Introduction to Water Assessment in GaBi

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List of Contents

1 Introduction

Freshwater scarcity is recognized as one of the most pressing environmental issues today and expected to rise in prominence even further in the future. Accordingly, there is an increasing interest in the LCA community to assess water use from an LCA perspective.

In August 2014, a new standard under the 14000 series (environmental management) has been released by the ISO (International Organization for Standardization): ISO 14046 - Life cycle assessment – Water footprint – Requirements and guidelines. The standard specifies principles, requirements and guidelines related to water footprint assessment of products, processes and organizations based on life cycle assessment (LCA). A water footprint assessment conducted according to this international standard:

- is based on a life cycle assessment (according to ISO 14044);
- is modular (i.e. the water footprint of different life cycle stages can be summed to represent the water footprint);
- identifies potential environmental impacts related to water;
- includes relevant geographical and temporal dimensions;
- identifies quantity of water use and changes in water quality;
- utilizes hydrological knowledge.

With this standard, regional impact assessment is officially introduced into the LCA world. GaBi follows these developments and introduced regionally specific elementary flows and new quantities as a first step towards a comprehensive assessment of water data. To make best use of this implementation, it is important to have a correct understanding of the principles that are underlying water assessment in the GaBi Software and Databases. This document introduces the GaBi water assessment terminology and details on how water use and water consumption can be assessed using GaBi Software and Databases.

2 Terminology

Water assessment in GaBi follows methods and terminology as defined by the UNEP/SETAC working group on water and the new ISO standard (BAYART ET AL. 2010, PFISTER ET AL. 2009, ISO 14046). According to these publications, the following terms are used:

- Water use: use of water by human activity. Use includes, but is not limited to, any water withdrawal within the drainage basin impacting water flows and quality.
- Water consumption: water removed from, but not returned to the same drainage basin. Water consumption can be because of evaporation, transpiration, product integration or release into a different drainage basin or the sea. Evaporation from reservoirs is considered water consumption.
- Groundwater: water which is being held in, and can be recovered from, an underground formation.
- Green water refers to the precipitation on land that does not run off or recharges the groundwater but is stored in the soil or temporarily stays on top of the soil or vegetation. Eventually, this part of precipitation evaporates or transpires through plants. Green water can be made productive for crop growth.
- Blue water refers to water withdrawn from ground water or surface water bodies. The blue water inventory of a process includes all freshwater inputs but excludes rainwater.
- Fresh water and sea water: "Fresh water" is defined as water having a low concentration of dissolved solids (ISO 14046)[1]. This term specifically excludes sea water and brackish water.

2.1 Consumptive and degradative use

The above-mentioned differentiation between "water use" and "water consumption" is key in water footprint assessments. "Water use" refers to water inputs and does not imply any information of the fate of the water after its use. Water use can further be classified as "consumptive use" or "degradative use", based on whether it is returned to the same watershed of its withdrawal or not (see Figure 1).

1 Freshwater typically contains less than 1 000 mg/l of dissolved solids and is generally accepted as suitable for withdrawal and conventional treatment to produce potable water (ISO 14046).

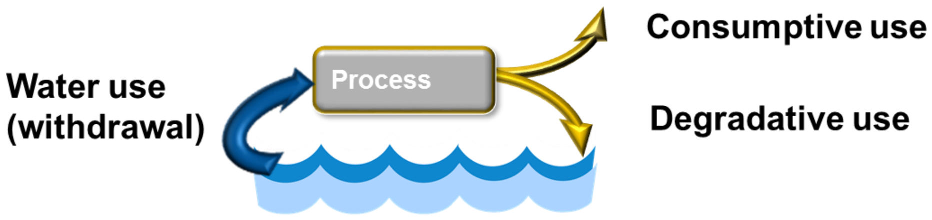

Figure 1: From water use to water scarcity footprint

"Consumptive use" describes all freshwater losses on watershed level which are caused by evaporation, evapotranspiration from plants[2], freshwater integration into products, and release of freshwater from technosphere into sea water (e.g. from wastewater treatment plants located on the coast line). Note that only "Fresh water consumption", not sea water, is relevant from an impact assessment perspective because fresh water is a limited natural resource.

"Degradative use", in contrast, denotes the use of water with associated quality alterations and describes the pollution of water (e.g. if tap water is transformed to wastewater during use). These alterations in quality are not considered to be water consumption. Please note that the term is used to refer to potential degradation. While emissions into water are usually covered in life cycle inventories, the term itself does not specify the extent of changes in water quality, nor their environmental relevance.

2.2 Water scarcity footprint

Water consumption is considered to have a direct impact on the environment (e.g. freshwater depletion and impacts to biodiversity). The blue water consumption can be derived directly from the LCA inventories (see 5.1 and 5.2).

In the impact assessment of water consumption, the location of water consumption is crucial. In water-abundant areas, the effects of water consumption of a certain amount will have a very low impact, while in dry areas the effects will be higher. These impacts are determined by characterizing water consumption at a specific place with regionally specific stress factors (see Figure 2).

2 Note: Typically, only water from irrigation is considered in the impact assessment of agricultural processes and the consumption of rain water is neglected. The rationale behind this approach is the assumption that green water (i.e. rain water) consumption does not contribute to water scarcity. Such an effect would only exist if crop cultivation results in alterations in water evapotranspiration, runoff and infiltration compared to natural vegetation. While this is arguably the case, the quantification of the effect is inherently difficult and uncertain, and hence not considered in LCA, as of today. Additionally, it remains arguable whether or not such changes (if they occur) should be covered by assessment of land use changes rather than in water inventories. However, rain water use is sometimes assessed in different methodological approaches or can be used for specific analyses.

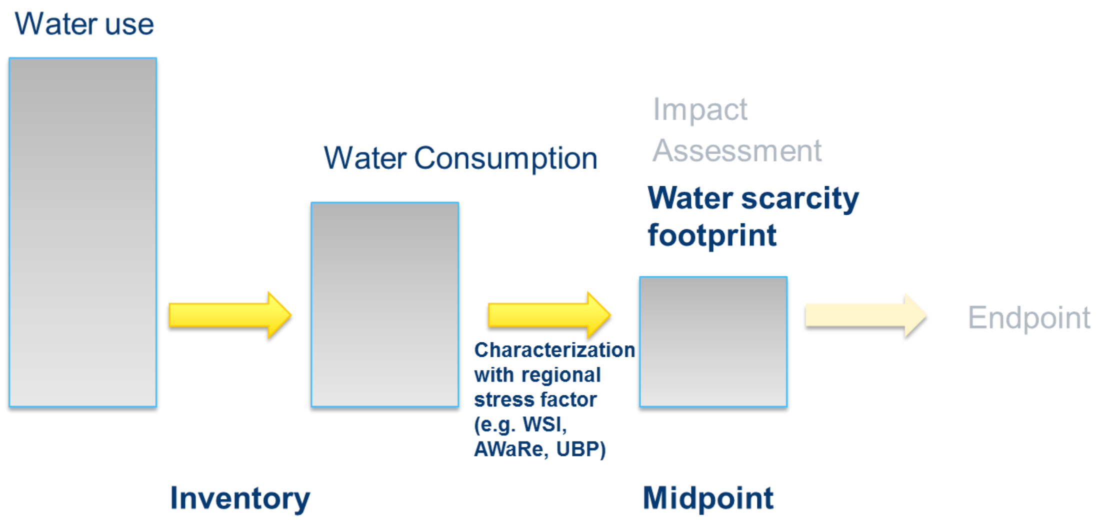

Figure 2: From water use to water scarcity footprint

Different methods to assess water scarcity are published (for a recent review see **Error! Reference source not found.**). The following methods are implemented into the GaBi software (please refer to the respective publications for a description of how the characterization factors are calculated):

- Pfister et al. developed the water stress index (WSI) (PFISTER ET AL. 2009). Because of its robust documentation and easy access to the characterization factors, it has been the most widely used water scarcity indicator so far. In the following this method is referred to as "**WSI**".
- More recently, the former UNEP/SETAC working group on water use in LCA (WULCA) has published a consensus method to assess water scarcity, called "available water remaining" (AWaRe) [3]. In the following this method is referred to as "**AWaRe.**" AWaRe is recommended to be used in the Product and Organization Environmental Footprint studies (PEF/OEF) within the EF framework of the European Commission (see EUROPEAN COMMISSION 2017, reconfirmed for EF transition phase 2019-2023). It is implemented in the water scarcity indicator of the EF indicator set and can be found in the Environmental quantities folder of GaBi.

In contrast to AWaRe, which accounts for the difference between water demand and water availability, the water accounting and vulnerability evaluation model (WAVE+) is based on the ratio of water consumption to availability. In addition to AWaRe, WAVE + also considers ground-and surface water stocks as well as absolute water shortage (aridity). In comparison to WSI, which is based on a water use (not consumption) to availability ratio, WAVE+ uses more recent hydrological data and is based on a higher spatial resolution. The method was developed by BERGER ET AL. 2018 and is an updated and methodologically enhanced version. In the following this method is referred to as **WAVE+**. In addition to the

[3] http://www.wulca-waterlca.org/project.html

above methods, other water assessment methods are available in GaBi: ReCiPe 1.08 water depletion method equals water use (only water input flows are considered). ReCiPe 2016 v1.1 Freshwater Consumption equals blue water consumption, without scarcity factors. And the UBP Eco Scarcity Method (indicator for Water resources) by FRISCHKNECHT AND KNÖPFEL 2013.

The methods mentioned above only address changes in water quantity. According to ISO14046, if only a specific aspect of water use is assessed (e.g. changes in the available quantity of water in a specific watershed, i.e. water scarcity), the resulting number should not simply be communicated as “water footprint”. Rather, a qualifier should be used to specify which aspects of water use have been assessed. Therefore, the changes in water quantity or availability are addressed as “**water scarcity footprint**”.

Changes in water quality are addressed in other, existing LCA impact categories, at least partially, with emissions to water and the respective impacts, e.g. eutrophication and toxicity. For a holistic “water footprint profile” water scarcity should be communicated alongside such impact categories that address changes in water quality.

3 Water elementary flows in GaBi Software

3.1 Input flows

The water resource elementary input flows in GaBi are differentiated per water source. The following figure provides a schematic overview over the structure of water input flows.

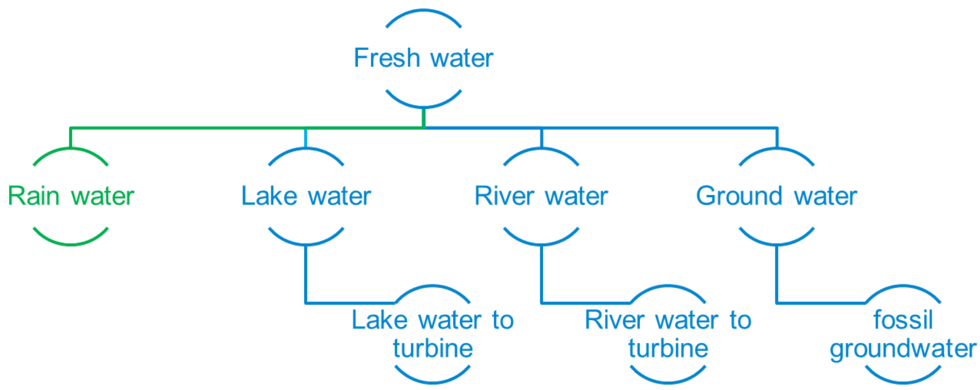

Figure 3: Structure of water input flows in GaBi Software

Fresh water flows are available with different levels of specification:

<u>Fresh water:</u> generic flow class to be used if no information is available whether the water used in a process is lake, river, ground or rainwater. Fresh water is always classified as blue water.

<u>Rain water</u>: refers to use of natural precipitation (green water). Typical examples are rain water use by crops or rain water harvesting plants.

<u>Lake water:</u> water extraction from a lake. A specific sub-category of this flow is lake water to turbine that refers to lake water used in turbines for the generation of electricity.

<u>River water:</u> water extraction from a river. In GaBi, this flow is usually used as default flow for surface water use in contrast to ground water use. A specific sub-category of this flow is river water to turbine that refers to river water used in turbines for the generation of electricity.

<u>Ground water</u>: water extraction from ground water (definition see section 2). A specific sub-category of this flow is fossil groundwater, which refers to non-renewable groundwater, i.e. water present in aquifers in which the rate of recharge is insignificant within the framework of the current water budget of the

aquifer. Fossil ground water is currently not part of existing Sphera datasets (due to limited data availability) but can be used by the practitioner when appropriate.

Note that in the main water scarcity characterization methods currently implemented in GaBi (WSI, AWaRe and WAVE+), no differentiation is made between lake, river, ground and fossil groundwater. However, using more specific flows in the life cycle inventory can provide useful information in the interpretation phase of an LCA study.

The water input elementary flows can be found under Resources → Material resources → Renewable resources → Water.

3.2 Output flows

The water resource elementary output flows in GaBi are differentiated per type of water use and the receiving water body. The following figure provides a schematic overview over the structure of water output flows.

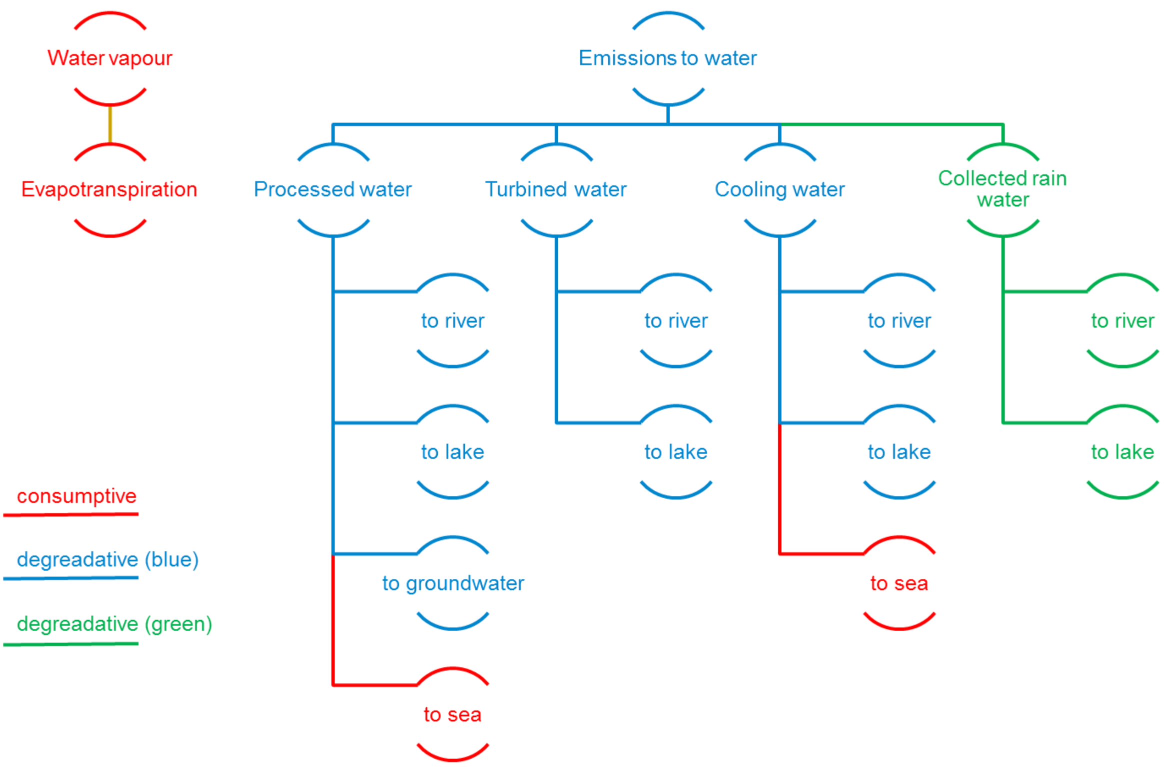

Figure 4: Structure of water output flows in GaBi Software

Water vapour and evapotranspiration are emissions to air and the typical form of consumptive water use.

<u>Water vapour:</u> water evaporated from a process.

Evapotranspiration: refers to water use in crop systems. More precisely, evapotranspiration is defined as the combination of two separate processes whereby water is lost on the one hand from the soil surface by evaporation and on the other hand from the crop by transpiration.

Water that is not evaporated is usually emitted back to a water body. In GaBi the water output flows to water are differentiated per source process and receiving water body.

Processed water: usually refers to waste water after treatment. This flow explicitly does not make any reference to the quality of the released water. The flow is used as the elementary output flow from waste water treatment processes in the GaBi processes, but can also be used to refer to direct release of water into the environment without treatment. Emissions of pollutants (chemical substances, nutrients etc.) should be assessed as separate output flows in the inventory. Processed water can be released to a river, a lake and the sea. Please note that the sea is not considered part of the watershed, and release to the sea is counted as consumptive use.

Turbined water: refers to the release of water from turbines, i.e. hydroelectricity generation. The differentiation between processed water and turbined water is important, because some impact assessment methods do not consider water use from turbines (e.g. Resource depletion water, ReCiPe midpoint (v1.09)).

Cooling water: refers to water used in cooling processes. The differentiation between processed water and turbined water is mainly done for interpretational reasons. Cooling water is usually not changed in chemical quality but might influence ecosystems in through changes in temperature, a potential impact not covered by the common impact categories.

Collected rain: water is used in cases where rain water is collected and returned to the watershed, e.g. in large industrial plants with a large area of sealed surface, where the precipitation needs to be directed into a waste water treatment. Those flows could of course also be used to model rain water output after intentional rainwater harvesting. Please note that these flows should be related to rain water as an input, and are not considered in blue water use or consumption.

3.3 Additional water flows in GaBi

There are many more water flows in GaBi than those mentioned above. Most of them are relating to operating materials, i.e. **product flows** and hence not non-elementary flows that are output from one process and input to another. Examples are "water (process water)" or "water (tap water)". They may be used in any model but must be connected to the respective delivering process.

Water (sea water) and water (brackish water) are elementary input flows but do not fall under the definition of fresh water, therefore are not consider in the water assessment quantities. A rare exception might be cases where seawater is treated and released as freshwater, but not back to the sea, which would result in a negative fresh water consumption.

3.4 Renaming of flows since SP33 (February 2017 release)

To increase the consistency with the ILCD/EF flow naming, the water flows were renamed with SP33. The following table (Table 1) shows the updated names of the flows in comparison to their original names.

Table 1: Renaming of flows in SP33

Original name (SP30)	New name (since SP33)
Input	
Water (fresh water)	Fresh water
Water (ground water)	Ground water
Water (lake water)	Lake water
Water (rain water)	Rain water
Water (river water)	River water
Output	
Water (lake water from technosphere, cooling water)	Cooling water to lake
Water (river water from technosphere, cooling water)	Cooling water to river
Water (groundwater from technosphere, waste water)	Processed water to groundwater
Water (lake water from technosphere, waste water)	Processed water to lake
Water (river water from technosphere, waste water)	Processed water to river
Water (lake water from technosphere, turbined)	Turbined water to lake
Water (river water from technosphere, turbined)	Turbined water to river
Water (lake water from technosphere, rain water)	Collected rainwater to lake
Water (river water from technosphere, rain water)	Collected rainwater to river

4 Regionalization

4.1 Regionalized water flows in GaBi

As mentioned in chapter 2.2, the impact assessment of water consumption needs to take the location of water consumption into consideration. **It is important to recognize that for the modern, consumption based water scarcity methods, for each process that has characterized water flows, a quantitatively and qualitatively correct and complete inventorying of the water input and output flows and the regionalization information is crucial.** Otherwise, if e.g. the output flow is not inventoried, the whole amount of input is considered, or if the geographical information of the input and output flow are not correct (e.g. country-specific input, global average/unspecific as output), relevant distortions occur. If hence a process is not regionalized regarding the water input flows, also the output flows should remain not regionalized.

In a first step, regionalization in GaBi is implemented on country level. Meaning that for each elementary flow listed above, a regional copy exists specifying the country where the water is used. The below table gives an example:

Table 2: Regional copies of water flows - example

Flow name	Explanation
Fresh water, regionalized, AR	Fresh water use in Argentina
Fresh water, regionalized, AT	Fresh water use in Austria
Fresh water, regionalized, AU	Fresh water use in Australia
…	etc.

The flows are available for more than 60 countries. The countries were selected based on their economic significance and coverage in the GaBi database. All EU28 countries are included in alignment with the EF methodological guidelines.

Please note that the country level might be insufficient in regional resolution depending on the goal and scope of the assessment for which GaBi data is used. Please refer to section 6 on limitations for details.

Additionally, all flows are provided for different water scarcity classes:

- extreme scarcity
- high scarcity
- low scarcity
- medium scarcity
- moderate scarcity
- OECD average scarcity

These flows might be used if the country of water use is unknown, but water scarcity can be estimated based on the broader regional context (e.g. Scandinavia will generally classify as having a "low scarcity"). The flows can also be used if a broader regional context is implicitly intended, i.e. "medium scarcity" to represent European average conditions. Additionally, these flows can also be used if the location of water use (and its respective water scarcity) is known on a higher resolution than country level. An example would be water use in the US, where some federal states have a low to moderate water scarcity while others show high to extreme water scarcity, so those flows could be used rather than the US average flows (see Figure 5 as an example).

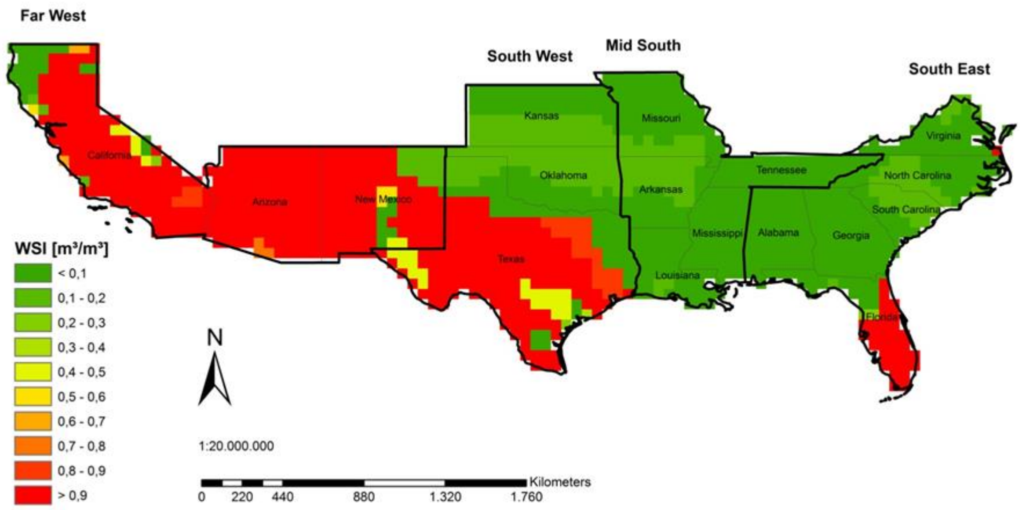

Figure 5: Heterogeneity of water stress – Example of the US cotton belt (Source WSI values: PFISTER ET AL. 2009, graph: author's own work). Average WSI in the US is 0.5 (PFISTER ET AL. 2009). Practitioners could use "high scarcity" flow for regions with high WSI (e.g. California, Arizona, Texas) instead of US average

4.2 Use of regionalized water flows in GaBi datasets

Altogether, around 14.000 process datasets are available in the GaBi databases, built from several times more processes in the models. It was not possible to include regional flows in every available dataset. Therefore, the focus was on datasets that are known to be the most significant contributors to water consumption in almost all product systems: energy and agricultural materials (see also PFISTER ET AL. 2011a, b). Consequently, all energy and agricultural datasets use country specific flows instead of the unspecified flows (e.g. "groundwater, regionalized, DE" instead of "groundwater"). However, this also means all other datasets still use the non-regionalized (unspecified) flows. As all datasets will have some energy datasets used as background datasets, every dataset in GaBi will comprise some regionalized and some non-regionalized flows. In the impact assessment phase, different options are implemented to characterize these unspecified flows (see section 5.3). The interpretation of the results needs to take this into account (see section 6 on limitations).

Important: Please refer to the Annex for a detailed manual how to set up a foreground system (user's own model) using regionalized water flows.

5 Impact Assessment – Water quantities in GaBi

The GaBi software contains inventory quantities for water use and water consumption, as well as the impact assessment quantities, WSI, AWaRe, WAVE+ and others (see section 2.2), as defined and described below.

5.1 Water use

The water input flows in GaBi refer to total water use. To quantify total freshwater use, all freshwater input flows are summed up. As stated previously, rain water is important for a complete inventory and thus part of the *total* water use and total freshwater use. However, for impact assessments, only blue water (surface and groundwater) is considered, excluding rain water (see above footnote 1). Normally, the focus lies in freshwater use and consumption. Sea water is also excluded in this aggregation. Thus, the flow based equations are:

Total freshwater use = total freshwater withdrawal/abstraction

= Fresh water + Ground water + Lake water (incl. turbined) + River water (incl. turbined)+ water (fossil groundwater) + Rain water

Blue water use **= Fresh water + Ground water + Lake water (incl. turbined) + River water (incl. turbined) + water (fossil groundwater)**

5.2 Water consumption

As mentioned above (see 2.1), freshwater that leaves the watershed is considered consumed. This is the fraction that is most interesting as this water is lost to the ecosystem and for downstream users.

Total freshwater consumption is defined as[4]:

Total freshwater consumption	= total freshwater use (water input) – total freshwater release back to watershed (degradative water outputs) = Fresh water + Ground water + Lake water (incl. turbined) + River water (incl. turbined) + water (fossil groundwater) + Rain water - Cooling water to lake - Cooling water to river - Processed water to groundwater - Processed water to lake - Processed water to river - Turbined water to lake - Turbined water to river - Collected rainwater to river - Collected rainwater to lake

In the respective GaBi quantity, this calculation approach is implemented by summing up all inputs (characterization factor 1) and then subtracting all degradative output flows (characterization factor -1).

Please note that in general, only blue water (surface and ground water) is considered. Therefore, rain water is typically excluded from freshwater consumption and the focus is only on blue water consumption (see above, footnote 1). In detail, the flow based calculation is:

Blue water consumption	= Fresh water + Ground water + Lake water (incl. turbined) + River water (incl. turbined) + water (fossil groundwater) - Cooling water to lake - Cooling water to river - Processed water to groundwater - Processed water to lake - Processed water to river - Turbined water to lake - Turbined water to river

5.3 Water scarcity footprint (WSI, AWaRe, WAVE+, UBP)

The WSI, AWaRe, WAVE+ and UBP quantities are based on the water consumption, i.e. the same calculation logic (inputs – degradative outputs) applies. However, in these quantities the flows are multiplied with the country specific characterization factors.

The quantities for WSI, AWaRe and WAVE+ can be found under Environmental quantities → water, the UBP quantity under Environmental quantities → UBP 2013.

For WSI, the resulting unit is water deprivation (in m^3) or "RED" water (Relevant environmental depletion, see PFISTER 2009)[5]. For AWaRe, the resulting unit is "User Deprivation Potential" (UDP) in m^3 world-equivalents. For WAVE+ the resulting unit is risk of freshwater deprivation (RFD) in m^3 deprived. For UBP, the resulting unit are points of Eco Scarcity.

[4] Please note that this quantity corresponds to the "blue water footprint" plus "green water footprint" as proposed by the Water Footprint Network (WFN). The WFN used the term "water footprint" different than ISO 14046, as regionalized impact assessment is not part of the water footprint according to the WFN.

[5] RIDOUTT AND PFISTER 2010 recommend applying normalization to water derivation (water consumption x WSI), This normalization is conducted using the global average water stress (0.602). The resulting unit is m^3 of water equivalents (m^3 water eq.) The interpretation of this value is 1 kg water as "if it was consumed on a global level". If users prefer to use this value, they need to divide the value provided by the WSI quantity by 0.602 (global average scarcity factor).

5.4 High, OECD+BRIC average and low characterization factor for unspecified water

The WSI and AWaRe quantities exist in three different versions, with a high, OECD+BRIC average, and low characterization factor for unspecified water. In these quantities, all characterization factors are the same, except those for the unspecified (non-regionalized) flows. As described in section 4.2, the unspecified (non-regionalized) flows are still used in many data sets. For those flows, different characterization factors are used in the different quantities. In the version “high”, the unspecified flows are characterized with a high scarcity factor - choosing this quantity assumes “unspecified water” is consumed in water stressed regions, such as the Middle East or Spain. The “OECD+BRIC average” version refers to the average water scarcity in the OECD + BRIC countries. This value was preferred over the global average (all countries) as the OECD + BRIC represent most of the worldwide economic activity. The “low” version represents less water stressed countries, such as in North-Western Europe.

As mentioned in section 2.2, additional to those consumption-based methods, other water assessment methods are available in GaBi (ReCiPe 1.08 water depletion, ReCiPe 2016 v1.1 Freshwater Consumption, Resource depletion water, mid-point v1.09).

5.5 Water consumption of hydropower production

Water consumption of hydropower is caused by evaporation of water from the surface of the reservoir (gross water consumption[6]). In the GaBi energy datasets, evaporation rates from PFISTER ET AL 2011A are implemented. However, there is an ongoing debate on the preciseness of, and methodological assumptions behind such values. In a recent publication, Bakken et al conclude (BAKKEN ET AL 2017):

“*Published values range from negative to more than 115 000 m^3 MWh^{-1}. (…) The extremely wide range in estimates is explained by an inconsistent methodology and the very site-specific nature of hydropower projects. Scientific challenges, such as allocation from multipurpose reservoirs, and spatial assignments in river basins with several hydropower plants, affect the results dramatically and remain unresolved. As such, it is difficult to propose “typical values” for water consumption from hydropower production*”

Please refer to BAKKEN ET AL 2017 and SCHERER AND PFISTER 2016 for details on difference of net and gross consumption, the impact of temporal resolution and multi-purpose use.

In addition to these uncertainties on the inventory level, there are also uncertainties on the impact assessment level. The regionalization on country level (see also section 6) of these datasets is particularly problematic for hydropower plants, which are often located in more water-abundant areas compared to the country average.

To cope with these uncertainties and starting with SP35, GaBi allows the user to assess the water scarcity footprint with and without the contribution of hydropower production. For this purpose, the subfolder ‘Water excl hydropower’ was introduced in the quantities folder ‘Environmental quantities / Water’. It

[6] When the evapotranspiration prior to the establishment of the reservoir is subtracted from the evaporation from the reservoir surface, it is termed net water consumption.

contains all water use, water consumption, AWaRe and WSI quantities without the contributions of hydropower. In terms of interpretation, these values represent an optimistic estimate of the gross water consumption of hydropower, while the values in the default water quantities represent a conservative estimate. It is recommended to use these two quantities for scenario analyses.

6 Limitations

Regionalized impact assessment is a comparatively new field in practical LCA work. The GaBi databases are ground-breaking in being among the first to implement regionalized impact assessment into a generic LCA database. However, it should be kept in mind that many published methods focus on specific modeling situations where detailed data is available (e.g. agricultural cultivation on a specific field in a specific region). Applying these methods to generic databases is complex in terms of the technical implications but also in terms of data availability. For some datasets, the specific region is unknown. For others, it is explicitly intended to represent regional averages (e.g. fertilizers in the EU). Others will represent averages, but with specific regional context (e.g. for generation of hydropower, several dams in specific water sheds from the country average).

Therefore, the implementation of water assessment in GaBi is subject to limitations that should be kept in mind when interpreting the results:

- For both WSI and AwaRe, the method developer provided characterization factors on water shed level, which is seen as the appropriate spatial resolution for water assessments. However, most LCI datasets are organized on country level. The application of characterization factors aggregated into country averages can lead to large uncertainty in the obtained results, especially for large countries such as Brazil or the US, where a wide range of regions with different scarcity levels are covered. Working with the different scarcity classes in the flow classification (extreme to low) and the different versions of the quantities (high, average, low for unspecified flows) should be used to set up scenarios to better understand these uncertainties.
- For an assessment of water scarcity, it is not only important where the water consumption takes place, but also when. Many regions in the world are water abundant in a certain period (e.g. rainy season) and extremely water stressed in another (e.g. dry season). Temporal specific characterization factors are available for WSI and AWaRe, but could not be implemented into GaBi due to the structure of the datasets and limited data availability. Though it should be noted that temporal variation in water availability is considered in the aggregated characterization factors to some extent (see PFISTER 2009 and AWaRe documentation[7]).
- In AWaRe, three different use classes are differentiated: agricultural water use, non-agricultural water use, and unspecified water use (the latter being the consumption weighted average of the two). Due to technical reasons, at this stage, only the characterization factors for unspecified flows are implemented into GaBi. The values for these characterization factors are usually closer to those for agriculture and thus higher than those for non-agricultural use. Consequently, in the current state of the implementation into GaBi, the AWaRe results for industrial processes are likely to be lower if the non-agricultural characterization factors are used (future implementation discussed)

[7] http://www.wulca-waterlca.org/project.html

- As described in section 4.2, only the energy datasets and agricultural materials use regionally specific water flows (since SP 33). While these processes will cover the largest fraction of water consumption in most production systems, potentially a significant fraction of water consumption remains unspecified and is subject to large uncertainty regarding water scarcity. The different versions of the WSI and AWaRe quantities (high, average, low for unspecified flows) should be used to set up scenarios to better understand these uncertainties.
- Section 5.5 discusses the uncertainties of the water consumption of hydropower production

Therefore, it is important to understand that water scarcity footprint values provided in GaBi should be a good starting point in water assessment, and not as the terminal stop. Absolute numbers should be interpreted with care. The GaBi assessment should preferably be used for hot-spot analysis, which proved to be robust despite the above-mentioned limitations. A refined analysis of the determined hotspots can add valuable information and improve the reliability of the results (see BUXMANN ET AL. 2016 as an example for such a stepwise approach).

7 Literature

BAKKEN ET AL 2017	Bakken, H.; Killingtveit, Å.; Alfredsen, K. (2017): The Water Footprint of Hydropower Production—State of the Art and Methodological Challenges, Global Challenges 2017, 1
BAYART ET AL. 2010	Bayart, J.; Bulle, C.; Deschênes, L.; Margni, M.; Pfister, S.; Vince, F.; Koehler, A. (2010): A framework for assessing off-stream freshwater use in LCA. Int J Life Cycle Assess 17(3), pp 304-313
BERGER ET AL. 2018	Berger, M.; Eisner, S; van der Ent, R.; Flörke, M.; Link, A.; Poligkeit, J.; Bach, V.; Finkbeiner, M. (2018): Enhancing the Water Accounting and Vulnerability Evaluation Model: WAVE+. Environmental Science and Technology, 52 (18), pp. 10757-10766, doi.org//10.1021/acs.est.7b05164
BUXMANN ET AL. 2016	Buxmann, K.; Koehler, A.; Thylmann, D. (2016): Water Scarcity Footprint of Primary Aluminium. Int. J. Life Cycle Assess. 2016:1–11
FRISCHKNECHT AND KNÖPFEL 2013	Frischknecht, R.; Büssel Knöpfel, S. (2013): Swiss Eco-Factors 2013 according to the Ecological Scarcity Method, Federal Office for the Environment FOEN, öbu - works for sustainability, Bern
ISO 14046	ISO Life cycle assessment – Water footprint -- Requirements and guidelines. International Organization for Standardization, 2014.
PFISTER ET AL. 2009	Pfister, S.; Koehler, A.; Hellweg, S. (2009): Assessing the environmental impact of freshwater consumption in LCA. Environ Sci Technol 43(11), 4098–4104.
PFISTER ET AL. 2011A	Pfister, S.; Saner, D.; Koehler, A. (2011): The environmental relevance of freshwater consumption in global power production. Int. J. Life Cycle Assess.2011;16(6):580–91
PFISTER ET AL. 2011B	Pfister, S.; Bayer, P., Koehler, A.; Hellweg, S. (2011): Environmental Impacts of Water Use in Global Crop Production: Hotspots and Trade-Offs with Land Use, Environmental Science & Technology 2011 45 (13)
RIDOUTT AND PFISTER 2010	Ridoutt, B.; Pfister, S. (2010): A revised approach to water footprinting to make transparent the impacts of consumption and production on global freshwater scarcity. Global Environmental Change 20 (2010), 113–120
EUROPEAN COMMISSION 2017	European Commission (2017): PEFCR Guidance document, - Guidance for the development of Product Environmental Footprint Category Rules (PEFCRs), version 6.3.
SCHERER AND PFISTER 2016	Scherer, L.; Pfister, S. (2016): Global water footprint assessment of hydropower, In Renewable Energy, Volume 99, Pages 711-720.

Annex: Regionalized water modeling in the foreground system

A. Introduction

Since SP33, GaBi uses regionally specific elementary flows and new quantities for regional impact assessment of water data (see section 4 and 5). To make best use of this implementation, GaBi users can implement regionalized flows in their foreground LCA model. This document introduces new datasets that facilitate this implementation and serves as a guide on how to use them.

We highlight here again that for modern, consumption-based water scarcity methods, both water input and output must always be quantitatively sufficiently accurate (as the difference of the two is the consumptive loss) and regionalized consistently, as otherwise a false, only seemingly occurring calculated transfer of water among regions is unavoidable, leading to distorted results.

B. Initial set up

When modeling the foreground system, there are two options to model water input and outputs:

a) Water extraction, treatment and release are part of the modelled system (e.g. waste water treatment on site) → elementary flows as input

b) The modelled system uses water as an operation material (e.g. "tap water" or "deionised water" as an input, water to a municipal waste water treatment plant as output) → GaBi datasets for provision of water and waste water treatment are used.

In case a), the user can simply use the appropriate regional elementary flows (e.g. if the modelled system is located in France, use the French version of the elementary flows provided in GaBi).

This guide refers mainly to case b). Before the introduction of regionalized flows, users simply had to select the most suitable dataset and connect it to their respective system. The geographic context of the datasets mattered most in terms of technological representativeness (water datasets in GaBi were available for the US, EU28 and DE). That meant that, e.g., using a DE dataset to model water provision (or treatment) in France did not lead to a strong distortion in the results. Now however, with country specific flows and their respective characterization factors, using these processes will mean that the whole water assessment in the foreground system will reflect German instead of French conditions. To prevent this, new, partially aggregated datasets have been introduced into the GaBi software.

C. Partially aggregated processes

All different water processes (both, provision and treatment) are provided as partially aggregated processes[8]. In case of water provision processes (tap water, process water, de-ionised water) this means that the energy and the water input are open, tracked flows (see Figure 6). The energy flow needs to be connected with the respective energy dataset (e.g. French grid mix if the modelled system is located in France). The water input flow needs to be connected with the regionalization dummy process (see next section).

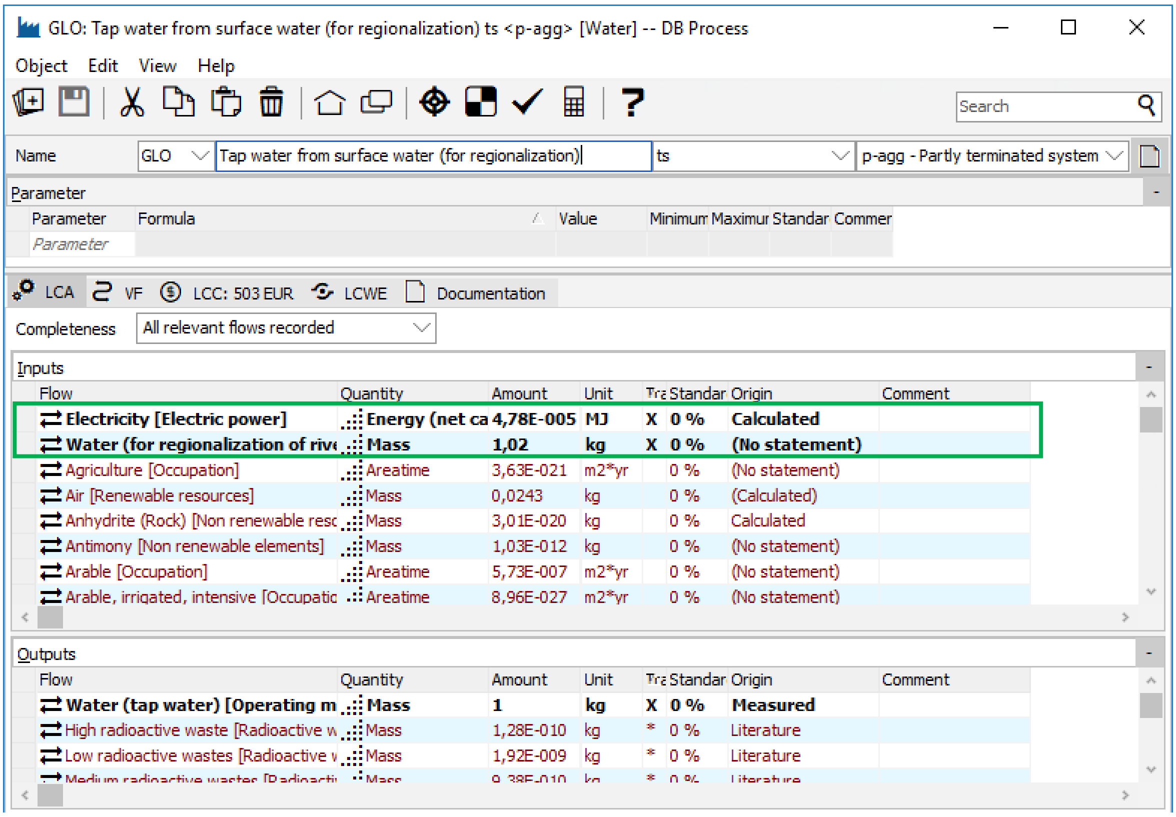

Figure 6: Provision of water (tap water) as partially aggregated process with open input flows

The same approach is followed for all waste water treatment processes. An open energy flow allows connection to a regionally specific electricity grid mix[9], the open water output flow needs to be connected with regionalization dummy process (see next section).

[8] In the GaBi Professional DB, these processes are indicated through the term “for regionalization” in brackets

[9] In the waste water treatment process, usually there is an energy input (electricity) and output (electricity generated from sludge treatment). In the p-agg processes these are already summed up, so that there is only either an input or an output of electricity.

D. Regionalization dummy processes

The regionalization dummy processes allow you to select the region (country) in which the foreground system is modelled. For the flow types used in the p-agg processes a dummy process exists (input: ground water, river water, lake water; output: processed water to groundwater, processed water to lake, processed water to river).

The region is selected by typing "1" into the respective free parameter field. The input processes select the respective water input, and are connected with a water provision processes (tap water, process water, de-ionised water), see Figure 7. The same approach applies for the output dummy: it should be connected after a waste water treatment process, and will select the respective output region.

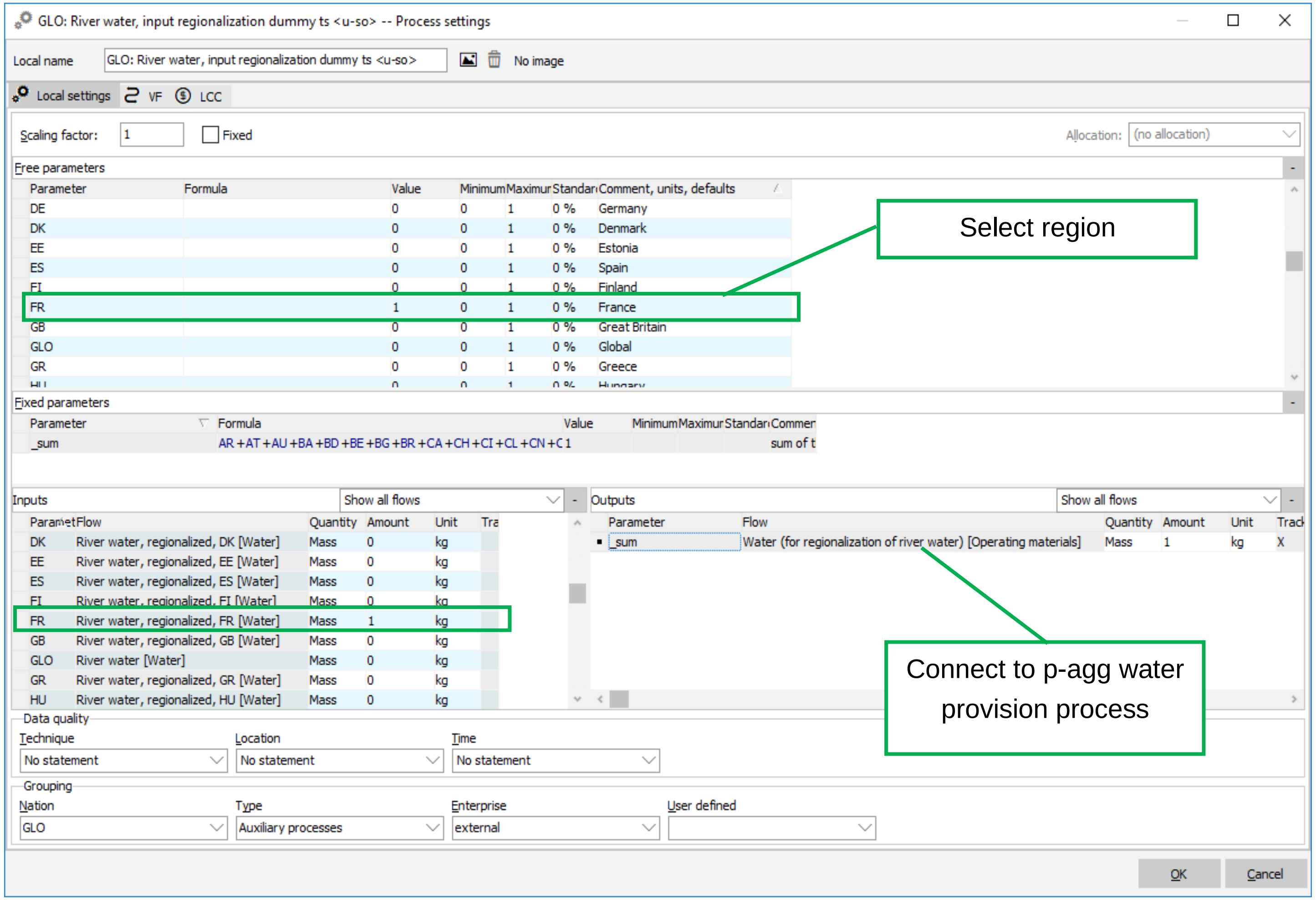

Figure 7: Regionalization dummy processes to select the region in which the foreground system is modelled

E. Example

In the Professional DB, an example plan with a simplified production system with regionalized water modeling is provided for illustration and to help you familiarize yourself with a sound modelling of regionalized water use (see Figure 8).

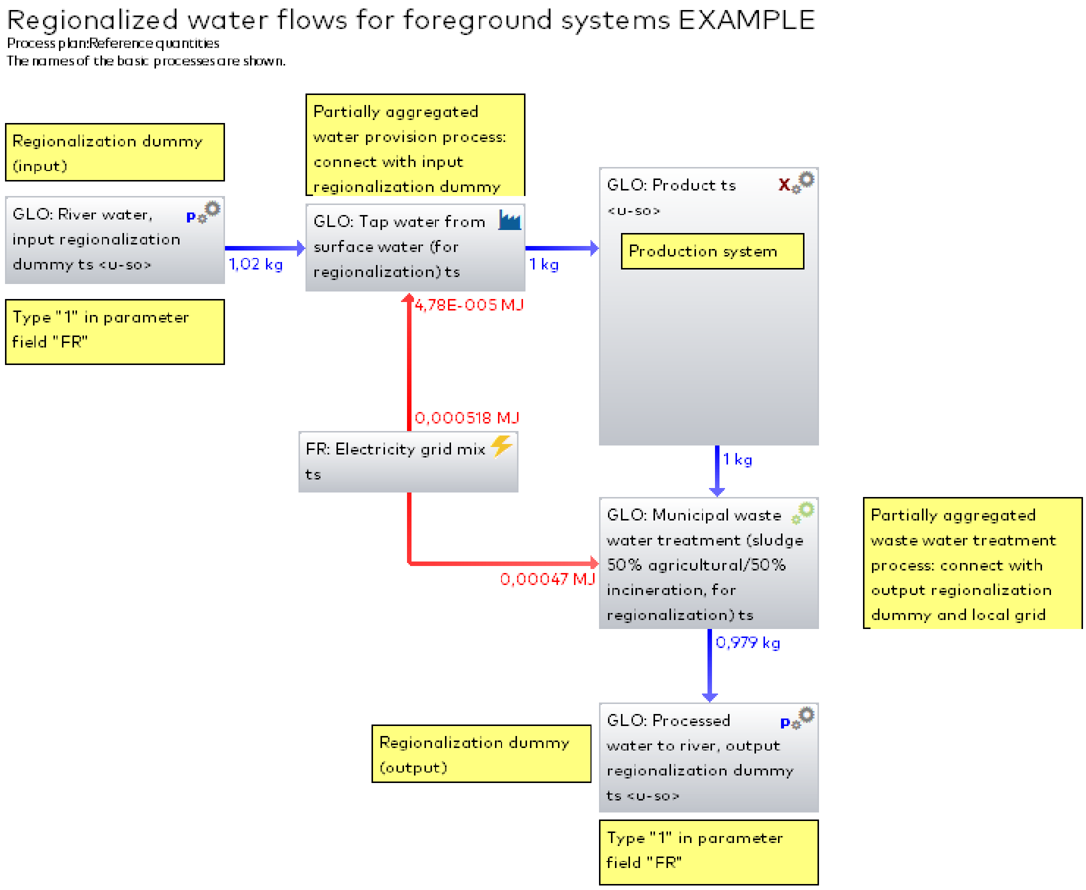

Figure 8: Example - simplified production system with regionalized water modeling

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