Modeling and Simulation of Thermal Systems with the TIL Suite and Dymola

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TLK ENERGY

founded
2015

in
Aachen, Germany

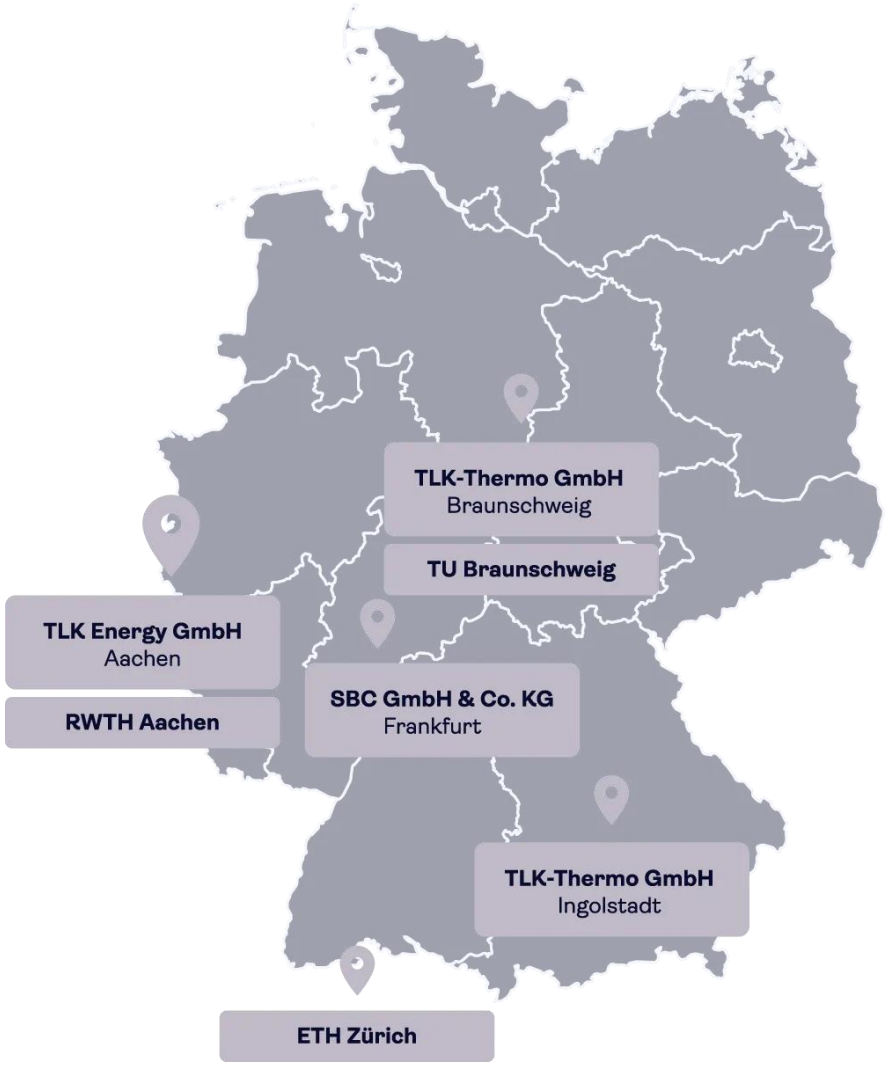
Partner of
TLK-Thermo

Joint venture with
SBC GmbH & Co. KG

Employees TLK
90

Our Services

- Engineering
- Software
- Webtools
- Trainings



We are a consulting and service company for thermodynamics, process engineering and dynamic modeling.

AGENDA

1. Dymola and Modelica
2. Model Libraries
3. Example Projects

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DYMOLA AND MODELICA

Dymola Software

- Modeling and simulation environment by Dassault Systèmes
- Based on the **Modelica** language
- Powerful solvers for large, complex systems
- Create models in text form (coding) or by graphical interface (drag-and-drop)

Dymola

Modelica Language

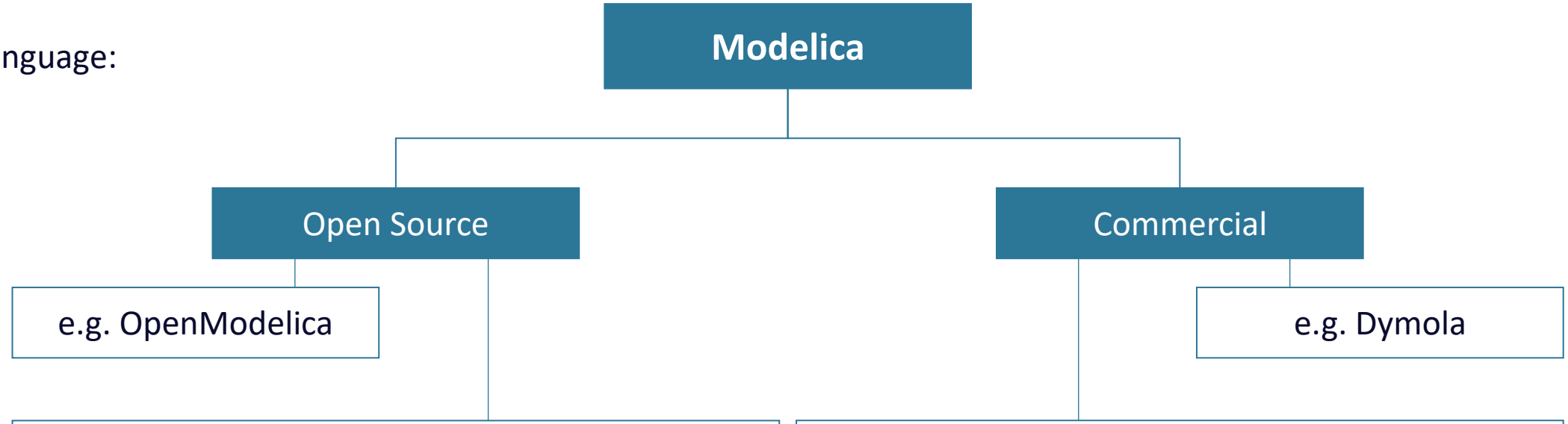
- Free and open modeling language
  - Maintained by non-profit organisation Modelica Association
- Object-oriented & Equation-based
- Suitable for mathematical description of multi-physical systems

  → Electrical, thermal, mechanical, hydraulic, …

Modelica

MODELICA ECOSYSTEM

Modeling Language:



https://modelica.org/libraries/

MODELICA FEATURES

- **Equation based modeling**

→ Allows natural and flexible description of physical systems

- **Graphical representatio**

→ Provides a easier unders

- **Exchangebility and Exter**

  Various interfaces for C, Pyt

  Supports FMI standard

→ Models can be easily exc
(Embed models in your o

LIVE-DEMO

Functional Mock-up Interface

Object orientation

→ Enables hierarchical and structured modeling

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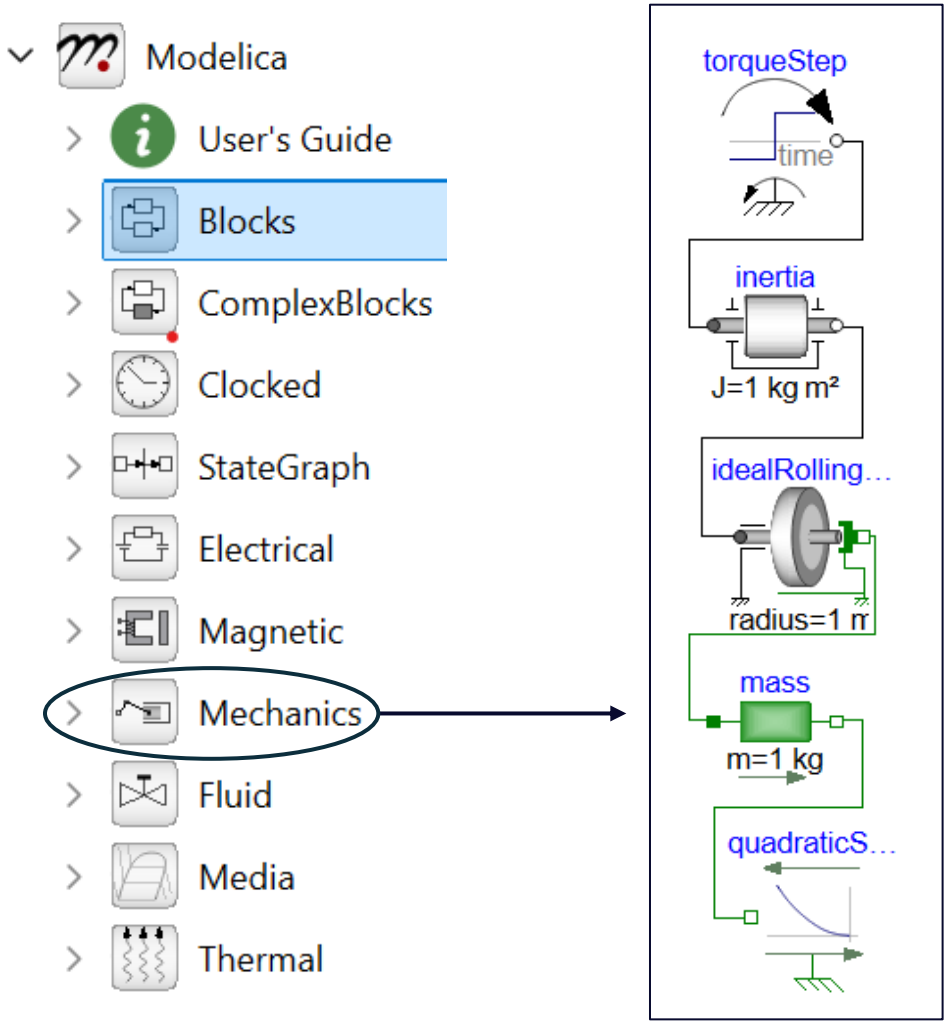
MODELICA STANDARD LIBRARY (MSL)

- Free library from the Modelica Association
- Integrated into Dymola by default
- Includes basic models and interfaces for
  - Mechanics
  - Electrics, electronics
  - Thermodynamics, Fluid Mechanics
  - Control systems, discrete modelling, Math



AGENDA

TIL SUITE

TIL SUITE – Software for Thermodynamic Systems

TIL – Thermal components and systems (two-phase flow)

TILMedia - Thermophysical properties (own solvers)

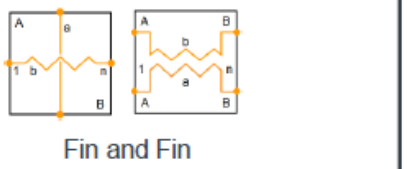
\+ **Add-Ons**

(Some) Customers

TIL SUITE

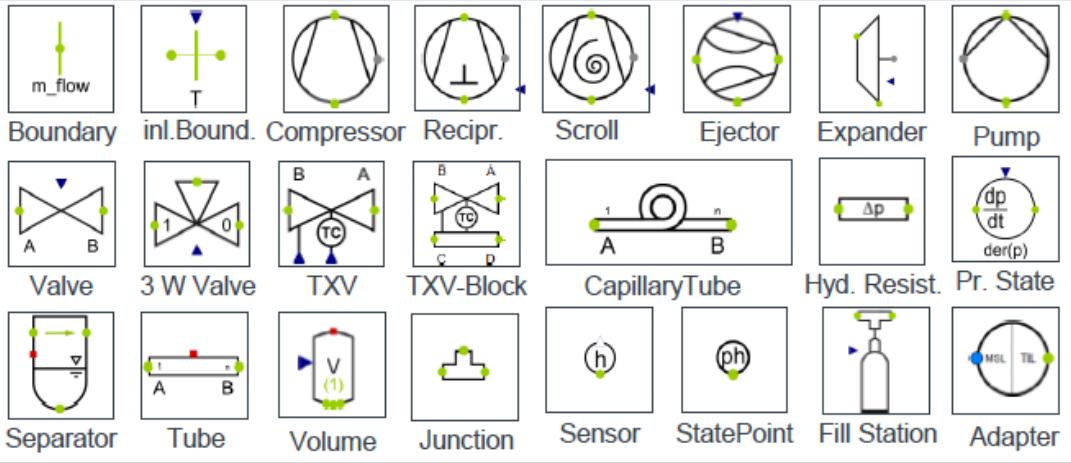
TIL Standard Components

Heat Exchangers

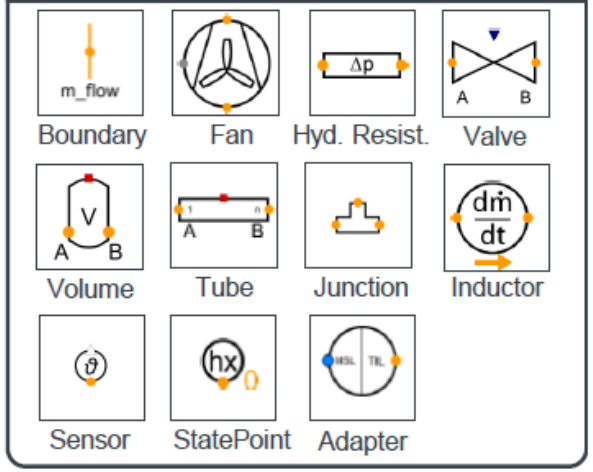


All Heat Exchangers using finite volume approach (FV). Various Moving Boundary models available.

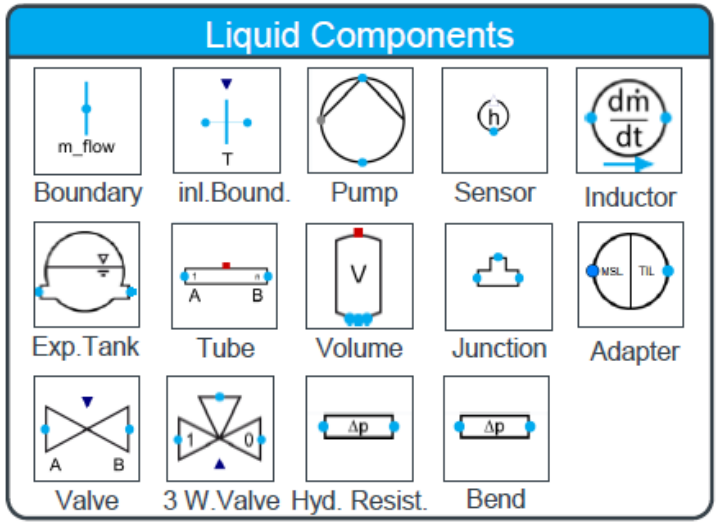
VLEFluid Components



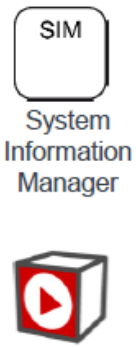
Gas Components



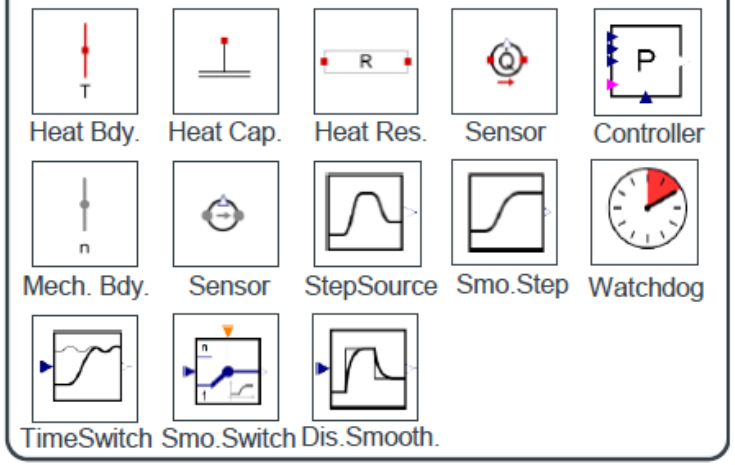
Liquid Components



Top Level



Other Components



TIL SUITE

TIL ADD-ONS

- ✓ **Automotive** – HVAC and battery thermal management
- ✓ **Hydrogen** – fuel cells, electrolysis, liquefaction, refueling stations
- ✓ **PCM Storages** – phase change thermal storages
- ✓ **Heat Storage** – stratified water tanks
- ✓ **Adsorption** – gas purification, drying, Direct Air Capture (DAC)

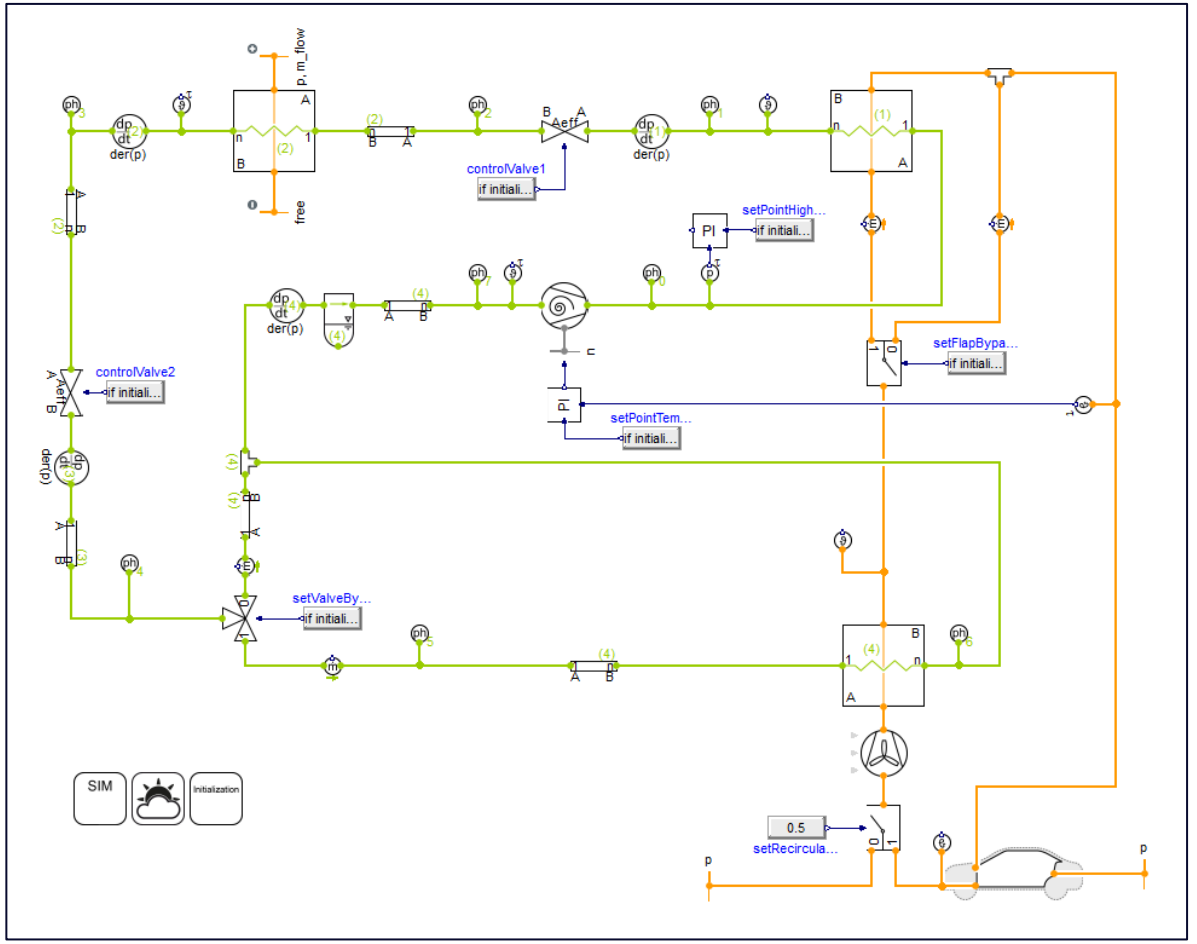
TIL SUITE

TIL ADD-ON Automotive

Use Cases

- Essential for the design of a vehicle ventilation system
- Cooling of battery or motor
- Efficient heating of the cabin

Example: Automotive Heat Pump and AC-Cycle

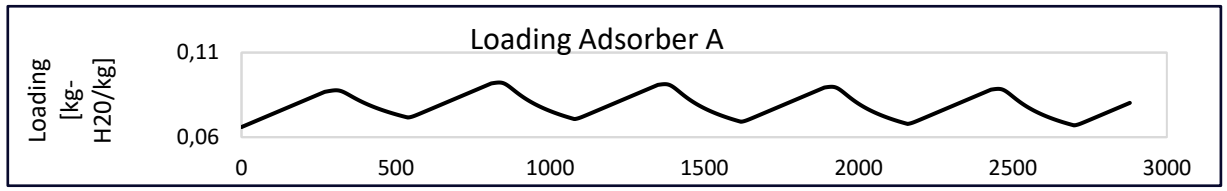


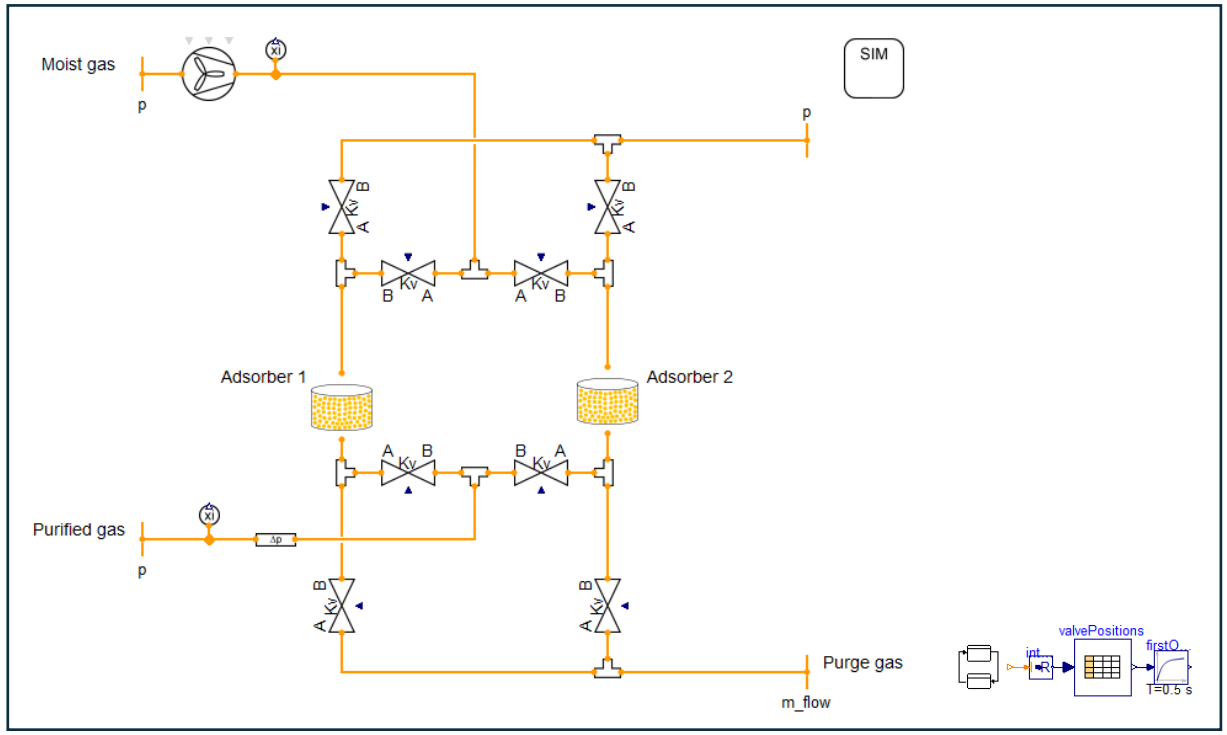
TIL ADD-ON Adsorption

Use Cases

- Gas separation
  - CO2 capture
  - Hydrogen purification
  - Moist air drying
- Industrial Drying
  - Paper production
  - Battery coils

Example: Thermal Swing Adsorption (TSA) System





AGENDA

PSL

Process Systems Library (PSL)

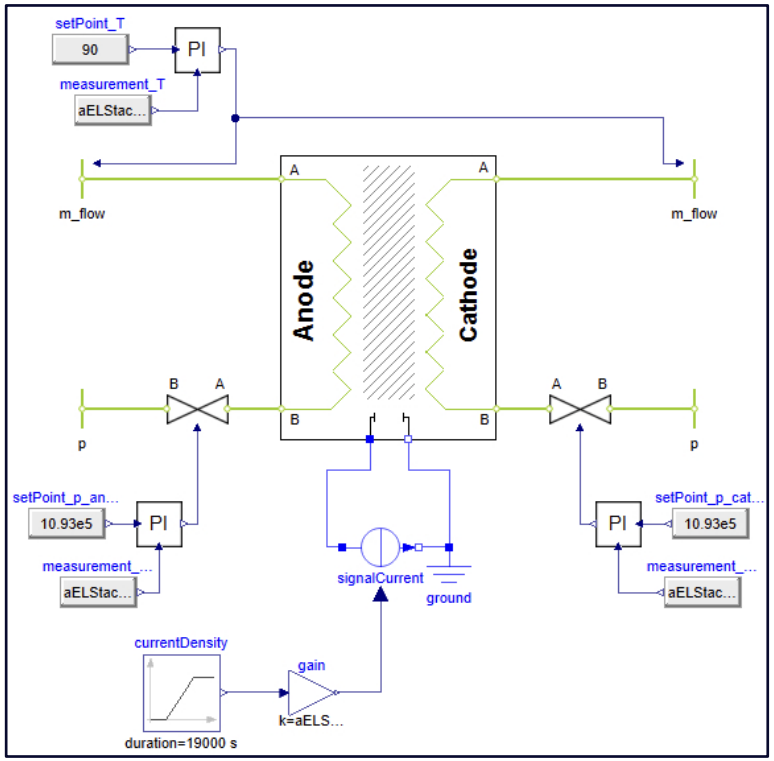
→ Dynamic simulation for two-phase mixtures

- Both phases have variable compositions
- Enables reactions and thermal separation processes

Use Cases

- Hydrogen production (PEM and alkaline electrolysis)
- New chemical processes (PtX)
- Carbon capture (amine based)

Example: Alkaline Electrolysis



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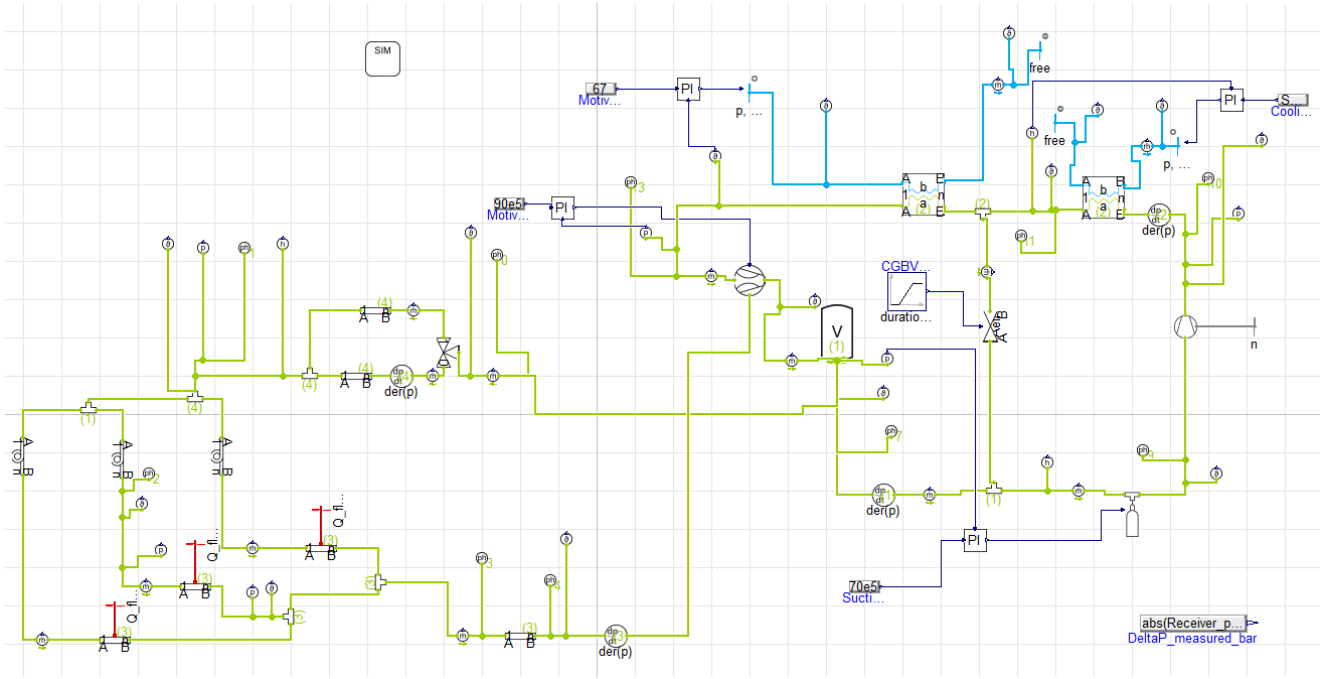
CERN AND NTNU

Xenon-refrigerant silicon detector cooling

- Adaptation of a CO_2 based refrigeration cycle to Xenon
- Very good agreement of simulation data with lab prototype measurements
- Contiero et al (2023), "A prototype with Xenon to simulate the future advance refrigeration unit for cooling of silicon detector trackers", 26th International Congress of Refrigeration, DOI: 10.18462/iir.icr.2023.0347



Evaluate qualitative design studies for cooling concept

Compare with lab experiment quantitatively

CERN | EP-DT Detector Technologies

NTNU

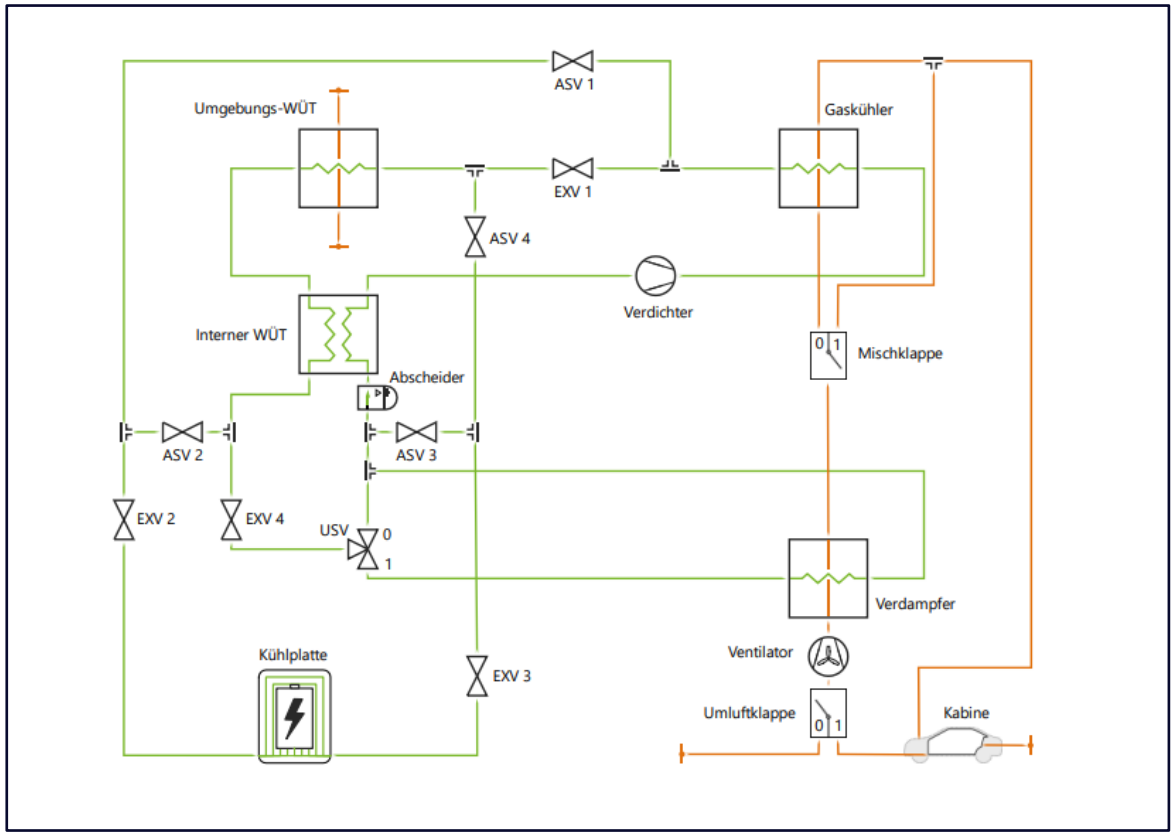
VOLKSWAGEN

Reversable CO_2 heat pump

- Direct (refrigerant) temperature control of the battery

→ Increased efficiency, weight and cost savings

- Model bases design of:
  - System layout
  - Control concept

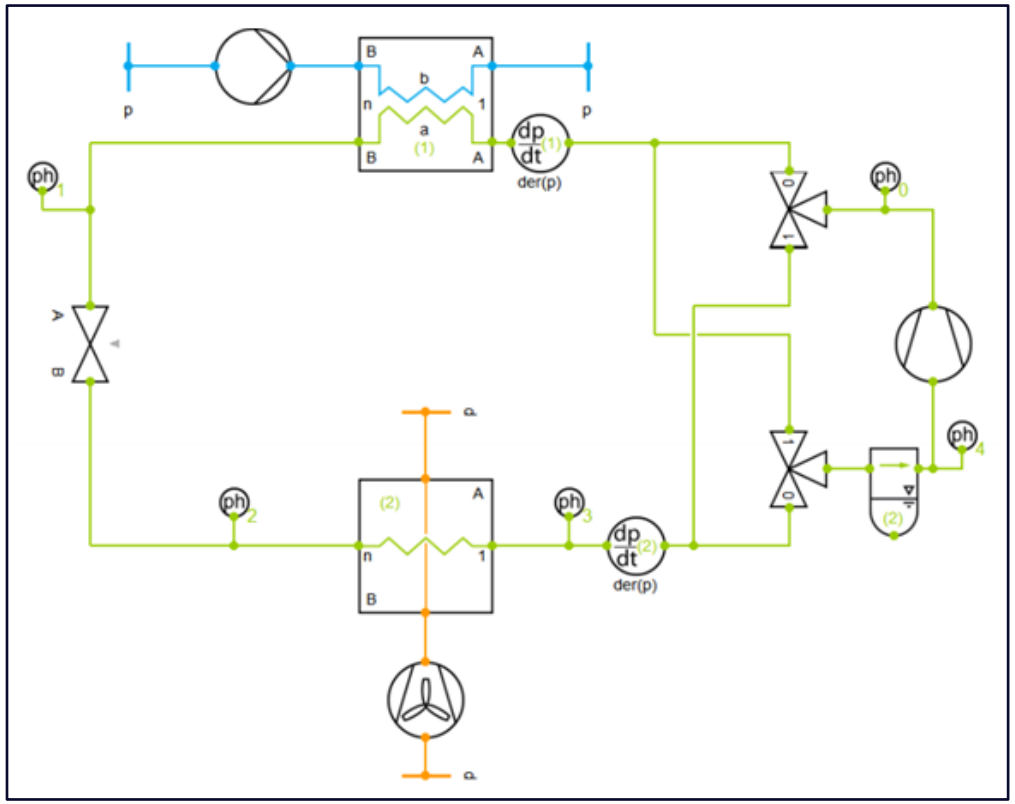


Test different ideas before building real prototypes

VAILLANT

Real Time Models for HiL Tests

- Real controllers tested with virtual heat pumps
- Robust and fast heat pump models developed with TIL
- Exported to dSPACE platform



Identify control issues at an early stage

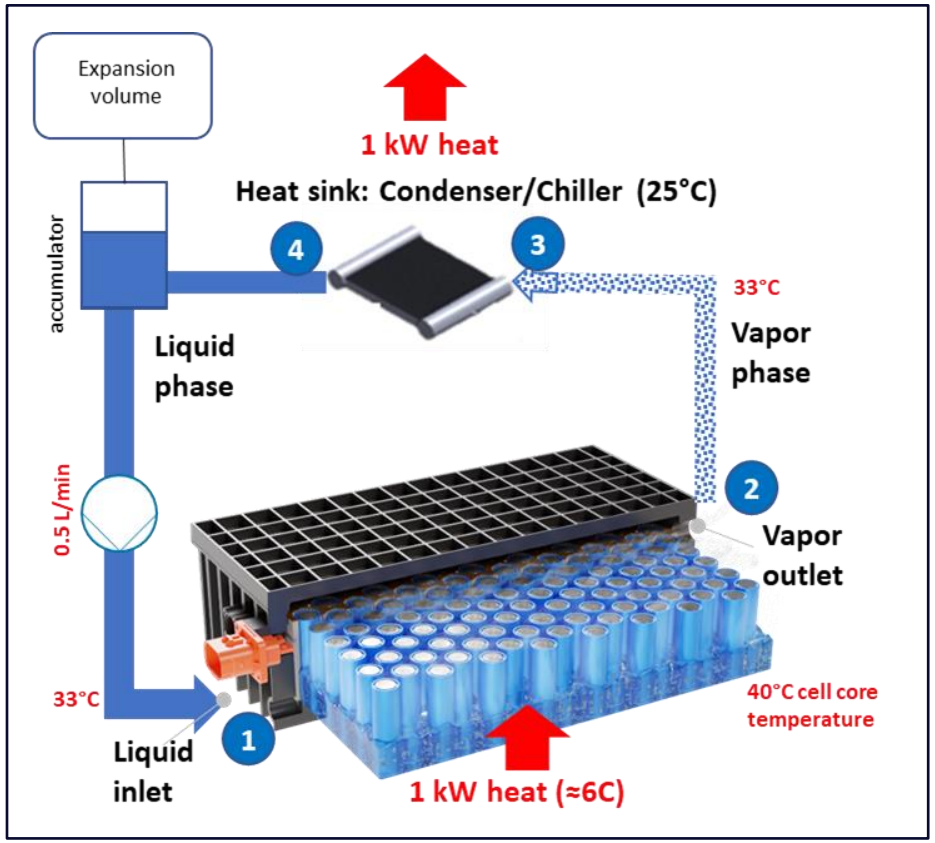
Reduce number of lab experiments

Vaillant

KAUTEX

Two-phase Immersion Cooling of Batteries

- Model based system design and component sizing
- Analysis of customer benefits including the overall thermal management system

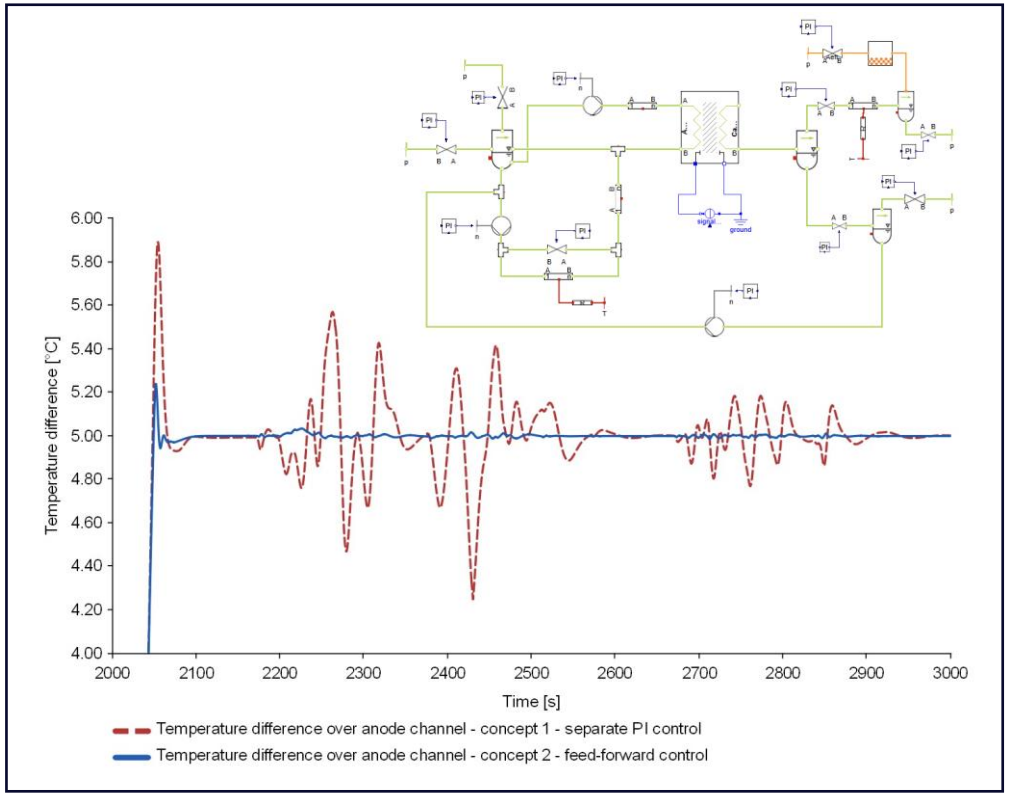


Convincing customers (automotive OEMs)

KAUTEX
A Textron Company

Stack Cooling for PEM Electrolyzers

- Waste heat needs to be dissipated
- Constant temperature difference is good for stack lifetime
- Transient load profile (e.g. coupled to wind turbine)
- Model based control design



Greatly improved control performance

NEUMAN & ESSER

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PRODUCT AND TRAININGS

Book **TRAININGS** to become proficient with Dymola and gain a deep understanding of the libraries.

TRAININGS

- **Experienced trainers**
- **Optimized concept**
- **Standard or customized**
- **Online and On-site**

Modelica/Dymola Training

- Jan 27 - Jan 29, 2025
- 9:00 am - 6:00 pm CET
- Online (flextime)

TIL Suite Training

- Jan 30 – Jan 31, 2025
- 9:00 am - 6:00 pm CET
- Online (flextime)

Customized training

- Your choice
- Your choice
- Your choice

https://tlk-energy.de/en/modelica-training

Contact

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THANK YOU FOR YOUR ATTENTION

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