A new way to sustainability:

Agent based modelling

Andreas Ciroth

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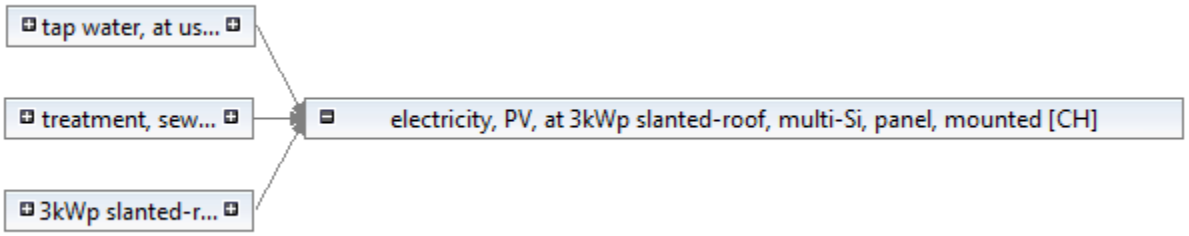
Agenda

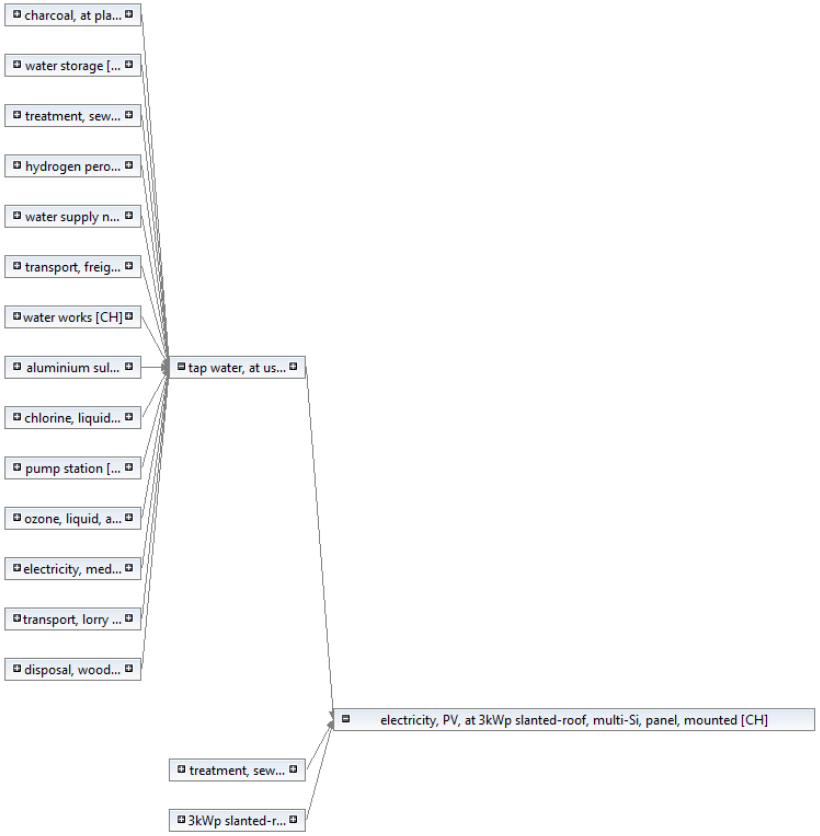
1. The classical LCA approach
2. Agend based modeling and sustainability
3. Principal and practical first examples
4. Bold outlook

1. The classical LCA approach

“the full life cycle”



“the full life cycle”



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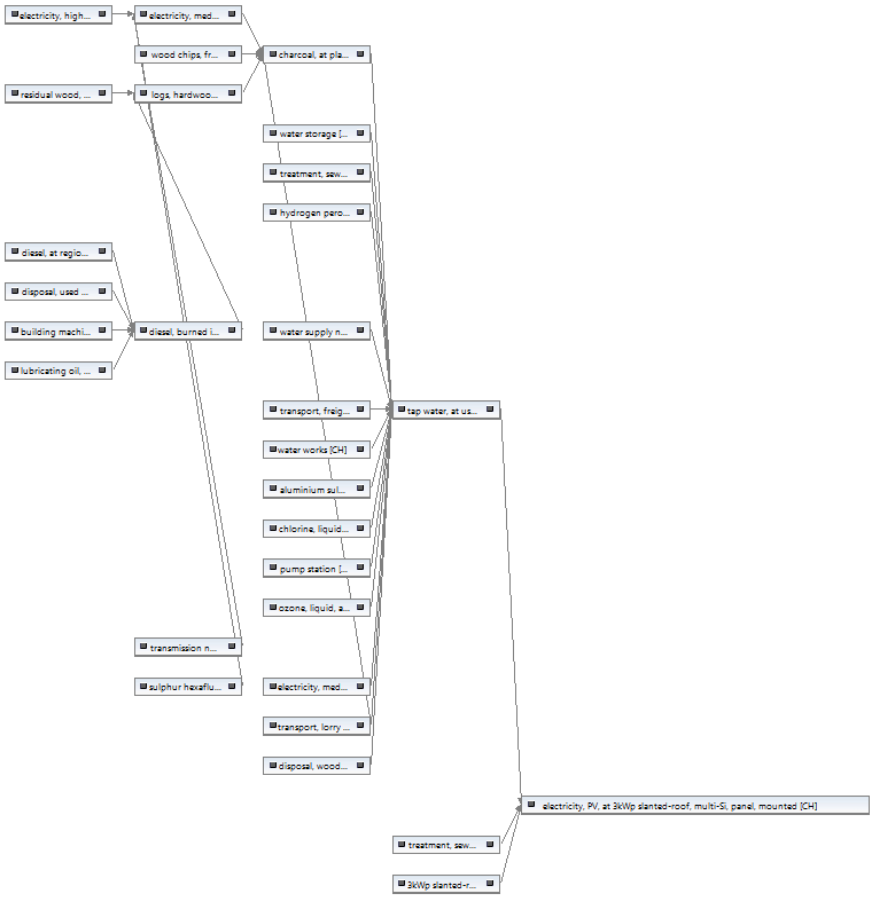

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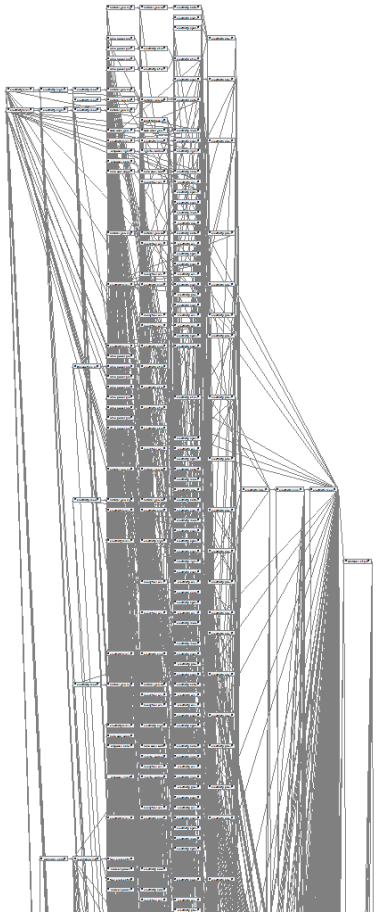


LCA modelling today

- Goal and scope driven
- Iterative
- The attempt to model the full life cycle of a product

the full life cycle

“there is no such thing as a physical life cycle”

Classical LCA modeling assumes an all-knowing LCA modeler

- Sequence and types of processes and products in a life cycle
  - Product substitutions
  - Consequences of changes
  - ...
- Impacts that occur based on the interventions

Classical LCA modeling assumes an all-knowing LCA modeler

- This is not incorrect
- Well-discussed and established framework to deal with this slightly artificial modeling situation (potential impacts, e.g.)

BUT

- Several problems unsolved in classical LCA
- Looking “from the other side” helps

Phase	Problem
Goal and scope definition	Functional unit definition
	Boundary selection
	Social and economic impacts
	Alternative scenario consideration
Life cycle inventory	Allocation
	Cutoff criteria
	Local technical uniqueness
Life cycle impact assessment	Impact category and methodology selection
	Spatial variation
	Local environment uniqueness
	Dynamics of environment
	Time horizons
Life cycle interpretation	Weighting and valuation
	Uncertainty in decision process
All	Data availability and quality

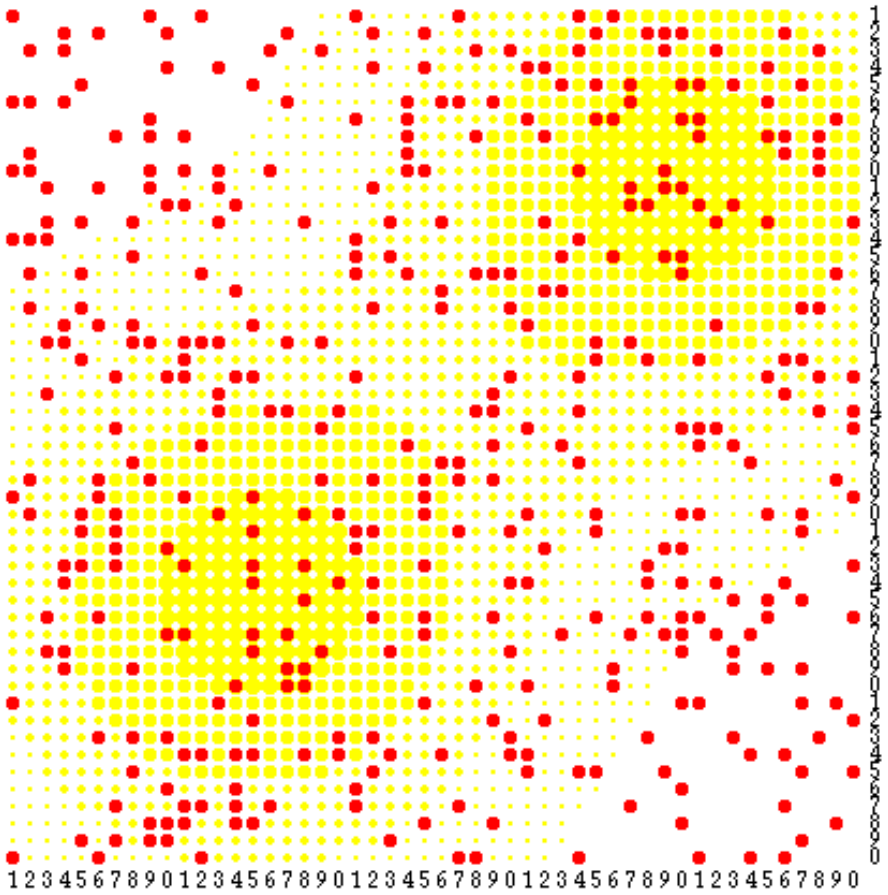
Reap J, Roman F, Duncan S, Bras B (2008a) A survey of unresolved problems in life cycle assessment. Int J Life Cycle Assess 13(4):290–300, 13(5):374–388.

2. Agent Based Modeling and sustainability

“The other side”: Agent Based Modeling

- Principle:
  - Define small, autonomous modeling units, agents, that each have an action space, follow rules, and have interests, and possibilities
  - Populate your model with many of these agents...
  - ...and let them interact

ABM example: Sugarscape



J. M. Epstein, R. Axtell: Growing Artificial Societies: Social Science from the Bottom Up. Brookings Institution Press/MIT Press 1996.

Ideal Outcome of an Agent Based Model

- Macroscopic, large scale structures, results..
- ..based on simple, easy-to-verify rules
- Macroscopic structures “emerge” and need not be modeled explicitly

Tempting applications for ABM
In the field of LCA

- Rebound Effects captured via utility function of agents
- Allocation (dealing with multi-functional processes): addressed as competition for process products
- Market behaviour (consequential vs. attibutional) can be captured directly (agents buy specific products
- Land use and land transformation modeling (LU similar to used products)

And Sustainability?

- Sustainability is about long-term survival and well-being of the human society on earth.
- ABM naturally deals with survival of populations.

3. Principal example

How to apply ABM to the LCA structure a) Goal and scope

Goal and scope should specify the model:

- The agents,
- Their action space
- Rules they follow
- Goals they have
- ….

How to apply ABM to the LCA structure

b) Inventory

Each process is one agent

- Interests: get input products, „sell“ output products
- Market simulation (compare CGE models) !
- Define similar products, available products

How to apply ABM to the LCA structure

c) Impact Assessment

Each endpoint is one agent type

- Depends much on the specific case and interest
- Agents try to avoid damage
- In principle, ecosystems (simplified) can be modeled
- More straightforward for resources

4. First examples

ABM First examples

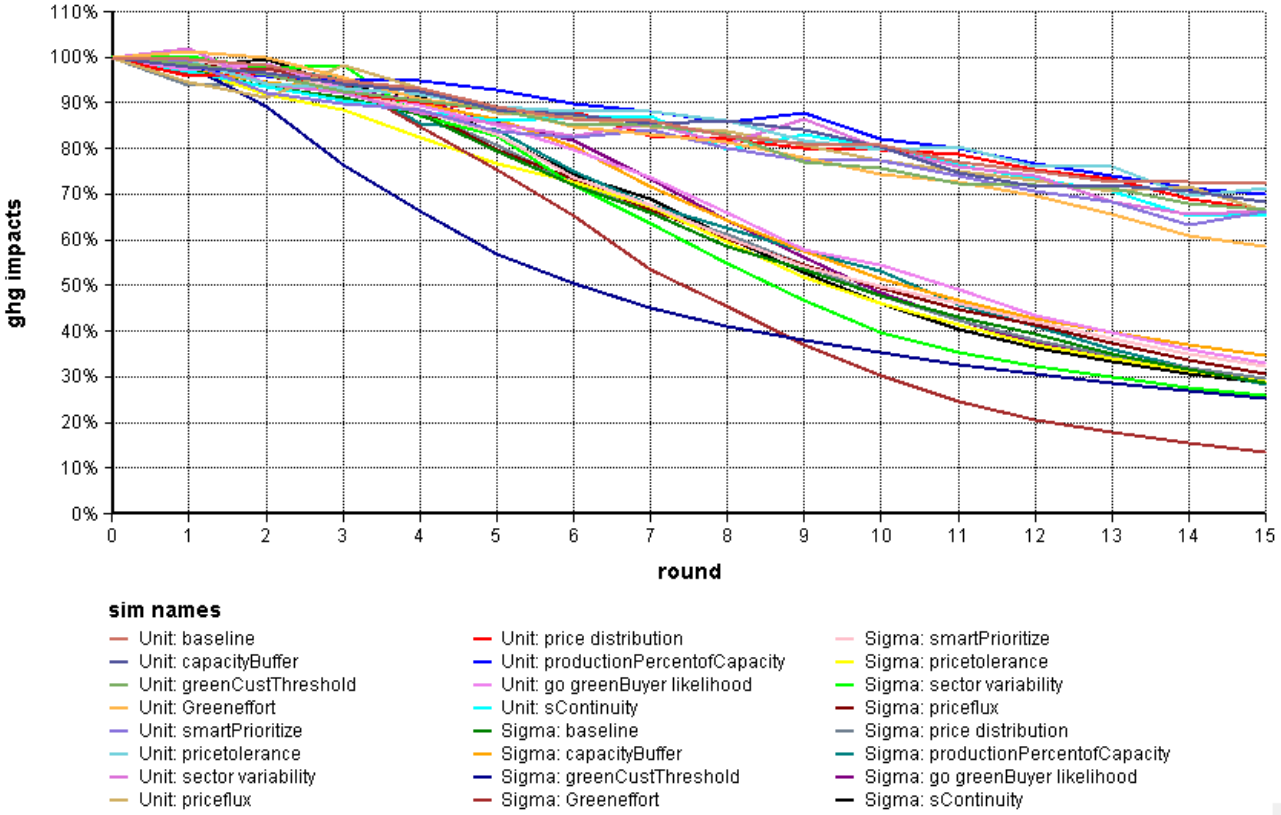
Simulating supply chain greening

- For I/O data, assume several similar companies per sector, as agents, and let these compete and interact
- Here: special interest in how „green consciousness“ is spread

Andrews, E., thesis, Harvard 2009
Green Purchasing Strategies Examined: A bottom-up simulation of environmental adaptation in an economy with, and without, green purchasing based on life cycle assessment

ABM First examples

Simulating supply chain greening



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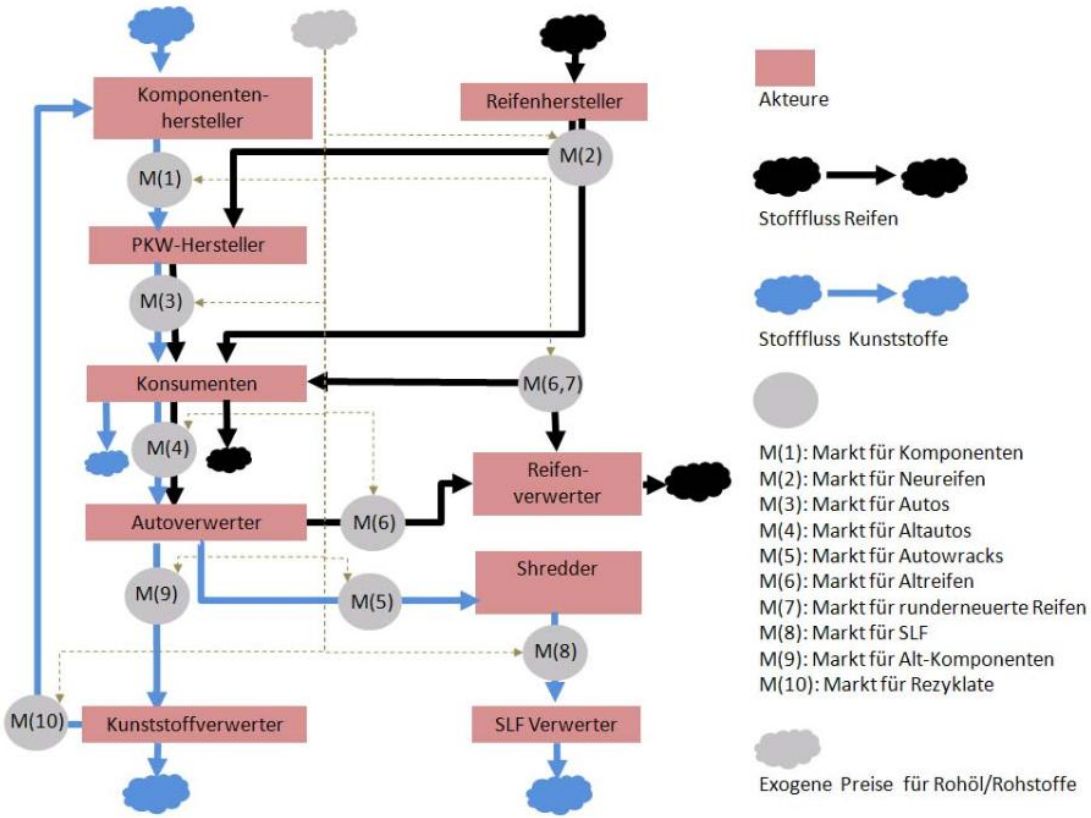
ABM First examples

Car recycling companies as agents



AMOSS project, Univ. Kassel, Simulationsmodell Amflows, 2009

ABM First examples

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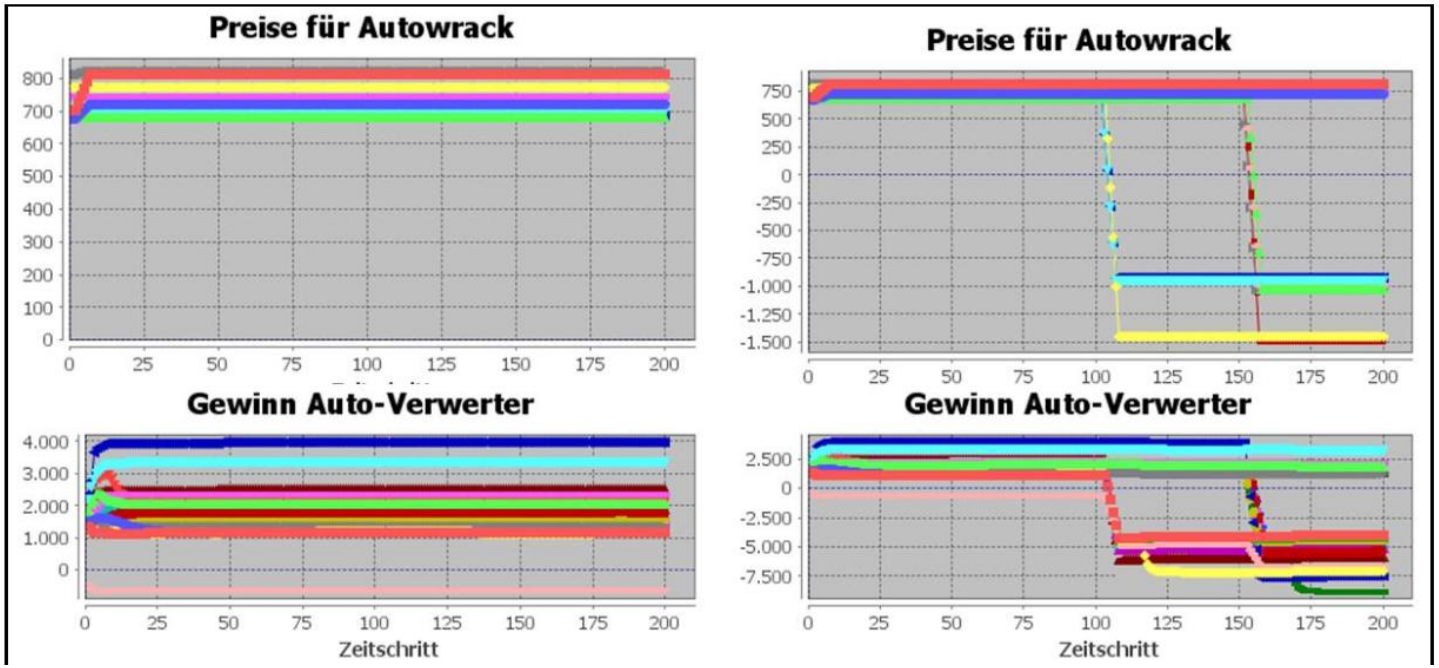
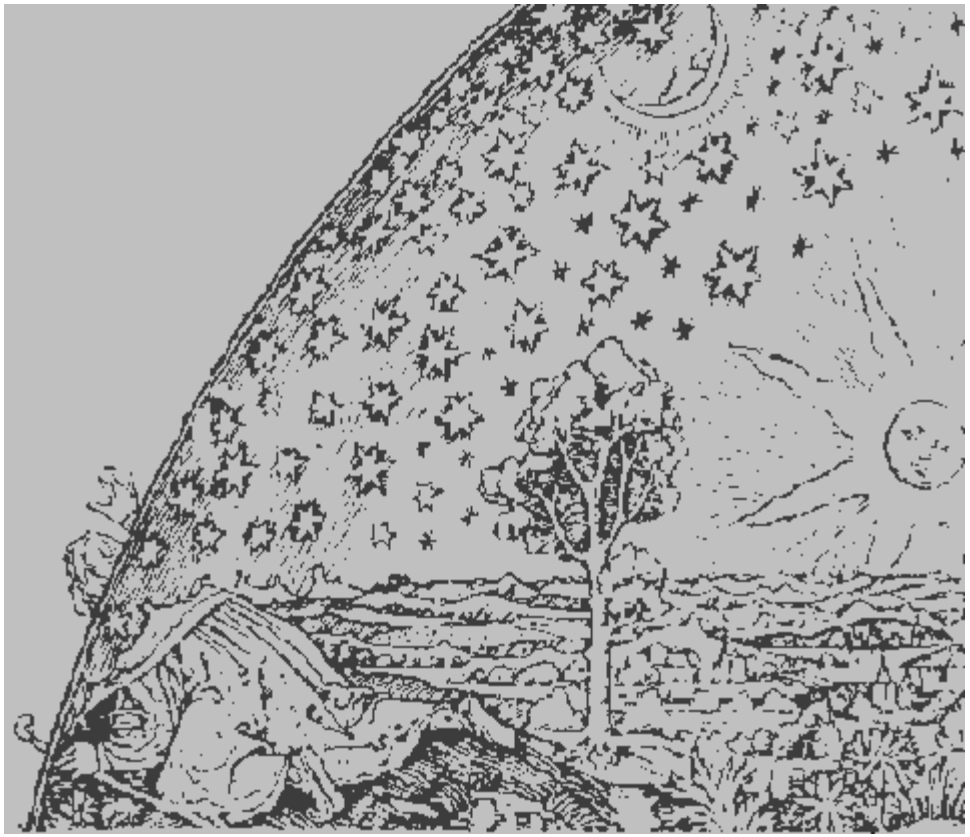


AMOSS project, Univ. Kassel, Simulationsmodell Amflows, 2009

5. Outlook



Conclusions & outlook

1. Agent Based Modeling offers a new view on sustainability and life cycle assessment questions..
2. ..and promises answers to those questions that are especially difficult in LCA
3. This is worth exploring...

Thanks.

Andreas Ciroth

GreenDeltaTC Berlin.

ciroth@greendeltatc.com