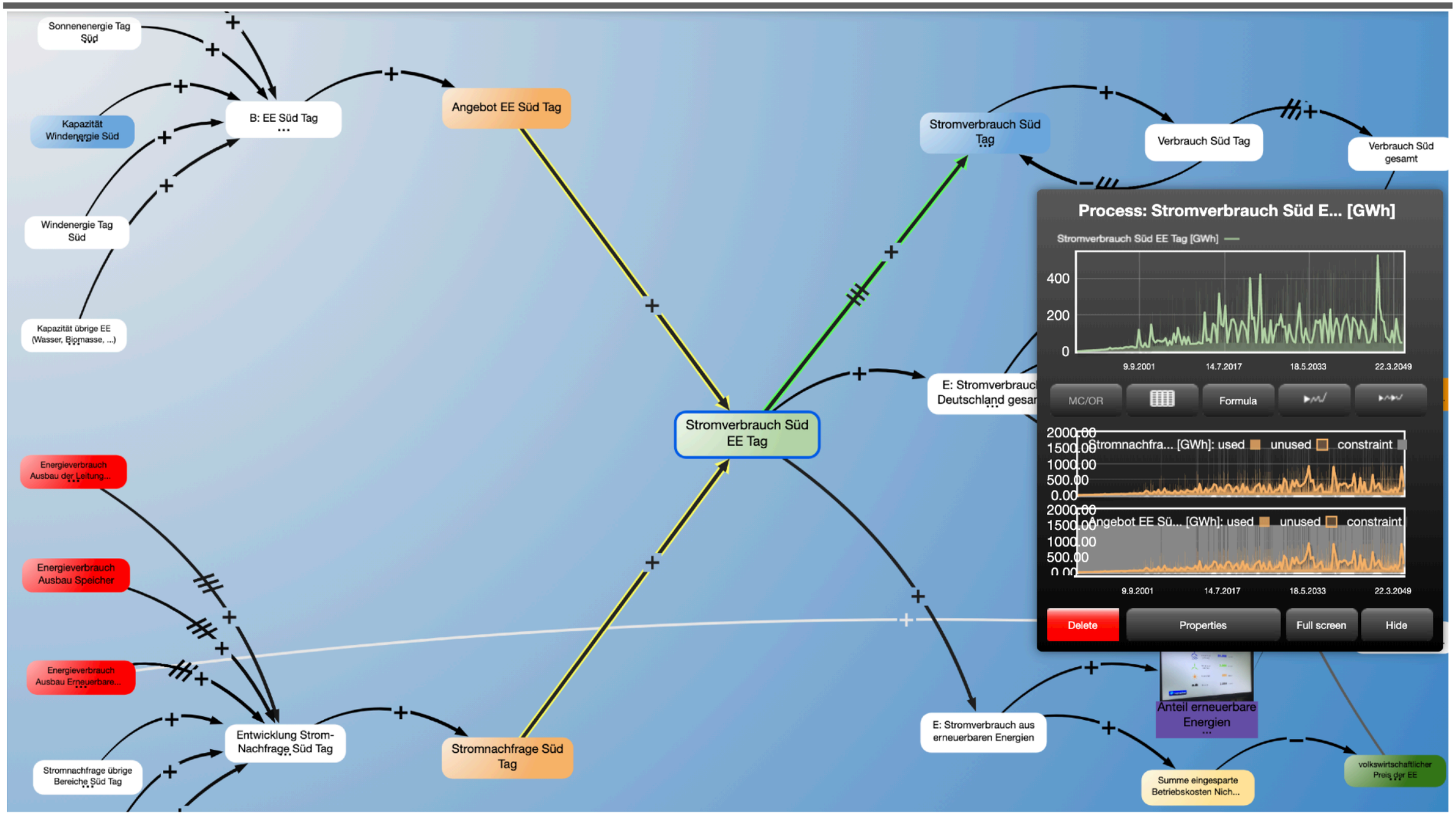
# Renewable energy - it’s doable

Consideo - Kai Neumann, Franc Grimm




*The process model shows (grey) when the supply or demand for renewable energies is the bottleneck (constraint).*

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# Renewable Energy - it’s doable

SYSTEMIC FINDINGS FROM THE D3EE AND THE GEE(R) MODEL FOR THE FEDERAL ENVIRONMENT AGENCY

*Decentralized renewable energies*

## Abstract

In two simulation models for the Federal Environment Agency, Consideo first systematically investigated the implications of a national and then that of a global transformation towards renewable energies.

The D3 EE model shows for Germany what net expansion would be necessary to achieve the self-imposed goals of greenhouse gas neutrality by 2050, including electrification of mobility, building energy and industry. The model shows that the current expansion will hardly make the goals possible even if the expansion is increased later, as the repowering of old plants will tie up capacities. It also shows the required overcapacity to survive the dark slumps via Power to Gas/Liquid and its backflow. It is interesting that although the price of electricity could still rise slightly, the economic benefits through increased domestic added value would be enormous.

The GEE(R) model then shows to what extent global expansion depends on the availability of key resources. Although the raw material reserves will be sufficient, the required mining and recycling capacities would be extreme depending on the expansion paths in the regions of the world. These paths are therefore also relevant for the prices of the expansion.

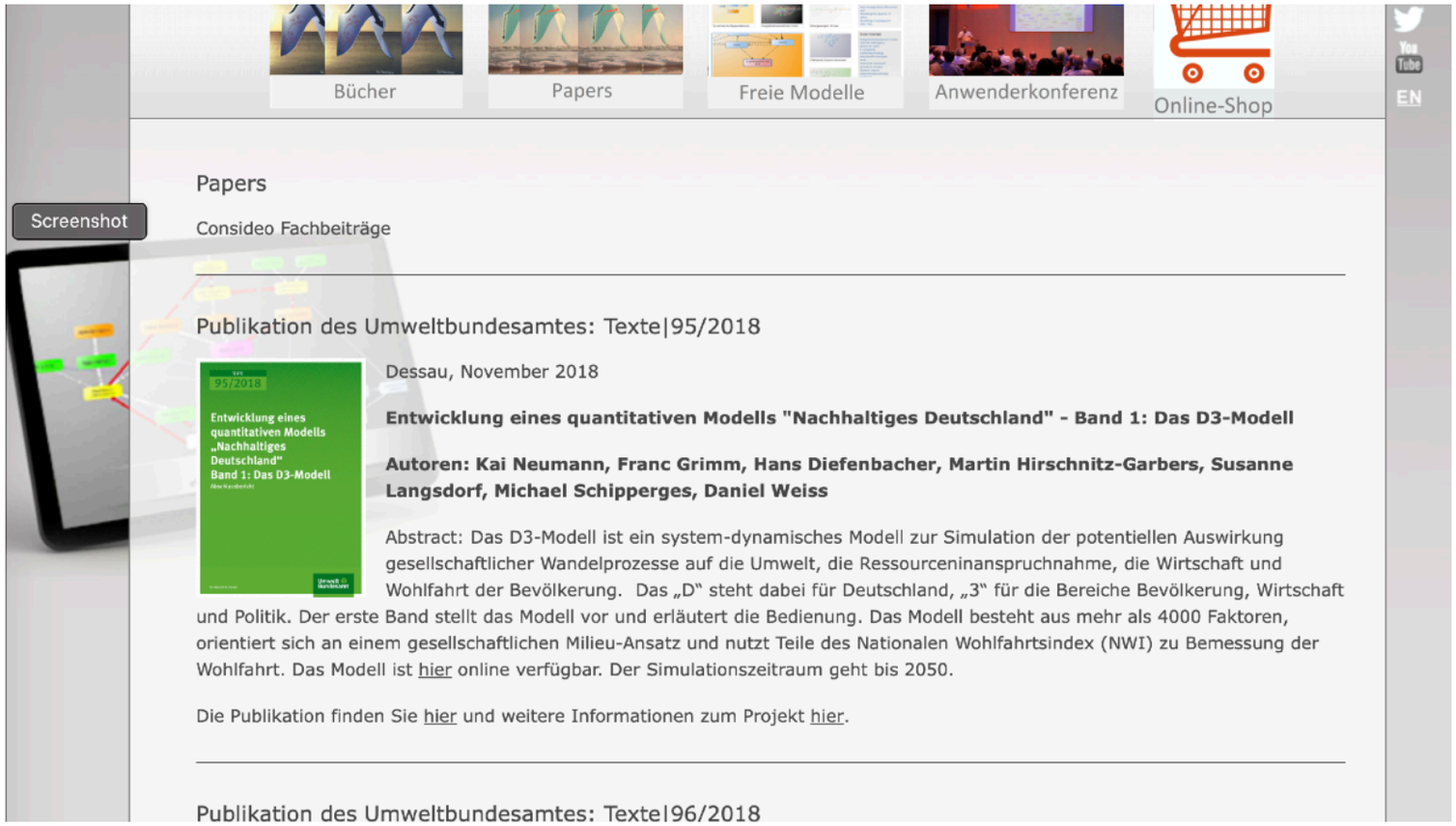
Many regions in the world will benefit from increased domestic value creation, but some will also be losers of change.

## The 'grey series'

Studies do not seem to reach policymakers at all, are usually too specific for the general public, and are all too often perceived as competition by other scientists or are then not taken up.

We can reach policy makers through the public, and for the scientific community we will continue to write official project reports and also peer-reviewed articles. But for the public, we want to offer an attractive format to read that gets to the heart of findings and action to be derived from them - our 'grey series' in reference to the term "grey literature".

"Renewable Energies - It Could Be Done" does not merely show, as other studies do, that 100 percent renewable energies would be possible in principle and presumably also economically viable, but takes a concrete look at the course and dynamics. This results in particular in economic implications related to the timing and extent and, in addition, the costs and benefits of expansion in the regions of the world.

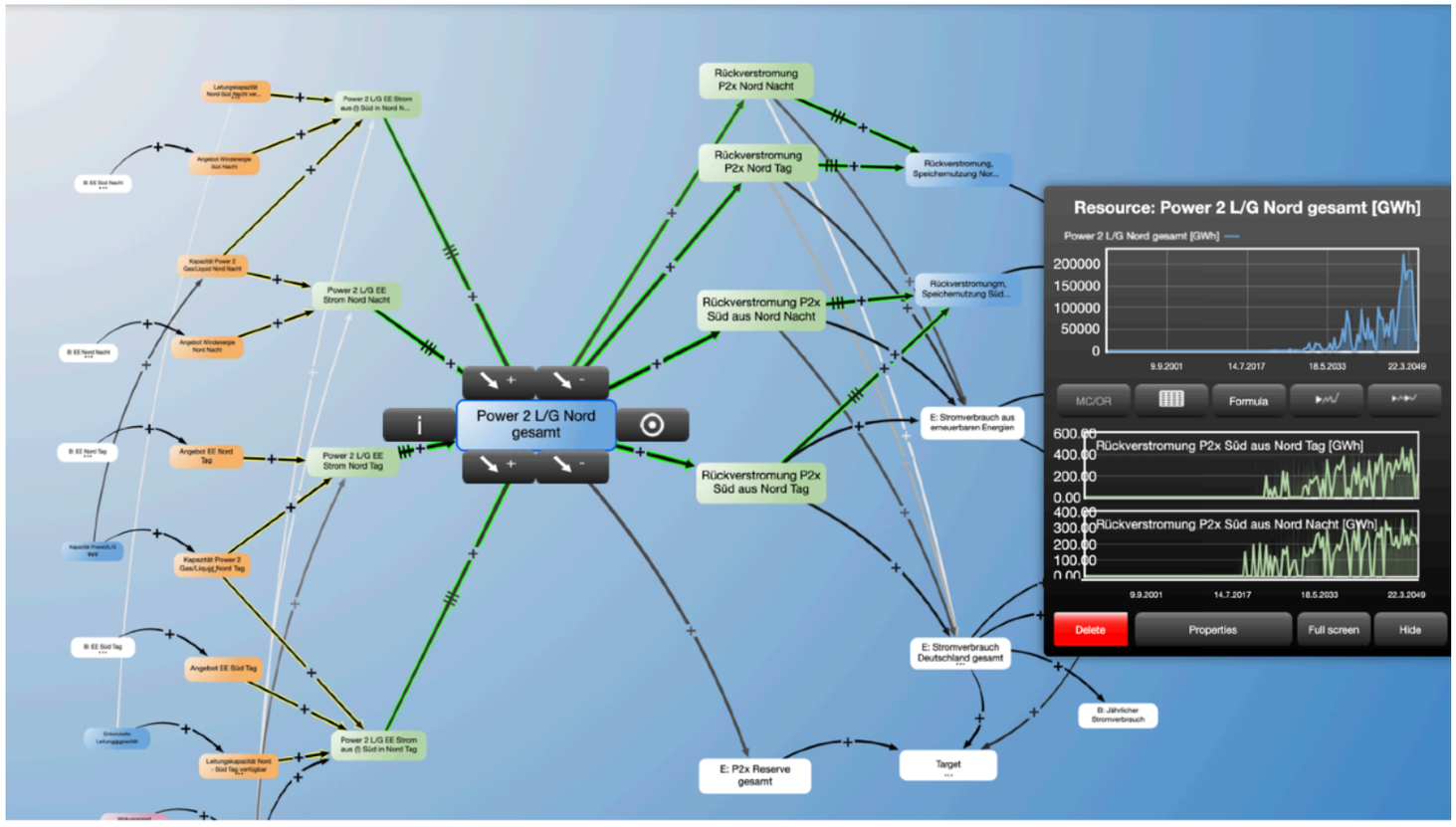



*Screenshot of the Consideo website with the project reports and scientific publications linked there (www.consideo.de/papers.html)*

## The D3 EE Model

The D3 EE model is a so-called process model, which was created in the context of the extensive D3 project/model (see paper "How and why change would be possible"), in order to look more closely at how much expansion of renewable energies Germany would need, and how many resources would be required for this.

The model divides Germany into North and South and calculates the demand and supply of electrical energy during the day and night. It includes onshore/offshore wind, PV, other renewables and of course the respective fossil energy sources incl. nuclear power as well as battery storage, load management and P2L/G and the line expansion between north and south.




*Section from the D3 EE model showing the conversion of excess capacity from the north into power to liquid/gas, which is then also required in the south for reverse power generation. Process models show how demand can be met and which resources are bottlenecks.*

For the economic evaluation of the expansion, the D3 EE model considers the depreciation costs of the plants with the so-called margin costs of the current energy supply. In addition, there are adjusting screws for the respective domestic value added, in order to be able to make assumptions, for example, as to how many plants and their raw materials come from within the country or are imported. Thus, in the case of later repowering, the value added would be further increased by recycling the raw materials.

Findings:

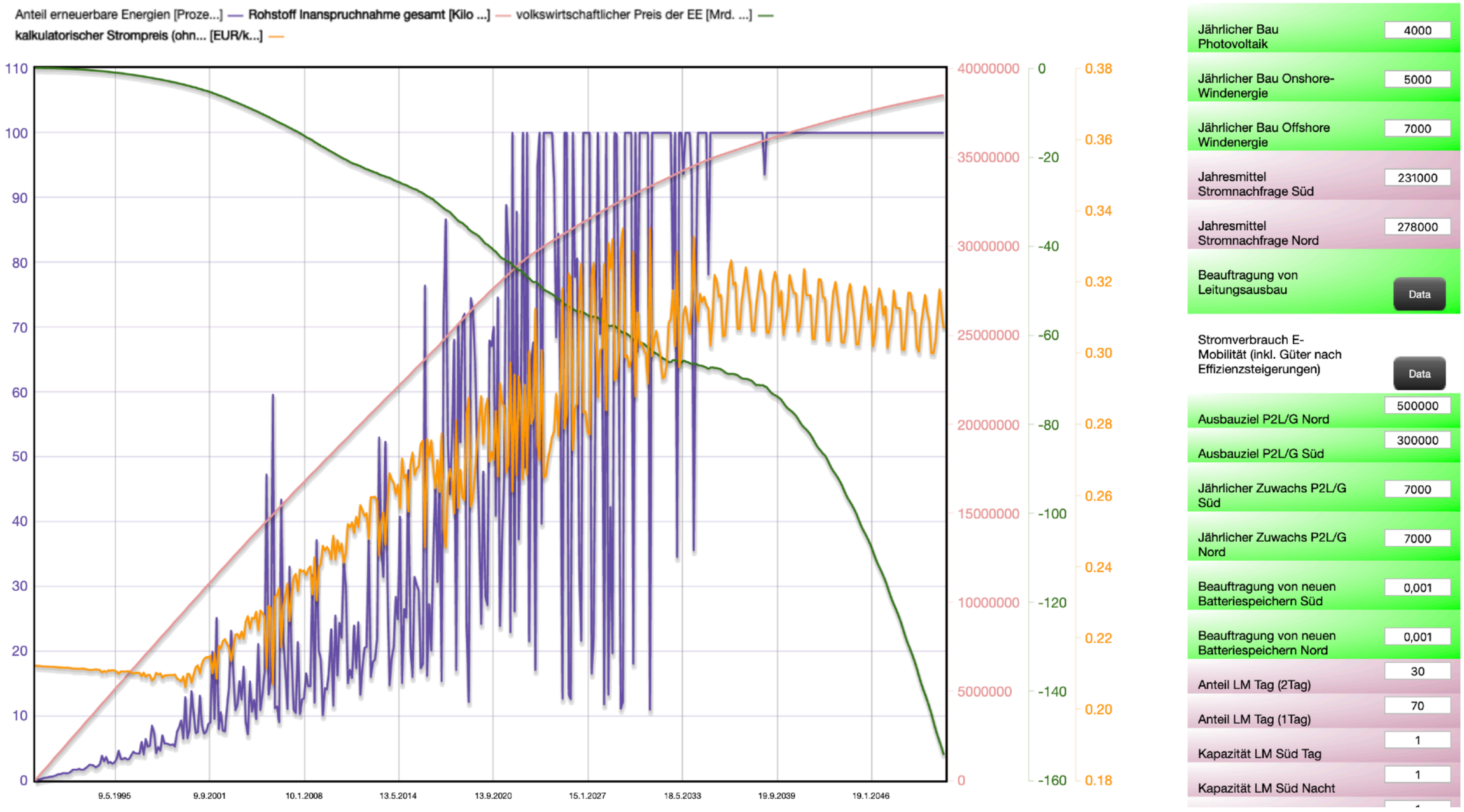
- Battery storage and load management seem to play little role after depositing average weather patterns, since power-to-liquid/gas reconversion is crucial for bridging longer, so-called dark lulls when viewed in isolation, on a national scale. Therefore, electrolysers that will be needed later anyway could be used for the surpluses even before the grid expansion. For this reason, P2G/L, which is fundamentally less efficient than direct electricity use, should not be used for heating buildings or for vehicles, since it is needed for industry, air traffic and precisely for reverse power generation.

- The amount of resources needed for the development of renewable energies would decrease compared to the amount of fossil resources saved.

- Current expansion paths - even if they were increased later - will not lead to a 100 percent renewable energy supply, since repowering old plants would require disproportionately high construction capacities in addition to the expansion. And when targets become unattainable, resignation sets in. In addition, other nations look to Germany as a pioneer, which is why globally, postponing the massive expansion would mean significant delays overall.

- Contrary to the main concerns about the energy turnaround, it is not expensive! It is investments in the domestic market which, depending on the share of value added, provide more jobs and high profits compared to imports of fossil fuels. However, lignite also has a high value added domestically. Although the price of electricity would rise even further, it could consequently be cushioned socially by additional government revenues.

# RENEWABLE ENERGY- IT'S DOABLE (THE D3EE AND THE GEE(R) MODEL)



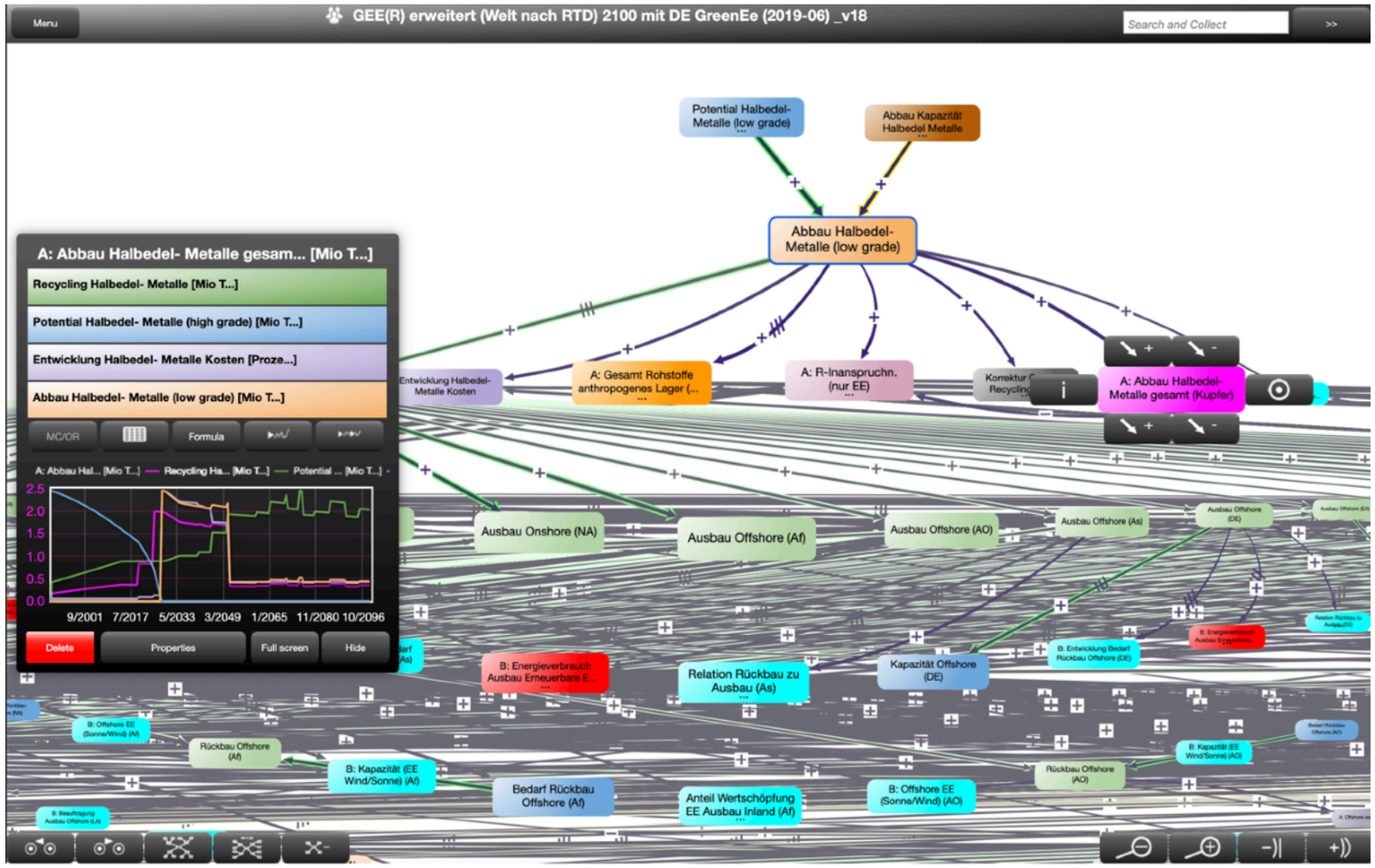

*Simulation cockpit from the D3 EE model. The scenario shows how the price of electricity would continue to rise, but the economic 'costs' of energy supply would fall significantly. It also shows that the use of raw materials would decrease and that, until 100 percent renewable energy is achieved throughout, more than half of the electricity would have to come from modern gas-fired power plants during dark periods.*

## Das GEE(R) Modell

The GEE(R) model for the Federal Environment Agency is also a process model that focuses primarily on the availability of the resources required for the global expansion of renewable energies.

Based on the World Energy Outlook, the regions in the world and, in addition, explicitly Germany are considered in the development of their energy requirements and the conceivable scenarios for the expansion of renewable energies. There is a global market for P2L/G, which allows surpluses of individual regions to be made available for power generation in other regions.

Except for silver - which is substitutable - all raw material deposits would be sufficient. However, the timing of the expansion and the associated costs are relevant for the regions (see figure).




*The raw material costs will only fall again in the balance between expansion and decommissioning (repowering), depending on the recycling rate. An early expansion can still draw on cheaper high-grade raw material deposits - a later expansion can draw on proportionately cheaper recycling raw materials.*

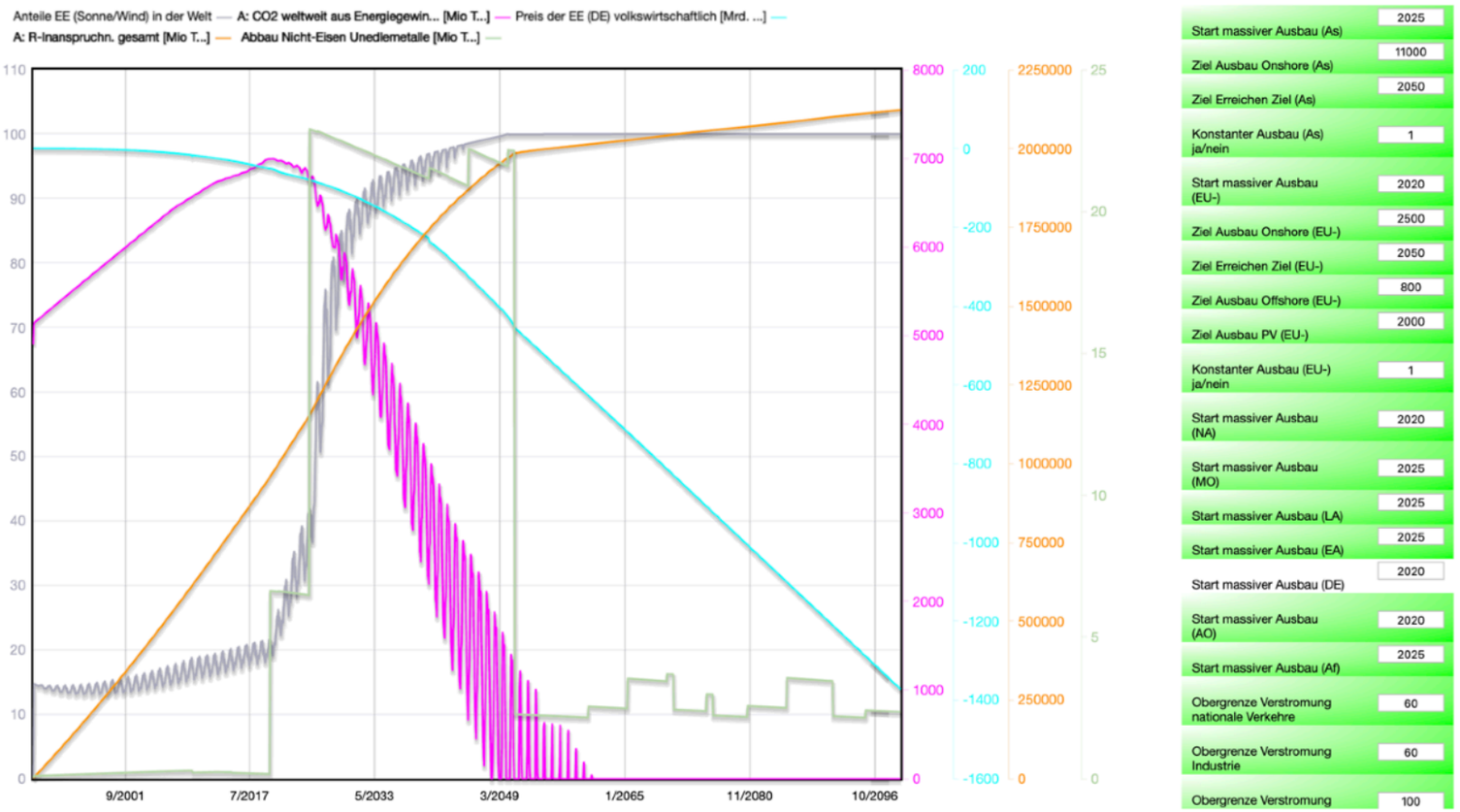
It is also worth noting that in all scenarios, the massive increase in the extraction of raw materials as well as the subsequent decrease in demand would be extreme.

# RENEWABLE ENERGY- IT'S DOABLE (THE D3EE AND THE GEE(R) MODEL)

While an increase in capacities for mining raw materials as well as construction capacities still seems conceivable, the question is how companies will behave shortly before the demand for raw materials levels off and how the shift from countries with raw material deposits to countries with old plants to be recycled on site will be structured globally. It is desirable here that raw material countries can also build plants and increase the value added.

Winners and losers is not only the question behind the prices for the construction of the plants, but also the elimination of exports of fossil energy sources or the renunciation of the use of own fossil raw material sources on the one hand, and the generation of surpluses from renewable energies for the export of P2L/G, for example, also by regions with large deposits of fossil raw materials and correspondingly existing infrastructures for the export of P2L/G on the other hand.

For the world as a whole, the challenge is to put the winners in charge, otherwise, under free market forces, the global energy transition must stall.




*The raw material costs will only fall again in the balance between expansion and decommissioning (repowering), depending on the recycling rate. An early expansion can still draw on cheaper high-grade raw material deposits - a later expansion can draw on proportionately cheaper recycling raw materials.*

## What we now need....

- Every country wants the energy turnaround and could say quite specifically how much more wind power, PV, etc. it has to build in the next few years. This would give the plant builders tailwind and make it clear to the population that "even more" is not to be fought, but to profit from it (citizen energy).

- The energy turns cause less costs than investments. They boost the economy. The increase in the price of energy can be more than compensated for by this. This must be explained.

- Countries with their own fossil raw materials profit less economically and should alternatively export surpluses as far as possible in the form of Power2Gas/Liquid.

- Reducing own expansion in favor of P2G/L imports is convenient, but economically and ecologically hardly sensible.

- A global CO2 price would make the switch cheaper even for countries with their own fossil resources. It would also avert further costs from society, such as the consequences of air pollutants).

- Since Power2Gas/Liquid and its reconversion into electricity are indispensable for the dark periods of temperate latitudes, electrolysers - logically unevenly utilized - could already be built. We also need synthetic fuels for long-haul air and sea transport and for parts of industry. With electrolysers, grid expansion would no longer be a bottleneck in the energy transition. Pilot projects would also give us a technological lead.

- The price of energy would also rise with conventional raw materials. Less demand does not lead to price reductions if less exploration takes place and the supply becomes scarcer.

- Other counter-arguments (bird deaths at wind turbines, demand peaks due to e-cars, etc.) must also be publicly exposed as incorrect.

# RENEWABLE ENERGY- IT'S DOABLE (THE D3EE AND THE GEE(R) MODEL)

- Because Power2Gas/Liquid is so important elsewhere and yet has lower efficiency than direct electricity use, we may not use this in cars, buses and trucks that can be powered by batteries. There is a separate 'gray paper' on this.

- Demand for raw materials for the plants seems critical - an early start ensures cheaper raw materials, but must not lead to resignation among poorer regions following suit. International compensation measures are needed.

- The so-called resource curse, especially due to the unbelievably fast increasing demand followed by repowering with recycling in other countries, requires fairly distributed value creation. Otherwise, the advanced countries will secure the cheap high grade raw materials now, take them into their anthropogenic stockpile by building the plants themselves, and build their next generation plants 25 years later from the locally recycled raw materials. The recycled raw materials are not made available to the world market by refining them on site (vertical integration by the companies). The less advanced countries will later only resort to more expensive raw materials - even if market forces and more efficient technologies partially compensate for this - and import the technologies of the advanced countries. These countries will lack the financial resources to do so, and the global limitation of greenhouse gas concentrations threatens to fail. A bioeconomy of at least some of these countries could counteract this - there is also a separate 'gray paper' on this.

- In the long term, we need sufficiency and efficiency and less material growth, as we have just been able to demonstrate in another project (KliReX). With a change of values and a CO2 and raw material tax, this would be the result, and not a difficult goal to achieve.

- We are also investigating resource conservation with its direct effects on the reduction of greenhouse gases in another project with Ecologic Institute.

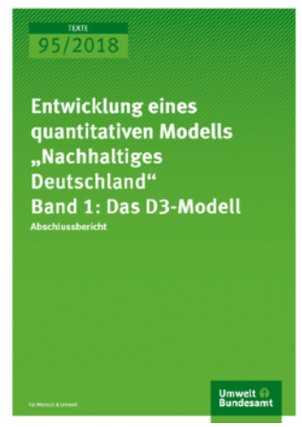
## Sources, references

The RESCUE study:

https://www.umweltbundesamt.de/rescue

The D3 EE Model:

https://www.umweltbundesamt.de/publikationen/entwicklung-eines-quantitativen-modells


## About Consideo

Responsible for the content are the authors (neumann@consideo.com; grimm@consideo.com).

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Consideo has the vision of a better world. The mission is to help people understand how things are interconnected. We work with the award winning software iMODELER for business, research, politics and private individuals.

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Consideo GmbH
Maria-Goeppert-Str. 1
23562 Luebeck, Germany
www.consideo.com