waste treatment, have slightly higher CO_2 equivalent emissions compared to the REF-option (with processes without waste treatment) – this comes from the waste treatment implying emissions and transports(, thus emissions again).

Step 3: Execute menu command **Extras\Settings** and cancel the hook at global switch „treated/disposed solid wastes...“, but leave all other global switches as they are. Finally, don’t forget to click on OK.

---

14 This is done by processes of the new type „waste treatment facility“ serving for the treatment/disposal of solid residues.

15 You can create the exact values (in table form) with card „Results“.

Step 4: Calculate the graph for the solid residues (ash) once again. (See step 2)

Now, you will see that the second option (coal-powerplant + waste treatment) produces as much ash as the corresponding first option (coal-powerplant REF). The same is true for options 4 and 3.

The deactivated global switches forces GEMIS to ignore links between waste treatment facilities and processes when it calculates the balance of solid residues

Thus – with this switch – you quickly can determine the sensitivity of your results concerning waste treatment.

6 Global Switch: Base for heating value related data

At first, we want to give you some information about the higher and lower heating value:

The lower heating value - abbreviation: LHV – is the amount of energy resulting from the complete oxidation of a fuel excluding the vaporization heat for the water vapor.

If processes use the vaporization energy by condensing the water vapor, an efficiency of over 100 % may result.

In international circles, and especially the USA, the higher heating value (HHV) is used as base for heating value related data – it equals the energy from the complete oxidation of a fuel including the vaporization heat of the water vapor, and thus is bigger than the LHV.

The differences between LHV and HHV are determined by the water and hydrogen content of the fuel – the bigger they are, the bigger are the differences.

For coal there is a factor of 1.05 between LHV and HHV (5 % more HHV than LHV), while the factor for mineral oil is approximately 1.1 and for natural gas it is about 1.15. For pure hydrogen the difference of 1.18 is relatively high.

Energy related characteristic data (efficiency, prices, emission factors) thus have to be **converted**, if the HHV instead of the LHV is taken as base for energy related data – and vice versa (see the following examples)

Example Efficiency:

The LHV of natural gas in Germany is 9.75 kWh/Nm^3, and a gas-fueled combined-cycle powerplant has an electric efficiency n_{el} (LHV) of 55 % related to LHV. This means that it generates 9.75 * 0.55 = 5.36 kWh electricity from 1 Nm^3 fuel input.

On the other hand, the HHV of natural gas in Germany is 10.81 kWh/m^3. If the combined-cycle powerplant continues generating 5.36 kWh electricity per Nm^3 gas input, an electric efficiency related to HHV of n_{el}(HHV) = 5.36 / 10.81 = 0.496 = 49.6 % results.

Moreover, the quotient of n_{el} (LHV) and n_{el} (HHV) = 55/49.6 = 1.109 equals the quotient of HHV and LHV: 10.81/9.75 = 1.109

Example Price:

The price of natural gas for residential and commercial customers in Germany is according to the GEMIS data base about 3.7 €cent/kWh (LHV), i.e. related to the lower heating value. From the example above, you know that the LHV of that gas equals 9.75 kWh/Nm^3, and so the price per Nm^3 can be calculated: 3.7 €cent/kWh * 9.75 kWh/Nm^3 = 36.1 €cent/Nm^3.

Now, if the base for prices is changed to the HHV, the Nm^3 gas continues costing 36.1 €cent but it contains 10.81 kWh (HHV) – so, a higher heating value related price of 36.1 €cent/Nm^3 / 10.81 kWh/Nm^3 = 3.34 €cent/kWh (HHV) results.

Again, the quotient of price (LHV) and price (HHV) 3.7 / 3.34 = 1.108 equals the quotient of HHV and LHV.

Example Emission Factor:

If you mark product "natural gas-DE-RE/CO-2000" (that's the GEMIS-name of natural gas for residential and commercial customers in Germany) in the GEMIS data base for products, you will see on card "Info" that the emission factor for CO_2 is 200.953 kg/MWh[16]. As before, this value is related to the lower heating value, i.e. per Nm^3 natural gas 200.953 kg/MWh * 9.75 kWh/Nm^3 = about 1959 g/Nm^3 – nearly 2 kg CO_2 are emitted.

However, the CO_2 emission factor related to the HHV is 1959 g/Nm^3 divided by 10.81 kWh/m^3 = about 181.3 kg/MWh (HHV) – again, the emission factor related to the HHV is 1.108 times smaller than the emission factor related to the LHV.

The conversion between LHV-related and HHV-related characteristic data always can be done with the quotient of LHV and HHV. As GEMIS „knows" both heating values for every fuel, it is easy to do an exact conversion.

To tell GEMIS, whether – for instance – your cost data of a certain fuel is related to its LHV or HHV, you can use the field „Base for heating value related data" in card „Global Switches " of window „Extras".

This window can be opened with menu **Extras\Settings.**

If you set the global switch to „HHV", GEMIS changes the base for the following data:

- Costs data (fuel prices),

16 If you see other units in GEMIS, you can change them to g/MWh at once: Click on menu **Extras\units** and select the unit „g/MWh" for emission factors.

- Fuel related emission factors (EF_{input}, or those of fuel deliverers),
- Efficiencies of energy processes and
- The specific (related to an energy unit) weight of fuels.

When GEMIS has switched to the HHV-base, the efficiencies of processes in the data entry window get a yellow background (card D*ata*, button *Design*).

GEMIS will show you the current state of the heating value base in its status line at the lower edge of the GEMIS window: HHV or LHV based input.

Now, test that switch:

Suppose, you have the offer of an American manufacturer to buy a gas heating system with an efficiency of 80% (HHV based!) and want to compare it with a German gas heating system.

Step 1: Close all windows in GEMIS. Open the global switches window with menu **Extras\Settings** and set all global switches except "Use saved turnover values". Click on „Data based on higher heating value" below and close the window *Extras* with a click on OK.

Step 2: Click on button Processes and mark process *gas-heating-DE-2000***.**

Create a duplicate using the local menu. Call it *Gas-Heizung-US-2000 respectively gas-heating-US-2000.*

Step 3: Double click on process *gas-heating-US-2000* and open its card "Data". Click on button Design and you'll see below, to the right the entry field (with a yellow backround) for efficiency. Enter "80" (for 80 %) and then click on OK.

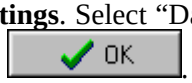
After this, close **all** windows in GEMIS.

Step 4: Open the global switches window with menu **Extras\Settings**, click on "Data based on lower heating value" and close the window by clicking on OK.

Step 5: Open window Processes again – process *gas-heating-atmospheric-USA* is automatically marked. Double click on that process and open its card "General data". Click on button Design and you'll see below, to the right the entry field (with a white background), with an efficiency based on the lower heating value of 88.67 %. Close the window again..

After the change of the base for heating value related data, GEMIS has converted the efficiency – you know now that the HHV-related efficiency of 80 % equals an LHV-related efficiency of 88.67 % for a gas heating system and can compare it with the 85 % of the "German" system.

You can do it vice versa, too:

Step 6: Close all windows in GEMIS again and open the global switches window with menu **Extras\Settings**. Select "Data based on higher heating value" and close the window by clicking on 

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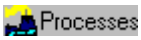
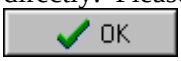
Step 7: Open window 

and mark process *gas-heating—DE-2000*. Double click on that process – as this process belongs to the generic data in GEMIS, you cannot edit it directly. Please accept that you "only want to look at the record" by clicking on 

and then open card "Data". Click on button 

and you'll see an efficiency (yellow background) of 76.69 %.

You know now that the LHV-related efficiency of 85 % of the "German" gas heating system equals a HHV-related efficiency of 76.69 %.

That's enough with this example.

Please note that GEMIS remembers, which settings you've selected for the global switches – when you restart GEMIS, the "old" settings of your last session are used. Perhaps, it's better now to reset GEMIS to LHV-reference before you continue – you know now, how to do it.

That's the end of the tour about global switches. We thank you for your attention and wish you'll succeed working with GEMIS in the future.

Tour 6: Combined Heat and Power (CHP) Processes

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1 Objectives of this Tour

Tours are step by step instructions introducing users to working with GEMIS.

First of all, this tour shows how to find combined heat and power (CHP) processes in the GEMIS database easily.

Then emissions and costs of CHP processes are compared with emissions and costs of processes supplying electricity and heat separately. Furthermore, the influence of credits (for the coupled product) will be examined.

For that purpose, a scenario of the type “multiple options” will be defined first, and results will be determined.

After it, you’ll enter a more detailed scenario of the type “energy only”. So you will be able to model CHP processes in GEMIS more precisely – also peak load boilers and local heat distribution systems will be considered.

After this tour, you’ll know the essentials for environmental analysis of CHP with GEMIS.

At first, we want to give you some general information concerning GEMIS processes and GEMIS scenarios modeling the combined supply of heat and power (CHP):

CHP is the joint delivery of heat and electricity.

Also, a CHP process must have only one **main product** (output) in GEMIS – electricity **or** heat. The second product then is a **coupled product** (heat or electricity). It is entered on card “Data”.

Nevertheless, you can balance **both products** (electricity + heat) **at the same time** in GEMIS scenarios – this happens best in “energy only” scenarios, where energy and power as well as heat distribution and peak load boiler can be represented in a detailed way.

2 Modeling of CHP Processes in GEMIS

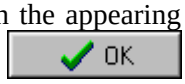
The following text deals with CHP processes in a more practical way:

Step 1: Start GEMIS and load project STANDARD or a GEMIS project that was already created by you.

The further proceeding depends on the following question: Did you already enter your name in the list of sources in GEMIS?

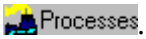
If you did it, you can continue with step 3; if not, continue here:

Step 2: Execute menu command **Data\Source**, position the mouse pointer in the list to the left and click on your **right** mouse key.

Select **New** in the appearing local menu and enter your name in the two white fields. Then click on 

and close window "Sources".

Before trying to enter completely new CHP processes in GEMIS, you should have a look at the CHP processes contained in the GEMIS database. To find them in the database that consists of over 12000 processes, you can use **data filters**.

Step 3: Click on 

. Open card **Filter** by clicking on tab *Filter*. Click on list box *Technology Group* (8. list box from below) and select entry „cogeneration (CHP)".

Now the number of processes in the list to the left is reduced considerably as only CHP processes are listed! Let's take an internal combustion engine (ICE) cogeneration plant fueled with natural gas as example process. To find it, you can do the following step:

Step 4: Take "fuels-fossil-gases" as data filter *Input Product Group.*

The number of CHP processes listed to the left is reduced once again – only processes using natural gas are displayed. How to find an ICE cogeneration plant producing electricity as a main product? That's quite simple:

Step 5: Select "electricity" as data filter *Output Product Group.*

Now only gas-fueled CHP processes that produce electricity (as main product) are displayed.

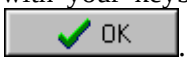
Step 6: Use your scroll bar and click on process name "*gas-ICE-cogen-cat-050-DE-2000/oil*" in the list of processes.

The unmarked name of this process is red, i.e. this record belongs to **generic data**[17] and thus is protected against data changes.

To be able to edit this process in the future without problems, make a copy of it:

Step 7: To do so, click with your **right** mouse key on the process name and execute command "Copy" in the local menu. After it, you click again with your right mouse key and select "Paste" in the local menu.

GEMIS asks you for the names for the copy in a little window.

Step 8: Click at the end of the given German name and cancel the German word "Öl". Then enter "Gas-2" with your keyboard. Please do the same with the English name and finally click on 

.

GEMIS has created a complete copy of the gas-ICE cogeneration plant and shows it under the new name "*gas-ICE-cogen-cat-050-DE-2000/gas-2"* in the list of processes. The color of the process name has changed from red to black – i.e. the new process is no longer protected.

Now you can edit this process – here is the description:

Step 9: Double click on the process name and select on card **Meta data** that is opened automatically in list box **Source** your own name.

After it, click on tab **Data** and have a look at the energy flow graph: from natural gas (red arrow) coming from a pipeline the cogeneration plant creates electricity (green arrow) and waste heat (dark brown arrow).

Furthermore, you can see in the **Outputlist** that process heat-*credit-oil-heating-DE-2000* is entered as "replaced Process" delivering 2 kWh "credit-heat-cogen-DE-2000" per kWh output (i.e. per kWh electricity).

Now the process representing the heat credit will be changed – the cogenerated heat will replace a gas heating system instead of an oil heating plant.

Step 10: Click in row *heat-credit-oil-heating-DE-2000*, open the local menu with your **right** mouse key, and select command *Edit credit*.

---

17 If you try to edit this process by double clicking on its name, a window appears indicating that you cannot edit it directly. You then have two possibilities: You can create either a temporary copy for viewing, or a „real" copy with a new name.

GEMIS opens a window, where the possible processes for auxiliary energy are displayed to the right.

Step 11: Click on process *heat-credit-gas-heating* and then on button 

.

GEMIS has changed the heat credit process – you can see it in the lower table.

You can have a look at the costs of your gas cogeneration plant. Just do the following steps:

Step 12: Click on tab „€ Costs“ – this will open card costs of the process.

You will see the specific invest-, fixed, and variable costs.

Please setup the units in the following manner to be able to understand these data better:

Step 13: Click on menu „Extras“ and select option *Units* – GEMIS will open the units window. Click on tab *Units 2*, and change the first list box to *kW* and the third list box to *MWh*. After that, click on tab *Currency* and select €. Finally, close the unit's window.

GEMIS will display the cost data of the gas cogeneration plant in €/kW or €/MWh – „E3“ is for 10^3, i.e. 1000.

The **lowest row** of the costs card shows you how expensive the generation of electricity is with the cogeneration plant:

- 31.9 €/MWh electricity have to be paid for the Capital costs[18],
- about 5.8 €/MWh electricity for the fixed costs,
- about 24.2 €/MWh for the variable costs, and
- about 61.3 €/MWh for the natural gas, at which 59 €/MWh electricity are the credit for used waste heat – thus remaining about 2.3 €/MWh electricity.

Altogether, generation of electricity costs 64 € / MWh or 6.4 €cent / kWh_{el}.

Before you close the data cards of your process, correct the comment of this record:

Step 14: Click on tab *Comment* and change the text in the comment fields so that at the end of the comment there is the word *gas heating* instead of *oil heating.*

In the following part of this tour your gas cogeneration plant will be compared with conventional processes for the generation of electricity or heat.

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18 This value depends on the interest rate for capital. You can fix it with menu *Data* - option *Economic characteristics*.

3 Comparison of CHP and Conventional Processes

At first, two electricity generator processes will be compared with the cogeneration plant. In GEMIS, scenarios are used for comparisons - you will create a scenario now:

Step 1: Close all windows in GEMIS and click on Scenarios.

Step 2: Position the mouse pointer in the list of scenarios and click on the **right** mouse key. Select option "New..." in the local menu. Enter the German name *KWK-Strom-netto* and the English name *cogen-el-net* for your new scenario and leave the setting "Multiple options..." in the field *Type of scenario.* Click on OK afterwards.

Your new scenario, which is still „empty", will be taken into the list of scenarios.

Step 3: Double click on your scenario in the list to edit your scenario. Card *Meta data* of your scenario record is opened. Enter your name as *Source.* (Click on the white field beside *Source* and select your name in the list.)

Step 4: Click on tab *Options* afterwards to open the corresponding card. Position the mouse pointer in the options table and click on the **right** mouse key. Select command *New option* in the local menu. Click once again on the **right** mouse key and select *New option* again. Overwrite the three default-texts ("Option 1") with

- "**electricity grid**",
- "**CHP**", and
- "**Gas combined-cycle power plant** ".

These are the names of your three options in your scenario.

Step 5: Click on Option *electricity grid* and then on tab *Data.* Position the mouse pointer in the table *Energy Source* and click the **right** mouse key. Select *New*, to insert a process delivering energy. Take the following selection criteria in the "Select Process" window:

- ***Input Product Group*:** electricity
- ***Output Product Group*:** electricity
- ***Location:*** Germany**.**

Use the scroll bar to find process *grid-el-DE-local-RE/CO-2005* and mark it by simply clicking on it. Finally, don't forget to click on OK.

The local electricity grid will be taken into the table *Energy Source* on card *Data* of scenario option electricity grid. In this scenario the process will deliver 1 kWh of electric energy.

Step 6: If there is another energy unit displayed (above the white field), change it to *kWh* – to do it, use menu *Extras – Units* or click on button kg TJ in the toolbar.

Enter the value 1 (kWh) into the white field and click on the "sum row" afterwards, to ensure that your computer has taken the value. (If you've done everything right, there will be a value of 1 kWh in the sum row, too.)

Step 7: Change to option 2 (CHP) by clicking on the red arrow on card *Data* ( ).

Step 8: Position the mouse pointer in the table *Energy Source* and open the local menu by clicking on the **right** mouse key. Select option "New". Reset the 3 data filters (Input category, Output category and location) to ”all”. Take your name as selection criterion *Source* and mark process *gas-ICE-cogen-cat-050-DE-2000/gas-2*. Finally, don't forget to click on OK.

The CHP-process is written in table *Energy Source*. It will produce 1 kWh of electric energy, too.

Step 9: Enter the value 1 (kWh) in the white field and click on the "sum row" afterwards. (If you've done everything right, there will be a value of 1 kWh in the sum row, too.)

Step 10: Change to option 3 (gas combined-cycle power plant) by clicking on the red arrow on card *Data* ( ).

Step 11: Position the mouse pointer again in table *Energy Source* and click on the **right** mouse key. Select option "New".

Step 12: Take the following filter criteria in the window *Select Process*:

- ***Input Product Group*:** fuels-fossil-gases
- ***Technology Group*:** power plants-combined-cycle (CC)
- ***Location:*** Germany
- ***Source*:** All**.**

Mark process *gas-CC-DE-2005* now and then click on OK.

The gas combined-cycle process is written in table *Energy Source*. It will produce 1 kWh of electric energy, too.

Step 13: Enter the value 1 (kWh) in the white field and click on the "sum row" afterwards. (If you've done everything right, there will be a value of 1 kWh in the sum row, too.)

Step 14: Click on tab *Options* now and control your inputs. If there is the value of 1 (kWh) for every option in row *Energy demand*, everything is OK and you can close window *Scenario ´cogen-el-net´*.

You will create results for your scenario now:

Step 15: Mark your scenario *cogen-el-net* and open card *Results*. Click on button *Greenhouse Gases.*

GEMIS will display the scenario results in a table after a few seconds of calculation:

The electricity grid causes 670 g CO_2 equivalents for 1 kWh of electric energy[19], whereas your CHP plant causes 211 g, and the gas combined-cycle power plant 427 g CO_2 equivalents per kWh.

Have a look at the pure CO_2 emissions, too! They are listed in the second column of the results table. Here the CHP process causes only 218 g/kWh – now we try to show you, how this value is coming about:

Step 16: Click on the cell of the CO_2 emissions of your CHP plant – i.e. in row *CHP* on column *CO_2*. Open the local menu by clicking on the **right** mouse key and select option *Explain value.*

GEMIS opens a new window where it lists the CO_2 emissions of all processes that are connected with generation of electricity with your CHP plant.

Your CHP process is listed at the top – in the column *Amount* 685.85 g CO_2 are displayed – that is much more than the sum of 218 g. What is the reason for that enormous reduction of emissions?

That's quite simple: You've given the CHP process a credit for the waste heat occurring at generation of electricity – the CHP plant replaces a gas heating system

GEMIS has done it – for 1 kWh electric energy 2 kWh of heat from a gas heating system are substituted and the corresponding emissions credited to the CHP process. You can control it in the following manner:

Step 17: Mouse click on the scroll bar at the right edge of window *Results*, keep the **left** mouse key pressed, and move the bar **to the bottom**.

Now you can see the sum of 218 g CO_2 in the last row of the table and directly above the gas heating system with **negative** CO_2 emissions of – 473 g!

Please do a simple calculation now: CHP emissions of 685.85 g CO_2 minus credit of 472.8 g CO_2 results in about 213 g CO_2 - 5 g CO_2 are still lacking for the displayed sum.

The missing amounts of CO_2 result from emissions of other processes concerned with generation of electricity from your CHP plant – above all, the compressors for the gas pipelines in Russia, Norway, and Germany emitting about 13 g CO_2 per kWh CHP electric energy (see top of table *Results*).

About –8 g CO_2 are credited to the CHP process from the German coal and lignite power plants (see bottom of table *Results*) as well as various smaller contributions from other processes, as the credit from the gas heating system not only affects its direct emissions but also the total life cycle for heat from the gas heating process – and electric energy (e.g. for pumps and construction) is integrated.

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[19] If there is another unit for mass displayed, change it to *g* – you can do it via menu *Extras – Units* or by clicking on button kg TJ in your toolbar at the top of the program window.

Enough with numbers and explanations – you may create other result tables now and inspect where the results came from with the local menu function *Explain value*. You will see now that you can disaggregate the scenario result in another way, too – proceed in the following manner:

Step 18: Close the windows *Explain result…* and *Results: Greenhouse gases.* Click on tab *Comparison* in window *Scenarios* afterwards.

Step 19: Select g*reenhouse gas emissions* in list box *Type of result, CHP* in list box *Option #1*, and *Gas combined-cycle power plant* in list box *Option #2*. Click on button *Table* then.

After a few seconds, GEMIS opens a new window where you will see a result table again. This time GEMIS shows the sum of the CO_2 equivalents of the two scenario options as well as the contributions of the processes to this sum – in the last two columns the corresponding location and data quality are displayed

The table is sorted that the highest contributions referring to the first column stand above and the negative contributions below.

If you like, you can additionally state a certain location for the emissions summed up – select for example *Germany* in the *Location* list box on card *Comparison* and click once again on button *Table*. Then GEMIS only displays the contributions arising in Germany.

You can do the same for a statistical sector of the economy (NACE): If you choose for instance sector *40.2 Manufacture of gas; distribution of gaseous fuels ...* in list box *NACE*, only 7 processes are displayed - they belong to the corresponding economical sector and have the location Germany.

Finally, you will create a result graph: just click on tab *Graph,* select the type of result you want to see, and then click on button *Graph*.

4 „Gross“ Comparison for CHP Processes

Now you won't compare your CHP process with systems generating only electricity, but with a **combination** of electricity and heat generating systems.

The advantage is that you no longer have to think of the credit for the CHP waste heat, as you introduce heat processes in the scenario.

Step 1: Close all result windows and mark your scenario *cogen-el-net* in the list of scenarios. Click on your **right** mouse key and select *Copy* in the local menu. Then click once again on your right mouse key and select *Paste*. Give your new scenario the new German name *KWK-brutto*, the English name *cogen-gross*, and confirm it by clicking on 

.

Step 2: Double click on your new scenario and open card *Options.* Then rename option *electricity grid* to *electricity grid+gas heating system* and option *gas combined-cycle powerplant* to *gas combined-cycle powerplant+gas heating system*.

Step 3: Click on tab *Data* and select the first option *electricity grid+gas heating system*. After that, click with your **right** mouse key into the table *Energy Source* and select *New*. Take the following selection criteria:

- Input Product Group: *fuels-fossil-gases*
- Technology Group: *heat-central heating.*

Then mark process *gas-heating-DE-2005* and click on 

.
The gas heating process is taken into the table *Energy Source* – enter the value "2" in column *kWh* and click on the sum row afterwards.

You've extended the scenario option in a way that there is an additional energy demand of 2 kWh of heat from a gas heating system. You're going to do that for option *gas combined-cycle powerplant+gas heating system*:

Step 4: Select option 3 (*gas combined-cycle powerplant+gas heating system*) by clicking two times on the red arrow  on card *Data*.

Step 5: After that, click with your **right** mouse key into the table *Energy Source* and select *New*. Take the following selection criteria again:

- Input Product Group: *fuels-fossil-gases*
- Technology Group: *heat-central heating.*

Then mark process *gas-heating-DE-2005* and click on 

.
The gas heating process is taken into the table *Energy Source* – enter the value "2" in column *kWh* and click on the sum row afterwards.

Option 2 (*CHP*) won't be changed - the generation of 1 kWh electricity and 2 kWh heat remains.

In order to make a gross balance, i.e. without taking credits into account, you simply have to delete the credit process in your ICE-process:

Step 6: Close all windows and click on 

. Setup your name in card Filter / list box Source and then mark your process “gas-ICE-cogen-cat-050-DE-2000/gas-2. Do a right mouse click and select command “Create duplicate”. Give your duplicate the name gas-ICE-cogen-cat-050-DE-2000/gross-3 and Gas-BHKW-Kat-050-DE-2000/brutto-3 and click on OK.

Step 7: Double-click on your new process, open card Data and mark the white entry field in the table below in row “heat-credit-gas-heating”. Do a right mouse click and select “Delete credit”. Close all windows afterwards.

Now you’ve deleted the credit in your gas-ICE – GEMIS now doesn’t know that a coupled product exists. But you know about the 2 kWh heat – and you can consider it in scenarios

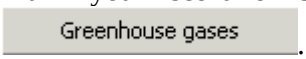
Let’s try how your “gross”-ICE behaves in a scenario:

Step 8: Open window  and mark your scenario “CHP-gross”. Do a right mouse click and select “Create duplicate”. Call it “CHP-gross2” and “KWK-brutto2” and confirm with a click on OK.

Step 9: Double-click on your new scenario and select card Options. Mark your option “ICE” and click on tab “Data”. Position the mouse pointer in the white data entry field in row kWh and do a right mouse click. Select “Edit”

Step 10: In the window opened you select “gas-ICE-cogen-cat-050-DE-2000/gross-3” and confirm with a click on OK. Close the edit window for your scenario afterwards.

Now we’re going to see how this influences scenario results:

Step 12: Mark your scenario CHP-gross2 and select card Results. Click on button 

.

The results table shows the following values:

Option “net+gas-heating” causes 1261 g CO_2-equivalents for 1 kWh electricity + 2 kWh heat, whereas your ICE causes 798 g and option gas-cc-powerplant+gas-heating causes 1018 g CO_2-equivalents.

To facilitate the work with CHP processes, there are already „net“ and „gross“ processes for all CHP types in the generic GEMIS database (project *Standard*) that has been saved on your computer with GEMIS installation.

In the name of CHP processes, behind the slash „/“, the substituted process is given

- */gross* is for electricity or heat supplying CHP processes **without** credit
- */oil* is for electricity supplying CHP processes with a heat credit basing on an oil heating system
- */gas* is for electricity supplying CHP processes with a heat credit basing on a gas heating system
- */el-CC* is for heat supplying CHP processes with an electricity credit basing on a new gas combined-cycle condensation power plant
- */el-mix* is for heat supplying CHP processes with an electricity credit basing on the German power plant mix
- */el-coal* is for heat supplying CHP processes with an electricity credit basing on a new coal condensation power plant

5 CHP Processes in Energy Only Scenarios: Gross Balance

Now you'll get to know another possibility for representing CHP processes in scenarios: instead of the scenarios of the type „multiple options" an energy only scenario will be created.

This type of scenario allows far more possibilities of modeling energy processes. However, it is limited to energy (electricity, heat, cold) and cannot include materials, transport services, waste treatment processes, or monetary services.

Before you continue, save your work in your new project and have a short break.

Now a new energy only scenario will be created. Two options will be compared. They cover the heat demand of a small residential quarter with 120 lodging units:

- Three small cogeneration systems with 90 kW_{th} each combined with peak load boiler and local heat supply
- 120 standard oil heating systems, electric current from the grid

For both options the thermal power demand on demand side[20] totals to approximately 1170 kW_{th} and the demand of thermal energy to 2000 MWh_{th}.

A local heat network with a loss of about 10% has to be implemented in option 1. The demand on heat supplier's side thus increases to about 1250 kW_{th} and 2200 MWh_{th}. The three small cogeneration units supply 270 kW_{th} together; the peak load boiler is bigger and produces 1000 kW_{th}.

However, when working with energy only scenarios it is important to know that they consequently **ignore credits** that have been set on CHP process level – here's the reason, why:

In this type of scenario you decide during the definition of options what to do with the coupled product of a CHP process – that's much more transparent than the "hidden" credits on process definition level.

You already know from the previous chapters that ignoring of credits represents a „gross" balancing: here you have to extend the balance frame so that always **combinations** of heat **and** electricity are compared.

The three cogeneration systems supply 135 kW_{el}, and with 6000 h/a full load operation time 810 MWh of electric current.

These data will be considered as demand for both options.

Now let's start entering the previously described energy only scenario:

---

20 GEMIS starts in energy only scenarios with the **demand** – normally, this is the demand on the **output** side of processes, as GEMIS "knows" the efficiency of heating systems etc. and considers it in its calculations. In our example the heat demand of 2000 MWh of 120 houses represents a heat demand of 16667 kWh per house. Assumed, the heated living space is 167 m^2 per house, a heat demand of about 100 kWh/m^2*a results equaling a new building according to the German heat shield regulations. The corresponding value for low energy buildings is 60-70 kWh/ m^2*a, whereas so-called passive buildings don't need more than 25-35 kWh/m^2*a.

Step 1: Click on Scenarios. Position the mouse pointer in the list area to the left and click on your **right** mouse key. Select *New...* in the local menu. Give your new scenario the new German name *Strom+Wärme*, the English name *electricity+heat*, and **change the type of scenario** to *Energy only (including capacity/load)*. Then click on OK.

Your new scenario will be taken to the list; it is marked.

Step 2: Double click on your new scenario *electricity+heat*. Enter your name as *source* on card *Meta data* and click on tab *Options*.

Step 3: Position the mouse pointer in the options table and open the local menu with your **right** mouse key. Select *New option*. Overwrite the two dummy names (*Option1*) with *electricity grid+oil heating system* as first option and *cogeneration plants+peak load boiler* as second option.

Step 4: Enter at the first option 135 kW as electric power, 810 MWh as electricity, 1170 kW as thermal power, and 2000 MWh as thermal energy. Then set the hook besides *Same demand*. Then the values of the first option are taken for the second option.

Step 5: Now select your first option and click on tab *Data*, to open the corresponding data card. Open card *Generation* and position the mouse pointer in the **upper** table. Click on your **right** mouse key and select *New* in the local menu. Take the following filter criteria:

- *Input Product Group*: fuels-fossil-oil
- *Technology Group*: heat-central heating

Then mark process *oil-heating-DE-2000* and click on OK.

The *Select Process* window closes and the oil heating process is taken into table *Generation*.

Step 6: Enter the value "120" in column *Units*[21], as 120 houses have to be supplied. Then, first click with your left mouse key on value 1600 (to set the input focus) and afterwards with your right mouse key on the value 1600, to open the local menu. Select *Adjust.*

GEMIS prompts in a window that operating time was increased – accept it by clicking on OK.

Now the 120 oil heating systems generate 2000 MWh of thermal energy and thus cover the heat demand. Now you have to think about the electric current needed – it will come simply from the local electricity grid. Where to enter it?

---

21 The process of entering „120" is finished correctly, only if the "120" has a **white** background. If there is still a **grey** background you have to leave the input focus by clicking somewhere else in the table.

Have a look at the *Balancing supply* table (below) – and search for row *electrical balance*. This row is for entering a process generating electric current in your scenario option – and that's what has to be done for the residential quarter. Therefore, continue as follows:

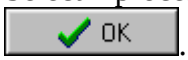
Step 7: Double click in row *electrical balance* on the white field, in which is written *no connection* – select process *grid-el-DE-local-RE/CO-2005* in the list box by entering a "g" and scrolling down, until you can click on that process. Your computer takes your input only if the process name *grid-el-DE-local-RE/CO-2000* appears on **white** background. To achieve this, you can click for instance at the text *no connection* in row *thermal balance*

After it, click on tab *Options* – in column *OK*, to the right, there will be an "x" – in this option demand matches with generation.

The input of the first scenario option is terminated successfully. There is still no "x" in column *OK* for the second option – here you still have to enter the cogeneration systems, the peak load boiler, and the local heat supply, to meet the demand.

Step 8: Select your second option and click on tab *Data*, to open the corresponding data card. Open card *Generation* and position the mouse pointer in the **upper** table. Click on your **right** mouse key and select *New* in the local menu. Take the following filter criteria:

- *Input Product Group*: fuels-fossil-gases
- *Output Product Group*: heat-heating
- *Technology Group*: cogeneration (CHP)

Select process gas-*ICE-cogen-cat-050-DE-2000-th/el-coal* and click on 

.

The cogeneration process is written to table *Generation*.

Step 9: Enter the value "3" in column *Units*[22], because you need three of the cogeneration modules to supply the houses.

Step 10: Position the mouse pointer once again in the upper table, click on your **right** mouse key and execute command *New*. Now take these filter criteria:

- *Input Product Group*: fuels-fossil-gases
- *Output Product Group*: heat-heating
- *Technology Group*: heat-boiler

Mark the gas boiler process *gas-heat plant-small-DE-2000* and click on 

.

[22] The process of entering „3" is finished correctly, only if the "3" has a **white** background. If there is still a **grey** background you have to leave the input focus by clicking somewhere else in the table.

The gas boiler process is written to table *Generation.*

Now the local heat grid will be included in the second scenario option:

Step 11: Click on tab *Transport and Distribution* (on card *Data*) and then click on your **right** mouse key. Choose *New* in the local menu. Take *Germany* as *Location* in window *Select Process* and then mark process *grid\local-heat-DE-SFB* and click on 

.

Change the value under *Length* to 0.5 km[23], as a compact residential quarter with small distances between the houses is simulated.

Step 12: Click again on tab *Generation.* Select the field in row *gas-heat plant-small-D*, column *Operating time*, and click on your **right** mouse key. Execute command *Adjust*.

GEMIS informs you that operating time has been reduced – it amounts to 533.8 full load hours for the gas boiler – accept it with *OK*.

Now all processes for the scenario option are entered and „active“ – the three cogeneration units and the peak load boiler supply the heat demand and the losses of the local heat grid.

Let’s inspect, if GEMIS is content with these declarations:

Step 13: Click again on tab *Options* and check, if there is an „x“ in column *OK* at option *cogeneration systems+peak load boiler*.

Yes, that’s true – for this scenario option, too, demand and generation are matching. The input of the scenario is finished now.

After window “Scenario ‘electricity+heat’” has been closed, you now can compare for instance the emissions of both options in this scenario. You just have to mark your scenario, click on tab *Results* and then on the appropriate buttons.

Or you create graphs – you can do it via tab *Graph* in window scenarios.

Step 14: Save your data (see menu **File)**, before you continue!

[23] The process of entering „0.5“ is finished correctly, only if the “0.5” has a **white** background. If there is still a **grey** background you have to leave the input focus by clicking somewhere else in the table.

6 CHP Processes in Energy Only Scenarios: Net Balance

In the previous chapter a gross balance for heat and electricity in a scenario was made – that‘s the “right” way to compare CHP processes with others.

Nevertheless, it is possible with energy only scenarios to work with credits and so to make net balances for only one main product – heat or electricity.

In this chapter you’ll learn how to do it.

Step 1: Close all windows in GEMIS and then open window *Scenarios*. Copy your scenario *electricity+heat* and call the copy *heat-only*.

Then double click on your new scenario to edit it.

Step 2: Open card *Options* and change the name of the first option to *oil*. Then cancel the values in the columns *electric power* and *electricity*.

Step 3: After it, open card *Data* of option *cogeneration units+peak load boiler* and click on tab *Generation*.

Step 4: **Double** click in row *electrical balance* on the white field, where is written *no connection* – a list box is opened. Enter an „e“ with your keyboard and then mark process *el-credit-mix-DE-2000*.

After this, click on the field **to the right** (column *Remaining demand el. [MW]*) – now you will see that GEMIS enters the values that represent the generation of electric current by the three cogeneration units (see table above).

The electrical balance is negative – thus the generation of electricity with the cogeneration units gets a credit based on the process chosen in the list box (*el-credit-mix-DE-2000*). This process represents the average power plant mix in Germany.

The cogeneration electricity is credited, because there is no longer an electricity demand in the scenario option – so the „surplus“ is fed back to the grid.

That’s all – with some mouse clicks you’ve changed the „gross“ scenario to a „net“ scenario, in which only heat is of interest and the cogenerated electricity is credited.

In *Energy only* scenarios you decide what to do with a coupled product of CHP process when defining the options – that’s much more transparent than the “hidden” credits on the level of process definitions.

The CHP tour is finished now and we wish your work with GEMIS will always be successful.

Tour 7: Allocations

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1 Objectives of this Tour

Tours are step-by-step instructions showing how to work with GEMIS.

This Tour tackles the GEMIS-feature „allocation“. Allocation is the distribution of (environmental) burdens of processes to several outputs (products) of these processes. The allocation can be based on e.g. heat values, mass or costs, or by crediting.

In GEMIS there are six different allocation-methods:

- no (allocation)
- by crediting
- by mass
- by energy
- by energy equivalent
- by economic value

The choice of the allocation-method takes place in process card „Meta data“ which is opened by a double-click on the process name.

It is not always possible to choose every method. Think of for instance processes delivering electricity. In their card “Meta data” method “by mass” is grey i.e. can’t be activated as their output (electricity) is without mass.

Or think of processes who have coupled products. If these coupled products aren’t linked to crediting processes, allocation by crediting is not selectable.

In the following chapters you’ll become familiar with the five allocation methods for an energy delivering process. But let’s do some preparing steps in GEMIS at first:

2 Preparation

Step 1: Start GEMIS und load data, i.e. project „Standard“.

Maybe, you might have to setup some units now:

Step 2: Click on the units button (

). Select „MWh“ as energy unit and „kg“ as mass unit. Then open card “Units 2” and choose „MWh“ as unit of “Energy for costs”.

Let’s take a small internal combustion engine (ICE) operated with natural gas as an example process. The following step shows how to find it:

Step 3: Click on 

. Then open card Filter and select as

- Search word: ICE
- Input Product Group: fuels-fossil-gases

- Output Product Group: electricity

Step 4: Duplicate the second process “gas-ICE-cogen-cat-050-DE-2000/gas” with the local menu and call the copy „gas-ICE-cogen-cat-050-DE-2000/gas-2“ and “Gas-BHKW-Kat-050-DE-2000/Gas-2“ in German.

Step 5: Then open its card Info by clicking on the appropriate tab on the right side, above.

Below References and Meta data you’ll see the Links of this process.

Step 6: If you want, you can “minimize” References and Meta data by a click on minus sign, with a blue frame, to the left of the headings.

The Main output under heading Links is simply electricity.

Step 7: For viewing its Info card just click on the blue word “electricity”. An Info card ist opened where you can see that no cost data and value zero respectively is entered for product “electricity”. Close the Info card of “electricity”.

On the Info card of your gas-ICE you can read that “credit-heat-cogen-DE-2000” is entered as coupled product. The crediting takes place at process “heat-credit-gas-heating-DE-2000”, i.e. based on a natural gas heating with reference year 2000.

Step 8: Click on the blue credit process name „heat-credit-gas-heating-DE-2000“ and you will see that a economic value different from zero is entered below under Costs/”Product cost set to” (21 € / MWh).

So in order to obtain reasonable results at „Allocation by economic value“, only the main output (electricity) has to be adapted. Continue as follows:

Step 9: Double-click on your gas-ICE process and open its card Data. Then do a right mouse-click in the output list below, row “Direct output”. Then execute option “Select output” and mark product „elektricity-DE-RE/CO-2005“ (DE is the location acronym for Germany; RE/CO is the acronym for the residential and commercial sectors; 2005 is the reference year).

Step 10: Then close card Data and click on the blue product link „elektricity-DE-RE/CO-2005“ on card Info of your gas-ICE. Card Info of „elektricity-DE-RE/CO-2005“ displays an economic value of 152.25 € / MWh. Finally, close the Info card and open your duplicate process via a double-click on its name in the list.

Card „Meta data“ shows in the allocation box above, to the right that “allocation by crediting” is selected.

Step 11: Select option „no allocation“ there and close the inner (process)-window.

3 Start of calculations

Step 12: Calculate results by opening card Results and clicking on button 

.

The SO2-equivalent value is: 770.5 g; the CO2-equivalents-value is: 798 kg.

Step 13: Then double-click on your process and select “allocation by crediting” in card Meta data.

Step 14: Calculate results once again (as in step 12)..

Now the SO2-equivalent value is 453.1 g; and CO2-equivalents amount to 211 kg.

Here are the 10 values for the five different methods of allocation:

Emissions of a gas-ICE with different methods of allocation	unit	no allocation	allocation by crediting	allocation by energy	allocation by energy equivalent	allocation by economic value
SO2-equivalents	g	770.5	453.1	256.8	428	603.9
CO2-equivalents	kg	798	211	266	443	625

4 Description of the Algorithms:

This chapter explains how the values in the table above are calculated:

4.1 no allocation

Both emission equivalent values represent the (gross-)total emissions of the gas-ICE. No emissions are allocated to any coupled product. So they are the maximum value for the delivered main output.

4.2 allocation by crediting:

If the creditable emissions for the coupled product heat are subtracted from the total values under 4.1, the values under allocation by crediting result. If you want to calculate the values, here some steps who will help you to find the emissions of the crediting process.

Step 15: Double-click on your ICE-process and open its card “Data”. Below, in the Output list you can see that the credit process (in column “replaced process”) is “heat-credit-gas-heating-DE-2000”.

Step 16: Close the inner window and open card “Filter”. Take “heat” as “Search word” and “crediting” as “Technology Group”.

Now you can see your crediting process “heat-credit-gas-heating-DE-2000” in the list to the left.

Step 17: Mark it and calculate its emissions using card “Results”

The value for CO2-equivalents is 293.5 kg / MWh. As 2 MWh are credited the following formula for allocation by crediting results: (798 – 2*293.5) kg = 211 kg. This is the value in the table above. The formula for SO2-equivalents is: (770.5 – 2*158.22) g = approximately 453 g.

4.3 allocation by energy

Both ICE-outputs are forms of energy: electricity and heat. On process level it is determined that per MWh electricity 2 MWh of heat are created. If only the main output (electricity) is considered a value of **one third** of the value for “no allocation” results.

4.4 allocation by energy equivalent

The energy equivalent for electricity amounts by definition to 2.5; for heat the deposited value is only 1. So – for the allocation by energy equivalent and the production of one MWh electricity and two MWh heat - a factor of 2.5*1 / (2.5*1+1*2) = 2.5/4.5 = **5/9** results, with whom the value under „no allocation“ has to be multiplied.

4.5 allocation by economic value

The economic value of the electricity above was 152.25 €/MWh The heat of your gas-ICE had the economic value of 21 €/MWh. So the factor for the calculation of allocation by economic value from no allocation is: 152.25 / (152.25 + 2*21) = **0,784**

Final remark:

Via card „allocation“ in menu Extras/Settings the allocation method is globally changeable.

The change happens to all processes if

1. they have the hook „Allow global overwriting “ (on their card Meta data) set and
2. if the method of allocation is applicable to them.

So the allocation method entered on process level might differ from the method actually used. There is a button which gives an overview about it: It is on card Meta data to the left of the allocation box and looks like:  . Click on it to see information about the chosen method of allocation.

In the following steps you are going to use it to become more familiar with it:

Step 18: Open card “Meta data” of your duplicate, select “allocation by crediting”, and set the hook at “Allow global overwriting”.

Step 19: Open the (global) card “allocation” via menu Extras/Settings and select the fifth option (allocation takes place corresponding to the amount of energy of the output) and then on 

.

Step 20: Click on the bulb ().

Now you can see that the setup allocation is “allocation by crediting” and the used method “allocation by energy”. Additionally, the percent shares for the used allocation are displayed.

We have reached the end of this tour and wish you good luck for your work with GEMIS. Your GEMIS developers team.