UNEP
United Nations Environment Programme

Exercise on Life Cycle Assessment dataset creation

In the context of UNEP's Global Guidance Principles for Life Cycle Assessment databases

Software: openLCA 1.4.2

Exercise version: 1.1, April 2016

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1 Introduction

While calculating a system that has already been defined in LCA software is typically rather straightforward, creating datasets to be integrated in LCA databases from "raw data", i.e. from information not taken directly from LCA databases, is typically more complicated (Wang, Ciroth et al. 2011).

Especially when it comes to linking the created datasets to each other or connecting them to background data, consistency, data compatibility, and other issues can arise: Data sets might use different conventions for flow names, different modelling conventions, or different ways to document the modelling, to name just a few examples. A database that is created from these data sets will probably appear confusing to the practitioner; more importantly, processes maybe cannot be connected in a meaningful way, in case studies using the database, and data exchange between different databases and LCA software systems can be difficult.

This series of exercises focuses on the task of creating Life Cycle Inventory (LCI) data sets from raw data according to the GGP. Goal is to create own LCI data sets and to raise awareness for data set interoperability issues, important especially for those who are interested in creating own data sets for example for a national LCA database.

For the exercise, openLCA, a free and open source LCA software (www.openlca.org), will be used[2]. This allows us to use features useful in LCA, especially the life cycle calculation and analysis, without advocating a commercial software.

To be realistic, the exercise does not assume perfect availability of data; rather, at several points which will be mentioned in the exercise, workarounds will be used and slight "glitches" and imperfections will still exist in the final exercise model. This is not uncommon for a first version of a life cycle model which will be built here. Due to the iterative nature of LCA, these imperfections can be addressed in a next version of the model built here.

Exercise 1: Get openLCA running

- Install openLCA on your computer and run it

Exercise 2: Create a new database

- Import the training database into openLCA

- Right-click in the Navigation window and select "Import database". Select the database in zolca format and click "Open".

[2] openLCA is freely available from the openLCA download site, http://www.openlca.org/downloads

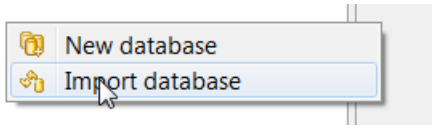

Figure 1. Import database into openLCA

Since background data such as electricity will be used in the exercise, a database is needed. The database that comes with this exercise is based on the USDA crop database provided by the United States Department of Agriculture (USDA). It is also known as LCA commons and is available free of charge on the openLCA Nexus website: https://nexus.openlca.org/database/USDA.
An electricity production process was taken from the NREL database of the National Renewable Energy Laboratory.

2 *Case study information: Cotton T-Shirt*

This exercise will look at a simplified cotton textile production process. The production chain can mainly be divided into three parts:

1. Cotton fibre production
2. Cotton yarn production (Spinning)
3. Cotton fabrics production

Transportation – although it might be needed in reality – will not be considered here.

2.1 Cotton fibre production

For the fibre production (see Figure 5) 20 grams of cotton seeds are needed; all other inputs and outputs for the production (1 kg Output) are listed in Figure 6.

Figure 2. Cotton field with ripe cotton, taken from https://de.wikipedia.org/wiki/Baumwolle

Figure 3. Cotton harvest, taken from https://en.wikipedia.org/wiki/Cotton_production_in_the_United_States

Figure 4. Cotton machine, taken from https://en.wikipedia.org/wiki/Compagnie_malienne_pour_le_développement_du_textile

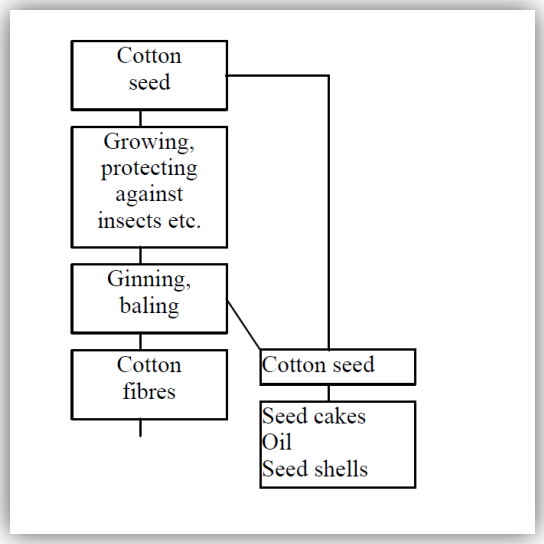

Figure 5. Production chain for cotton fibres taken from Kalliala (1999), p.9

	Unit / kg	Polyester	Cotton	Organic
Parameter				
Energy consumption:	**MJ**	**97,4**	**59,8**	**53,6**
Electricity	MJ	15,2	12,1	13
Fossil fuel	MJ	82,2	47,7	40,6
Non-renewable resources:	**kg**	**2,4**	**1,4**	**1,3**
Natural gas	kg	0,36	0,35	0,14
Natural gas, feedstock*	kg	0,29		
Crude oil	kg	0,41	0,53	0,57
Crude oil, feedstock*	kg	0,87		
Coal	kg	0,14	0,52	0,56
Coal, feedstock*	kg	0,37		
LP gas	kg		0,03	0,03
Hydro power (MJel)	**MJ**	**0,4**	**1**	**1**
Natural uranium	**mg**		**14**	**15**
Fertilizers	**g**		**457**	
Pesticides	**g**		**16**	
Water	**kg**	**17,2**	**22200**	**24000**
Emissions to air:				
CO2	g	2310	4265	3913
CH4	g	0,1	7,6	6,1
SO2	g	0,2	4	4
NOx	g	19,4	22,7	22,7
CH	g	39,5	5	5
CO	g	18,2	16,1	17,2
Emissions to water:			**NK**	**NK**
COD	g	3,2		
BOD	g	1		
Tot-P	g	0		
Tot-N	g	0		
*feedstock values included to the energy consumption values				
NK = not known				

Figure 6. Fibre production data taken from Kalliala (1999), p.18; NOTE: Commas in this table serve as decimal separators

From Figure 6, you see that the type of fertilizers and pesticides are not further specified in the data. This will need to be addressed in a next step; e.g. there are obviously different fertilizers (N, P related, chemical and natural fertilisers) with different composition, supply chain, and impacts in the fertilizing process. Furthermore, emissions of pesticides to water and soil as well as N2O emissions are expected, but not reported in this source.

2.2 Cotton yarn production

The process for producing the cotton yarn (spinning) consumes 9961.7 kWh according to Koç and Kaplan (2007) (see Figure 8) and 3000 kg yarn can be produced with this amount.
Assume that there is 10% loss of material.

Figure 7. Cotton yarn spinning, taken from http://www.geograph.org.uk/photo/3521089

Consumption place	Energy consumption, kWh	Share, %
Machines	7121.5	71.3
Compressors	769.5	7.7
Illumination	322.7	3.5
Air Conditioning	1748.0	17.5
TOTAL	9961.7	100.0

Figure 8. Total energy consumption for yarn production taken from Koç and Kaplan (2007), p.23

2.3 Cotton textile production

For the machines in the weaving process Koç and Cinçik (2010) determined a specific electric energy consumption of 1.1950 kWh/kg woven fabric (see Figure 10).

Figure 9. Cotton weaving machines, taken from http://www.yourarticlelibrary.com/industries/cotton-textile-industry-in-india-production-growth-and-problems/19704/

Assume that there is 1% of material loss during the weaving process.

Machines	Operatin time, min.	Electrical energy used by machines, kWh	Specific energy used by machines, kWh/kg
Warping machine	493.3	28.700	0.0030
Sizing machine	881.0	302.500	0.0320
Automatic drawing in machine	348.4	34.900	0.0037
Air jet weaving machine	915 hour	10980.000	1.1500
Total for machines		11346.100	1.1950
Compressors	915 hour	15372.000	-
Total		27718.100	-

Figure 10. Energy consumption of machines taken from Koç and Ciçik (2010), p. 18

Assume that our T-shirt is woven, sized and warped. This is a possible way of production; another would include knitting, cutting and sewing instead. These production steps obviously should be very clear beforehand (i.e. before starting to collect data) since they are more difficult to change afterwards.

3 Workshop

The exercise is divided into 3 parts.

- In the first part process datasets are created on the basis of the information given.
- In the second part, when all process datasets are created, they will be put together and linked to each other on the product system level.
- Finally, a discussion will show the areas that are most critical for dataset creation

Exercise 3: Creating processes

- Separate into 3 groups
- Each group creates one of the processes from the cotton textile production chain in openLCA:
    - Cotton fiber production
    - Cotton yarn production
    - Cotton textile production

- Use the data from chapter 2. Before creating a process in openLCA, all flows (product, elementary, waste) must be defined/created first. To create a new flow, right-click on the "Flows" folder and select "New flow". Name the flow and choose the flow type and property. For this exercise three product flows are needed (as outputs of the three processes):

Cotton fibres
Cotton textile
Cotton yarn

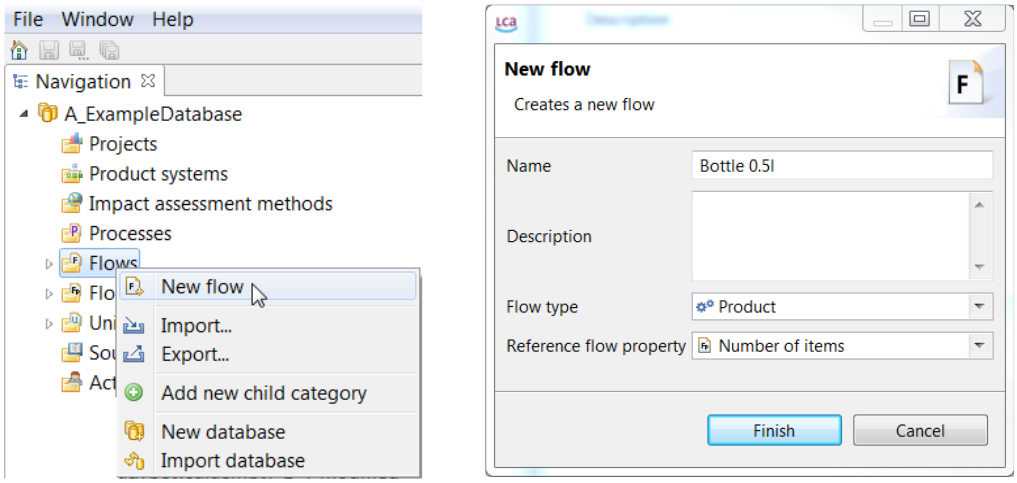

Figure 11. Creating a new flow

- Creating a process works in the same manner. Besides the name, the quantitative reference (which is the reference output of the process) needs to be chosen.

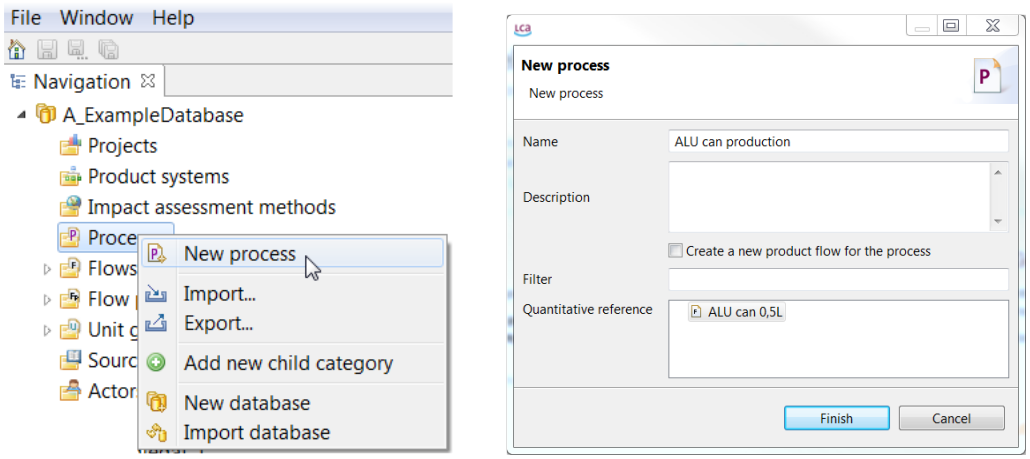

Figure 12. Creating a new process

The following three processes need to be created for this exercise:

- Cotton fibre production
- Cotton textile production
- Cotton yarn production

After their creation the process datasets can be filled in the "Inputs/Outputs" tab (see Figure 13).

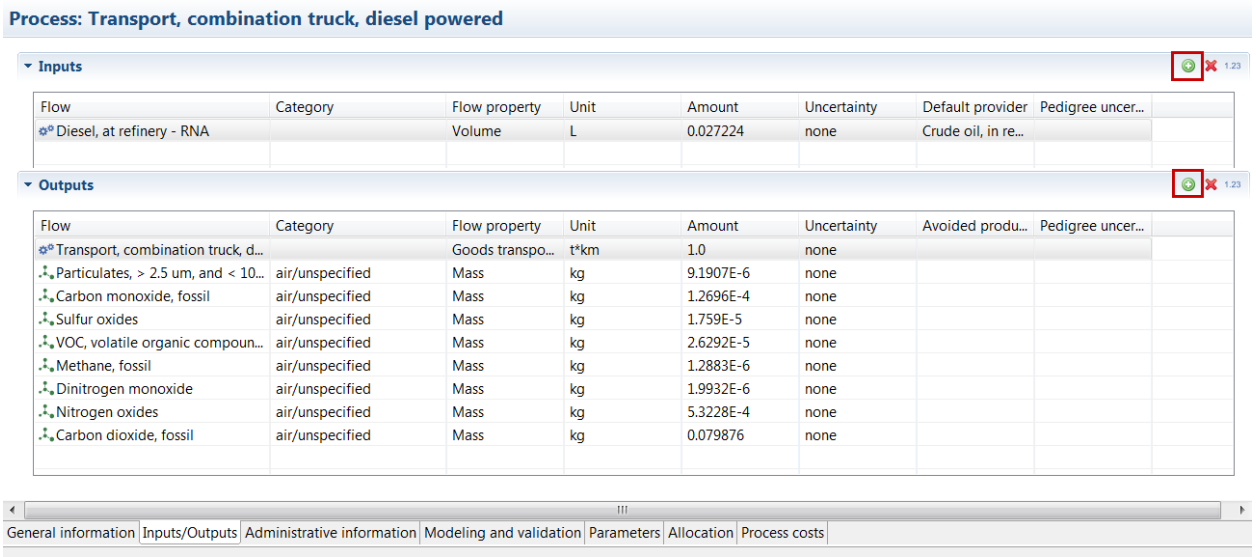

Figure 13 Defining inputs and outputs of a process

Based on the data given, the three processes can look like this in openLCA:

Process: Cotton fibre production

Inputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Default prov...	Pedigree un...
cottonseed; at harvest in 2...	Agriculture, forestry...	Mass	kg	0.02	none		
Electricity, at grid, US, 200...	Electricity	Energy	MJ	59.8	none	Electricity, a...	
Fertilizer, unspecified		Mass	g	457.0	none		
Pesticides, unspecified		Mass	g	16.0	none		
Water, unspecified		Mass	kg	22200.0	none		

Outputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Avoided pro...	Pedigree un...
Cotton fibres		Mass	kg	1.0	none		
Carbon dioxide, in air	air/unspecified	Mass	g	4265.0	none		
Methane	air/unspecified	Mass	g	7.6	none		
Carbon monoxide	air/unspecified	Mass	g	16.1	none		
Nitrogen oxides	air/unspecified	Mass	g	22.7	none		
Sulfur dioxide	air/unspecified	Mass	g	4.0	none		

Figure 14. Cotton fibre production process

Note that, as fertilizers, pesticides and water are not available as product flows in the database yet, they need to be created first before they can be added to the process. Those flows should also be further specified (what kind of fertilizer, water etc.) in a next step.

Process: Cotton yarn production

Inputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Default provider	Pedigree uncer...
Cotton fibres		Mass	kg	1.1	none	Cotton fibre pr...	
Electricity, at grid, US, 2000 - RN...	Electricity	Energy	kWh	3.32	none	Electricity, at g...	

Outputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Avoided product	Pedigree uncer...
Cotton yarn		Mass	kg	1.0	none		

Figure 15. Cotton yarn production process

You also see that material lost within this process (100g as difference between cotton fibres and cotton yarn) is not yet considered in the example process.

Process: Cotton textile production

Inputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Default provider	Pedigree uncer...
Cotton yarn		Mass	kg	1.01	none	Cotton yarn pr...	
Electricity, at grid, US, 2000 - RN...	Electricity	Energy	kWh	1.68	none	Electricity, at g...	

Outputs

Flow	Category	Flow property	Unit	Amount	Uncertainty	Avoided product	Pedigree uncer...
Cotton textile		Mass	kg	1.0	none		

Figure 16. Cotton textile production process

→ see GGP 2.2 generation of unit process dataset, esp.:

2.2.3 raw data collection

2.2.4 calculation and

2.2.5 other supportive information

Exercise 4: Creating product systems

- Create together a product system, name the system and choose the reference process (i.e. the last process in the production chain).

- For this exercise, the different process datasets should be imported into one database.
- Right-click on the Product systems folder and select “New product system”. Give the product system a name and choose the reference process (Cotton textile production).

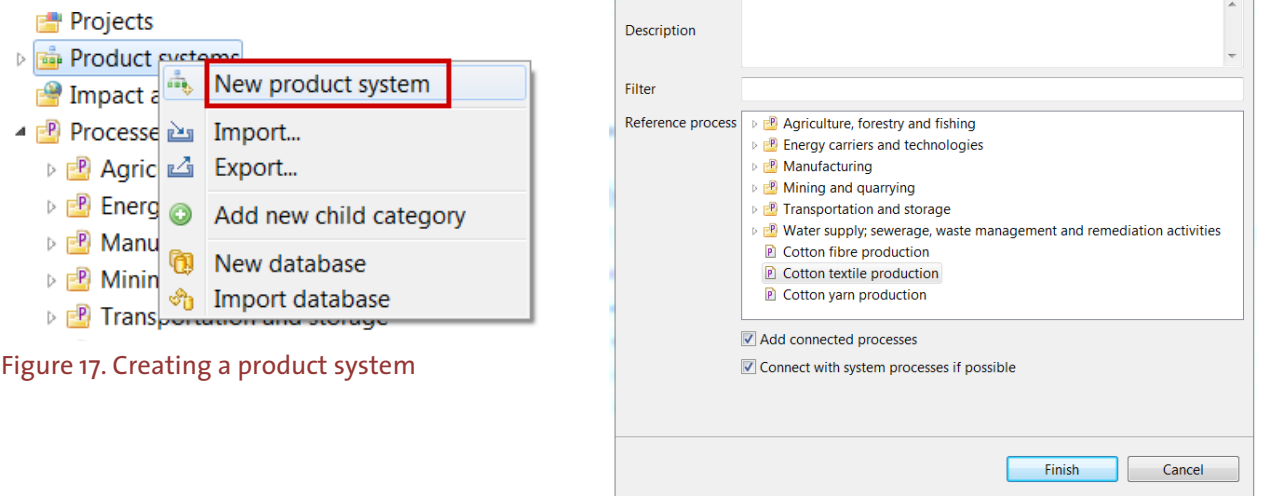

Figure 17. Creating a product system

- Check the model graph to see what connections have been build up.

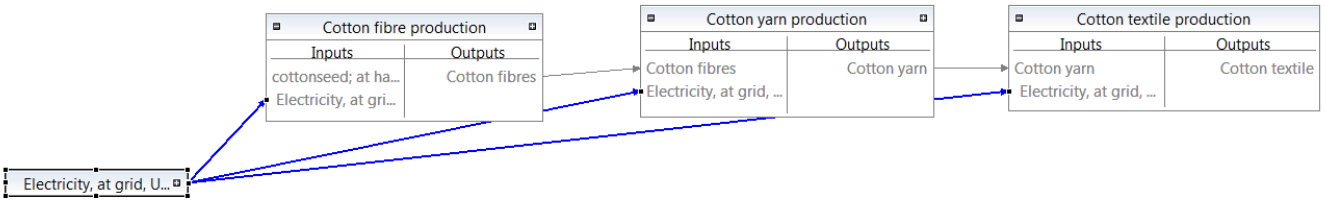

Figure 18. Model graph for the product system

openLCA can automatically build the supply chain and link the datasets to background processes from the database such as electricity production. This happens when you select “Add connected processes”

and “Connect with system processes if possible”.
The unit processes are linked internally via the product flow names.
To comply with the GGP, information about the product system should be inserted in the “General information” tab (→ GGP 4.2 dataset documentation).

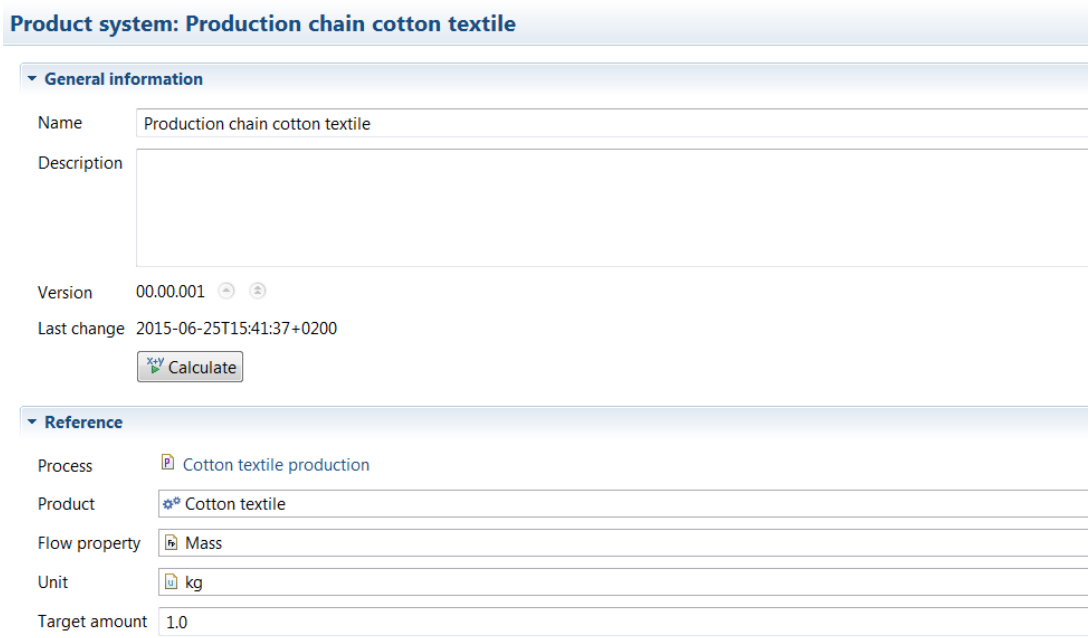

Figure 19. General informations tab for product system

In the model graph, one can right-click on a process and select “open in Editor” where all information about the process dataset is shown again and can be edited. Here the participants can see what the others have documented and they can add further information. Information about the electricity process from the database can also be checked this way (Figure 20).

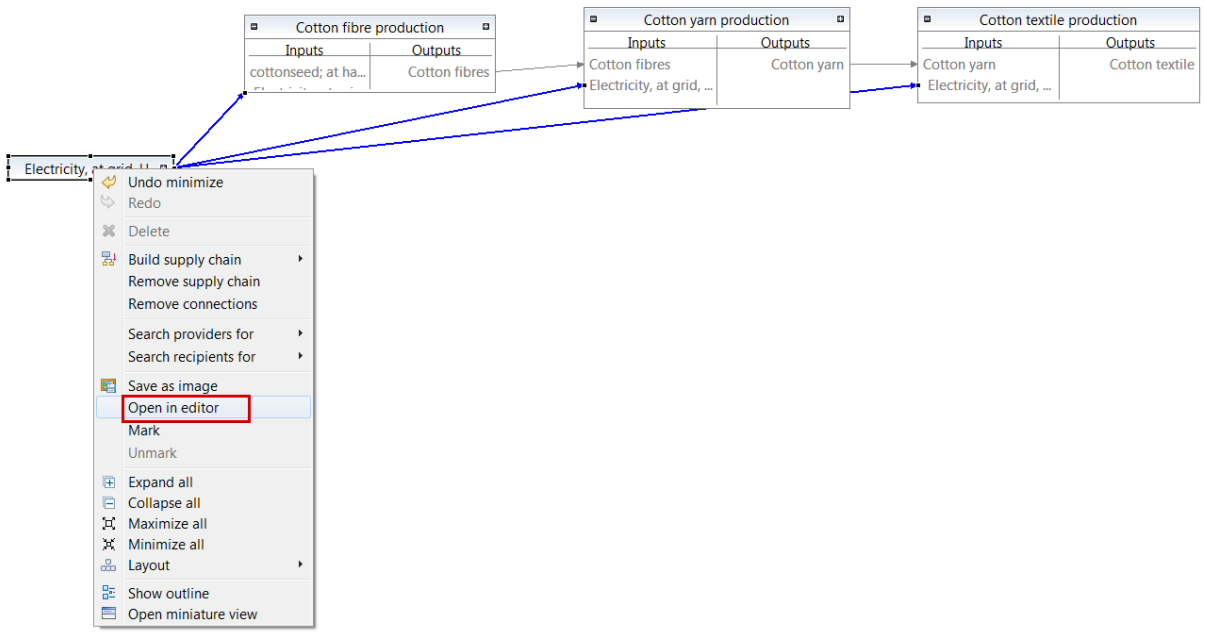

Figure 20. Opening a process from the model graph of the product system

Exercise 5: Discussion

- Discuss which issues occurred and what questions arose during the process and product system creation

- What information is needed when creating datasets?
- What information was not available from the data given?
- What should have been agreed upon beforehand? (Flow names, flow types, reference flow..?)
- If needed, repeat the exercise after the discussion

4 References

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Koç and Cinçik (2010): *Analysis of energy Consumption in Woven Fabric Production*. In: FIBRES & TEXTILES in Eastern Europe 2010, Vol. 18, No. 2 (79), pp.14-20

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