TLK-Thermo GmbH

TIL Suite simulates Thermal Systems

Software containing models for thermophysical properties, thermal components and systems

TIL Model library for thermal components & systems

Continually developed and applied by

Technische Universität Braunschweig

TLK-Thermo GmbH

C-Code

Platform

1997

MODELICA

TIL 0.1

2006

TIL 1.0

2008

TIL 2.0

2009

TIL 3.0

2012

Content

TIL
model library for thermal components and systems

TILMedia for MODELICA
model library providing thermophysical properties

TILFileReader
imports tabular data from files

TIL Suite

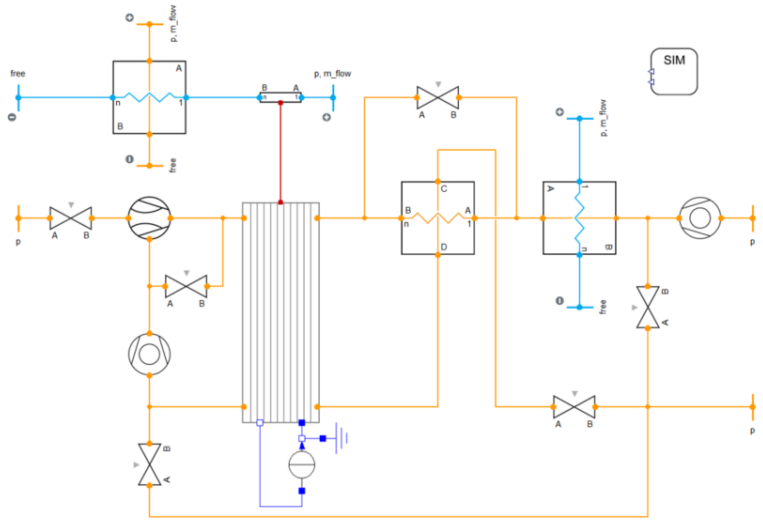
TIL Add-On Libraries
Additional components and systems available to TIL

Training courses
Modelica and TIL introduction and advanced trainings

Addition

TIL Automotive Applications

Fuel Cell Systems



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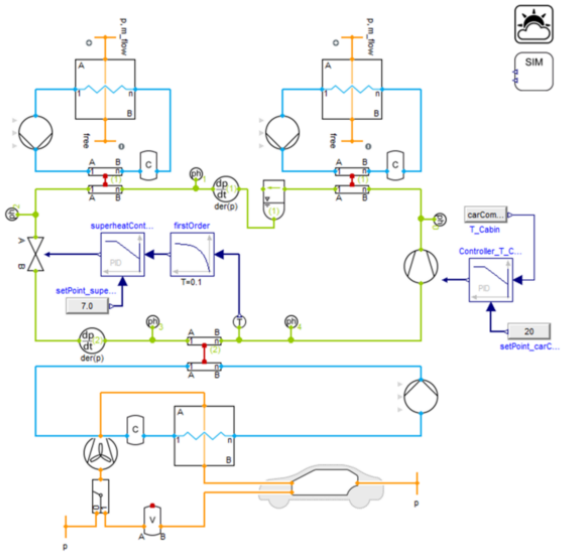
Secondary Loop



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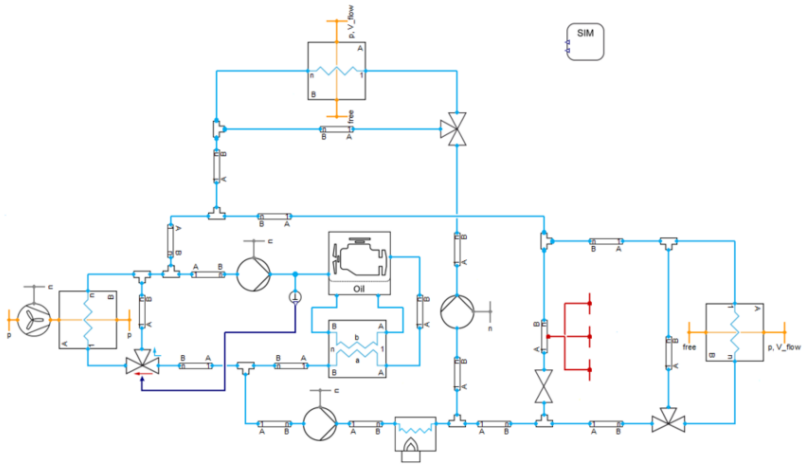
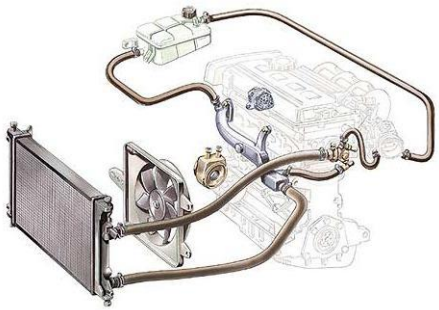
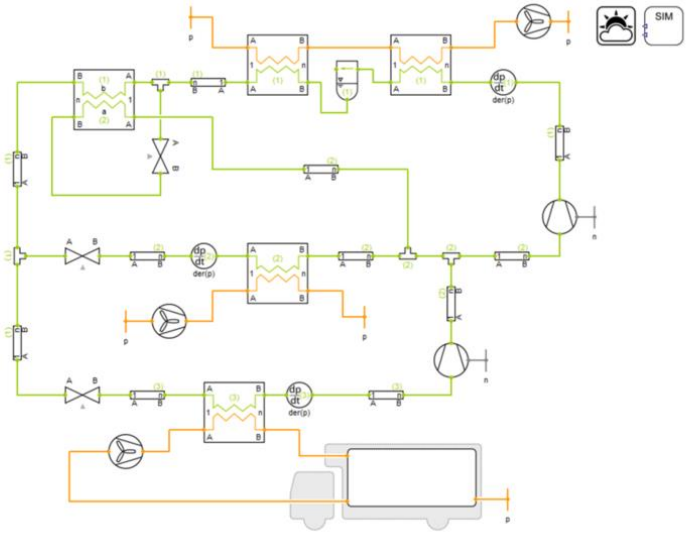
TIL Automotive Applications

Cooling Systems





Transport Refrigeration



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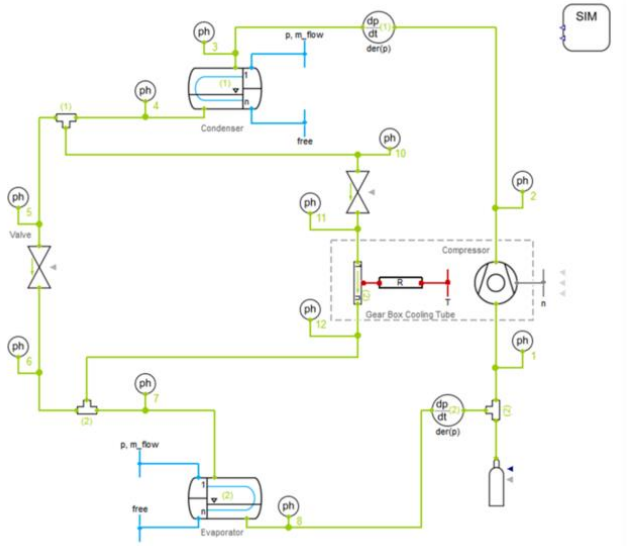
TIL Industrial Applications

Industrial Refrigeration



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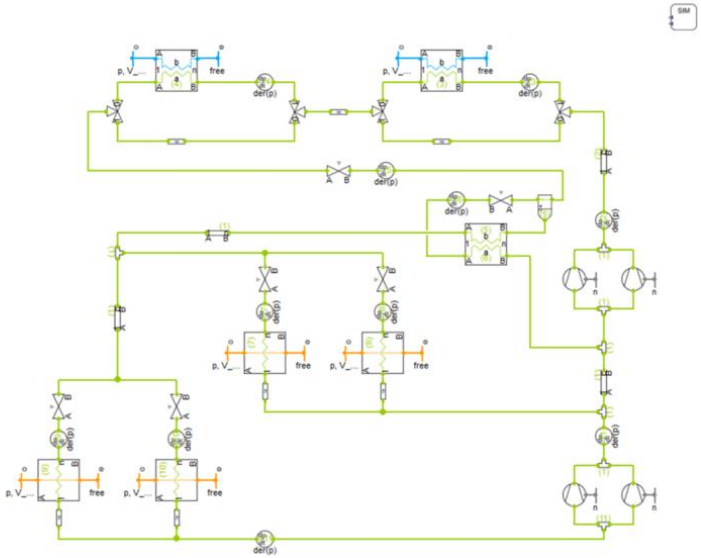
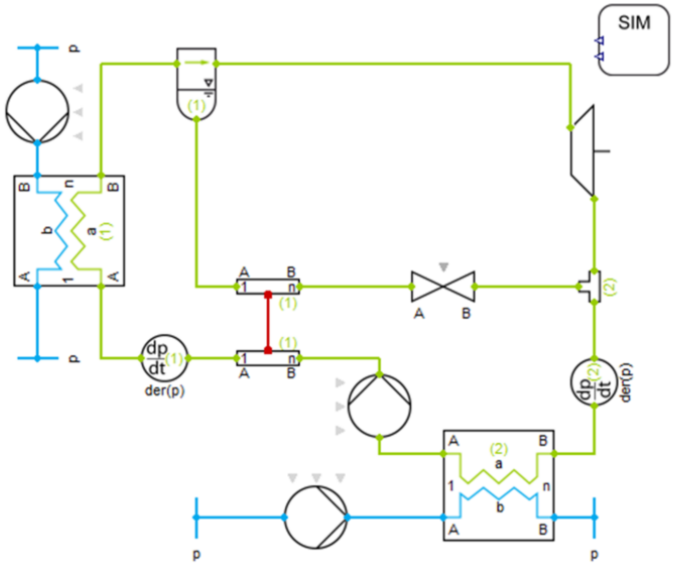
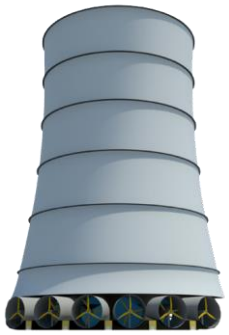
Supermarket Refrigeration



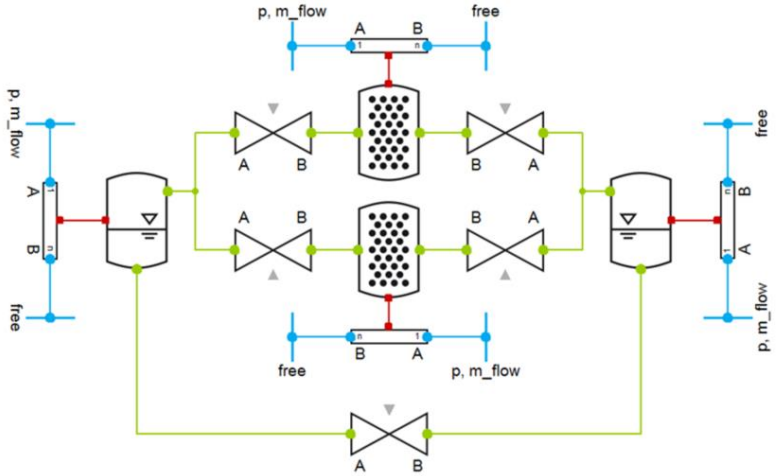
TIL Industrial Applications

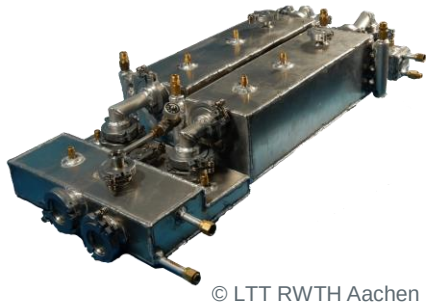
Kalina Cycle





Sorption Refrigeration





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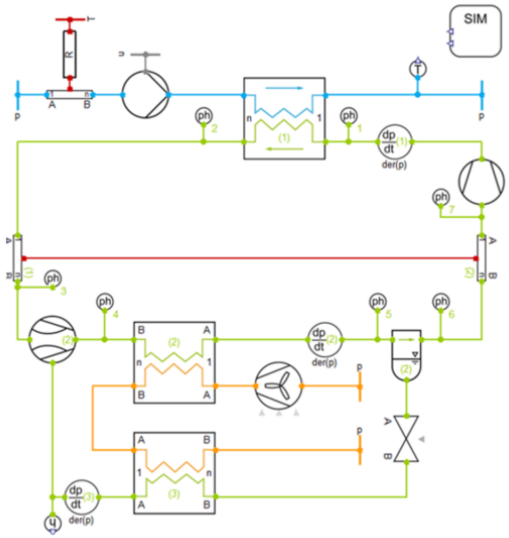
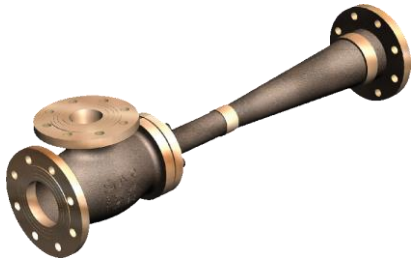
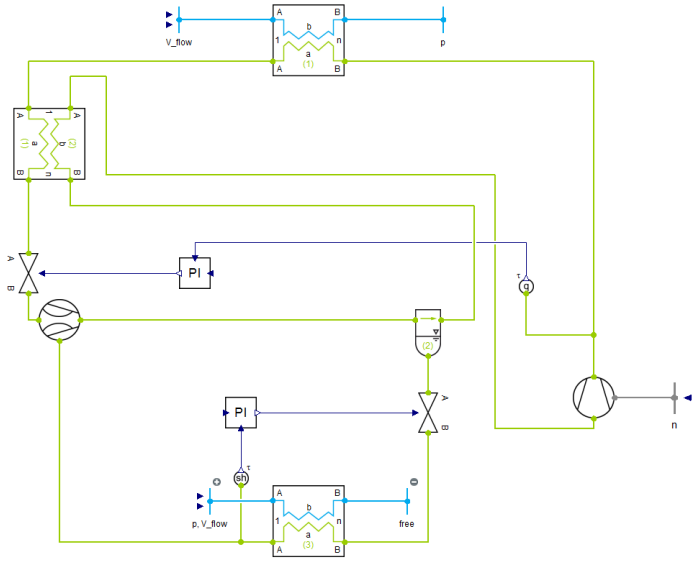
TIL Heat Pump Systems

Ejector Systems





Domestic Heat Pump System



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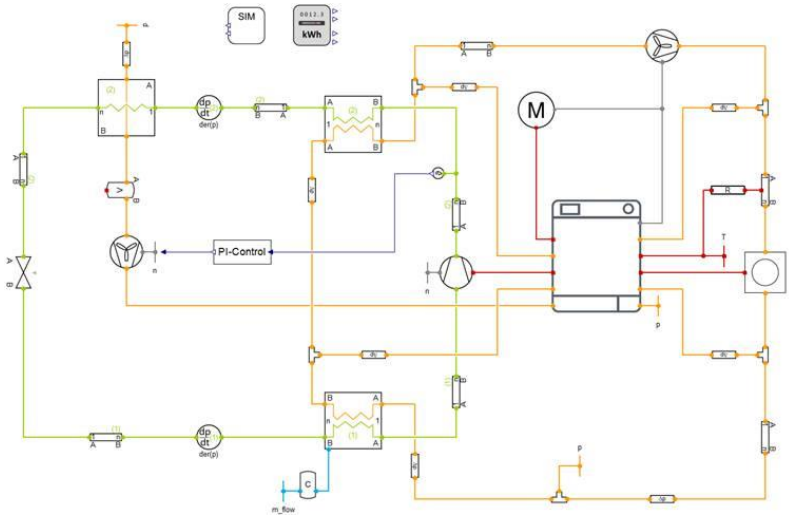
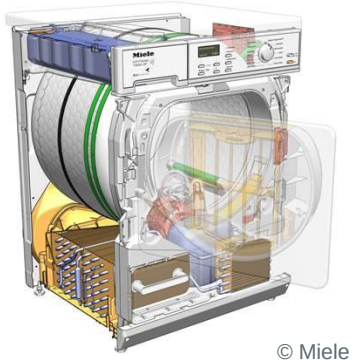
TIL Heat Pump Systems

Tumble Dryer





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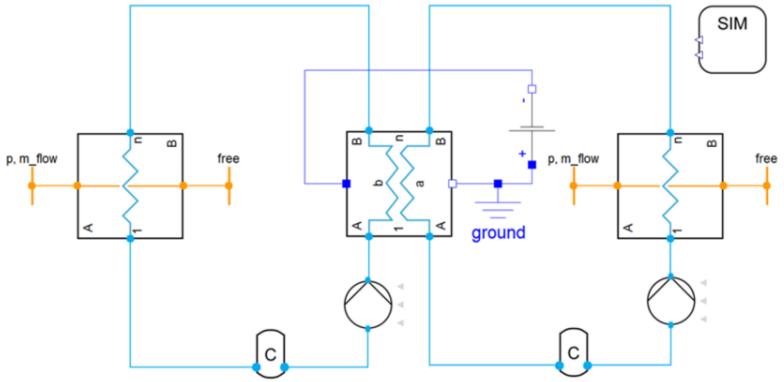
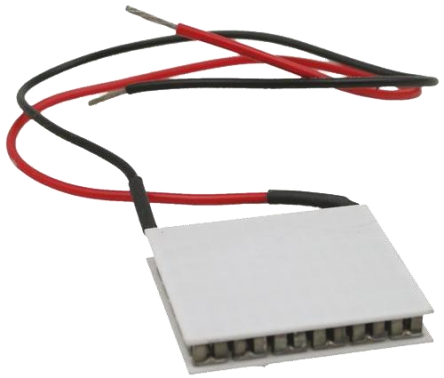
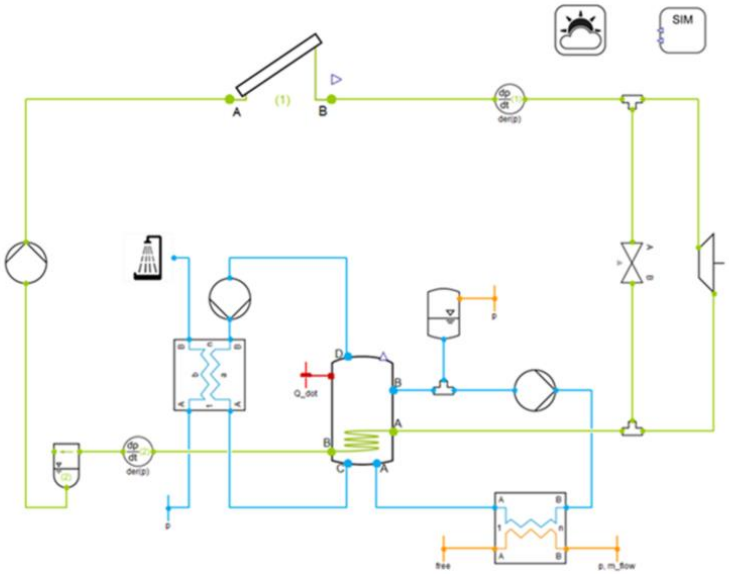
Thermoelectric Systems

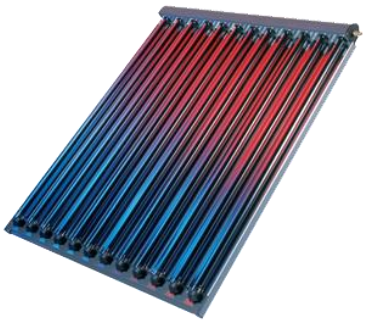




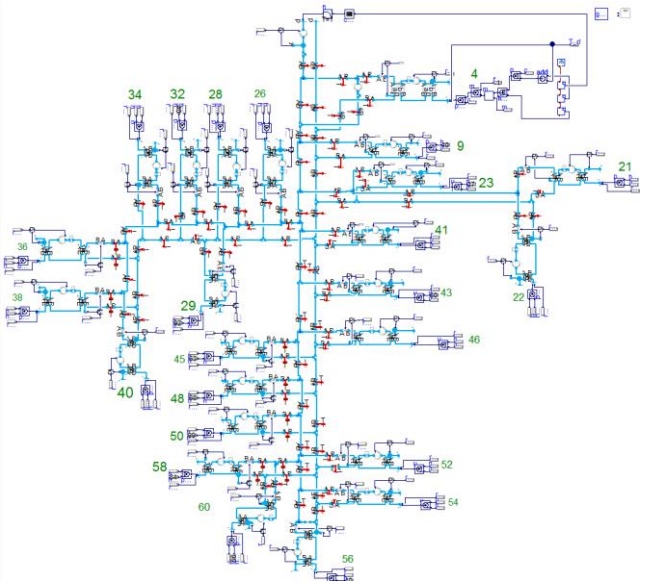
TIL Special Scopes

Solar Organic Rankine



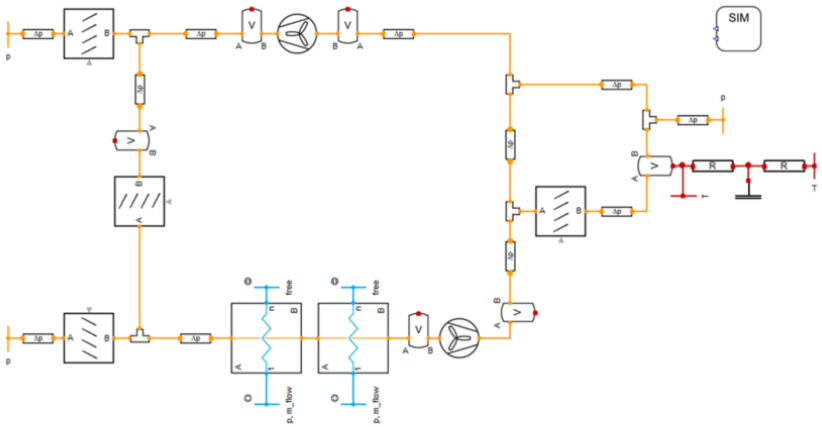


District Heating Grids

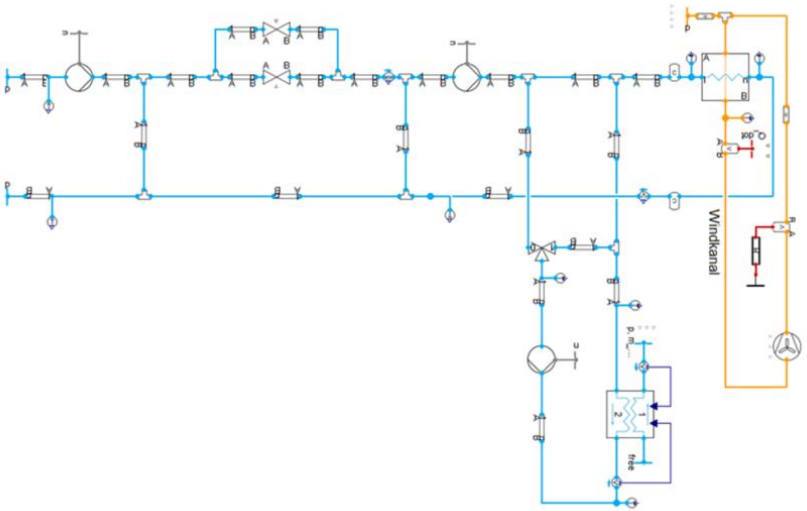


TIL Special Scopes

Air Handling Unit



Climatic Wind Tunnel

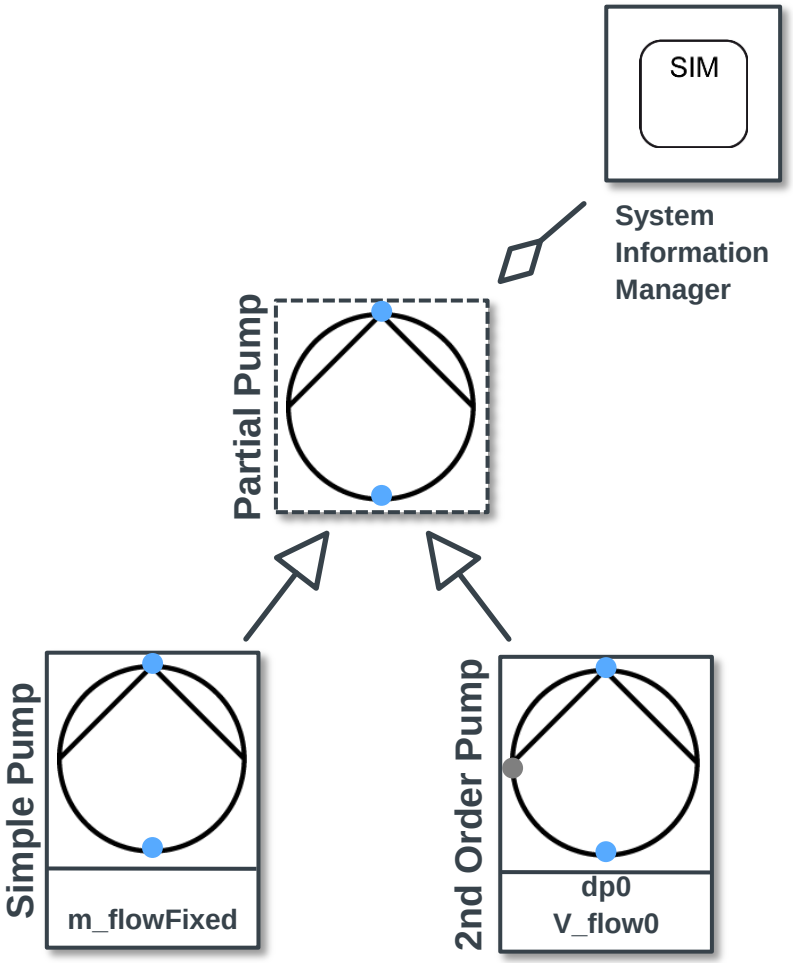


TIL Design Concept

Goal: make even complex thermodynamic models

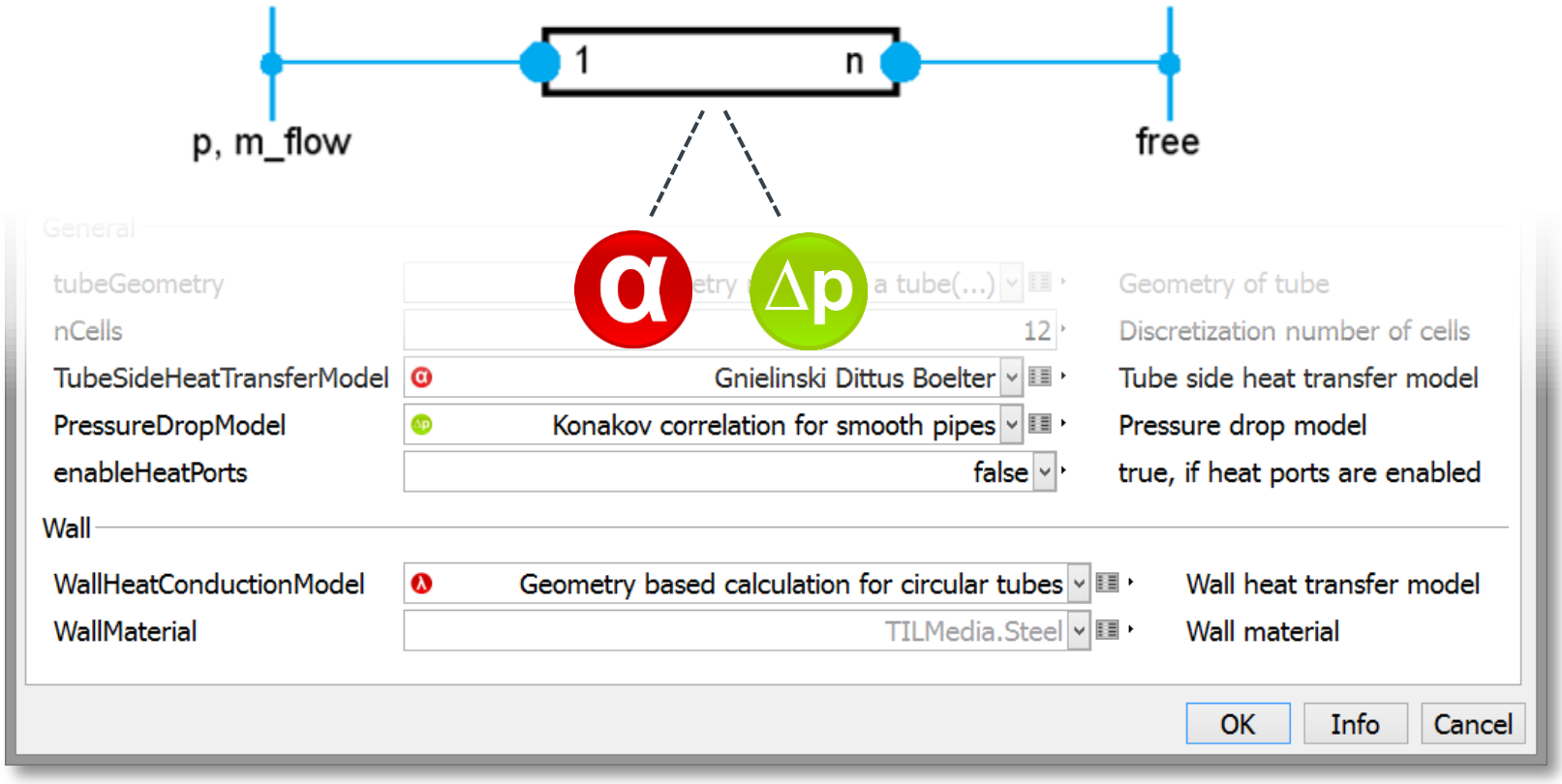
- easy to read
- easy to change
- easy to learn

TIL therefore uses a shallow object-oriented structure to maintain readability of models



TIL Exchangeability

Pressure drop and heat transfer correlations can easily be selected and exchanged from drop down menus.



TIL Extensibility

Create your own models using inheritance to extend existing TIL models.

- Component models e.g. compressor

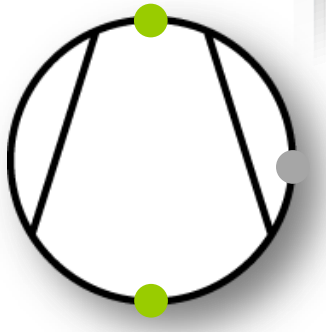
Heat transfer models

Pressure drop models

MyCompressor - MyCompressor - [Modelica Text]

File Edit Simulation Plot Animation Commands Window Help Linear analysis

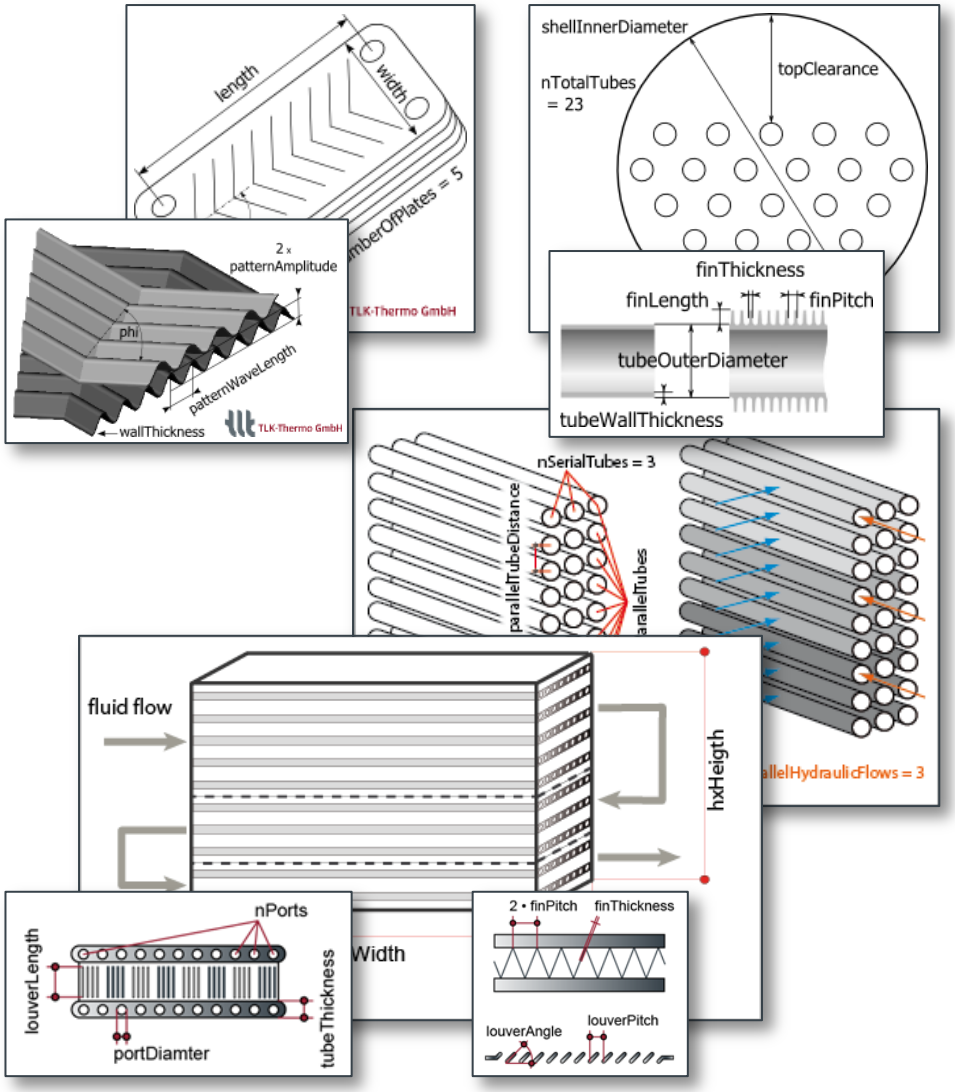
```
model MyCompressor "Efficiency based compressor model" extends
  TIL.VLEFluidComponents.Compressors.BaseClasses.PartialEffCompressor;

  parameter Real pi0 = 25;
  parameter Real a= 0.9;
  parameter Modelica.SIunits.Efficiency isentropicEfficiency = 0.7
    "|Compressor Efficiencies|Isentropic efficiency";
  parameter Modelica.SIunits.Efficiency effectiveIsentropicEfficiency = 0.7
    "|Compressor Efficiencies|Effective isentropic efficiency";

 Real pressureRatio;

equation
  pressureRatio = portB.p/portA.p;
  volEff = ((pi0 - pressureRatio)/(pi0-1))^2*a;

  isEff = isentropicEfficiency;
  effIsEff = effectiveIsentropicEfficiency;

end MyCompressor;
```



TIL Detailed Thermodynamic Models

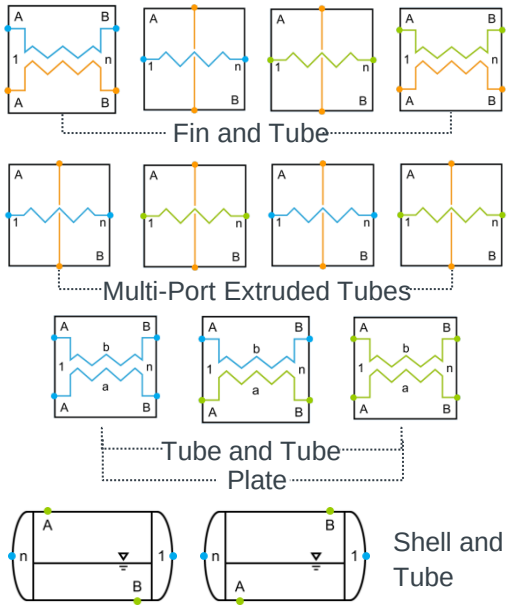
TIL models use geometry based heat transfer and pressure drop correlations.

Advanced thermodynamic modeling concepts for both steady state and transient simulations are implemented e.g. Moist air: evaporation, condensation, dynamic water balance.



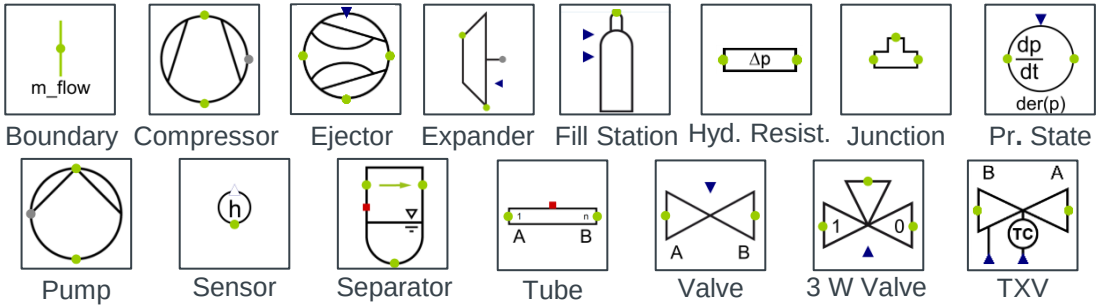
TIL Standard Components

Heat Exchangers for Liquid, Gas, Moist Air and VLEFluid

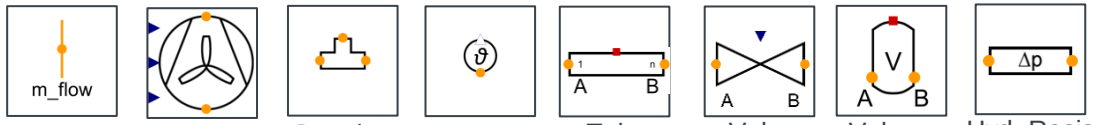


Various Moving Boundary heat exchangers for real time simulation

VLEFluid Components

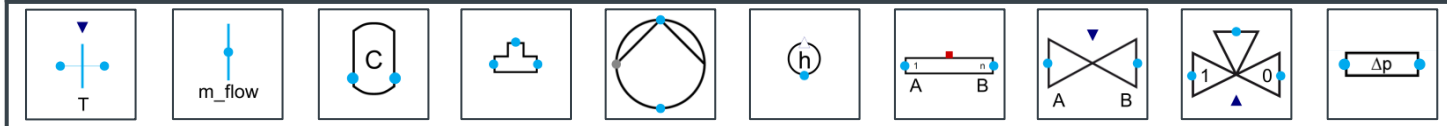


Gas Components



Other Components

Liquid Components



Top Level

Content

TIL Suite

TIL
model library for thermal components and systems

TILMedia for MODELICA
model library providing thermophysical properties

TILFileReader
imports tabular data from files

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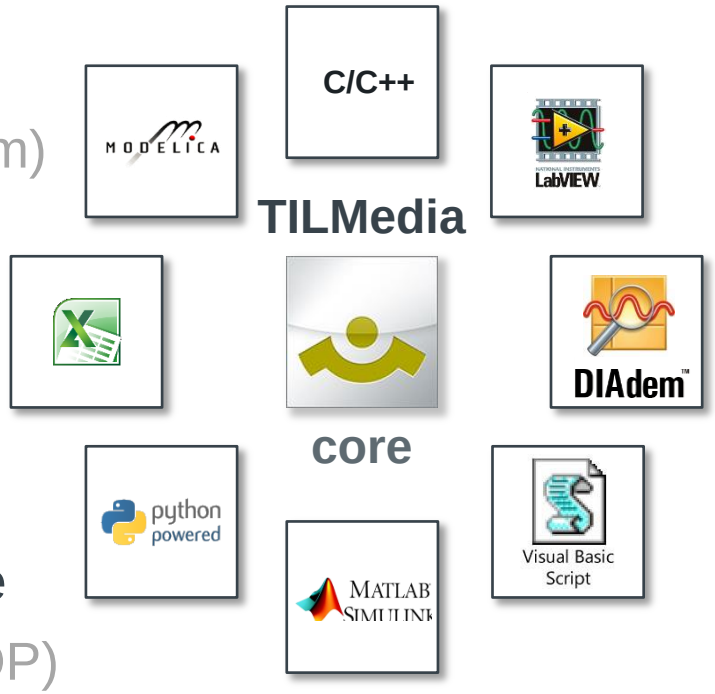
TIL Media Substance properties optimized for stable and extremely fast dynamic simulations

- Calculation methods to express thermophysical properties of:
  - Incompressible Liquids
  - Ideal Gases
  - Real Fluids (with vapor liquid equilibrium)
    - Mixtures
- Optimized mathematical equations with extremely high calculation speeds and high accuracies
- Several hundreds of substances available (also from external sources e.g. REFPROP)



- TILMedia Suite interfaces one property core for various software

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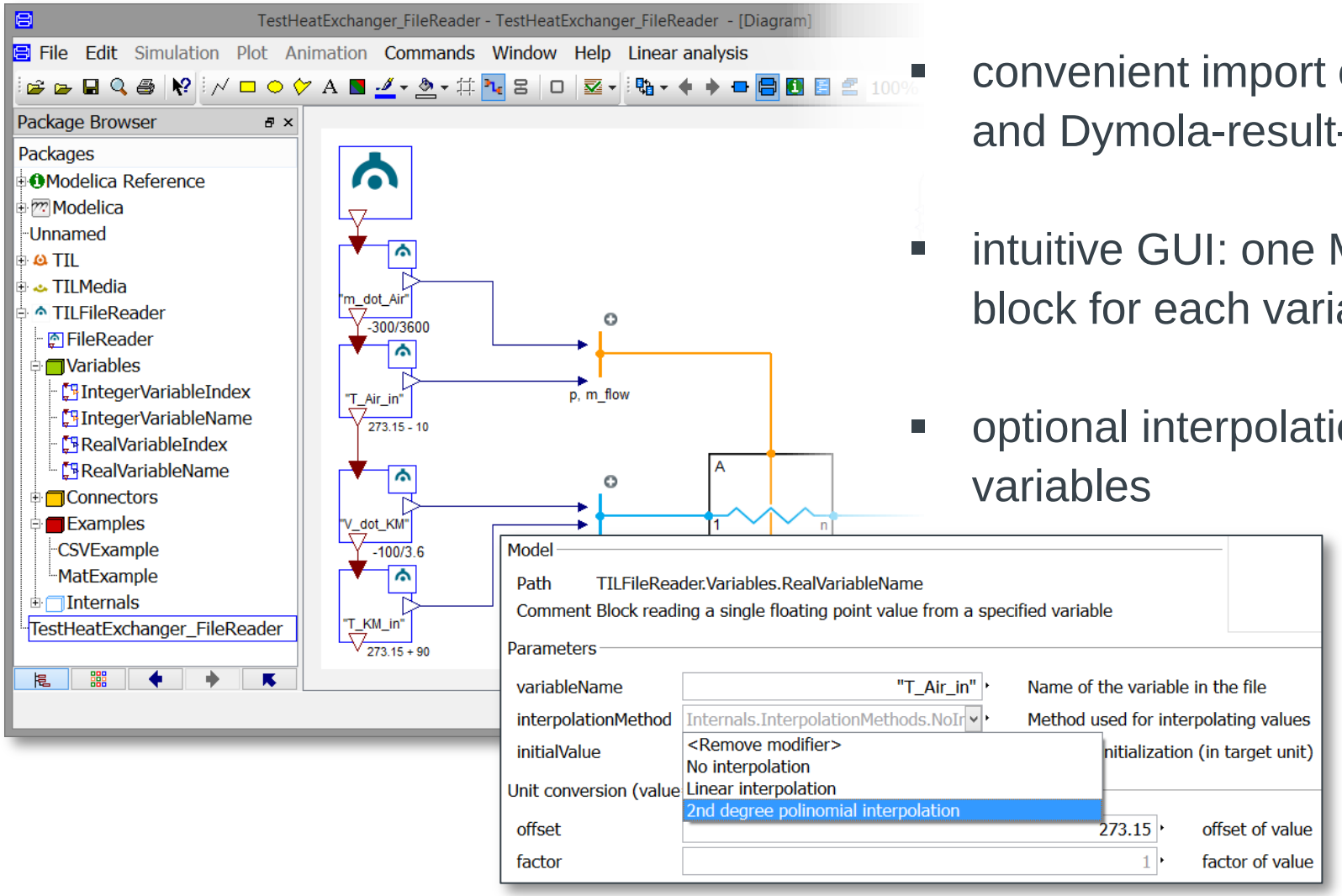

- convenient import of csv- and Dymola-result-files
- intuitive GUI: one Modelica block for each variable
- optional interpolation of variables

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TIL Suite

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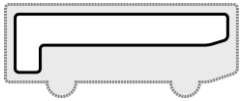
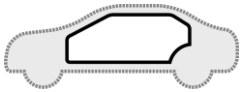
TIL Add On Cabin

Busses

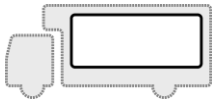


Cars

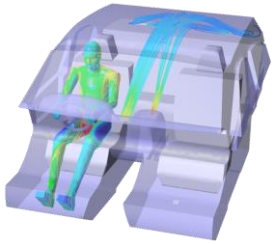


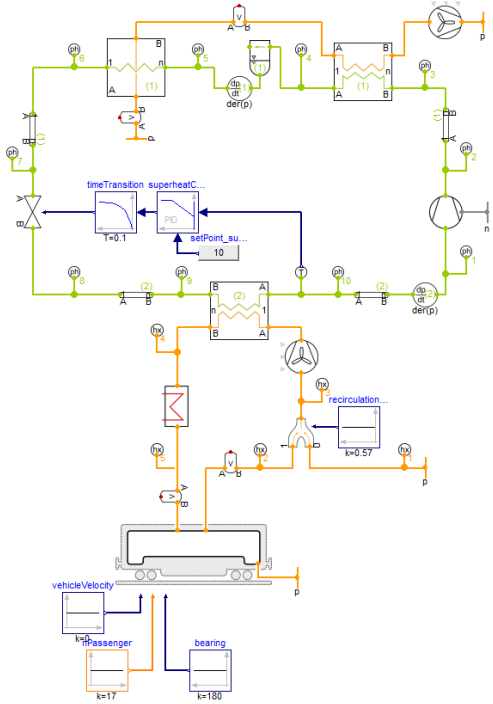
Railway

Transportation



- One or more dimensional gas/ air cabin compartment models
- One or three layer wall models with manifold options for parametrization
- Global sited environment settings for:
  - General ambient conditions
  - Solar conditions
  - Vehicle positioning
  - Wind settings
- Several Examples

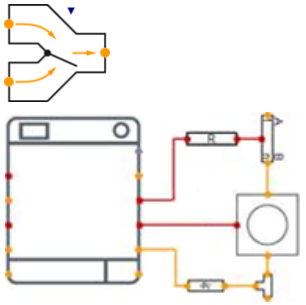




TIL Additional Components, Systems and Activities

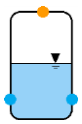
Gas Components

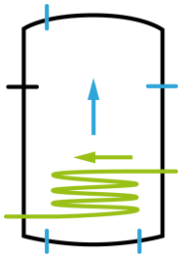
- Dampers / Flaps
- Tumble Dryers & Systems
- Simple Buildings
- Turbo compressor
- Compressor within measured data field

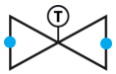


Liquid Components

- Expansion reservoirs
- Heat storages
- Tube with dead-time element
- Ideal stirred volume with heat port
- Thermostatic valve

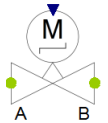






VLEFluid Components

- Controllable turbo compressor
- Controllable swash-plate compressor with detailed thermodynamics
- Advanced separator with detailed modeling of outlet conditions
- Minimally discretized tube with temperature profile propagation
- Electromagnetic valve



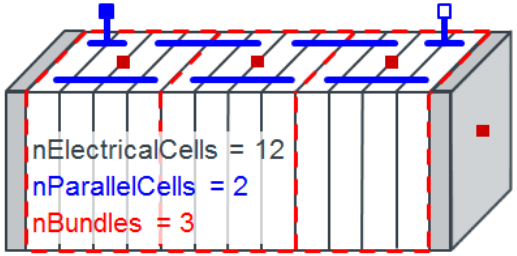
Transport Phenomena

- Thermosiphon liquid and refrigerant flow
- One and two-phase valve flow
- Models for slip

TIL Additional Components, Systems and Activities

Extras

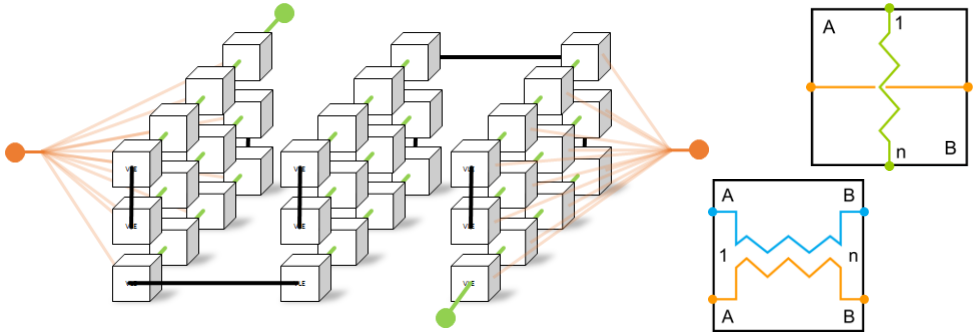
- Battery, electrical & thermal cells, stacks, modules & systems



- Fuel Cell models & systems
- Thermoelectric modules
- Solar Organic Rankine
- Car engine
- Simple electrical motor & converter
- Adapter between TIL and other libraries (MSL, ACL, …)
- Tools for parameter-studies and simulation post-processing

Heat Exchangers

- **2D / 3D Fin and tube**, Models enable detailed temperature distributions and dimensioning tasks of heat exchangers



- **Finite Difference Method** for steady state calculations
- **Hybrid cooler** with optional evaporative cooling on the fins
- **NTU** (Number of Transfer Units) heat exchanger models for various geometries and flow configurations
- **QETD** Heat flow and entry temperature difference table based models
- **Cold storage / heat exchanger** using substances including a solid liquid equilibrium (SLE)

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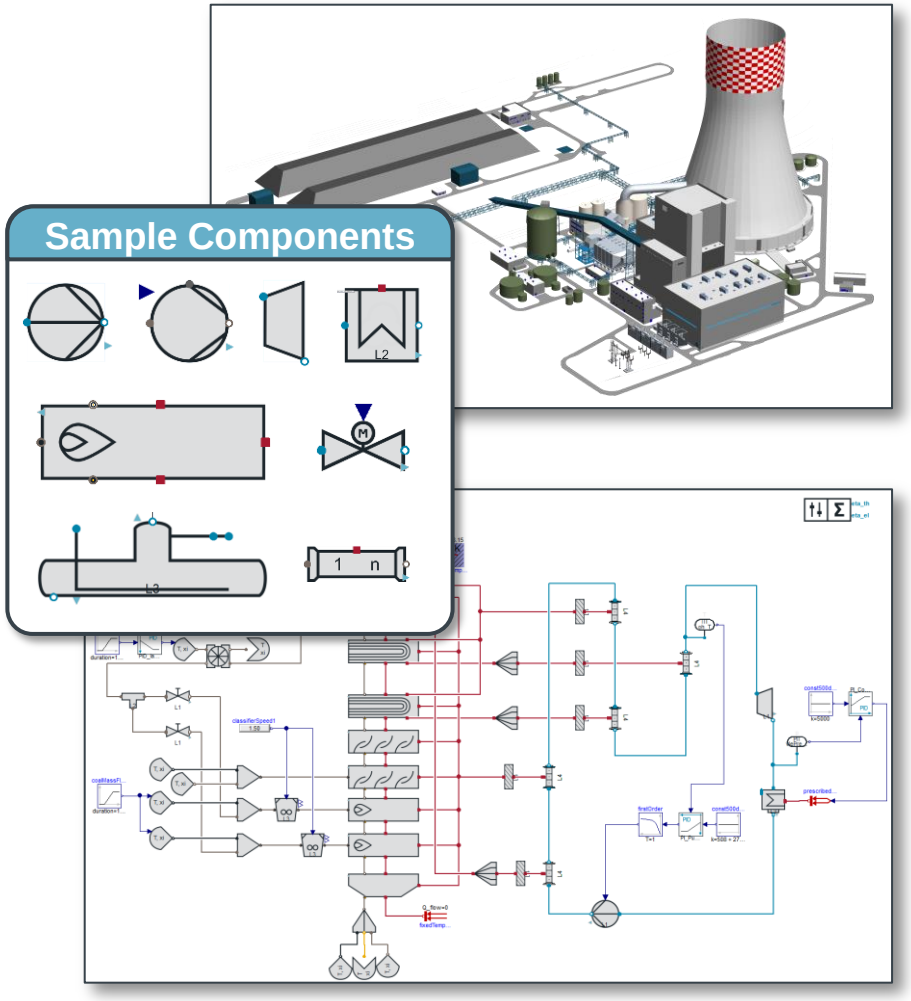
ClaRa simulation of Clausius-Rankine cycles

- Library for modeling and simulation of state of the art power plants in high detail
- Stand-alone, independent of TIL
- Models for pumps, fans, turbines, heat exchangers, furnace, electric motors, mills, valves, piping and fittings, storage tanks and flue gas cleaning
- Free of charge & open source
- Well documented models
- TILMedia substance properties



Content

TIL
model library for thermal components and systems

TILMedia for MODELICA
model library providing thermophysical properties

TILFileReader
imports tabular data from files

TIL Suite

TIL Add-On Libraries
Additional components and systems available to TIL

Training courses
Modelica and TIL introduction and advanced trainings

Addition

Training courses

Modelica Training

Two days introduction to object-oriented modeling and simulation of thermal systems

TIL Training

One day introduction about the Modelica libraries TIL Suite

Modelica Advanced

Fundamental mathematical principles for system simulation

TIL Advanced

Optimize the efficient work with TIL on basis of concrete examples

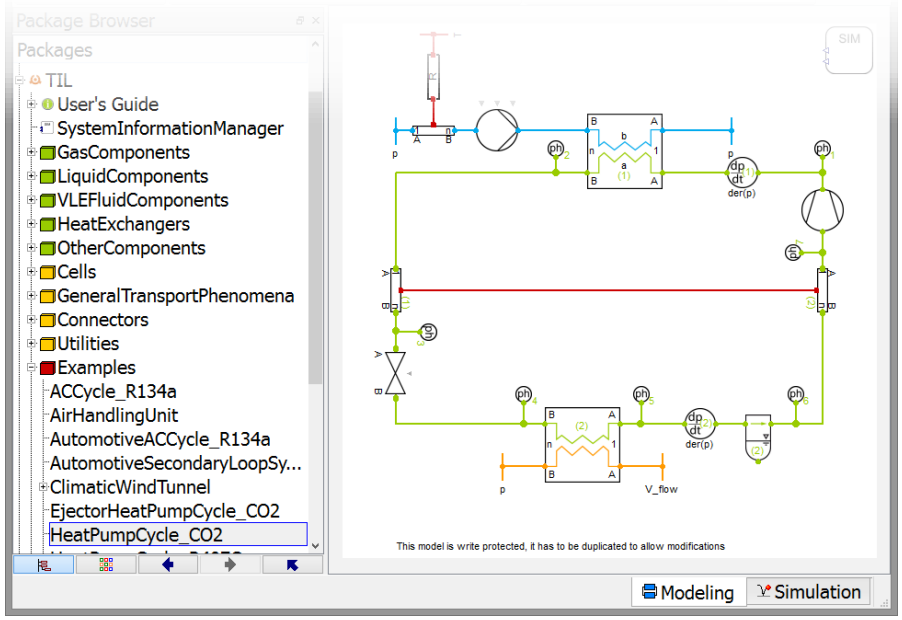
Further Training courses independent of TIL available e.g. Mobile air conditioning, DaVE

Summary

Services, Software and Training from one source

TIL Suite contains …

- Open source or encrypted model library for thermal systems
- Optimized substance properties for extremely fast simulations
- Tabular data import from files



Advantages are …

- Exportable models & systems
- Real-time capability
- A well proven design concept
- Maintaining many proper models and examples for long-time
- Additional and user-defined components available

Thank you

TLK-Thermo GmbH

If you have any questions,
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