GaBi 4

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# GaBi 4 Manual

Introduction to GaBi 4

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# 1 Introduction to GaBi 4

The GaBi 4 software system is a **tool to create life cycle balances.** It provides support when managing large data sets and modelling product life cycles. GaBi 4 calculates different types of balances and helps you to analyze and interpret the results.

In order to correctly assess the meaning of balances and the limit of the tools provided by the software, it is helpful to become clearly familiar with the system properties. You should become familiar with what the terms “integrated tool for decision making,” “comprehensive database,” “modular structure,” “open system architecture,” “user guide” or “transparent balance results” mean and how these features can be beneficial. Following is a brief introduction to the most important features of GaBi 4.

First, an overview of the possible uses of GaBi 4: GaBi is a **software tool for comprehensive balances**. You can perform comprehensive balances such as those introduced over 10 years ago by the IKP University Stuttgart and PE Europe GmbH. As a method for the assessment of the technical, economic and environment impacts of products, services and systems, comprehensive balances can be used to fulfill eco-balance (or Life Cycle Assessment (LCA) methods. GaBi is different from these methods due to its analysis method, which has been expanded to include technical, environmental and (starting with GaBi 4) also socio-economic aspects.

However, the use of GaBi 4 is not limited to comprehensive balancing and environmental balancing. The system can be used as part of all modelling and analysis methods related to process chains, because the fundamental features (material and energy analysis, reference to study objectives, boundary conditions and reference quantities as well as environmental life style impact assessment) are similar for all methods.

The procedure for eco-balancing is standardized in the ISO **14040 series**. Read chapter 3 on how to use GaBi 4 according to ISO 14040. The description is oriented toward the procedure in actual practice. Please note however, that using GaBi 4 does not automatically result in the conformity of your balance with the ISO 14040 standards and other standards.

GaBi 4 is **a modular system**. This means that: plans, processes and flows as well as their functions form modular units. As a result, the GaBi system has a clear and transparent structure, making it easier to use. Data on the life cycle inventory and assessment, life cycle impact assessment and weighting models are carefully separated from each other. Therefore, the individual models remain easily manageable and are only used during the calculation of balance.

GaBi also provides you with the **modular display** of a **product’s life-cycle**. Individual life-cycle phases (manufacturing, use or disposal phases) can be grouped in categories and can be processed separately from each other.

Another feature of the modular structure is that the **software and databases are independent from each other.** The database is responsible for saving all information (e.g. product models, eco-profiles, material properties etc.) related to a project. GaBi databases are predefined according to a basic structure (see chapter 4). The software supplies the user interface and ability to construct and analyze databases.

The **databases** which are supplied with the system, contain life cycle balance data from inquiries made from the IKP University Stuttgart and PE Europe GmbH. Please see the corresponding documentation for additional details for modelling using the database content, included with each database in HTML format. In addition to the “professional“ and “lean” core databases, 10 additional databases and a number of additional datasets are available. More information is available at the software homepage www.gabi-software.com.

The **open architecture** of GaBi makes the system **flexible and transparent**. This is helpful because eco-balance as a new science, constantly undergoes further innovations and new technical procedures, which we provide as part of the on-going development of the software. GaBi can be easily expanded with the life cycle balance data of new systems, the latest findings in life cycle impact assessment or weighting models. This flexibility also makes it easier for you as a user to process studeis and resolve issues.

The transparency of balance results is another major advance of the new GaBi 4 system. You can now calculate the balances of different levels of detail. This facilitates the identification of weak points. In addition, the balance results can be traced back to individual *processes* within the process chains at any time.

## 1.1 What is New in GaBi 4

The GaBi software system has been used daily in the past few years since the release of version 3 or the performance-enhanced 3v2 by a large number of customers as well as, of course, IKP and PE Europe. In Germany the user interface and functionality were tested intensively for their suitability and practicality. The change and improvement proposals were combined into a continuous process by the GaBi development team and served as the basis for the overall concept of the GaBi 4 version.

In terms of functionality and speed, GaBi 4 is a milestone in the development of GaBi software and in the history of eco-balance software in general. The software was expanded and/or perfected to an enormous extent in several central areas. Despite extensive changes, GaBi 4 is completely compatible with GaBi 3 or GaBi 3V2. Therefore all studies can be imported to GaBi 4 format without a loss of information.

The developers placed a great deal of emphasis on making the user guide as intuitive as possible when designing GaBi 4. This again results in a significant improvement in user interface.

In addition to the improvements listed above in existing functionality, socio-economic dimension has been integrated into the software as an additional component. The “Life Cycle Working Time“ (LCWT) feature represents the incorporation of work place-related socio-economic aspects into a comprehensive balance. As a result the GaBi software system now incorporates all three-core areas of sustainability – ecological, economic and social issues.

The new features can be sub-divided into seven main areas:

1. Improvement of the user interface,
2. expansion of modelling flexibility and graphic interface,
3. re-development of the GaBi Analyst,
4. expansion of assessment options within the balances,
5. increase in performance,
6. re-development of life-cycle costing, and
7. incorporation of life cycle working time modeling functionality.

**On 1. Improvements to the user-interface:**

Key features include: directly switching between object types, implementation of multiple right mouse click menus, provision of information via scrolling text menus, expanded search functionality, the separation of LCA, LCC and LCWT using tabs and the ability to customize the colour of *flows* on *plans* by category.

**On 2. Expansion of modelling flexibility and visualization,**

The new, unlimited allocation possibilities (cf. chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**) and expanded parameter functionality significantly improve the modelling capability of GaBi 4. In addition to process parameters, introduced in GaBi 3, plan-level and global parameters can be defined in GaBi 4. Plan parameters can be used in all *processes* and *plans* which are located on a *plan*. In addition, they can be carried from a *plan* to the directly connected *plans.* Global parameters are valid throughout the database and can be used in each *plan* and each *process* within the database. (chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** for more details.)

**Parameter Explorer:**

The GaBi parameter explorer was developed in GaBi 4 in order to enable transparent use of multiple types of parameters in complex models. It can be started from the GaBi DB Manager, a *plan*, the balance window or the GaBi Analyst. The GaBi parameter explorer shows all of the *processes* and sub-plans on the *plan* and displays the location of parameters in a model in a hierarchy. *Processes*, where parameters are used, are marked in colour. All parameters can be changed from a single location in a co-ordinated manner.

**Graphic Interface**

The graphic interface was expanded to include reference quantities on plans such as optional display of flow quantities and names and the ability to display images instead of process boxes. Also the graphic interface is improved in the balance and the Analyst.

**On 3. GaBi Analyst:**

The GaBi Analyst has been re-designed. Two additional, very efficient analysis capabilities were added to the methods available in GaBi 3V2: sensitivity analysis and Monte Carlo analysis. As a result, the GaBi Analyst now allows you to perform comparative analyses as well as calculate stochastic distributions of the system you are modelling.

**Scenario analysis:**

The Scenario Analyst allows you to compare the impact of different system configurations/conditions. Any number of parameters can be selected to create a scenario to be compared directly with other scenarios. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**Parameter variation:**

Parameter variation enables you to perform gradual variation of key variables, enabling an understanding of how a system will perform under changing conditions. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**Sensitivity analysis:**

Using sensitivity analysis, a change in result is determined in relation to change in input values. The results of a sensitivity analysis are broken down according to the "most sensitive" input variables. This enables you to identify key parameters influencing the system and how they change under different systems conditions. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**Monte-Carlo analysis:**

In a Monte-Carlo analysis, random results of a distribution for the selected parameters and flow data (including the characterization factors) of a model are applied to determine the stochastic distribution of potential balance results. The Monte Carlo analysis also serves as a tool to determine the significance of results. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**Batch mode of the GaBi Analyst,**

Analyses in GaBi can also be calculated in Batch mode. This means that you can perform multiple, complex scenarios, parameter variations, sensitivity analysis or Monte Carlo analyses when your PC is not in use. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. However, this will only be necessary in rare cases.

**On 4. Expanded balances:**

The GaBi balance window has been developed to enable analysis and interpretation of LCC and LCWT, as well as more flexible and easier access to results overall.

Some key words here are: Categorization filter, balance view, weak point analysis etc.

**Categorization filter:**

GaBi allows you to assess process chains in terms of four different category filters. These categories are defined on unit processes on plans. Process categories can be defined by nation, type, operation or be user-defined. This makes it possible, for example, to separate the percentages of internal and external *processes* in a balance. Additionally, the percentage contribution of all transport processes can be determined or the percentage of internal company emissions vs. total emissions can be identified. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**Balance views:**

GaBi 4 provides the ability to define and save customized views of the balance. If, for example, you are only interested in the primary energy consumption, and global warming potential (GWP), and acidification potential (AP), eutrophication potential (EP), a balance view can be defined which only includes the desired *flows* or *quantities*. This facilitates the targeted export of results into spreadsheet programs. More on this in chapter 3.5.9.

**Weak point analysis:**

Using weak point analysis, results can be hidden or emphasized in colour, in the balance window. This feature enables threshold values to be defined for exclusion from balance results. In addition, empty cells and columns can be hidden to improve interpretation. More on this in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

**On 6. LCC (Life Cycle Costing):**

With GaBi 4 process related cost categories can be analysed related to the life cycle of a product or a system. GaBi 4 automatically calculates process and flow-related costs based on cost factors. In combination with categorization filters, the costs of different life cycle phases can be modelled. Internal or external company costs can be displayed separately and analysed in the balance.

**On 7. LCWT (Life Cycle Working Time):**

New features in GaBi 4 include the ability to record and assess human work time and additional aspects in terms of their quality over a complete life cycle. It is therefore possible for the first time to analyse not only environmental and economic but also socio-economic aspects for sustainable product development.

## 1.2 Understanding the Structure of GaBi

The following form the basis of each GaBi database: objects balances, plans, processes, flows, quantities, units, users, projects, quality indicators, weighting and global parameters (cf. Fig. 1)

A detailed description of each object type is provided in chapter 4. At this point we will only give a brief overview in order to make the next chapter more understandable. A balance (i.e. the results of an comprehensive balance) primarily consists of a list of all inputs and outputs which result from the life cycle of a product. The inputs and outputs in the balance are defined in GaBi as **flows**.

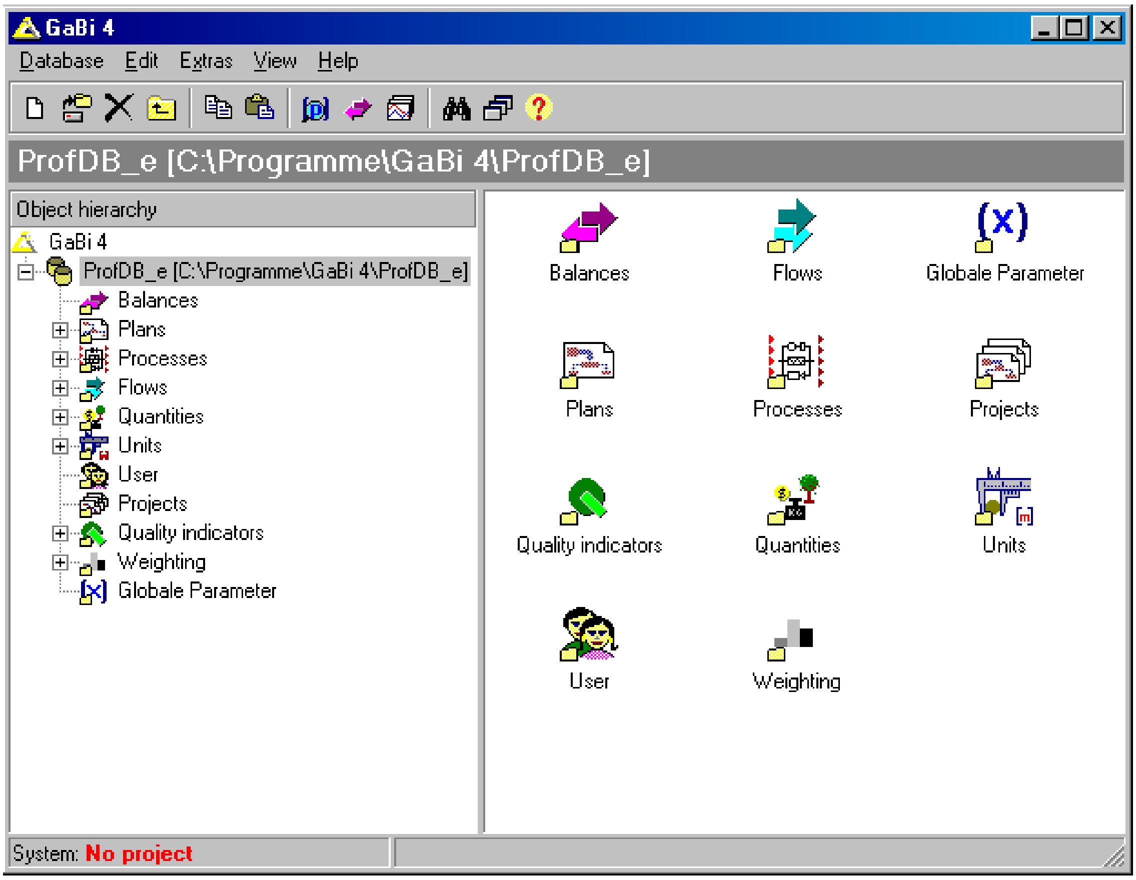


**Fig. 1: GaBi database structure**

Let us take for example a gold washer which washes out river sand with a sieve. River sand and water are **input flows** and gold, earth and wastewater are **output flows**. In GaBi terminology, washing the gold is considered a **process**. GaBi processes are therefore lists which consist of input and output flows which represent the manufacture of a product, the procurement of a raw material, transport, service etc. Also considered flows are the new socio-economic characteristic values.

Because in reality life-cycle modelling is generally more complex than the gold-washing example, generally more than one *process* is required to manufacture a product. Raw materials must be obtained and processed. They are transported from the place they are obtained to a processing location, and from there to a production facility. Here, for example, diesel is used as an energy source which, in turn, must be obtained and processed. In production, a number of materials are combined into a product as part of an often complex processing procedure. For example this product consumes energy in the use phase and is slowly combusted in a waste incineration plant to obtain energy.

In GaBi ***plans*** *are used* to combine the individual *processes* into various stages of a product's life-cycle.

In summary, the creation of a life-cycle balance is completed as follows: The ***processes*** necessary to manufacture a product are determined including their associated ***flows***. The individual ***processes*** are connected on ***plans*** in order to produce a product. The balance result list of the input and output flows of all *processes* over the life-cycle is simply defined in the model.

All other GaBi objects are related to this method of creating a model. Flows are defined identified in GaBi using **quantities**. The reference unit of many *flows* is "mass". For example **u*nits*** are in turn assigned to each *quantity.*

In GaBi several *quantities* can be assigned to a *flow*. For example, the *flow "gasoline"* has the reference quantity "mass". It can also be assigned to the "volume" *quantity* because it has a heat value, a price etc. All of these properties can be defined in GaBi using *quantities*. The *flow* can then be converted to different units. Diesel for example, has a volume of 1.3605 l and a heat value of 43.49 MJ per kg. You can determine its current daily price at your gas station and enter it yourself (see Fig. 2)

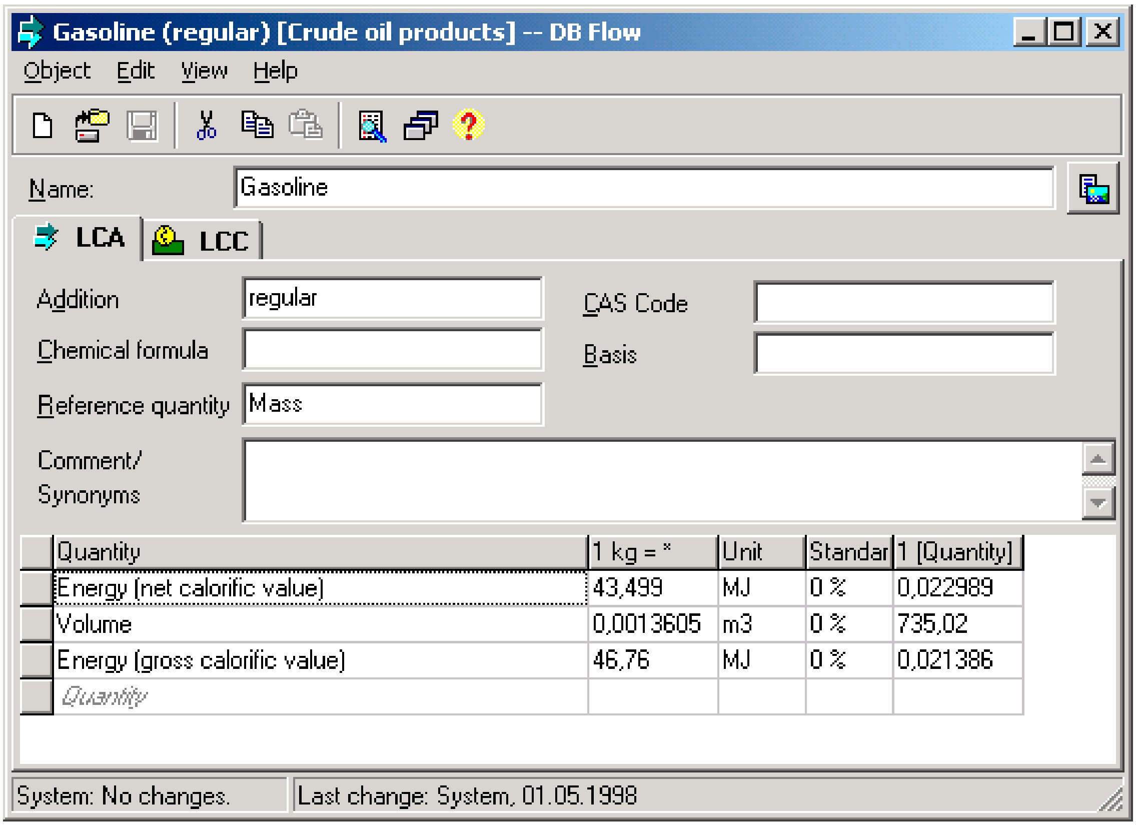


**Fig. 2: Variables of a flow**

Often, balances are not only represented on the life cycle balance level or according to their characterization as environmental life cycle impact categories. The results should then also be added to the emissions of a certain region in reference (*normalization*). Or they should be summarized to one indicator value (e.g. after the CML model or the EcoIndicator) through the weighting of individual environmental strains. The conversion factors necessary for normalization and weighting can be found under the GaBi object ***weighting***.

All additional GaBi database objects are not essential parts of a comprehensive balance, but rather are used for:

- increasing the flexibility of modelling ***(global parameters),***
- recording the data quality of a study ***(quality indicators),***
- organization of a database ***(projects),***
- the administration of GaBi users ***(users).***

## 1.3 Modeling and Analyzing Systems with GaBi

### 1.3.1 Goal and Scope Definition

The project definition is the determination of the goal and scope and should be the starting point of your balance. This is an important step which ensures the validity, communicability and comparability of the balance results. The project definition, is, however, flexible enough that it can be adapted at anytime during execution if individual results and interim results warrant. Specifically, product functions, the functional unit and the reference flow must be determined as part of the project definition.

GaBi integrates ISO 14041 requirements into the project definition to the extent that they are relevant to the functionality of the system software.

Within the *projects* object type, you can document the goal and scope of your balance in written form by defining a GaBi project. GaBi allows you to process several different *projects*. The *flows*, *processes*, *plans* and balances created during a session are automatically assigned to the activated *GaBi project.*

When feasible other ISO 14040 requirements were also taken into account, including:

- The allocation method used is indicated in the relevant GaBi process window (if the process is allocated), the allocation procedure is transparent and permits allocations according to *variables* which are defined by the user.
- The requirements for data quality were taken into account by Gobi quality indicators and time, geographical and technological entries within the GaBi process.
- The life cycle impact categories used and the method for life cycle impact assessment are transparent due to the object structure and are expandable through user definition.
- Weightings (evaluations and normalizations) are transparent due to the object structure and can be expanded through user definitions.

### 1.3.2 Life Cycle Inventory

GaBi provides support when developing a life cycle assessment through a number of features. These features support three major goals of system development:

1. The provision of a transparent framework for the input, management and use of life cycle assessment data.
2. Making frequently used fundamental data sources available for the timely development of balances and the ability to expand and customized the database.
3. The automated calculation of result values.

Data input and management are vastly improved and accelerated due to the use of the GaBi system. In order to manage and use the balance data efficiently, you should first become more familiar with the object types *flows* and *processes*.

#### *1.3.2.1 Flows*

The basis of modelling using GaBi is the object tyep *flow*. A GaBi flow is a representative of an actual material or energy (and in further analysis also money) flow. *Flows* are used by processes (in ISO nomenclature: “modules“ as in and outputs) and represent the link between *processes* within a life cycle. The GaBi database has a comprehensive hierarchical division of flow definitions called the "flow group hierarchy”. The hierarchy provides a pre-defined set of flows categorized by type. You can find a standard flow group hierarchy at www.gabi-software.com .

During the development of a model energy or material flows are assigned to processes. Values assigned to flows of the same name are totalled during the balance calculation by GaBi. The procedure is the same for flow groups. In the GaBi balance view, different detail levels can be displayed. You can also first view the total resource consumption of two balance systems in comparison to then do a detailed analysis to determine individual flow contributions.

Other advantages of the flow group hierarchy can be illustrated using the following example: We assume that we want to model the generation of power from hard coal in two steps. Feed coal is obtained in a transport process and is the initial material for a power plant process which generates electrical power. (Auxiliary materials and emissions are not of interest here.) Hard coal is located in the “non-renewable energy resources“ flow group. It must be included with inputs for the hard coal transport process. A “hard coal“ flow must be entered for the outputs of this process which is located in another flow group, specifically the “Fuels” flow group. By inputting the flow groups, you will also retain information on how the hard coal transport process transforms the hard coal used as a resource into a fuel material. The “hard coal“ fuel is then added to the power plant process as an input. The electrical energy “power“ forms the electrical energy “flow”. If you use the power plant process only in one process chain and forget to switch on the hard coal transport function beforehand, hard coal will come up as a fuel under the inputs of your balance. In addition, you will notice that your process chain does not go all the way upstream, or “back to earth”. Thus, major advantage of the flow group hierarchy is that it makes model completion tests possible.

#### *1.3.2.2 Processes*

GaBi processes are representative of actual processes, technical procedures or groups of procedures. They roughly correspond to the term “unit process“ in ISO 14040. Like flows, *processes* in the GaBi system are hierarchically grouped and can be stored. The process hierarchy enables you to save and use *processes multiple* times. In addition, a data foundation of processes is provided in the database to aid in the completions of a model. In particular upstream data, such as energy generation, basic material generation, etc., does not have to be specially collected by the user depending on the goal of scope of the study.

#### *1.3.2.3 Allocations*

If *processes* have several product outputs (co-products), all remaining *flows* assigned to a process can be distributed among the product outputs. In ISO 14040 this is called an “Allocation”. GaBi 4 makes it possible to easily perform allocations to be performed. It also allows allocations to be performed without changing the data set of a *process* in the database.

#### *1.3.2.4 Plans*

Plans are used in GaBi to assemble processes in the product system. Essentially, plans are the process maps which visually depict a stage or sub-stage in the system.

GaBi plans can be nested in order to display complex balance systems. Thus you can also nest a *plan* within another *plan* - in the same way that you use *processes*. For example, you can develop a process plan for a manufacturing process, and use it in several places in your model. The nesting levels of process plans is unlimited, however circular references are not allowed in the software.

#### *1.3.2.5 Balances*

The GaBi object type “balances” compare all inputs of one or several balance systems with their outputs. *Balances* are calculated based on the system model. GaBi balances therefore contain the results of the life cycle inventory. Balances can be viewed multiple ways, using different units, category filters, impact categories, etc. Thus the balance window can be used to perform life cycle inventory analysis, impact analysis and interpretation.

### 1.3.3 Life Cycle Impact Assessment

According to ISO 14040 the goal of balancing the system is the assessment of the potential environmental impact. The assessment is divided into two substeps which must be performed (according to ISO) as a minimum:

- Assigning life cycle balance data to life cycle impact categories (classification).
- Modelling the life cycle balance data within the life cycle impact categories (characterization).

GaBi performs these two sub-steps in the *Balances* window simultaneously. You can very easily toggle between life cycle balance variables such as "mass“ or “energy” and life cycle impact categories such as “global warming potential – GWP” or “ozone depletion potential – ODP” in the GaBi balance window.

The object oriented structure enables you to view the classification (assignment of material flows to environmental impacts) and equivalency factors (quantification of material flows relative to the environmental impact of a standard material flow) and to make changes at any time using current scientific findings via the database manager. The data supplied in the GaBi database for classification and characterization published by ISO, SETAC, WMO and IPCC and the resulting characterization sets provided by CML, EDIP, EcoIndicator or UBP.

In order to summarize balances to aid in decision-making, weighting, can be performed from the balance window. This procedure is not required by the ISO 14040 series. With GaBi you can perform a single score calculations such as EI95. In this case, you can make use of the weightings supplied or define your own weighting key(s) and apply them to the balance results. The results of a single score calculation can be disregarded in order to determine key system contributors.

### 1.3.4 Life Cycle Interpretation

In this step of LCA, the results of the life cycle balance and the life style impact assessment are summarized and analysed to aid in decision-making.

This can include critical tests of the system data according to ISO 14040. GaBi ensures that important factors, which serve as the basis for a critical test, can be documented correctly. This includes: the goal of the study, the reference amount, the system boundaries and the basis for data collection. Definitions of the objects *Projects and Quality Indicators* are available in Chapter 6 and should be read to familiarize yourself with the capability to integrate documentation for each GaBi object (Chapter 6 in the section “Working with GaBi”).

In addition, GaBi provides methods for the interpretation of data quality (Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** in the section "Working with GaBi") as well as sensitivity analysis, scenario calculation and stochastic error calculation using Monte Carlo simulation (Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** in the section “Working with GaBi”).