



*The Sustainability Quick Check Tool (SQCB):
A Web-based Tool for Streamlined Biofuel LCA*

Web description

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1 Introduction “Why a SQCB?”

Upcoming regulations like the Swiss mineral oil taxation order and development of standards for sustainably produced biofuels like those of the Roundtable for Sustainable Biofuels (RSB) require often calculations of greenhouse gas emissions or even of environmental impacts on a life-cycle basis (LCA). On one hand this causes complex projects, which are for many small producers too costly and would prevent them to enter e.g. the Swiss market for biofuels. On the other hand, environmental impacts of many biofuels production chains have already been assessed, so that knowledge on results and critical factors already exists.

Goal of this project is to use this knowledge to develop a web-based tool which allows a rapid evaluation of biofuels on an LCA basis. This tool allows manipulating the relevant parameters of a biofuel production chain and comparing the resulting environmental impacts with the requirements of the Swiss mineral oil taxation order. The tool uses the knowledge which was accumulated in the Empa report¹ on biofuels from Zah et al.. The “Sustainability Quick Check for Biofuels” (SQCB) tool should facilitate the entry of small producers from developing countries on the Swiss market and so contribute to a more sustainable production of biofuels.

¹ <http://www.news-service.admin.ch/NSBSubscriber/message/attachments/8514.pdf>

2 Theoretical background

2.1 Principle of the tool

The Sustainability Quick Check for Biofuels (SQCB) tool allows the user to enter own data of the product life cycle for the parameters that (i) are most relevant and (ii) induce the highest variability for the environmental performance of a biofuel. In general, such important parameters are primarily related to the cultivation and the processing of a biofuels. Parameters which have a low impact on the overall results or which are quite similar among different value chains, like e.g. transport or usage of the biofuel, are taken as background data from the reference life cycle database, which is ecoinvent². Figure 1 shows the basic principle of the SQCB.

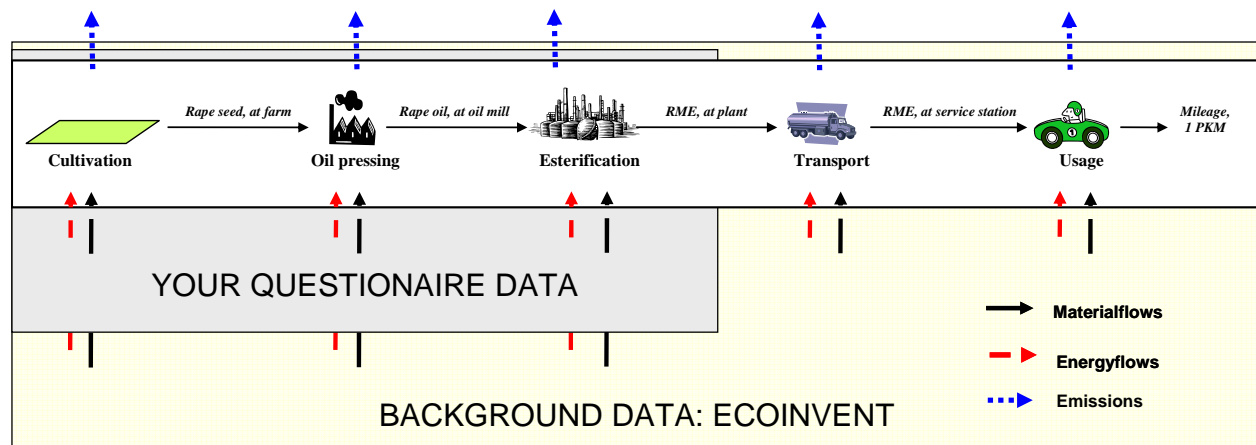


Figure 1: Basic principle of the SQCB. The most important input parameters of the life cycle of biofuels can be entered in a questionnaire. Where specific data is lacking or where simplifications only induce minor variability, the SQCB relies on background data from the ecoinvent database. Emissions are calculated on the basis of the entered data.

The questionnaire of the SQCB strongly focusses on data entry for the agricultural step (mineral and organic fertilizers, pesticide use, irrigation, yield, former land use) and the processing steps (energy use, chemicals, allocation, etc.). In addition, compliance with the requirements for social criteria has to be confirmed.

2.2 Workflow “How does it work?”

The user can enter the most sensitive parameters of the life cycle of biofuels. Subsequently, the life cycle inventories of all process steps are computed and normalized to the functional unit of “driving one person km (pkm) with an average car”. On this basis, life cycle impact assessment methods are applied with focus on greenhouse gas emissions (global warming potential, GWP100) and on total environmental impact points (Swiss method of ecological scarcity, UBP06). The results are graphically compared to a biofuel reference path and to a fossil reference. In addition, the environmental impacts are checked against sustainability criteria. If the criteria are not fulfilled, the user may change his entry data and get more insights on the measures he should take to fulfil them. Figure 2 shows the workflow of the SQCB.

² www.ecoinvent.ch

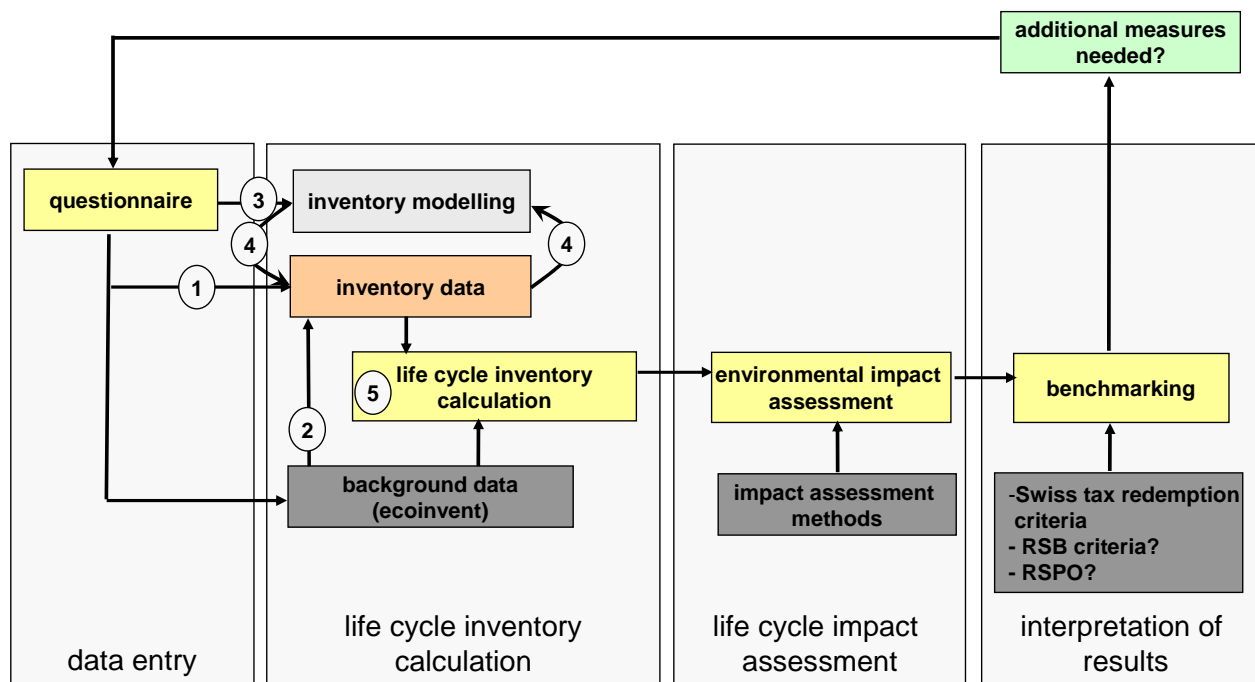


Figure 2: Workflow of the SQCB

Questionnaire

Although the life cycle of biofuels is influenced by a large number of factors, only few have a high relevance on the overall environmental impact assessment. The questionnaire of the SQCB strongly focusses on data entry for the agricultural step (mineral and organic fertilizers, pesticide use, irrigation, yield, former land use) and the processing step (energy use, chemicals, allocation, etc.). In addition, compliance with the requirements for social criteria has to be confirmed.

Life Cycle Inventory (LCI) calculation

As shown by Figure 2, different paths for the transformation of questionnaire data into LCI data are used. In general, some of the data entered by the user can directly be used as inventory data, e.g. the amount of mineral fertilizer applied per ha (step 1). Another part of the life cycle inventory is used by default from the background data, e.g. the machine use on the field (step 2). In addition, the LCI is supplemented with data resulting from models using (i) questionnaire data as input (step 3) or (ii) already determined LCI flows (step 4). For example, the CO₂ emissions from land use change are modelled on the basis of questionnaire data, whereas the N₂O emissions or Nitrat emissions are calculated according to the amount of mineral fertilizer applied, i.e. the already determined LCI flows. When all required LCI flows are completed, the life cycle inventory is calculated (step 5). In this step, all LCI flows are allocated and normalized to the functional unit of 'driving one person km (pkm) with an average car'.

Life Cycle Impact Assessment (LCIA)

In the subsequent step, the normalized inventory flows are multiplied with their respective environmental impacts. The life cycle impact assessment is applied with focus to greenhouse gas emissions (global warming potential, GWP100) and the Swiss method of ecological scarcity (UBP06). This endpoint method evaluates environmental damages by means of the difference between environmental impacts and legal limit values in the context of the Swiss legal framework. This method is chosen in order to reflect accurately the overall ef-

fects on the environment, as the driving parameter of the changes in the system is placed in Switzerland. However, if required additional impact methods could be added simply.

Benchmarking

The results are graphically compared to an average biofuel reference path (e.g. biodiesel from rape is compared with biodiesel from rape) and to a fossil reference (petrol, low sulphur, at regional storage). Moreover, the results are currently benchmarked against the Swiss criteria for the tax exemption of biofuels. Furthermore, the user can evaluate the critical factors of his value chain. If the criteria are not fulfilled, the user can change his entry data and get more insights on the measures he should take to fulfill them. If the results are positive, the user has a first indication that deposing a request for tax exemption can be worthwhile.

3 The questionnaire

3.1 Basic structure “What is the basic structure?”

The study of Zah (2007) showed that the most important steps in the production chain of biofuels are the agriculture and the production of the biofuels. This is valid for the emissions of greenhouse gases as well as in the evaluation of the overall environmental impacts with different methods. The data entry for the questionnaire is structured as shown in Figure 3.

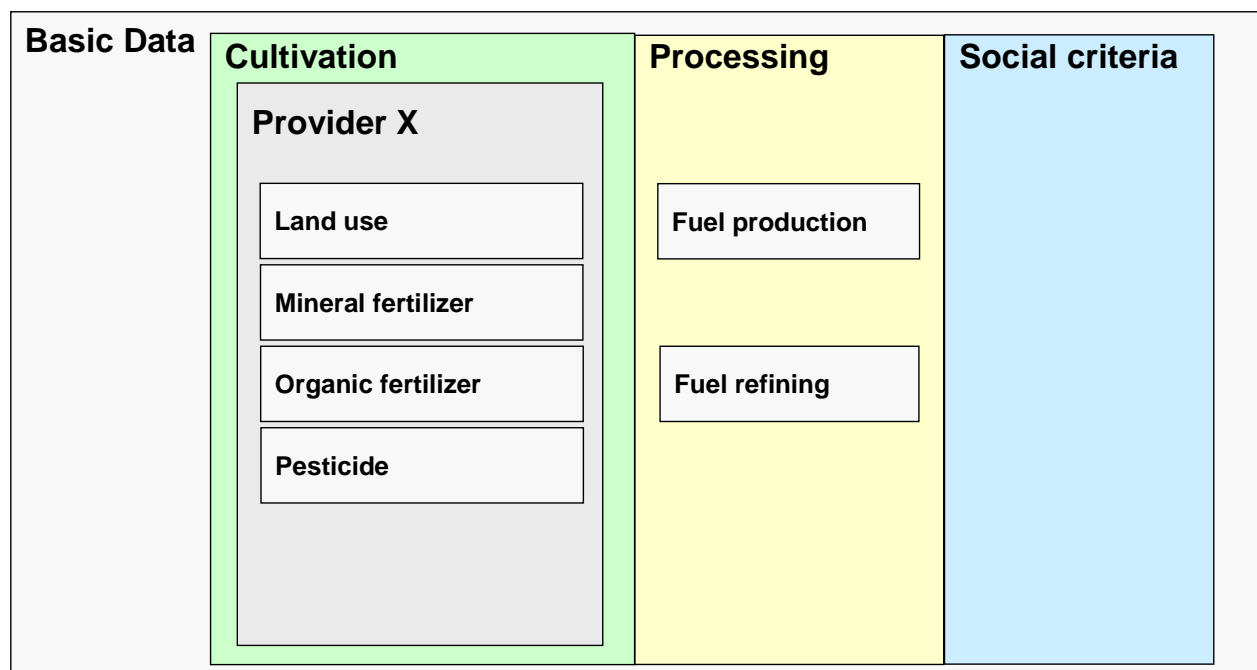


Figure 3: Structure of the questionnaire

The relevant parameters in the agriculture on the input side are the use of fertilizers, pesticides and land transformation of tropical rain forest or other soils with high carbon stocks. On the emission side, dinitrogen oxides, nitrate, phosphate and heavy metal emissions are relevant for the results of the assessment. These emissions are to some extent dependent on the input of fertilizer but also on climate and soil conditions. In the processing step, the results depend mostly on the energy demand of the process and the allocation factors.

The questionnaire allows therefore entering the inputs of fertilizer and pesticides in the cultivation step. It also requires some basic data like crop yield or geographical information, which are used for the calculation of emissions in the agricultural step. In the processing step, data on energy efficiency and chemicals have to be entered.

In addition to the environmental aspects of the life cycle of biofuels, the Swiss ordinance sets requirements also on social aspects (MinöStV 2008). As the assessment of the social factors follows other rules as the assessment of environmental impacts, this part of the SQCB questionnaire aims mainly at increasing the awareness of the user for this aspect.

In general, the navigation within the SQCB follows the structure as shown in Figure 4. The entry of the data is downstream, i.e. from the entry of the basic data to the cultivation and processing up to social criteria. However, except for the basic data, which is a precondition for all other data entries, the data can be entered as preferred by the user. The navigation is implemented as shown in Figure 4.



Figure 4: Navigation

The user can navigate using both the navigation bar on the left hand side and the navigation bar on the top. After the user has entered the data required, all data entries are validated meaning that the SQCB checks if (i) all required data is available and (ii) the data entered is correct. The user gets a feedback on which data should be corrected / completed. If all data is correct, the user can calculate his results.

In general, help buttons are placed below the input field. Using this button, the user can get additional information which explains and eases the data entry.

3.2 Basic Data “What crops does the SQCB contain?”

In this project we focus on the biofuels and feedstock which have been studied in the Empa report. Feedstocks or biofuels which are considered by the Swiss mineral oil tax ordinance as not being able to satisfy the minimal requirements (cereals) or those for which no sustainability reporting is required (waste, residues from agriculture) are not taken into account. In this first step wood is not considered, as its production chain is very different from the other feedstocks. Therefore the biofuels considered are the following (Table 1).

Table 1: Feedstocks and biofuels covered by the SQCB tool.

Feedstock	Biofuels	Countries in ecoinvent
Potatoes	Ethanol	CH
Sugar beet	Ethanol	CH
Sugar cane	Ethanol	BR
Sweet sorghum	Ethanol	CN
Rapeseed	Methylester	CH, RER
Soy beans	Methylester	(CH), US, BR
Oil palms	Methylester	MY

Not considered are methanol, which has a too small market, vegetable oil, which is used only for lorries, and cereals (rye, wheat), which are at this time heavily criticized because of ethical considerations.

“Which data can be entered?”

On the basis of the crop, the SQCB tool chooses a production pathway, at this time biodiesel or bioethanol (Figure 5).



Figure 5: Basic data

The user has to choose between different types of processing where available (e.g. cold pressing / hexane extraction for the milling step in biodiesel production) and should select the country where the feedstock is cultivated.

The user must then enter overall delivery of biomass for each of his providers. The tool collects specific cultivation data for each provider, as it is assumed that farmers delivering biomass to a plant can have different environmental profiles. With this procedure, the tool allows comparing different providers.

3.3 Cultivation Data

The main material and energy inputs in an LCA inventory of cultivation are summarized in Table 2. The most relevant ones with regard to the LCA results are asked for in the SQCB questionnaire. For inputs judged of low relevance for the SQCB tool, like machine use, default data is used.

Table 2: Main material and energy inputs in an LCA inventory of cultivation and their modelling in the SQCB tool.

Input type	Default value	User's total value	User's specific value	Comment
Fertilizer (mineral and organic)	x	x	x	For the total values, the split of different fertilizers from reference data set
Pesticides	x	x	x	For the total values, the split of different pesticides from reference data set
Machine use	x			
Irrigation	x		x	
Transports	x			
Grain drying	x			

The data entry for the cultivation is divided in 4 steps (land use, mineral fertilizer, organic fertilizer and pesticides). These pages are explained in the following chapters.

3.3.1 Land use

Figure 6 shows the structure of the land use page.



The screenshot shows the 'Cultivation' page of the 'sqcb Sustainability Quick Check for Biofuels' application. The interface includes a top navigation bar with 'Home' and 'Start' buttons, and a main navigation bar with 'Basic Data', 'Cultivation', 'Processing', 'Social Criteria', 'Validation Calculation', and 'Results' tabs. The 'Cultivation' tab is active.

Left Sidebar:

- Cultivation Data
 - Feedstock Provider 1
 - Land Use
 - Mineral Fertilizer
 - Organic Fertilizer
 - Pesticides
- Processing Data
- Social Criteria
- Validation/Calculation
- Results
- Reset entered data

Main Content Area:

Yield: 3.133 (yield in t/ha)

Ecozone: Temperate oceanic forest (Ecozone)

annual rainfall: 1040 (annual rainfall in mm)

winter-type precipitation distribution?: Yes, No, Winter Precipitation

Soil Information:

USDA Soil Order: Alfisol (Please look up here)

mean slope: 1% < x < 3.5% (mean slope)

Cultivation Practice:

tillage method: Fall plow (Tillage Method)

anti erosion practice: Up & down slope (anti erosion practice)

annual irrigation: (annual irrigation in m3)

conventional drainage?: Yes, No, yes/no

Land Use Information:

Land Use: Cropland (Type of land use on the 1st of January 2004)

Acreage: 100 (% of total acreage)

peat land?: Yes, No, Check box if land is peat land

Figure 6: Cultivation data, Land use

Main questions on this page are the following:

- What is the crop yield?
- In which ecological and geographical context is the crop cultivated?
- What are the characteristics of the cultivation practice?
- What land use changes does this crop production induce?

The user gets more detailed information by using the help buttons.

3.3.2 Mineral fertilizer

Figure 7 shows the structure of the mineral fertilizer page.

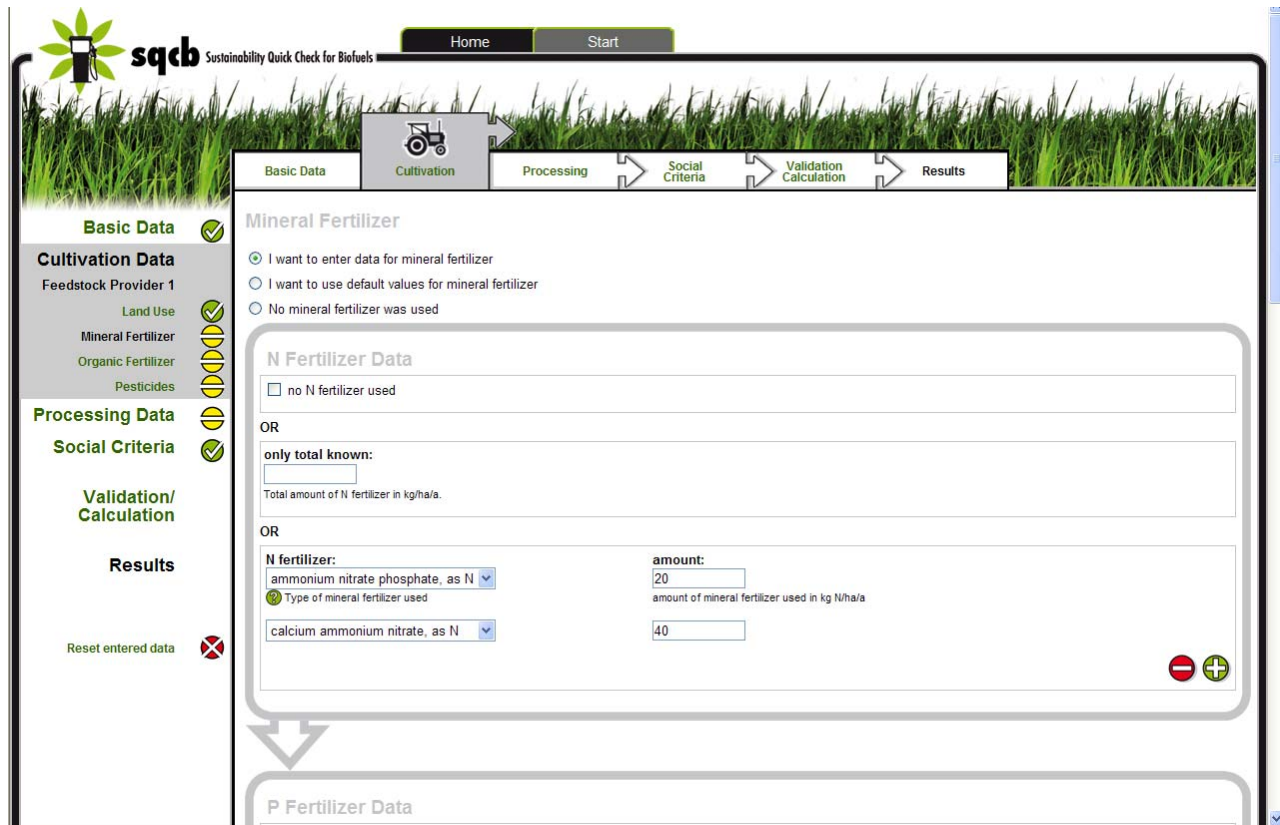


Figure 7: Cultivation data, Mineral Fertilizer. The bottom of the page with the detailed entry for K-fertilizer is cut off.

On this page, the user can choose between

1. no mineral fertilizer use
2. only total use
3. entering specific data of mineral fertilizer

When choosing 1., the user comes to the next page.

When choosing 2., the user enters the total quantity of the specific nutrients. The SQCB tool uses the repartition in the specific fertilizer types of the ecoinvent reference data to calculate the inputs of specific fertilizers.

When choosing 3., the user can enter specific data and choose between 10 N-, 6 P- and 4 K-fertilizers (see Table 3).

Table 3: Fertilizers in the SQCB tool

Fertilizers	Country	unit	nutrient
ammonium nitrate phosphate, as N	RER	kg	N
ammonium nitrate, as N	RER	kg	N
ammonium sulphate, as N	RER	kg	N
calcium ammonium nitrate, as N	RER	kg	N
calcium nitrate, as N	RER	kg	N
diammonium phosphate, as N	RER	kg	N
monoammonium phosphate, as N	RER	kg	N
potassium nitrate, as N	RER	kg	N
urea ammonium nitrate, as N	RER	kg	N
urea, as N	RER	kg	N
ammonium nitrate phosphate, as P2O5	RER	kg	P
diammonium phosphate, as P2O5	RER	kg	P
monoammonium phosphate, as P2O5	RER	kg	P
thomas meal, as P2O5	RER	kg	P
triple superphosphate, as P2O5	RER	kg	P
single superphosphate, as P2O5	RER	kg	P
potassium chloride, as K2O	RER	kg	K
potassium nitrate, as K2O	RER	kg	K
potassium sulphate, as K2O	RER	kg	K

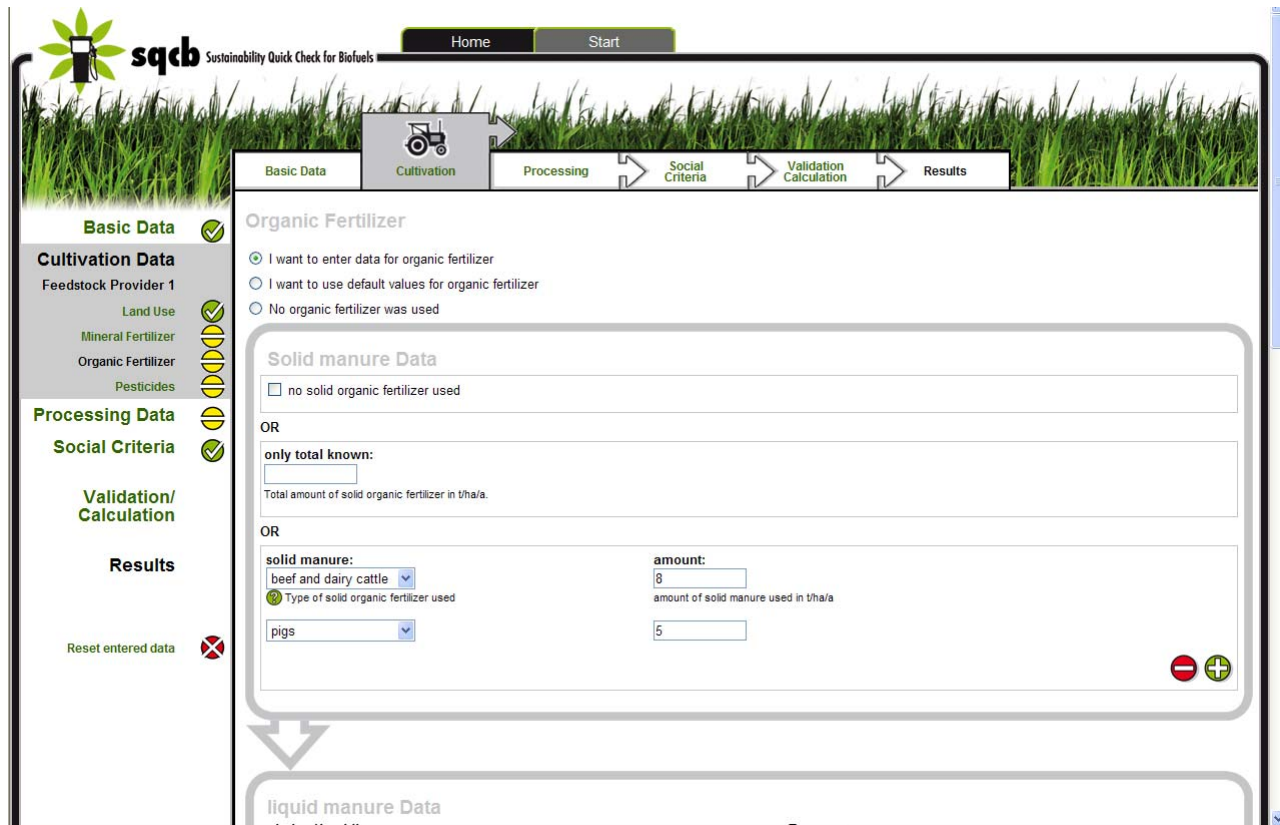
If the specific fertilizer of the user doesn't exist in the tool, the user is advised to choose a fertilizer with similar nutrients composition.

Table 3: Composition of the multi-nutrient fertilizers (Nemecek and Kägi 2007)

Fertilizer type	N	P ₂ O ₅	K ₂ O	Ca
ammonium nitrate	35%			
calcium ammonium nitrate	27%			
urea	46%			
urea ammonium nitrate	32%			
calcium nitrate	16%			
single superphosphate		21%		
triple superphosphate		48%		
Thomas meal		17%		32%
potassium sulphate			50%	
potassium chloride			60%	
ammonium nitrate phosphate	8%	52%		
potassium nitrate	14%		44%	
monoammonium phosphate	11%	52%		
diammonium phosphate,	18%	46%		

3.3.3 Organic fertilizer

Figure 8 shows the structure of the organic fertilizer page.



The screenshot shows the SQCB (Sustainability Quick Check for Biofuels) web application. The interface is divided into several sections:

- Navigation:** 'Home' and 'Start' buttons at the top.
- Progress Bar:** A sequence of steps: Basic Data, Cultivation (active), Processing, Social Criteria, Validation Calculation, and Results.
- Left Sidebar:** A menu with categories:
 - Basic Data:** Feedstock Provider 1, Land Use, Mineral Fertilizer, Organic Fertilizer, Pesticides.
 - Processing Data**
 - Social Criteria**
 - Validation/Calculation**
 - Results**
 - Reset entered data (with a red X icon)
- Main Content Area:**
 - Organic Fertilizer:** Three radio button options:
 - I want to enter data for organic fertilizer
 - I want to use default values for organic fertilizer
 - No organic fertilizer was used
 - Solid manure Data:**
 - no solid organic fertilizer used
 - OR
 - only total known:** A text input field for 'Total amount of solid organic fertilizer in t/ha/a'.
 - OR
 - Specific Data:**
 - solid manure:** A dropdown menu with 'beef and dairy cattle' selected. Below it, a green checkmark icon and the text 'Type of solid organic fertilizer used'.
 - amount:** A text input field with '8' entered, labeled 'amount of solid manure used in t/ha/a'.
 - Another dropdown menu with 'pigs' selected and another text input field with '5' entered.
 - Navigation arrows at the bottom of the form sections.

Figure 8: Cultivation, Organic fertilizer. The bottom of the page with the detailed entry for liquid fertilizer is cut of.

On this page, the user can choose between

1. no organic fertilizer use
2. only total use
3. entering specific data of organic fertilizer

When choosing 1., the user comes to the next page.

When choosing 2., the user enters the total quantity of liquid or solid manure. The SQCB tool uses an average nutrient composition for the liquid resp. solid manure.

When choosing 3., the user can enter specific data and choose between liquid manure from pig or cattle resp. solid manure from pig, cattle or poultry. Dilution water is entered separately.

3.3.4 Pesticide

Figure 9 shows the structure of the pesticide page.

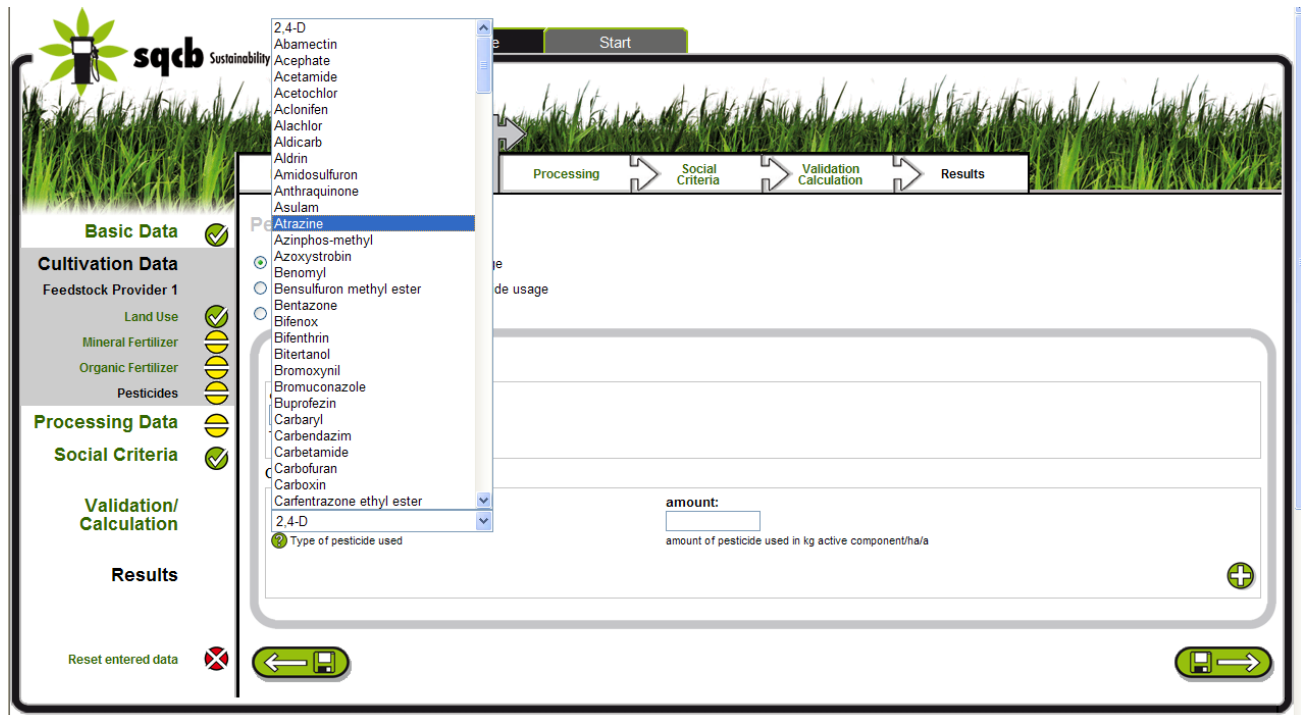


Figure 9: Cultivation, Pesticide.

On this page, the user can choose between

1. no pesticide use
2. only total use
3. entering specific data of pesticide

When choosing 1., the user comes to the next page.

When choosing 2., the user enters the total quantity of pesticides. The SQCB tool uses the repartition in the specific pesticides of the ecoinvent reference data to calculate the inputs of specific pesticides.

When choosing 3., the user can enter specific data and choose between about 200 pesticide types.

3.4 Processing data

On this page, the user can choose between using default values from the ecoinvent reference data set or enter specific data. By ticking the latter choice, the processing step divides then in two steps, production of the raw fuel and fuel refining. For biodiesel, these two steps are milling and esterification, for ethanol, distillation and dehydration (Figure 9).

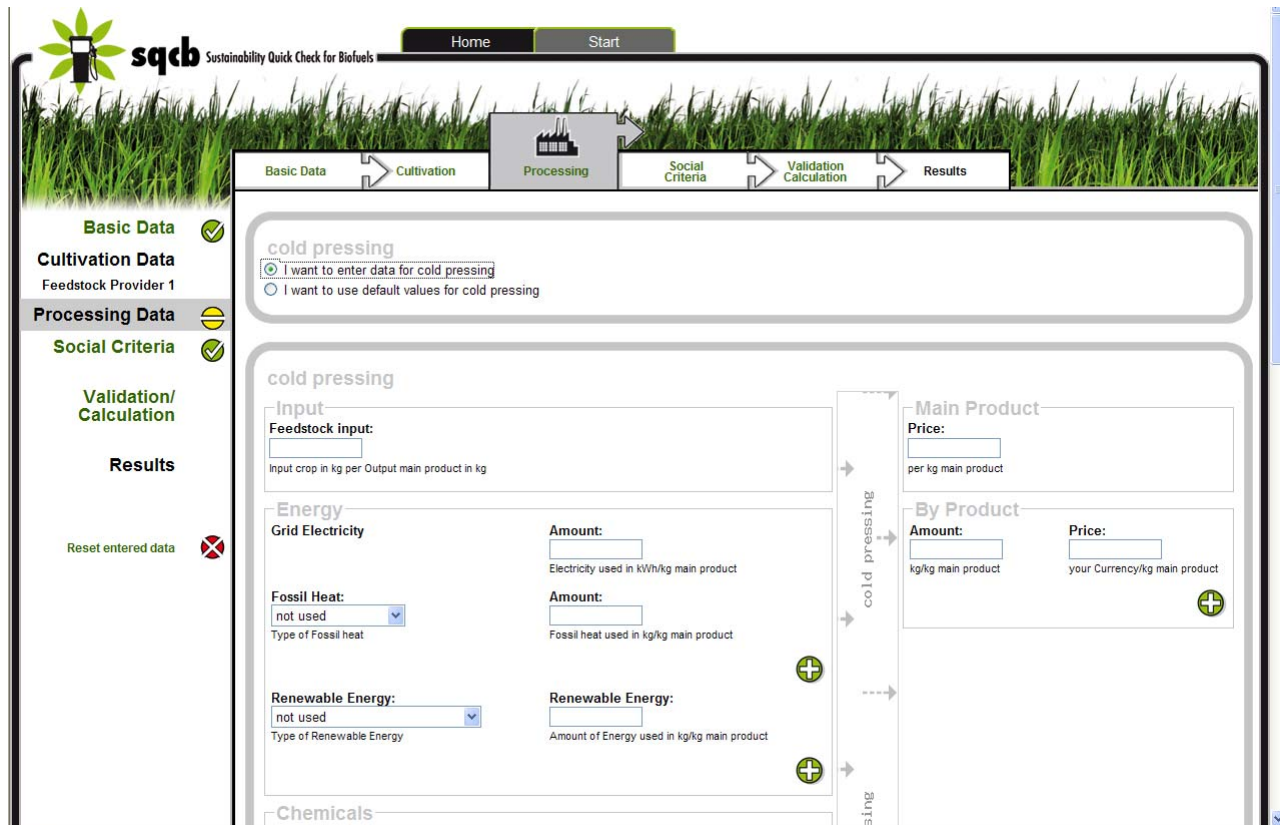


Figure 10: Processing, Fuel production. The bottom of the page with the detailed entry for fuel refining is cut off.

For each step, the user can enter energy use, chemical use and raw material requirements of his production process. He has also to enter the prices of his product and by-products as well as the relative production of by-products so as to allow the calculation of the allocation factors.

3.5 Transport and fuel use

No data entries of the user are possible with respect to the transportation of the fuel to the gauging station and the use of the passenger car. The required LCIs are automatically supplemented on the basis of background data, which is the ecoinvent database.

3.6 Social criteria

Aim of this page is to increase the awareness of the user as regards to the fact that the production of biofuels must fulfil minimum social criteria. The page requires entry for the main social aspects that are covered by the Swiss legislation, which are

- Guarantee of free association and protection of the right to organize
- Interdiction of forced labour
- Interdiction of child work
- Interdiction of discrimination

The user can tick yes or no by these points.

4 Disclaimer

SQCB reduces the need for user entries to the most relevant and best-known parameters of the biofuel production chain. Based on this questionnaire, a specific inventory is automatically modelled and linked with background data to a full life cycle inventory. SQCB calculates the environmental impact assessment and checks the results against sustainability criteria.

The simplified modelling approach limits the applicability of the SQCB to value chains similar to the reference chain in the tool. For example, complex biorefineries with multiple co-products and feedstocks cannot be modelled in this framework. Furthermore, in-depth know-how on land transformation, cultivation and fuel processing of the specific biofuel chain is needed for an accurate environmental impact assessment. SQCB is therefore only to be seen as a **rapid screening** that gives a first estimation on the overall sustainability and potentially critical factors of a biofuel production chain. SQCB can not cover a complete reproduction of the far more complex reality.

The user of SQCB hereby agree of having notified that the use or outcome of SQCB system and data base do in any case neither stipulate a legal basis for an application at the responsible Federal Office nor do positive outcomes or results guarantee a positive judgement for an application.

SECO as owner and data holder of the SQCB data base as well as Empa, Agroscope Reckenholz-Tänikon ART and HTW Berlin as designers of the SQCB exclude any kind of responsibility for the accuracy and correctness of background data as well as the generation of knowledge, results or benchmarking due to SQCB calculation, the use and commercialization thereof or any kind of damage directly or indirectly derived from the use of SQCB.