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EUCALC

Explore sustainable European futures

Initial version of the model

D8.1

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Short Description
This deliverable is a practical presentation showing the overview of the current model development, we designed it to include many illustrations and visuals.

Quality check	
Name of reviewer	**Date**
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Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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List of abbreviations and glossary

Ambition	The degree of low carbon mitigation effort.
Levers	Sliders which move from a minimal abatement position (level 1) to an extremely ambitious position (level 4).
Model	The model performing the calculation to provide results for the specified lever positions.
Module	Unit of the Model. The modules are connected together to form the model. The modules are developed by different partners of the consortium and are most of the time called sectors.
CORE Model	The CORE model is the first version of the model working with the CORE modules. Those modules form the central part of the model and are the following: - 1.1 Lifestyle - 1.2 Technology - 2.1 Buildings - 2.2 Transport - 3.1 Industry - 4.3 Agriculture - 5.0 Power - 5.3 Biomaterials
Non-CORE additions to the model	The future versions of the model will include some additional features in the CORE modules. In addition, the future versions of the model will include the following modules: - 1.2 Climate - 3.2 CCUS - 4.2 Minerals - 4.4 Water - 4.5 Biodiversity - 5.4 Water-energy nexus - 6.1 Energy security - 6.2 Education - 6.3 Human health and safety - 6.4 Employment - 6.5 Working conditions - 7.1 baseline projection - 7.2 GTAP-EUCalc interface - Economy - EU & Rest of World

Compilation	The process of translating from a program description (in KNIME) to an executable program (in Python).
Python	The programming language in which the compiled model runs.
Node	A KNIME calculation element or group of calculation elements.
Metanode	Metanodes are nodes that contain sub-workflows, i.e. in the workflow they look like a single node, although they can contain many nodes and even more meta nodes.
CalcNode	A KNIME node which the project has written in Python.

1 Executive Summary

This deliverable is a practical presentation showing the overview of the first version of the model. We designed it to include many illustrations and visuals.

This document shows how the model runs and how we assemble the different modules. We explain the way we share the visualization of the model internally and with stakeholders to validate the model as well as to be transparent regarding our method.

Regarding the timing of this deliverable; in the original project planning, the 'initial version of the model' (D8.1) was expected by end of 2017, and the '28+1 version of the model' (D8.2) was expected end April. However, we chose to upload both deliverables simultaneously. The delay in D8.1 is explained by our choice to radically change the underlying technologies and architecture.

The technology and architectural change facilitate the inclusion of additional model features (e.g. more precise analysis by model, coverage of multiple geographies, use of visual programming, collaborative working, solution scaling).

2 Introduction

This deliverable serves as an overview of the work done on the EUCalc model over the last one and a half year. It contains practical content with examples, prototype description, images and figures without going through the rationale of the architectural, modelling, and programming environment choices. To understand the argumentation supporting each of these choices, refer to deliverable D8.2.

The model development progress is illustrated in Figure 1. The execution limitations of the initial version are illustrated in orange on Figure 1: the data collection is not yet fully accomplished for all modules and the visual programming in KNIME does not yet reach the depth expected of CORE module (i.e. it is currently less complex than the Global Calculator[1]).

Regarding the timing of this deliverable; in the original project planning, the 'initial version of the model' (D8.1) was expected by end of 2017, and the '28+1 version of the model' (D8.2) was expected end April. However, we chose to upload both deliverables simultaneously. The delay in D8.1 is explained by our choice to radically change the underlying technologies and architecture. This choice is significantly more time consuming for the early phases of the project than an iterative improvement of the excel based solution used in the Global Calculator. On the other hand, the development environment allows us to have directly the 28+1 countries incorporated inside the model without having to go through the first step. On the long term, we also consider that this radical technology and architectural change will enable the inclusion of many more features in the model.

Regarding the project timing, we are confident the model development can remain on track regarding the inclusion of additional features and modules in the next months. This is what we present in the next section of this document.

[1] The Global Calculator is a model of the world's energy, land and food systems to 2050 (http://tool.globalcalculator.org/globcalc).

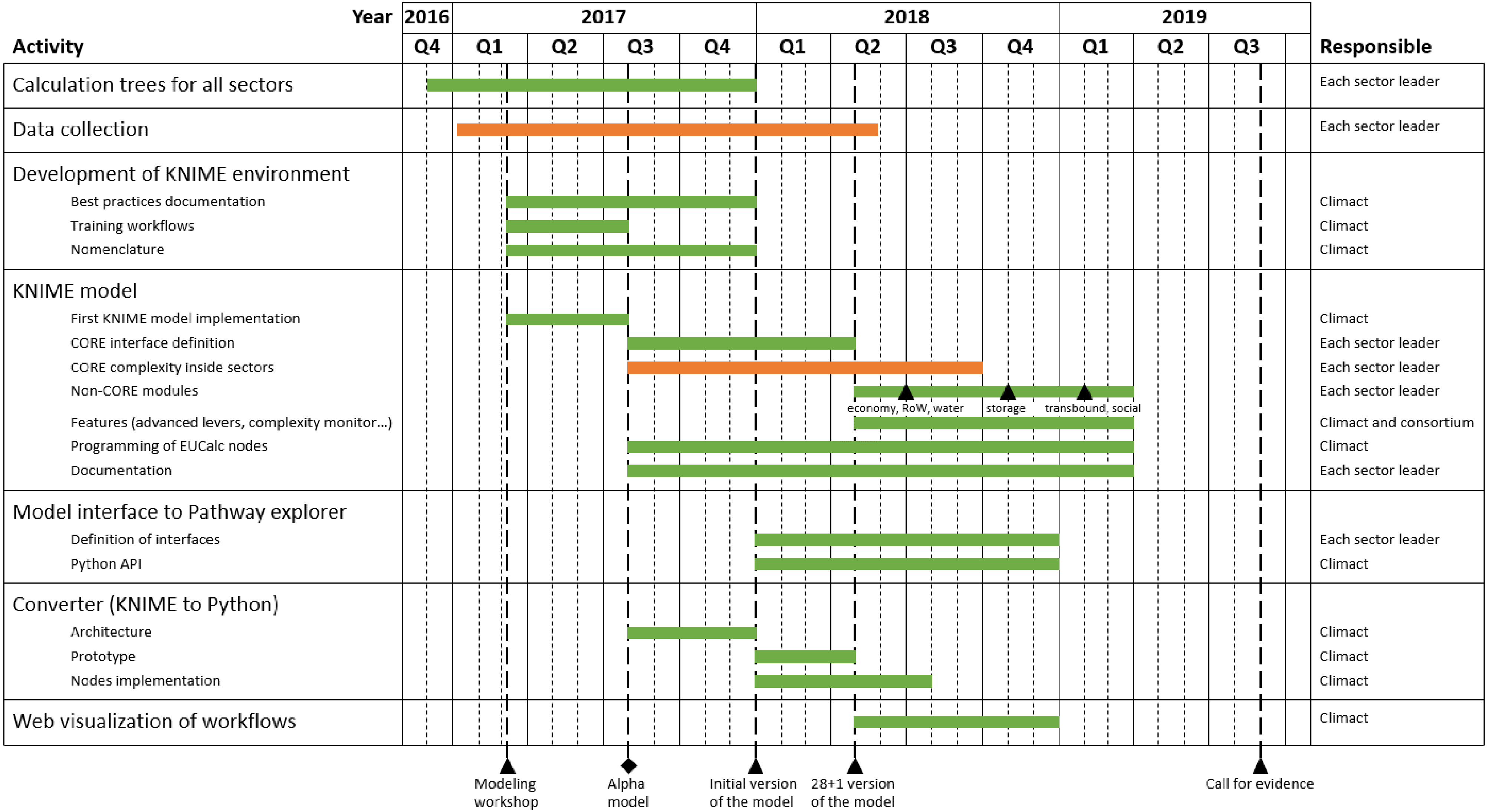

Figure 1.Overview of the planning of the model development.

***Green** bars represent on-time activities. **Orange** bars represent ongoing activities that are a little bit delayed. **Red** bars represent ongoing activities that are significantly delayed (there is no such delay in the activities for the moment).*

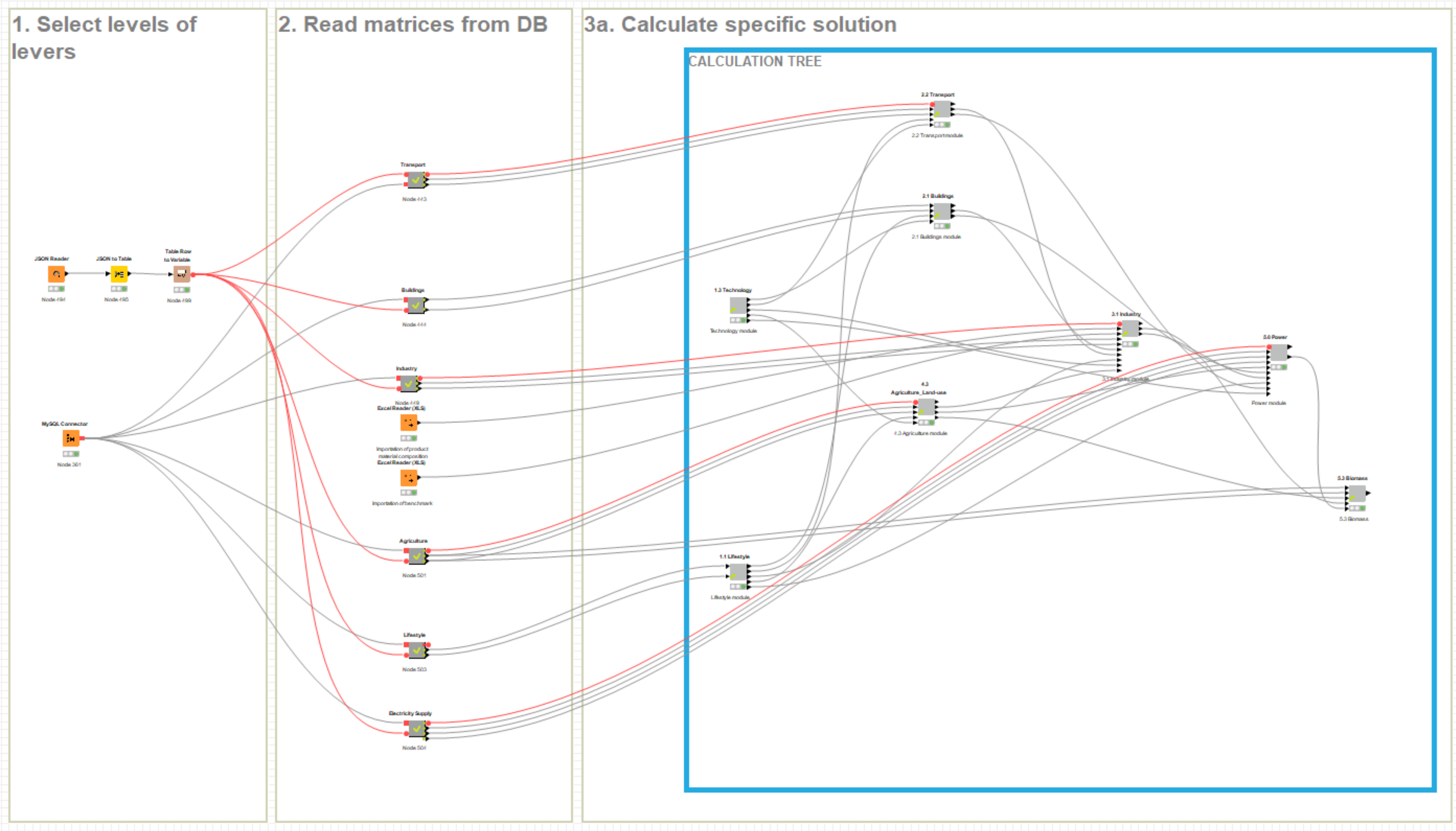

Figure 2 Overview of the KNIME model

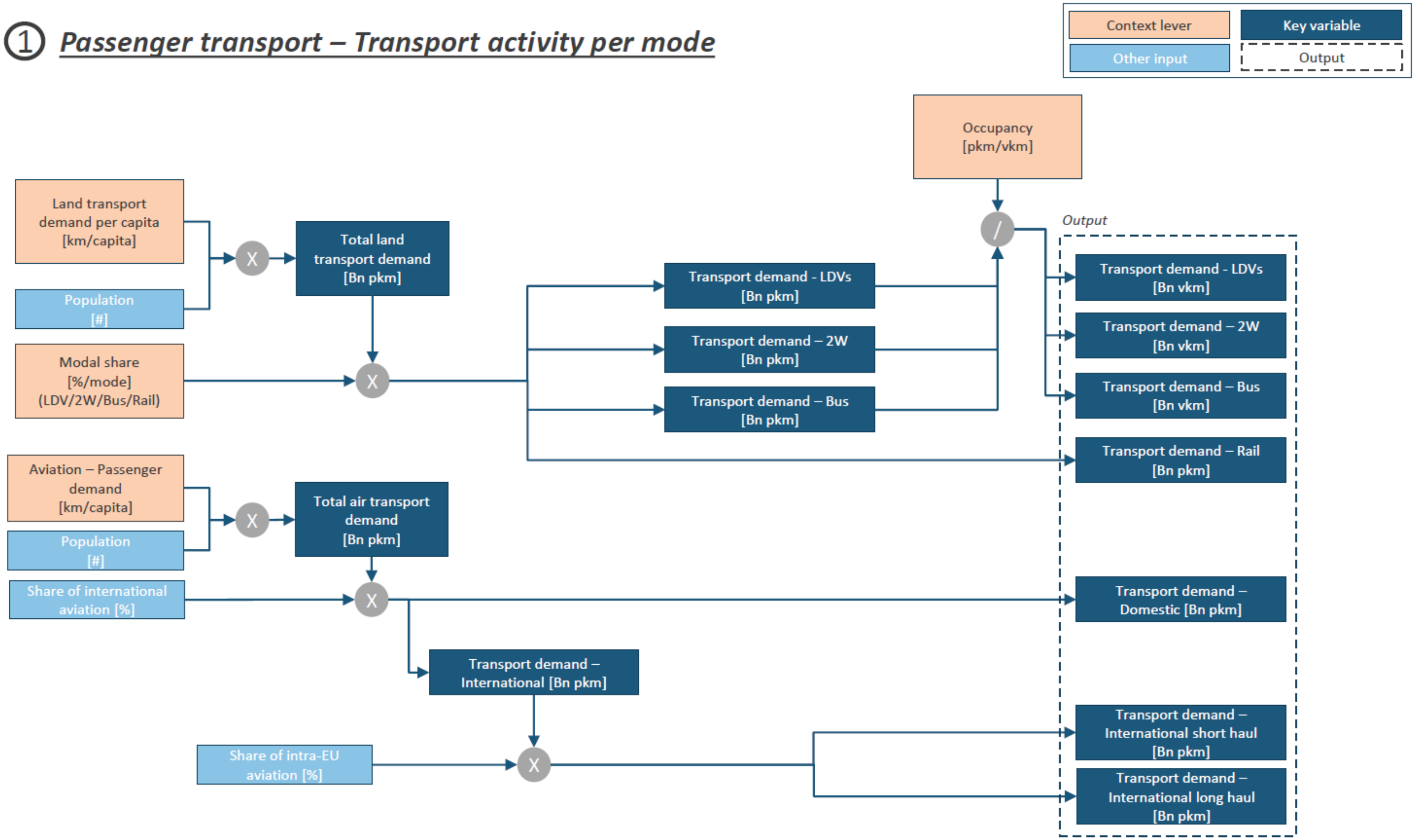

Figure 3. Calculation tree for the transport sector

3 Model presentation

The overview of the KNIME model, with all the different sectors of the CORE model is illustrated on Figure 2[2]. KNIME is a visual programming language (see further details about the technology in Deliverable 8.2), its calculation flows must be read from left to right. Users can iteratively zoom in each box (node) to access the workflow details and documentation on demand. While this type of overview may be surprising for users less exposed to visual programming, there is a growing consensus that these flows provide one of the easiest ways to communicate data analytics.

When zooming in each of these nodes, all KNIME workflows are decomposed in three main steps; as illustrated by Figure 2:

1. Select levels of levers: The level selection for each lever and the initialization of the data base connection;
2. Read matrices from DB: The corresponding links of the lever to the database;
3. Calculate specific solution: The calculation trees developed by each sector leader.

This last step follows the rationale illustrated in Figure 3 for the transport sector. When grouping the nodes of each module in one meta node, we obtain the overall model in Figure 4. This last image is simplistic but easy to understand and is the kind of image we use for internal and external discussion when presenting the model.

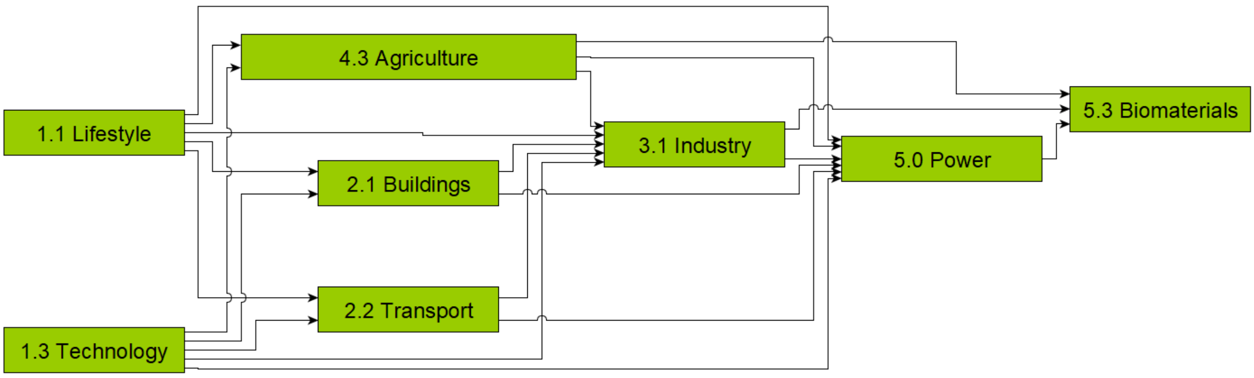

Figure 4. CORE model representation

Then the module results are written to be used by another module or as final model results. To ensure a common understanding between all modules, e.g. which parameters are sent and received by each module, we iteratively defined the module interfaces.

Using a predefined Google sheets template, the teams iterated until alignment (see

Figure 5). One sheet has been developed for each interface between two modules leading to roughly 35 interfaces. These aligned interfaces have then been implemented inside the KNIME model.

In Table 1, we illustrate the outputs of the model which originate from each module. This very preliminary view is still work in progress. Also, it only illustrates the final model outputs, excluding the inter-modules input/outputs (e.g. from Transport to Industry).

[2] The segmentation between CORE and Non-CORE is illustrated in the glossary

Category	2.1 Buildings	2.2 Transport	3.1 Industry	4.3 Agriculture	5.0 Power	5.3 Biomaterials
Activity & indicators	• Living space per person • # buildings per type	• Travel per person • Efficiency of vehicles	• Energy consumption per vector	• Food consumption	• Composition of the production mix • Natural gas import/local	• /
Product & materials	• # m² buildings per type	• # vehicles per type	• # Consumer goods • Material demand and production	• # animals • Crop surface	• # power plants by type	• Biomaterial use by type
Resources (incl. land use, water)	• In Non-CORE	• In Non-CORE	• In Non-CORE	• In Non-CORE	• In Non-CORE	• In Non-CORE
Energy	• Final energy consumption per vector • Energy demand per floor area	• Final energy consumption per vector	• Final energy consumption per vector	• Final energy consumption per vector	• Final energy consumption per vector • Total energy produced • Energy self sufficiency	• Final energy consumption per vector
GHG	• Emissions scope 1 • Scope 3 in non-CORE	• Emissions scope 1 • Scope 3 in non-CORE	• Emissions scope 1 • Scope 3 in non-CORE	• Emissions scope 1 • Scope 3 in non-CORE	• Emissions scope 1 & 2 • Scope 3 in non-CORE	• Emissions scope 1 • Scope 3 in non-CORE
Social impacts (employment, skills), Energy system costs, Transboundary effects, Pollution/health effects, energy poverty, Biodiversity, Food & materials self-sufficiency, equity measure	• In Non-CORE	• In Non-CORE	• In Non-CORE	• In Non-CORE	• In Non-CORE • Energy production cost	• In Non-CORE

Table 1. CORE Model outputs

Legend		
	Core	
	Non-Core	

Compare with Industry interface definition

Naming convention	Alignment with Industry	Inputs	type	subtypes	Unit	country	year	Format check
	Yes	/	/	/	/	/	/	Column name, type, values...

Naming convention	Alignment with Industry	Outputs	type	subtypes	Unit	country	year	Quality checks	Format check
fts_tra_cars-ICE[num]	Yes	Vehicles	Cars	ICE	# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_car-FCV[num]	Yes			FCV					
fts_tra_car-EV[num]	Yes			EV					
fts_tra_trucks-ICE[num]	Yes		Trucks and bus	ICE	# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_truck-FCV[num]	Yes			FCV					
fts_tra_trucks-EV[num]	Yes			EV					
	Yes		Batteries & Fuel cells (for cars)		# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
	Yes		Batteries & Fuel cells (for trucks & buses)		# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_ships[num]	Yes		Ships		# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_trains[num]	Yes		Trains		# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_planes[num]	Yes		Planes		# new vehicles	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_road[km]	Yes	Infrastructures	Road		km	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_rail[km]	Yes		Rail		km	Memberstate level	yearly	ranges, non-nega	Column name, type, values...
fts_tra_trolley-cables[km]	Yes		Trolley cables		km	Memberstate level	yearly	ranges, non-nega	Column name, type, values...

Figure 5 Interface definition between transport and industry (one of the 35 Google sheets)

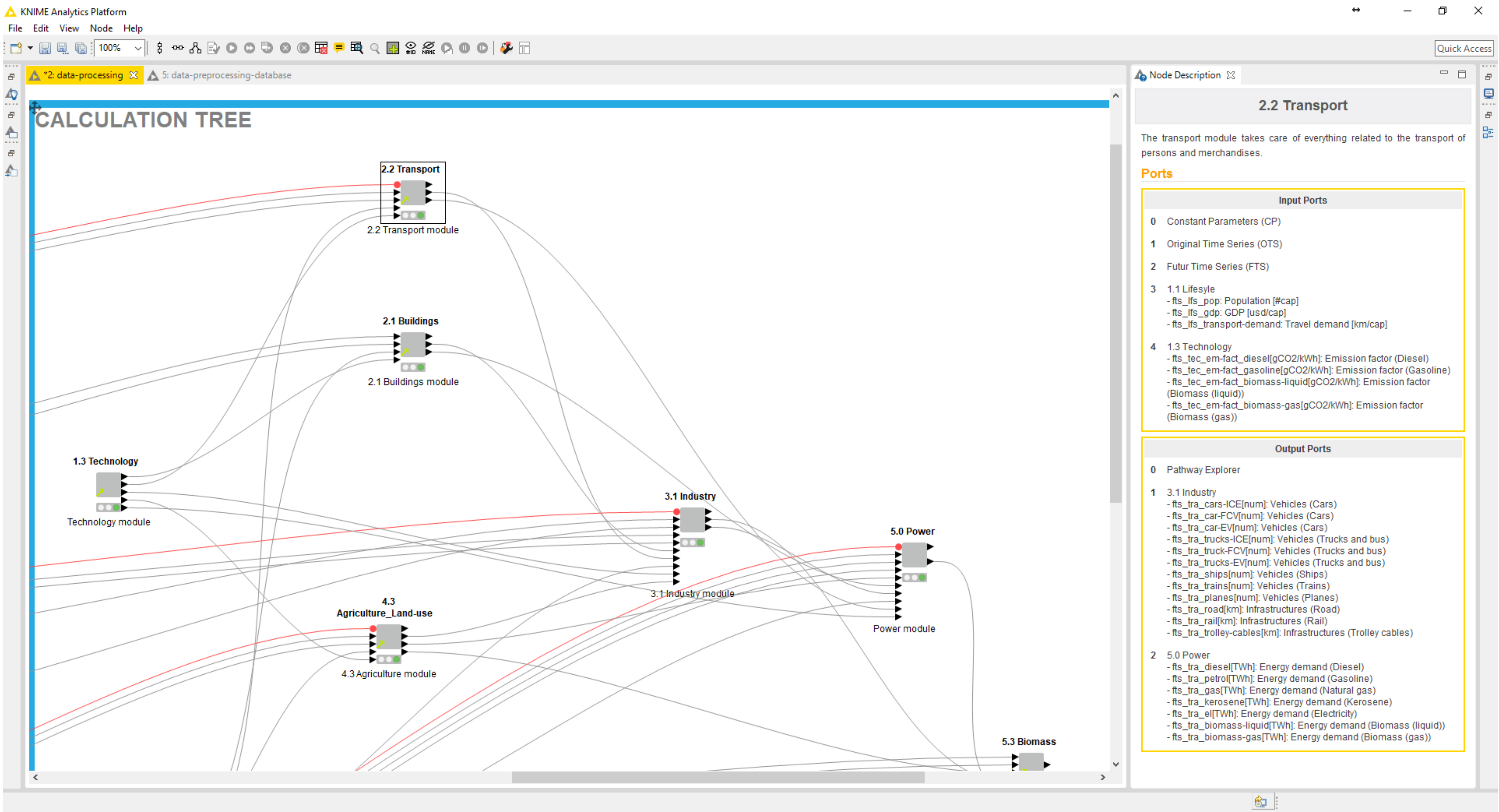

Figure 6. Transport interface (on the right) with other sectors

The Figure 6 shows an example of interface between the transport module and all the other modules. We see on the right of the figure the list of inputs and outputs that are received and produced by the transport module. The definition of those interfaces inside the KNIME is critical to keep the model transparent and to avoid mistakes during the development process. The interface alignment enables the teams to work in parallel on the development of their sector model. This collaborative way of working is a strong new feature of the new programming environment.

The model of each sector can be grouped in one “metanode”. KNIME enables modelers to develop their sector model “metanode” (Figure 8) and share different versions of it with the team. Climact is in charge of collecting the sector metanodes and connecting them together in the main model overview.

Inside each sector-metanode that we just described, the sector leader has the responsibility to develop his/her own calculation trees. The Figure 9 shows what is inside the transport metanode. The documentation is there to explain to the user that there are two sections, one to calculate historical data and another one for scenarios (projections function of the position of the levers). When digging into the historical section we go deeper and deeper in the granularity of the model, as shown in Figure 10 and Figure 11.

The objective behind the visual programming and the granularity proposed is to be able to have a transparent representation of the model allowing the team and anyone to understand how it works; very much in the same way a user understand a calculation tree (e.g. Figure 3). This is central to keep the transparency of the model.

Until now, we went from top to down, from the CORE model to the sectors implementation. The reflection of the whole model is also addressed inside the consortium by looking at model representation as shown in Figure 12. This allow us to keep an overview of the final model, to validate it and to prepare the integration of the non-CORE modules inside the KNIME model.

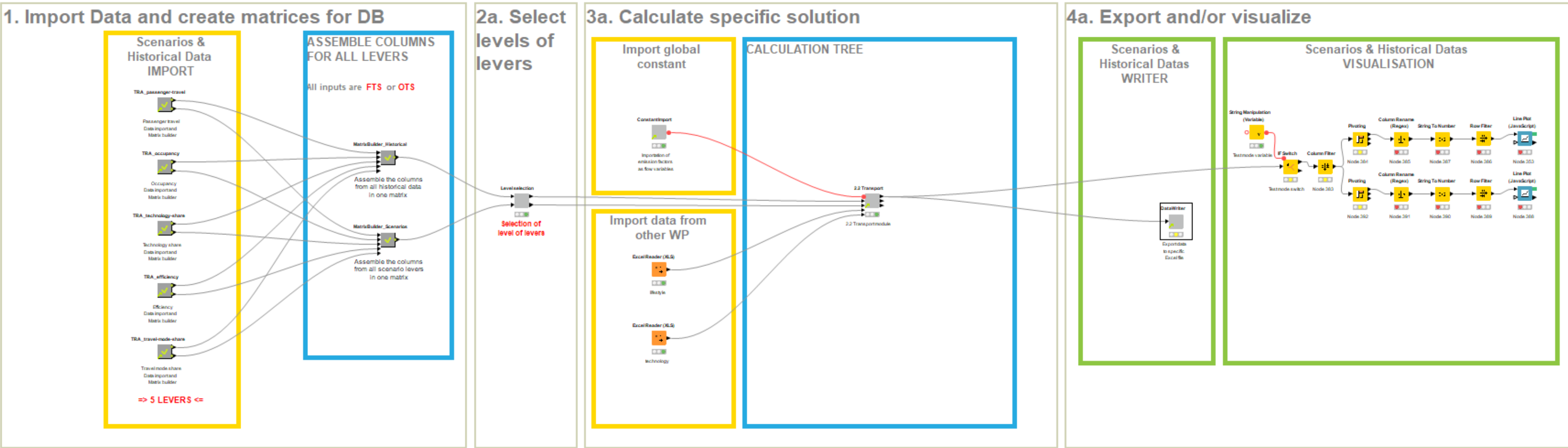

Figure 8. Transport workflow allowing the modeler to work separately from other sectors

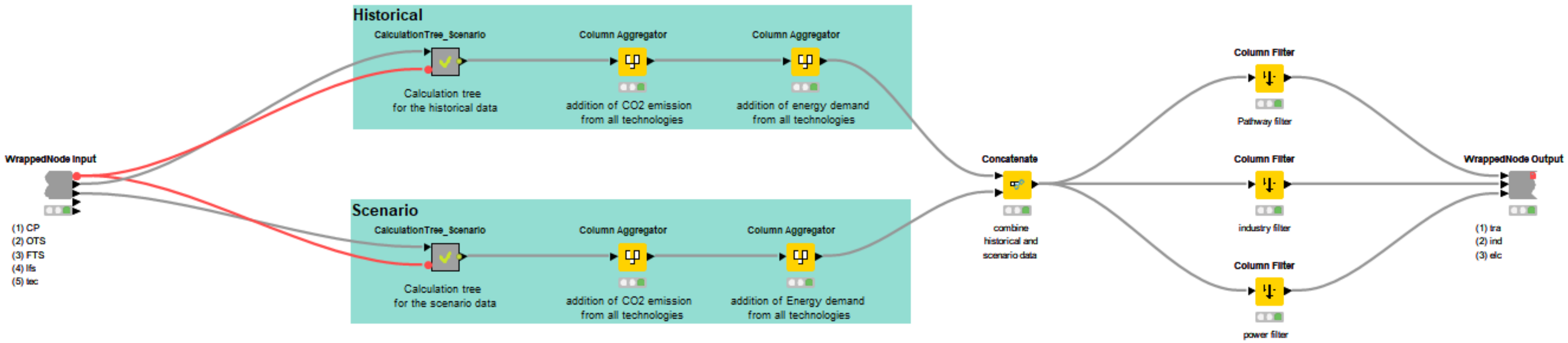

Figure 9. Transport metanode

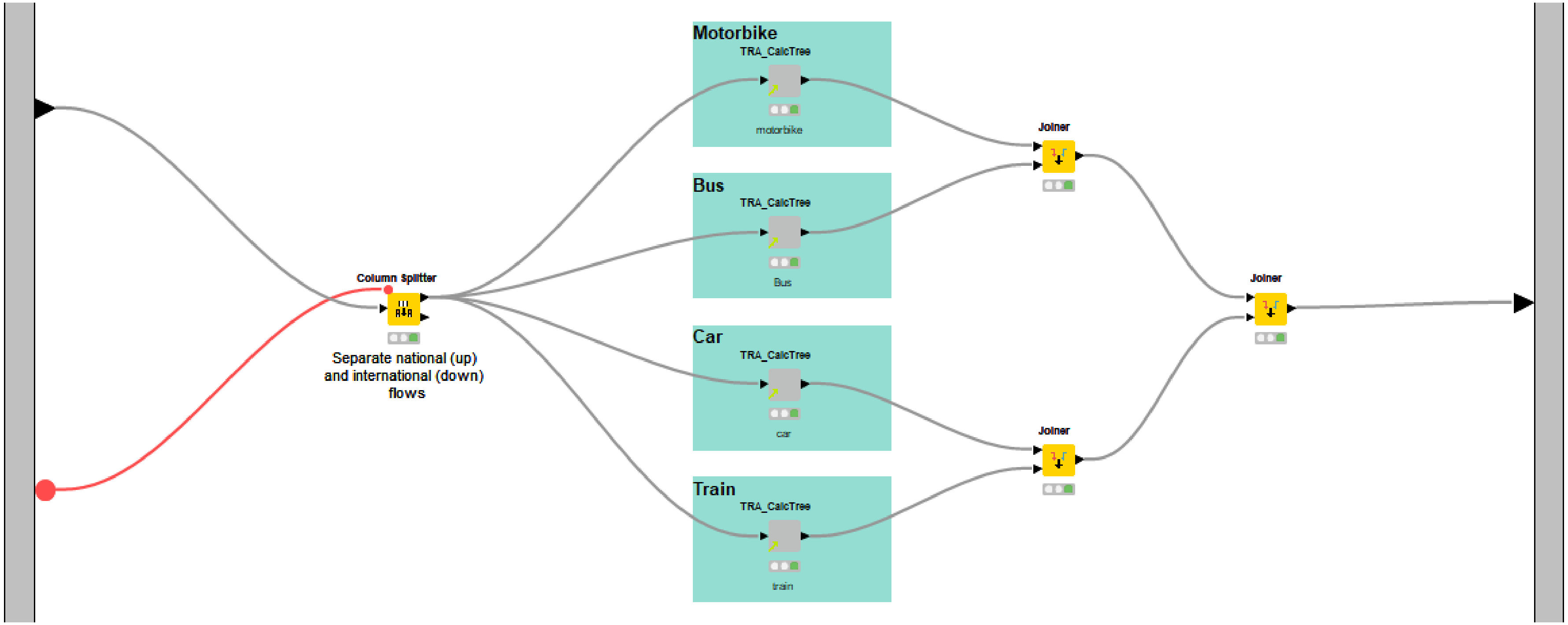

Figure 10. Historical section of the transport module

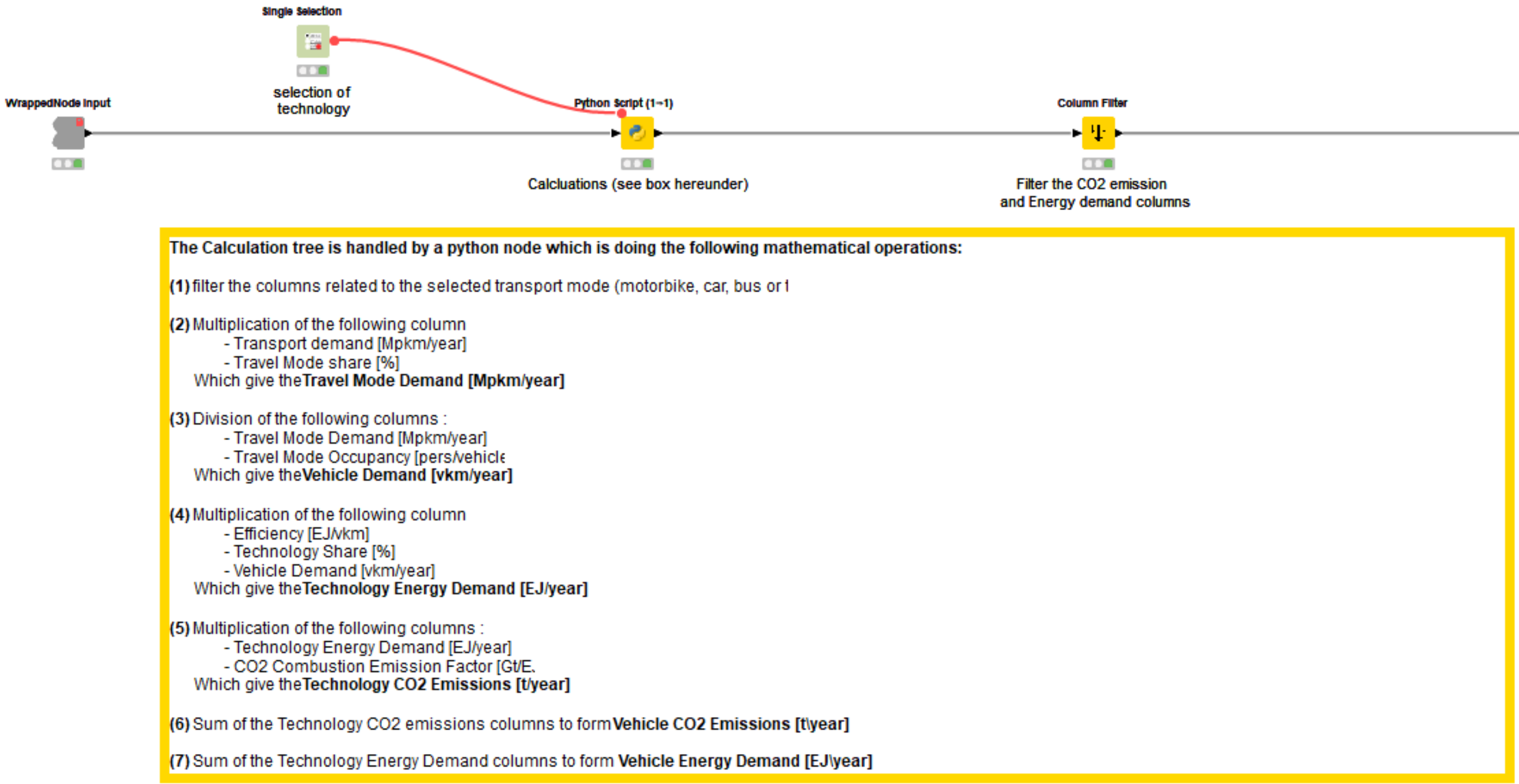

Figure 11. Motorbike section of the historical-transport module

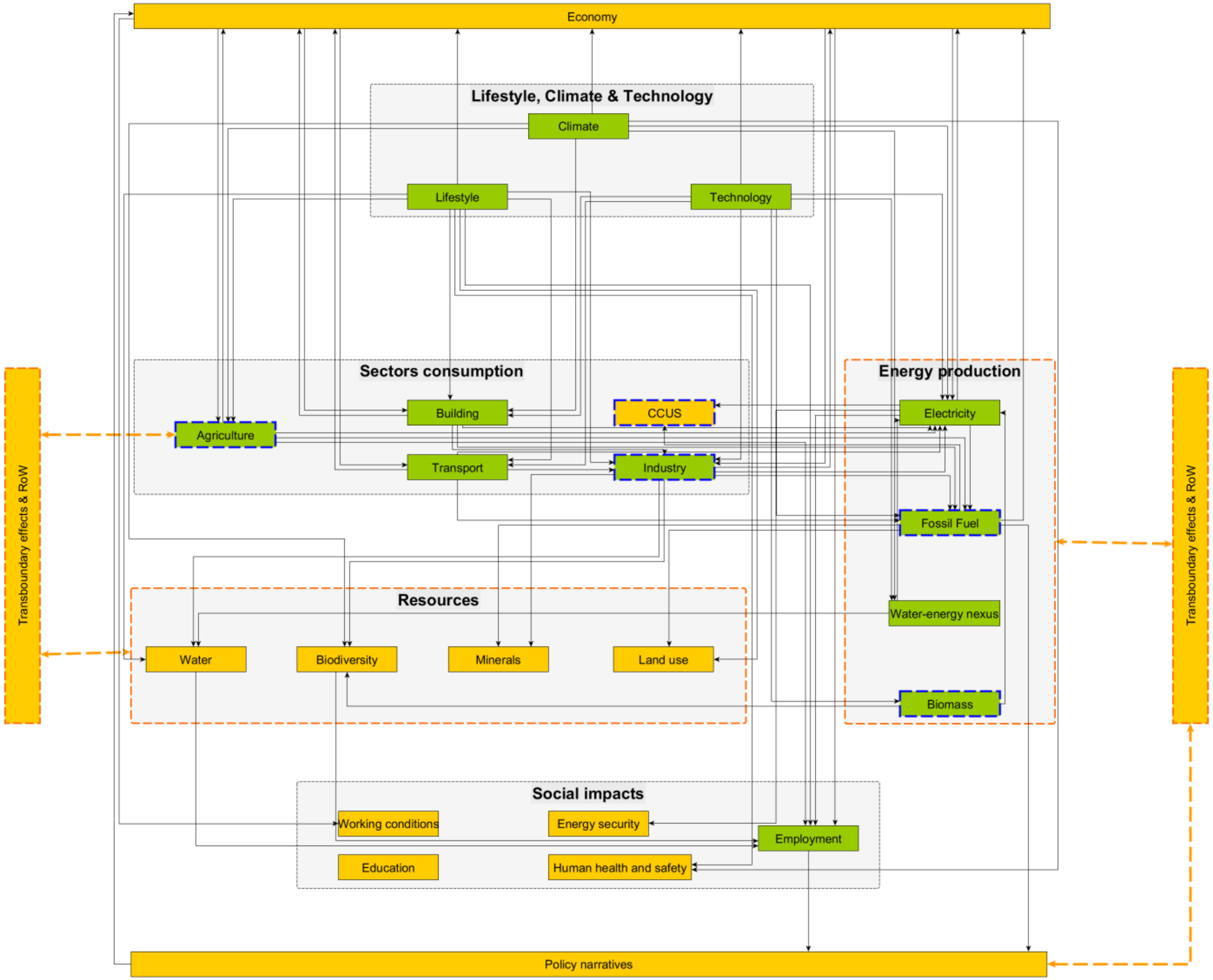

Figure 12. Example of overview of the model for consortium discussion and interaction with stakeholders