Institute of
Engineering Thermodynamics

Life-cycle based ecologic sustainability assessment of energy scenarios

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(1) Motivation and Research Questions:

Energy system models used for policy advice **generally focus on cost minimization** while achieving given CO_2 emission targets. **Other environmental impacts** (such as emissions of air and water pollutants, resource demand and land occupation) are generally not considered in these models. However, different transformation pathways achieving similar CO_2 emission reductions may not only differ by total system costs, but also by environmental impacts. Furthermore, established energy system models only take in to account direct emissions, but no emissions from upstream processes.

• Which ecological **co-benefits and un-intended side effects** can be expected from a climate friendly energy system transformation?

• How do different climate-friendly transformation pathways differ in terms of their other ecological impacts?

• How do other ecological impacts depend on the degree of CO_2 emission reduction?

• What is the ecologic impact of upstream processes in the energy system?

(2) Method: coupling of energy system model with prospective LCA data

Life Cycle Assessment (LCA) is an established method to analyze ecologic impacts of products taking into account impacts during all life cycle phases of the product. Here, we couple (prospective) LCA data for energy technologies with an energy system model in order to estimate life cycle impacts of the energy system as a whole (see Figure 1):

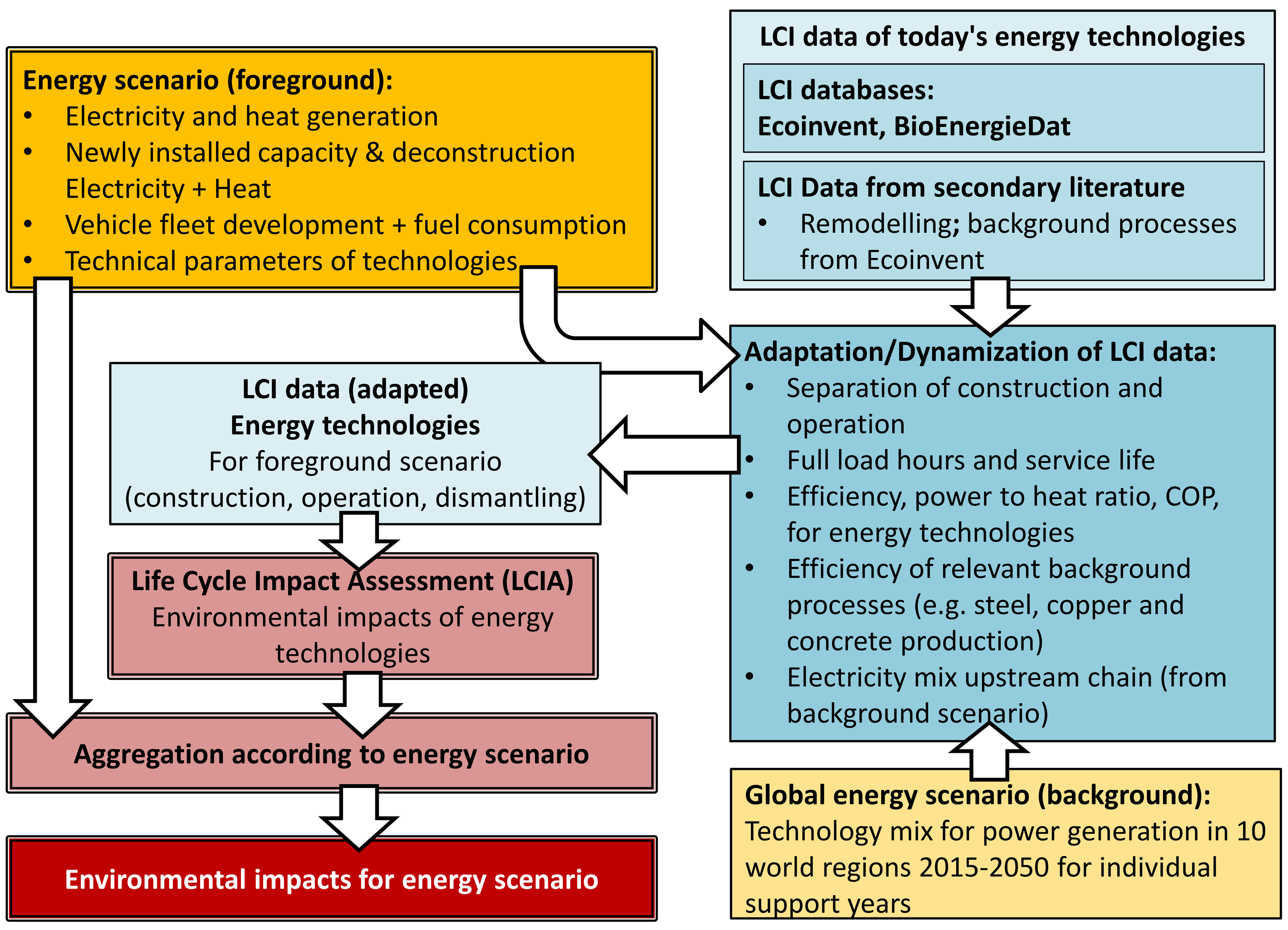


Figure 1: Overview over the coupling and adjustment approach

(3) (Preliminary) results

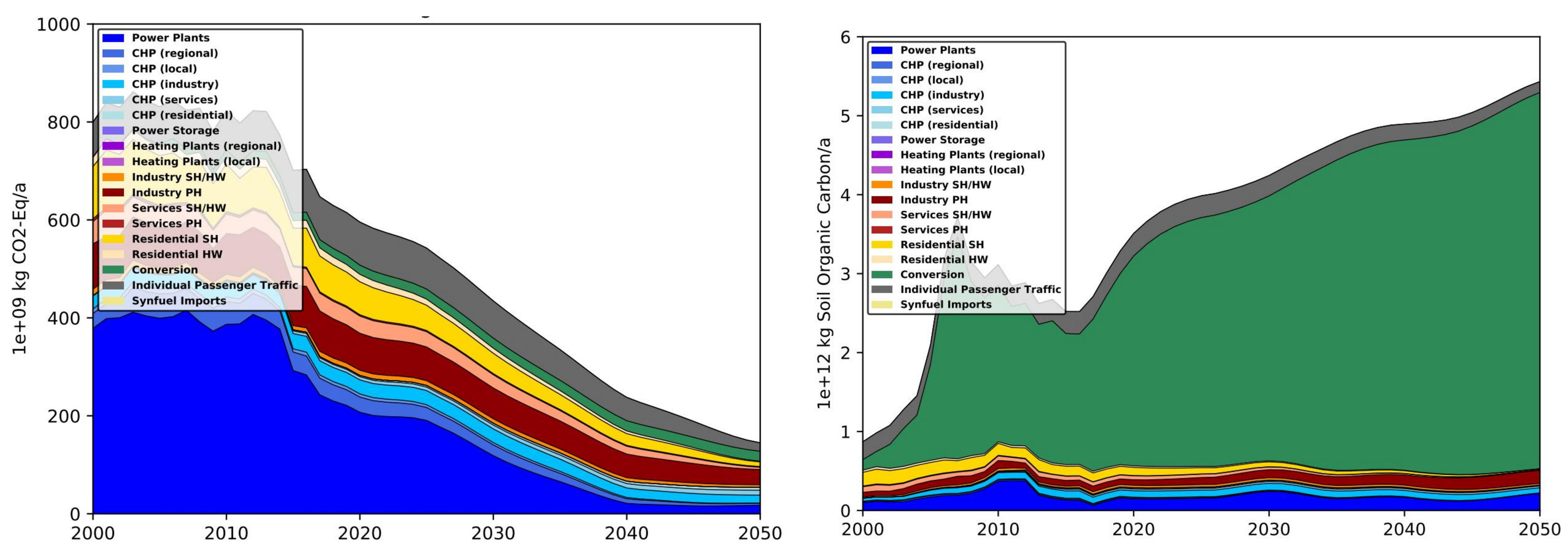


Figure 2: Life cycle based GHG emissions (left) and land use (right) in one example scenario (preliminary results – do not cite!)

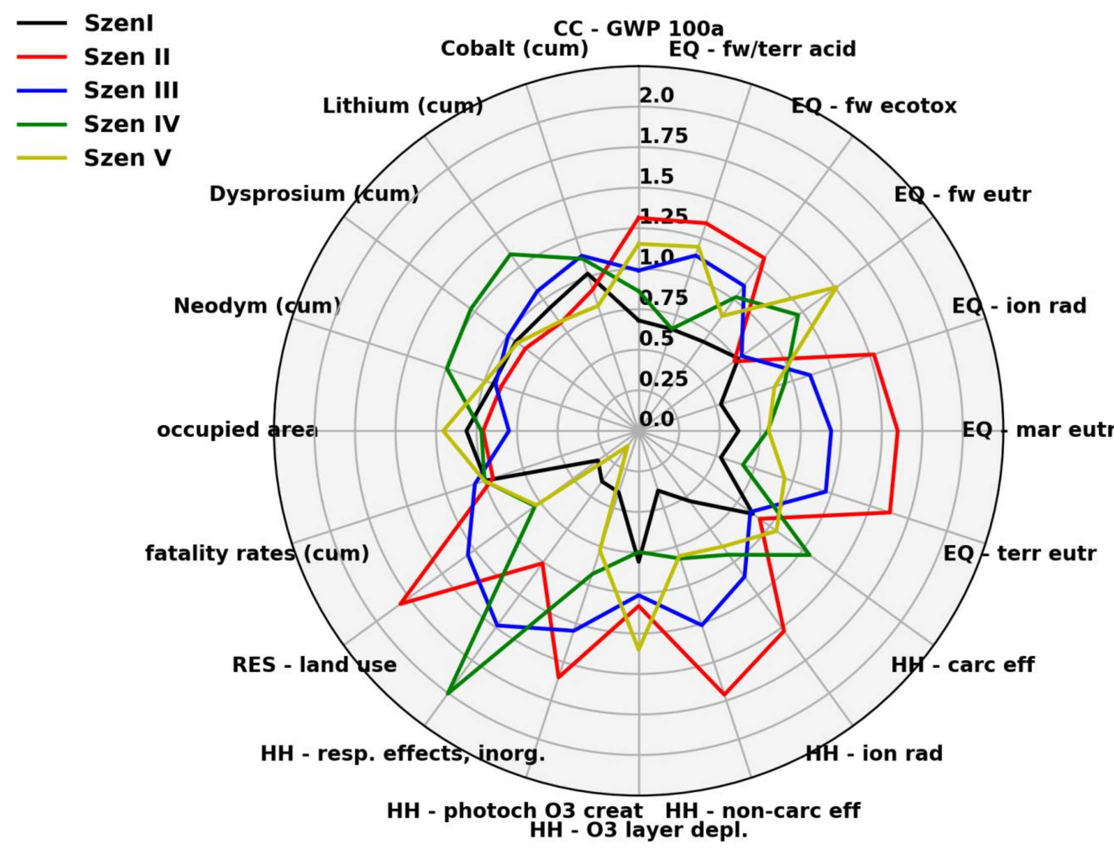
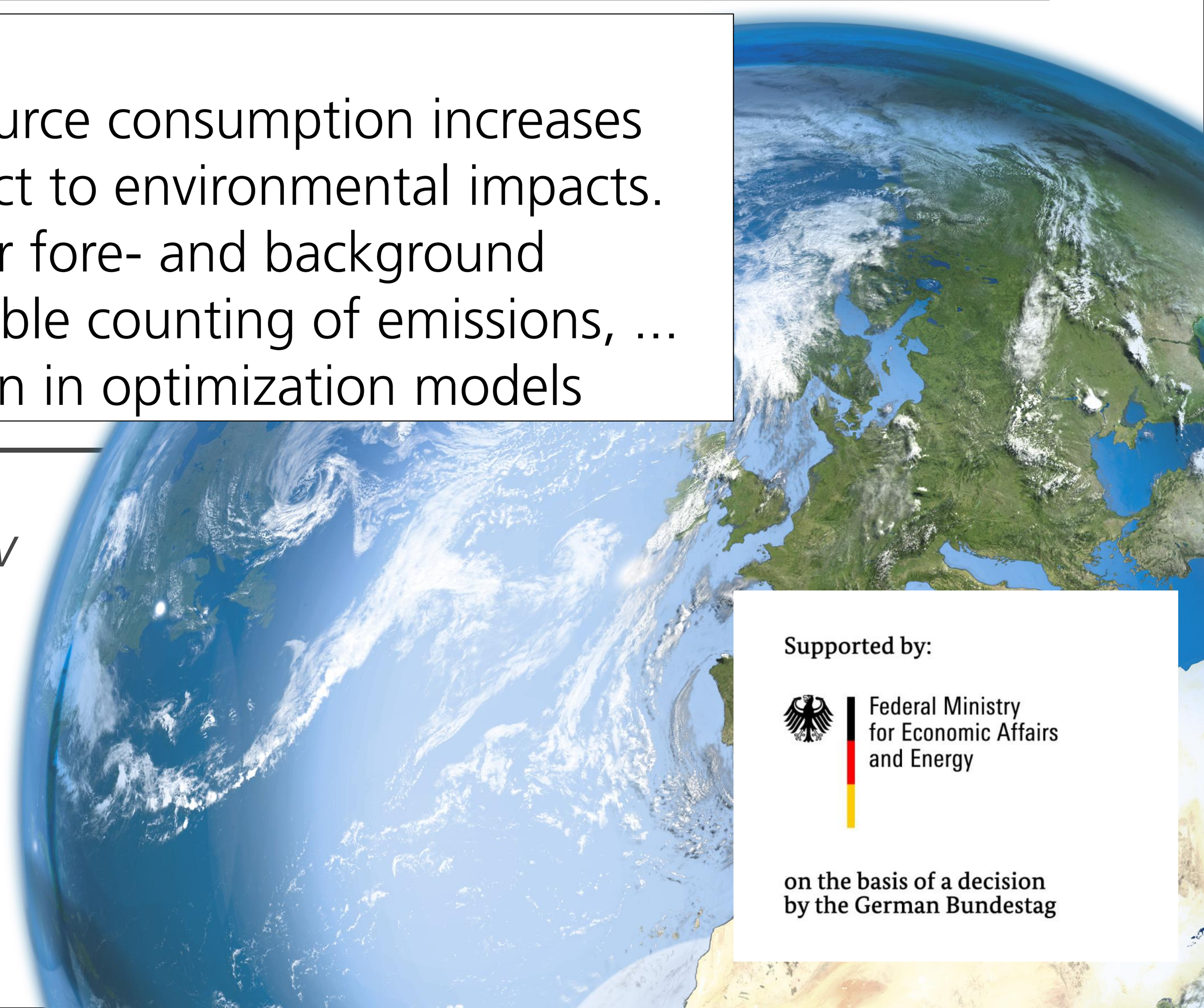


Figure 3: Comparison of environmental impacts of five different scenarios with 80% CO_2 emission reduction (normalized to average impact of all five scenarios) (preliminary results – do not cite!)

(4) (Preliminary) implications and outlook

- LCA-based GHG emissions significantly larger than direct CO_2 emissions only
- Emissions of air/water pollutants generally decrease during transformation, resource consumption increases
- Different transformation strategies with similar CO_2 reductions differ with respect to environmental impacts.
- Challenges: lack of (prospective and representative) life cycle inventories (LCI) for fore- and background technologies and processes, adjustment of heat & transport in background, double counting of emissions, ...
- LCA-based indicators as additional constraints or as alternative objective function in optimization models



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