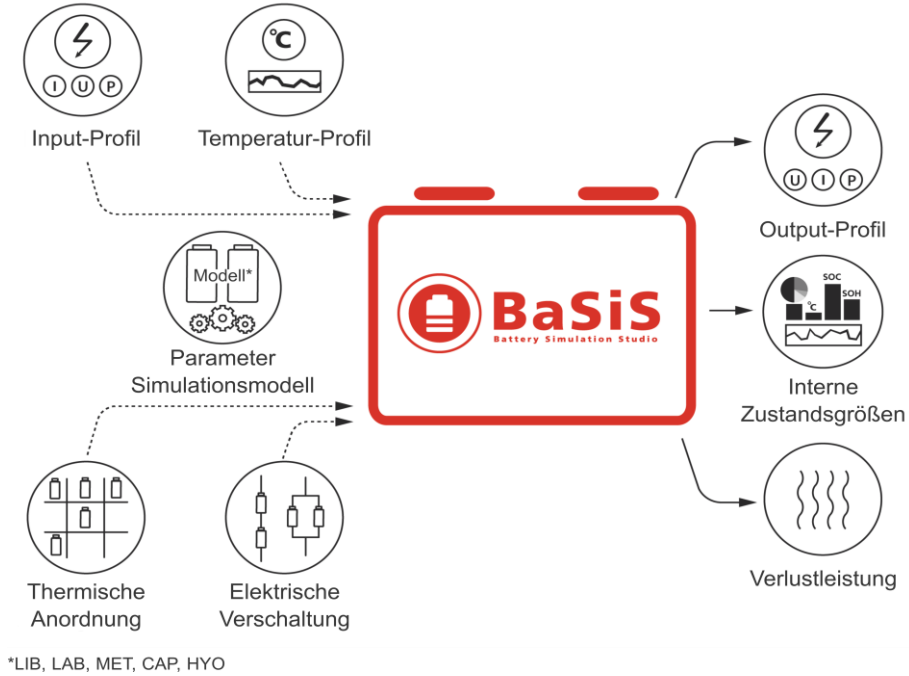
Modeling of Electrolyzers

BaSiS – Battery Simulation Studio



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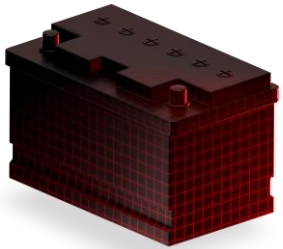
BaSiS – Technology

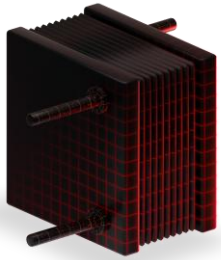
The provided **BaSiS Models** simulate the specific characteristics and work principles of different Energy-storage systems.

BaSiS LIB
Li-Ion-Batteries

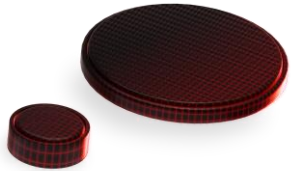


BaSiS LAB
Pb-Batteries

BaSiS CAP
Supercapacitors



BaSiS HYO
Electrolyzers



BaSiS MET
Metallic Batteries

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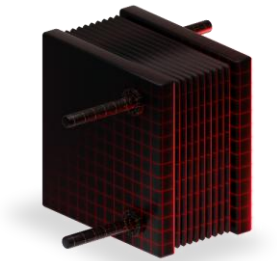
BaSiS HYO

Model Highlights

- Prediction of the behavior at arbitrary operating states
- Detailed insights into the internal processes
- Simulation of dynamic short-term processes and aging effects
- Complete individual parameterization in our Laboratory available



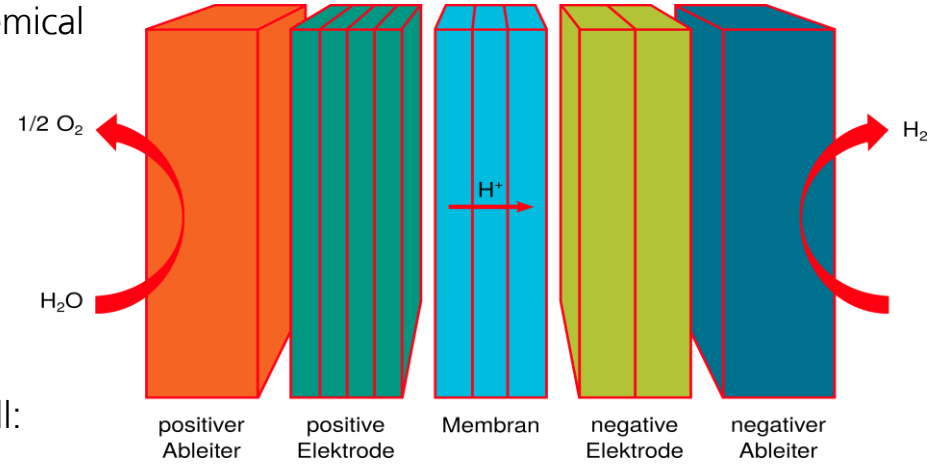
Technical advantages

- Low computational effort
- Real-time capability for HiL use
- Adjustable accuracy and calculation speed
- Available for common operating systems
- Interfaces for: MATLAB® / SIMULINK®, Functional Mock-up Interface, Python

BaSiS HYO (Elektrolyzer) – Cell Model

Discrete Cell-Model

- Modeling and simulation of the physical and electrochemical (transport-)processes throughout the entire cell
  diffusion, exchange of charges, current densities, etc.
- Calculation of the time-dependent evolution of internal state variables throughout the entire cell:
  concentrations, pressures, overpotentials, temperature
- Calculation of the macroscopic characteristics of the cell:
  voltage, current, resistance, etc.



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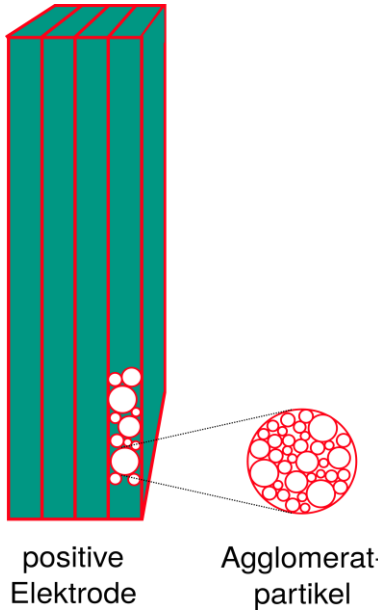
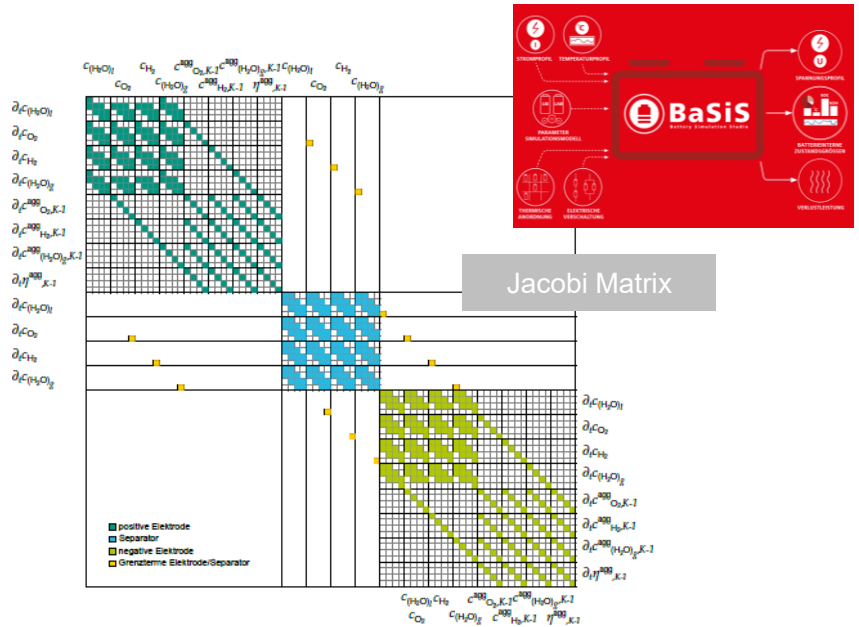
BaSiS HYO (Elektrolyzer) – Cell model – Agglomerate

- Each segment of the electrode is represented by agglomerated particles of various sizes
- The particles have a porous inner structure, giving them a large surface area to exchange charges
- Modeling and simulation of internal (transportation) processes (physical and electrochemical) and internal state variables within the particles of the agglomerate



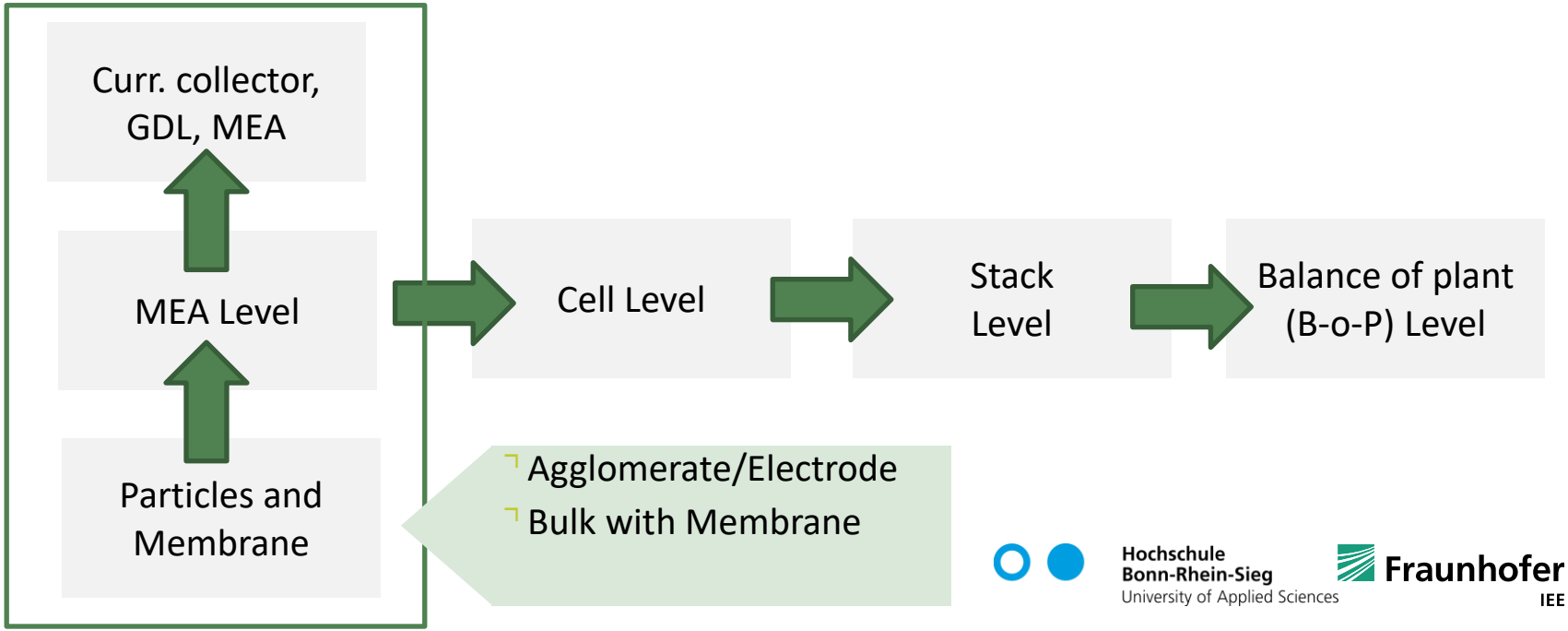
Elektrolyzers - Model Equation and Jacobi Matrix

1. Balance of Material Flow
   - Bulk
   - Agglomerate
2. Balance of charges
3. Energy Balance
   - temperature (only temporal)
   - cell potential



Source: Tatjana Dabrowski, BaSis HyO Dokumentation

Cell to B-o-P Model Process



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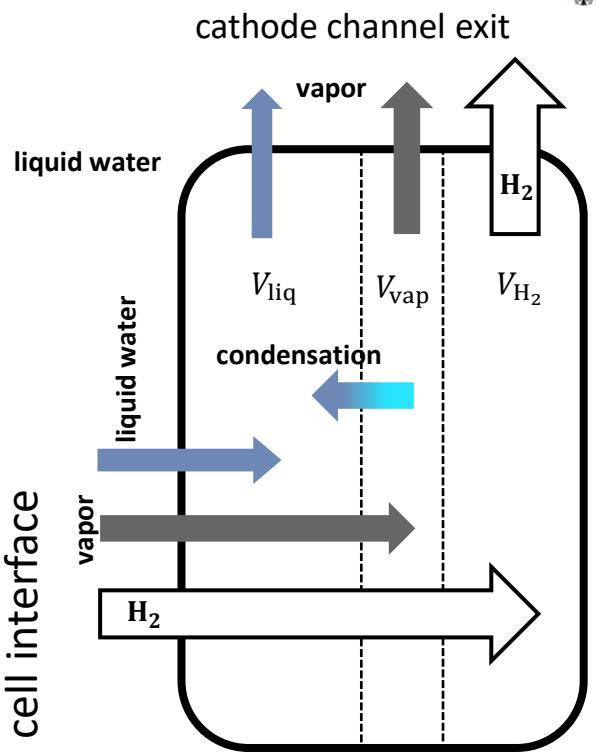
Cathode – Channel Model

- Assumptions
  - Lumped Variables
  - Ignoring compression
  - All gases are ideal
- State Variables
  - Volume fraction liquid water
  - Temperature in the channel (spatial average)
- Model equations
  - Components of the balance of mass
  - Balance of enthalpy
  - Heat transfer via conduction



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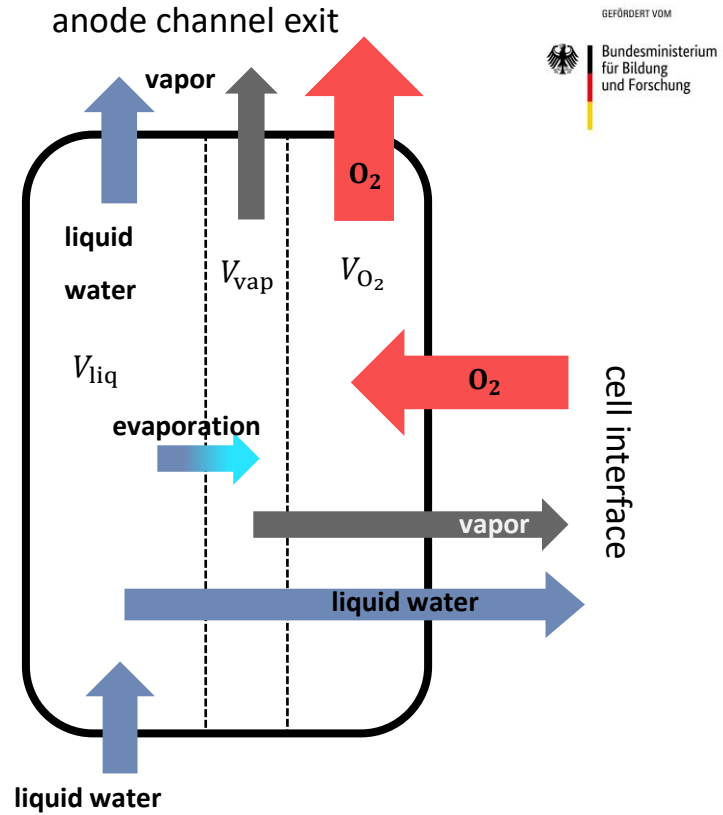
Anode – Channel Model

- Assumptions
  - Lumped Variables
  - Water saturated with oxygen
  - Ignoring compression
  - All gases are ideal
- State Variables
  - Volume fraction liquid water
  - Temperature in the channel (spatial average)
- Model equations
  - components of the balance of mass
  - Balance of enthalpy
  - Heat transfer via conduction



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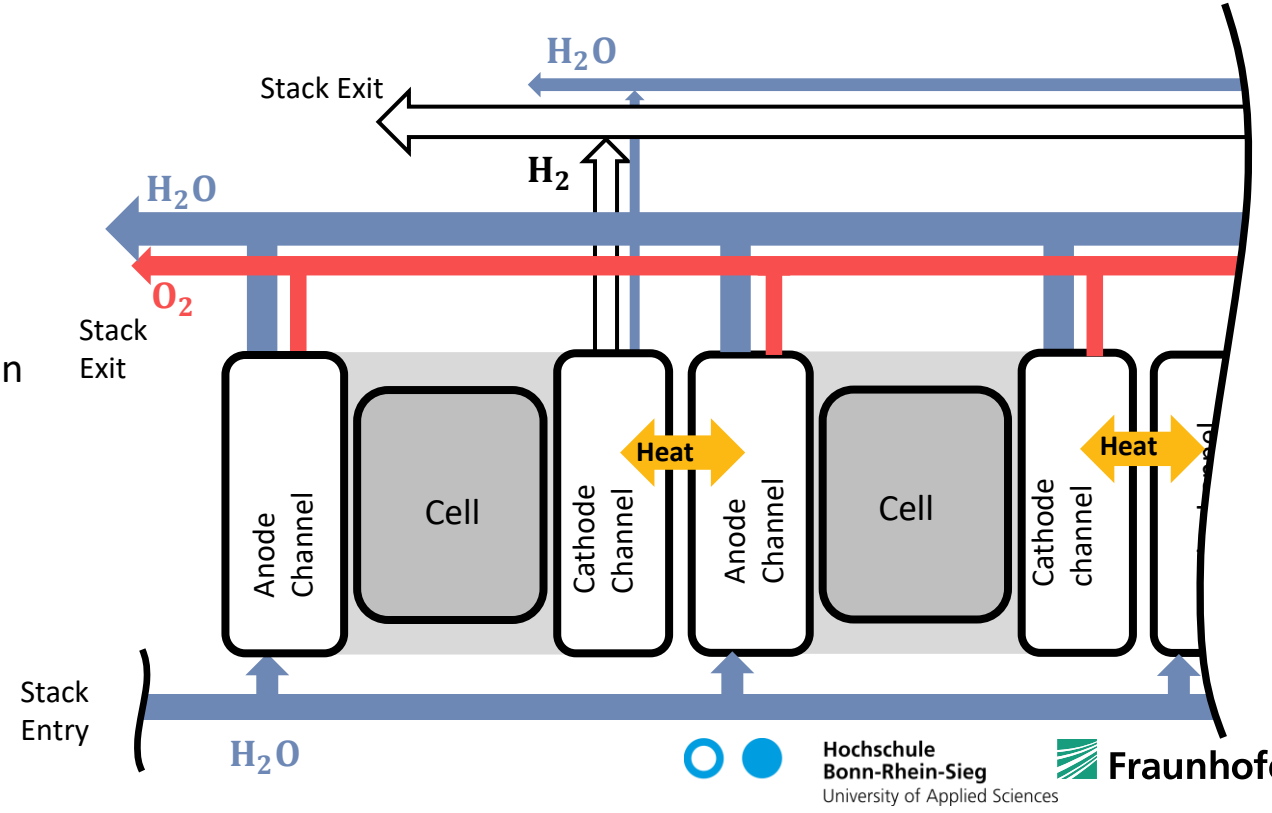
Stack Model

- heat transfer between channel panels
- hydraulically connected in parallel



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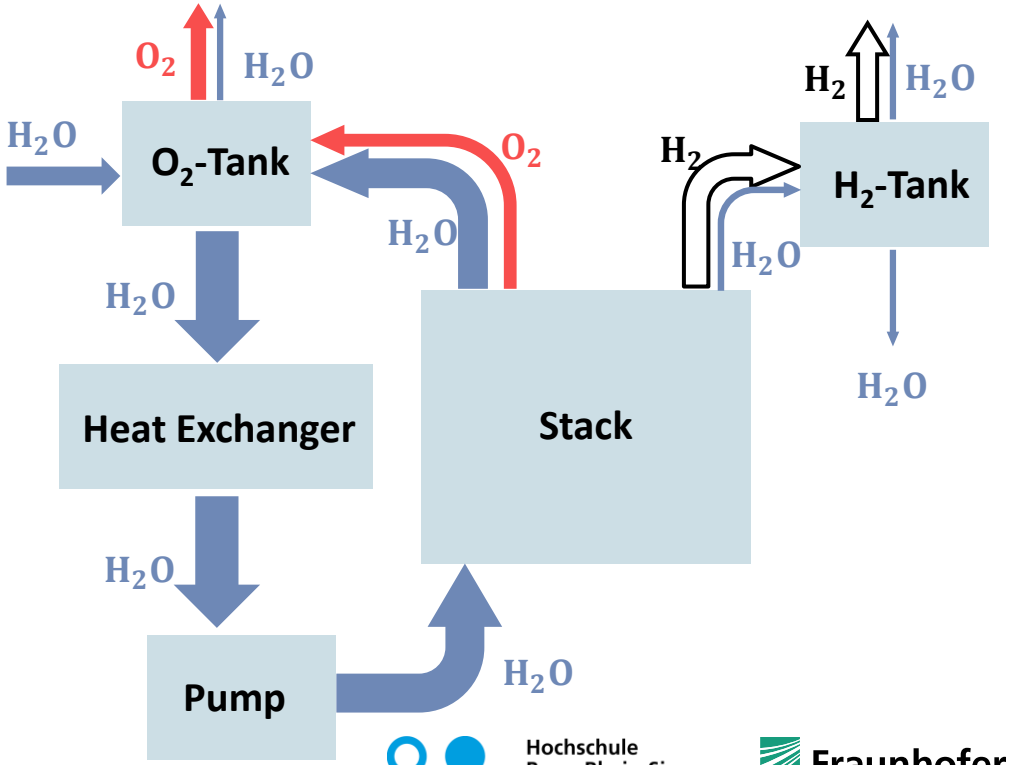
B-o-P Components

- Water loop Anode
  - Consisting of: O_2, H_2 Tank
  - Heat Exchanger, Pumps, …
- Focus of the Model
  - Water supply
  - Temperature Development
  - Pressure losses
  - …



Parameters

- Determination of detailed model parameters in our laboratory
- Testing of PEM electrolyses cells and short stacks, up to:
  - 10 V / 1 200 A
  - 50 bar(a) pressure on anode and cathode
  - 100 °C DUT temperature
- Independent anode/cathode operation and circulation
- Electrochemical impedance spectroscopy (EIS), up to:
  - 30 A amplitude (@ +20 / -2.5 V)
  - 10 µHz – 100 kHz
  - 8 independent channels

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Summary

Cell Model:

- Electrochemical Model of MEA
- Heat Model

Dynamic B-o-P-Model:

- Anode / Cathode Channel
- Stack Model with Heat model
- Water Loop with Models for Pressure and Temperature Development

Output Variables of the Cell Model:

- Current-voltage-characteristic
- Cell resistances and losses
- …

Output Variables of the B-o-P Model:

- Dynamic behavior of the components
- …

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Thanks for your attention

https://www.battery-simulation-studio.com/en/welcome/

https://www.iee.fraunhofer.de/de/testzentren-und-labore/elektrochemische-speicher.html