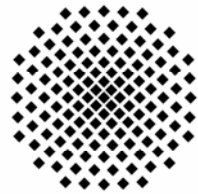

Generic Energy Models in Life Cycle Assessment



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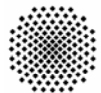
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Generic Energy Models in Life Cycle Assessment

InLCA/LCM 2006, October 4-6, 2006, Washington DC

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Energy

World Indicators (2003) by IEA ¹

- Energy Production ~10,700 [Mtoe]
- Electricity Consumption ~15,200 [TWh]
- CO₂ Emissions (fuel combustion) ~25,000 [Mt of CO₂]

World Energy Production

- Various sources (coal, oil, gas, hydro, nuclear, renewables, ...)
- Various supply chains to final energy
- World wide trading and exchange

⇒ Energy Sector with high relevance in industry, society and also in LCA

¹ IEA (International Energy Agency) „Energy Statistics“



Major trade movements – Example: Crude oil



Source: BP Statistical review of world energy 2004



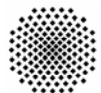
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Generic Energy System Modeling in LCA



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Requirements of Energy Modeling in LCA

Requirements of Energy Modeling in LCA

- to be covered:
 - complete fuel supply chain should be covered
 - international trading and transportation (import / export structure)
 - various conversion technologies
- adaptation options should be included:
 - technologies (e.g. direct or combined heat and power generation, combustion systems)
 - country and technology specific boundary conditions (import mixes, emission limits, ...)
- systems must be based on same physical / chemical context
 - ⇒ one single basic model per fuel and process step
- variations must be possible (e.g. in efficiency / flue gas cleaning)
 - ⇒ parameterization, generic adaptable models



Generic Modeling in LCA – Approach

Energy modeling approach (combustion fuels)

- mining / production / supply of energy carriers
 - ⇒ identify key parameters (fuel type and country specific)
- distribution / worldwide trade and transport
- country specific supply and consumption mix
 - ⇒ fuel properties (physical / chemical)
- fuel conversion to final energy and transfer to consumer
 - ⇒ refinery / power plant / ...

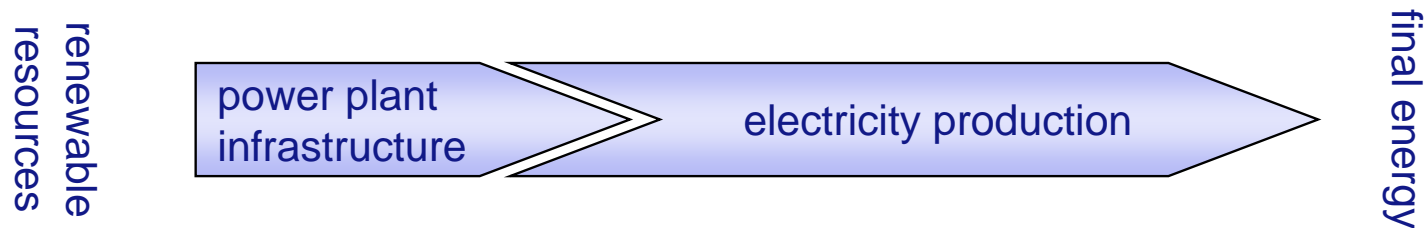


Generic Modeling in LCA – Approach

Energy modeling approach (water / wind / solar / geothermal)

- infrastructure to get access to energy sources
(dams / windmills / solar elements / boreholes / ...)
⇒ identify key parameters (size, availability of renewable resource, efficiency, ...)
- power plant infrastructure (turbines / converters / ...)
- production of electricity and transfer to consumer

(no trade and transport of primary energy carriers)



Modeling Principles and Parameterization

Modeling Principles

- define the functional unit of the system related to the main subject
- identify how the product is related to the functional unit and identify system internal interactions
- combine function related components to sub systems
- accomplish allocations if necessary
- apply parameters for significant system properties (key factors with main influence to results)

Parameterization

⇒ variable parameters

- to be adapted in each model and to allow transferability to similar boundary conditions
- default values (e.g. for technology levels) represent general average settings

⇒ fixed parameters

- calculated within the model
- calculation formula defines parameter value
- Basis: physical / chemical / technical context



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Advantages and Use

Advantages of generic parameterized models

- variability, adaptability and manageability
- consistency of models and consistency in database
- analyzability
(scenario analyses / parameter variations / sensitivity analyses / Monte Carlo analyses)

Use of generic models

- Use of generic models
 - use of models = adaptation to different boundary conditions
(can also be done by person without detailed knowledge of background system)
 - **variable parameters** can be adapted
 - default values represent average conditions
 - automatic calculation of results on physical and chemical basis via **fixed parameters**

⇒ easy to adapt to various boundary conditions, high flexibility, comprehensive analyses



Modeling Example: Power Grid Mix Germany with Natural Gas Supply Chain

(similar modeling for other countries)



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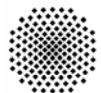
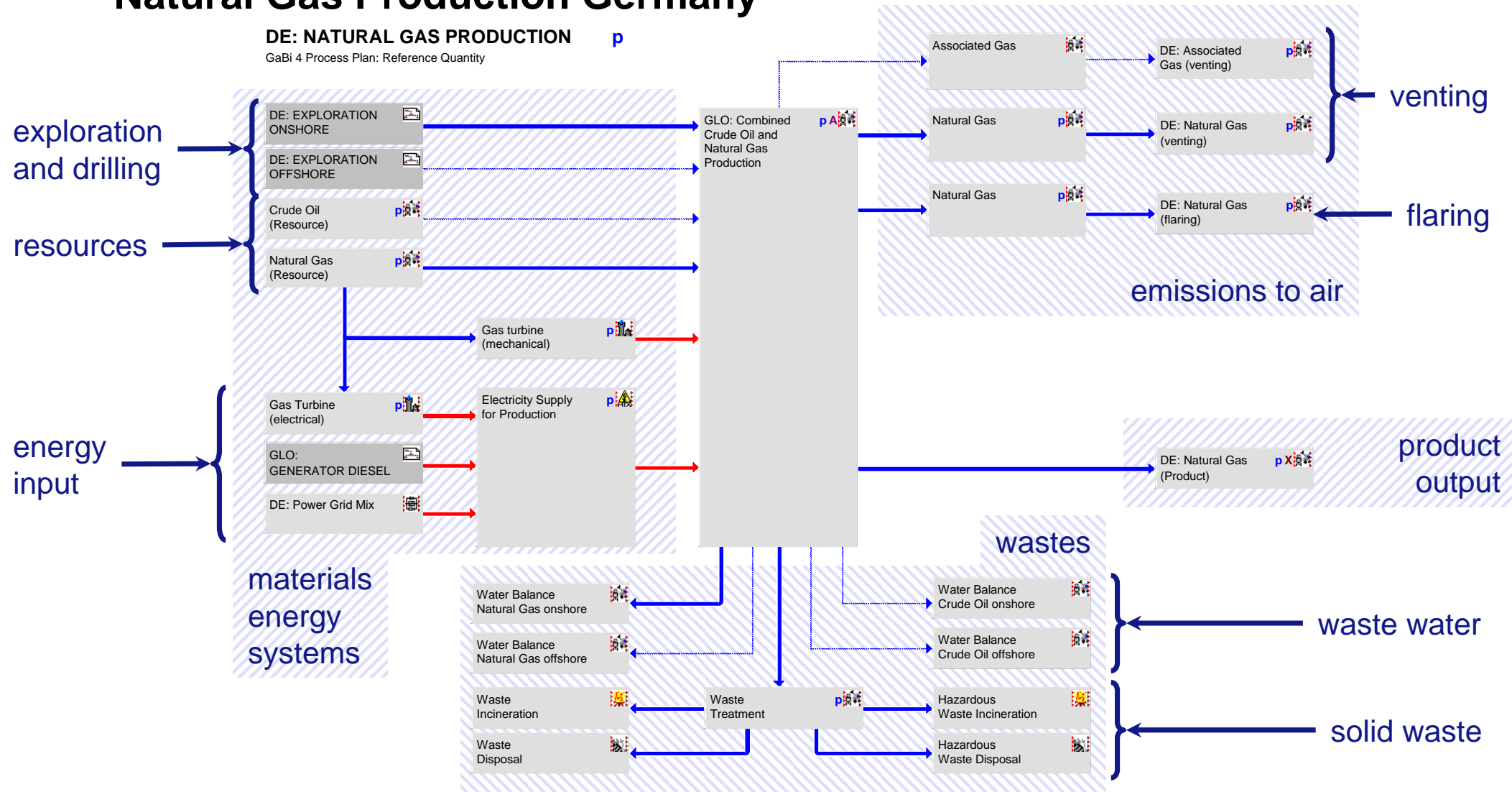


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Natural Gas Production Germany

DE: NATURAL GAS PRODUCTION p
GaBi 4 Process Plan: Reference Quantity



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Variable Parameters in Natural Gas Production

Parameterization

- share onshore / offshore production
- energy demand
- energy supply (source / efficiency / type of energy conversion)
- waste production and treatment
- waste water production and treatment
- Drilling (depth / length, energy consumption, ...)
- flaring rate
- venting rate
- production of natural gas and share of by-products (NGL and crude oil)
- sulfur content and sulfur deposition



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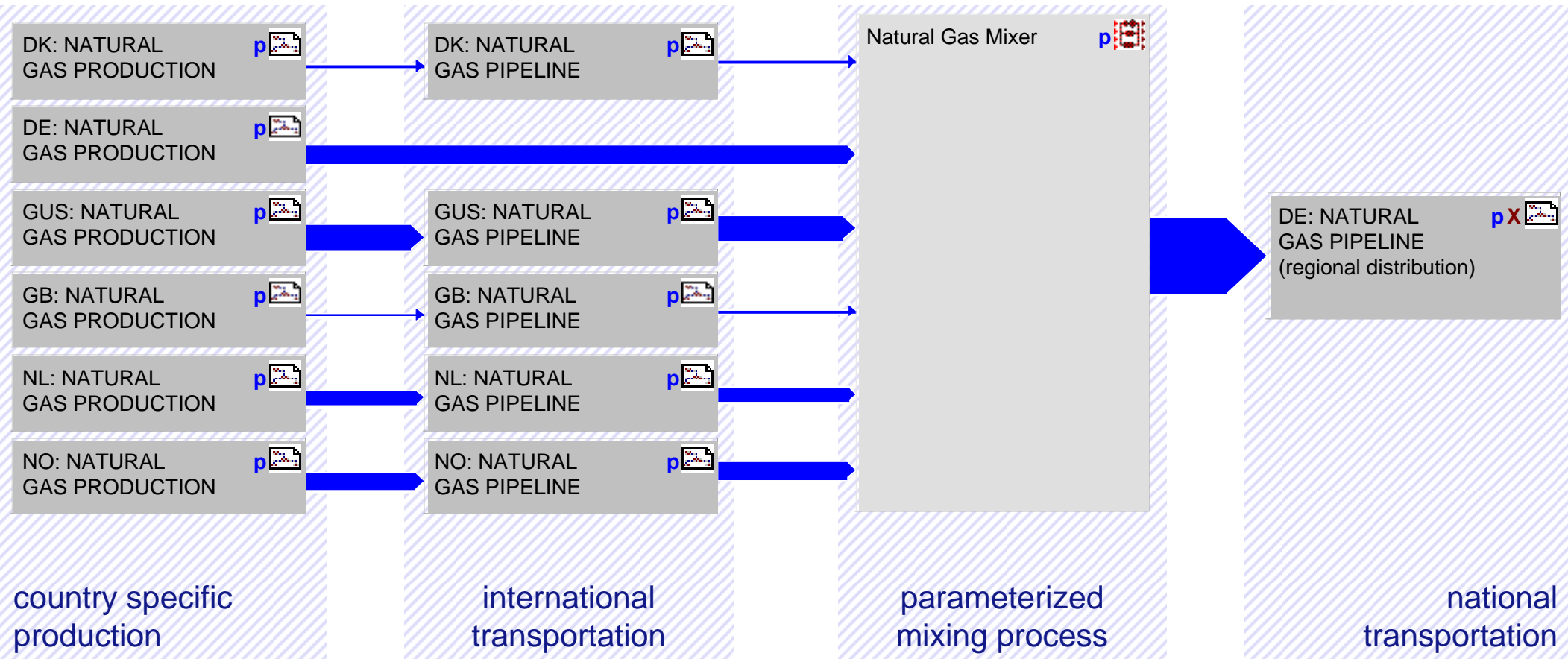
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Natural Gas Supply Germany

DE: NATURAL GAS MIX

GaBi 4 Process Plan: Mass



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Variable Parameters in Natural Gas Supply

Parameterization

- import mix by country origin
- distribution losses high pressure pipeline (international transportation)
- distribution losses medium and low pressure pipeline (national / regional transportation)
- transport distances
- distances between compressor stations
- efficiency of compressors
- energy supply of compressors (power from grid / gas turbine)



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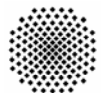
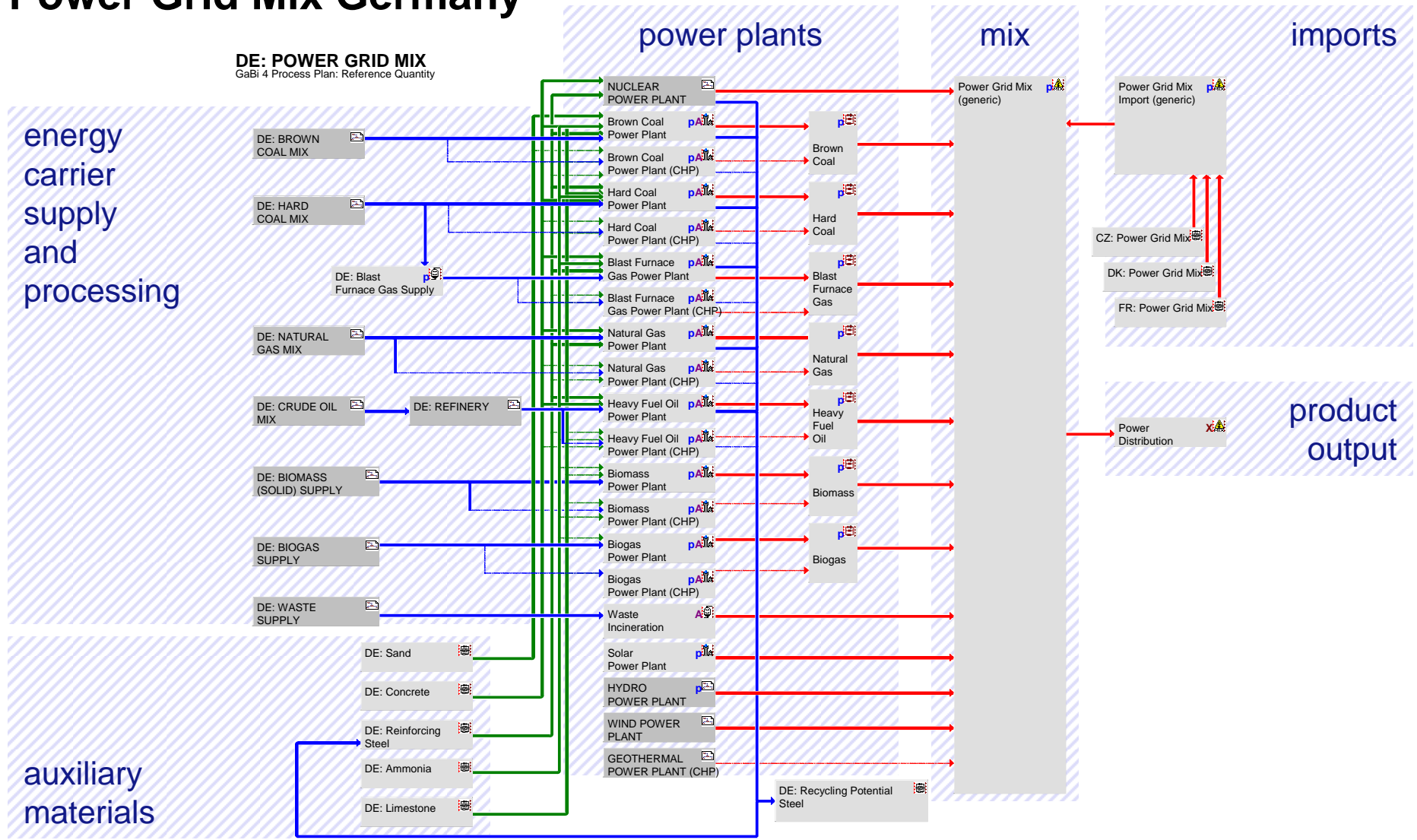


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Power Grid Mix Germany

DE: POWER GRID MIX
GaBi 4 Process Plan: Reference Quantity



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Variable Parameters in Power Grid Mix

Main General Parameters

- power grid mix
- import share and import mix by countries
- distribution losses

Main Power Plant Parameters

- share of direct electricity production and combined heat and power (CHP)
- power plant emission factors (CH_4 , CO , N_2O , NMVOC, NO_x , ...)
- efficiency factor and electricity own use
- Flue gas cleaning system and efficiencies (dust / SO_2 / NO_x removal)



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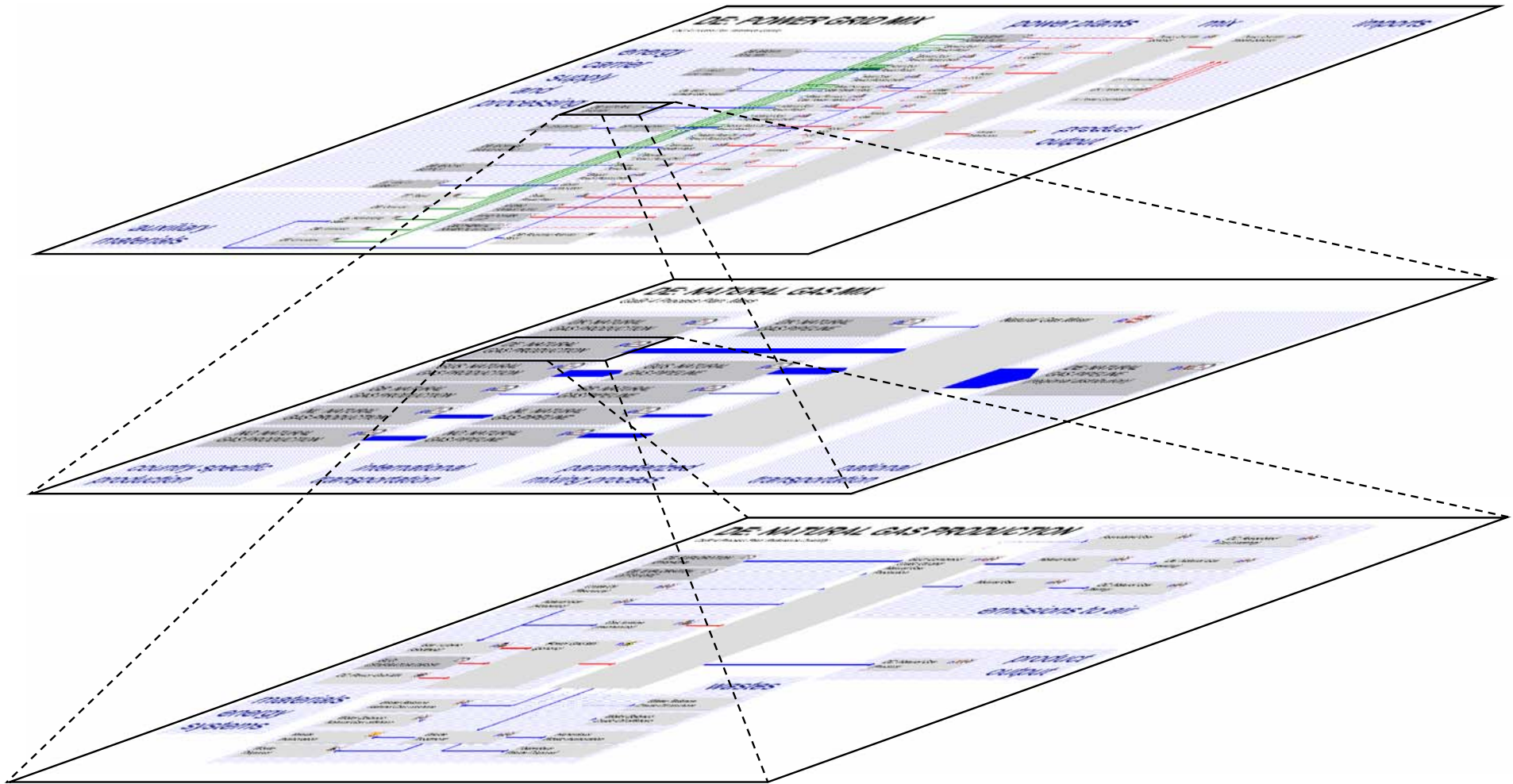
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Generic Energy System Modeling – System Hierarchy



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Conclusions



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Generic Modeling in LCA – Conclusions

Conclusions

- sophisticated system modeling is possible
- complex systems and interactions can be modeled
- time efficient modeling of similar systems
- usability for system experts and LCA experts
- analyzability (parameter variations) enables comprehensive quality checks

⇒ detailed and flexible models with manageable effort

⇒ adaptability to country specific boundary conditions

⇒ basis for comprehensive and consistent LCA databases



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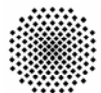
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Thank you for your Attention



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