

KULI 5.1

base

hvac

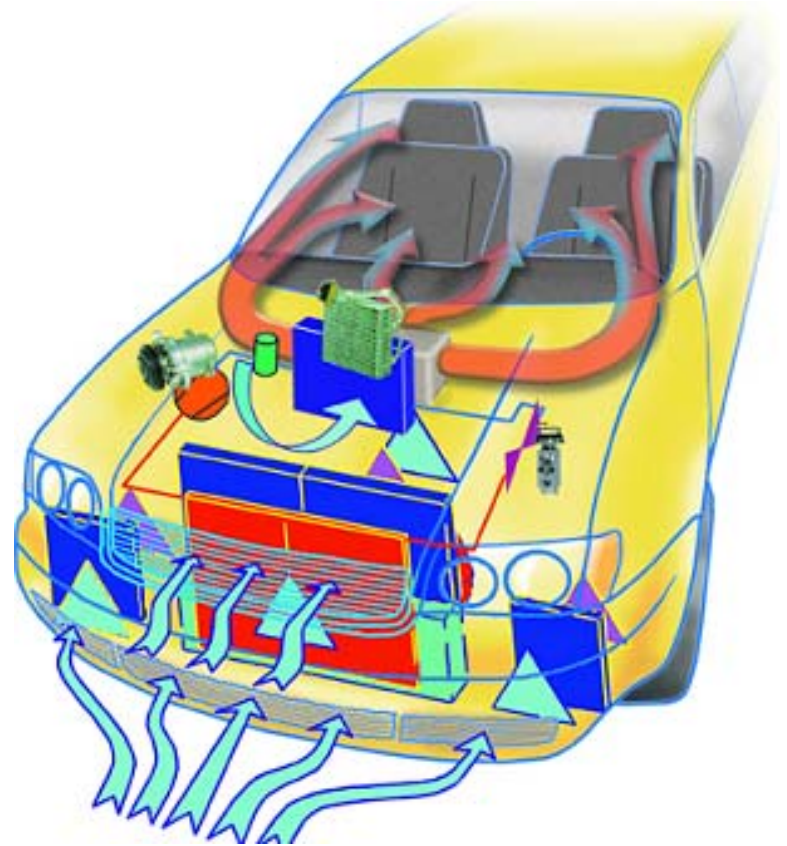
advanced

drive

New Features in KULI

General

- **New Module Structure**
- **License Borrowing**
- **Improved Handling**
 - 2D Graphics Window
 - CFD-Interface
 - Media Data
 - Postprocessor
- **Simple Mode / Expert Mode**



KULI - New Module Structure

base

- Fluid and air flow network
- Sensors & actuators
- Post-processing

+ RAD70

+ CAC70

+ OC70

+ PFC70

+ Transition

+ Fan
Parameter

+ Subsystems

advanced

- Interfaces
- CFD (SWIFT, StarCD, Fluent)
- Matlab /Simulink
- COM

+ Automatic
Optimization

hvac

- HVAC System
- Passenger Compartment
- R134a
- CO₂
- Heating

+ Heat pump
mode

drive

- Transient simulation
- Engine model
- Driving cycle
- Transient control by sensors & actuators

Borrowing of License

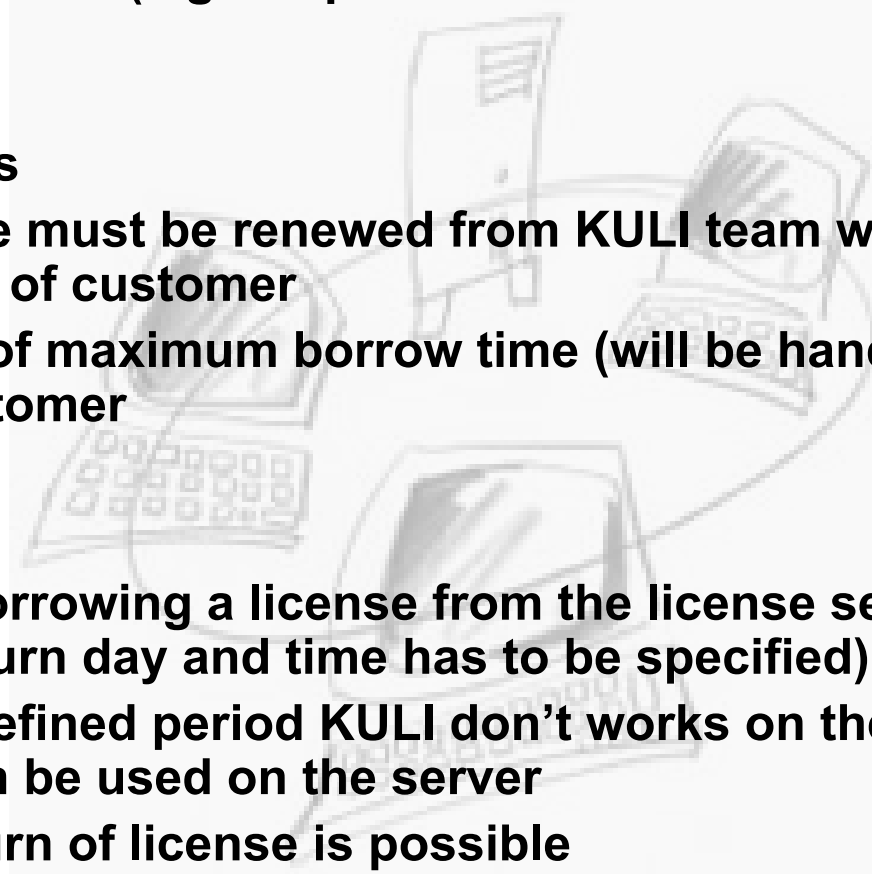
- **Borrowing of a temporary license from a server to e.g. a notebook is now possible (e.g. for presentation or measurement on a test bench)**

Preconditions

- **License file must be renewed from KULI team with feature borrow on request of customer**
- **Definition of maximum borrow time (will be handled in license file) by the customer**

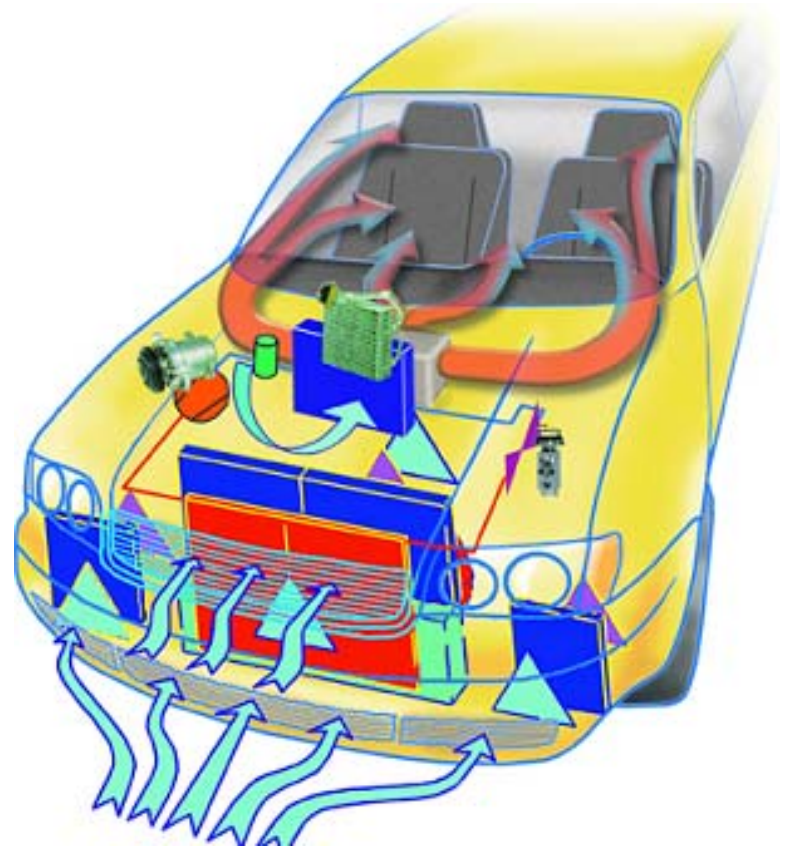
How it works

- **Client is borrowing a license from the license server for a defined period (return day and time has to be specified)**
- **After the defined period KULI don't works on the notebook, but the license can be used on the server**
- **Earlier return of license is possible**



KULI base – New Features

- Improved Handling of Graphics, Media, Settings
- Additional Sensors & Actuators
- Additional Components
- Control Objects
- Subsystems



KULI base - Enhanced Graphics Handling

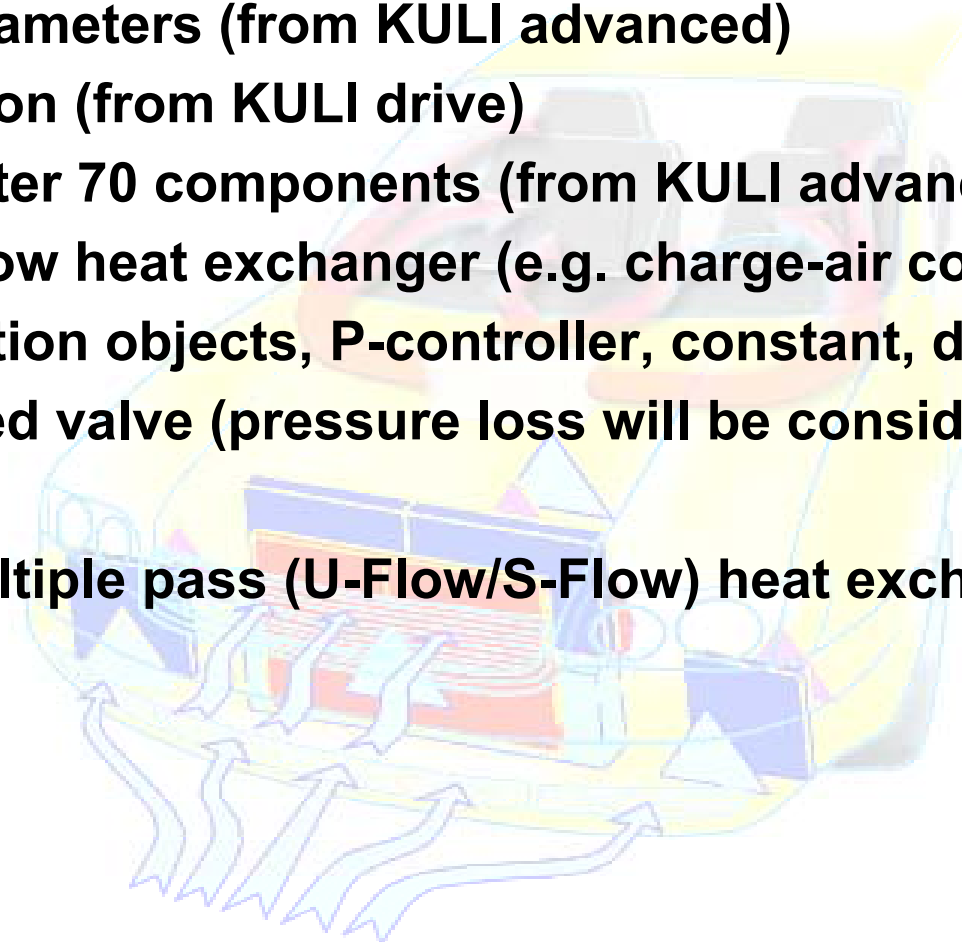
- **Simple mode / expert mode toolbar**
- **Multi selection**
- **Moving of selected components**
- **Copying of components**
- **Show comments or show ID**
- **Zoom with mouse scroll wheel (new shortcuts)**
- **More sensors/actuators**
- **Sensors/actuators available at circuit**
- **3D-Graphs transparency option**
- **Open/closed circuits are visible in graphic window**

List of Shortcuts in Graphic Window (Fluid Circuit)

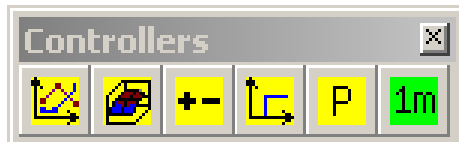
- **Ctrl + r** rotate object
- **Ctrl + s** save file
- **Ctrl + a** save file as
- **Ctrl + c** copy selected components
- **Left mousebutton** mark objects
- **Ctrl + left mousebutton** move
- **scrollwheel** move vertical
- **Shift + scrollwheel** move horizontal
- **Ctrl + scrollwheel** Zoom in/out

KULI base – New Components

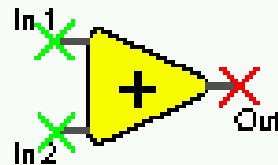
- Fan parameters (from KULI advanced)
- Transition (from KULI drive)
- Parameter 70 components (from KULI advanced)
- Crossflow heat exchanger (e.g. charge-air coolant)
- Calculation objects, P-controller, constant, delay object
- Improved valve (pressure loss will be considered)
- Two/Multiple pass (U-Flow/S-Flow) heat exchanger



Controller / Calculation Objects



1. Calculation controller



Out = In1 + In2

Out = In1 - In2

Out = In1 * In2

Out = In1 / In2

Out = In2 - In1

Out = In2 / In1

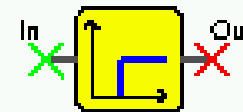
Out = minimum

Out = maximum

☒ Gain

1.5

1. Delay controller



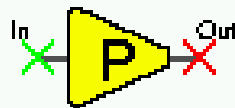
Delay

15

☐ Simulations

☒ Seconds

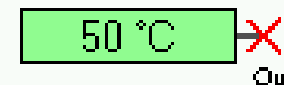
1.P - controller



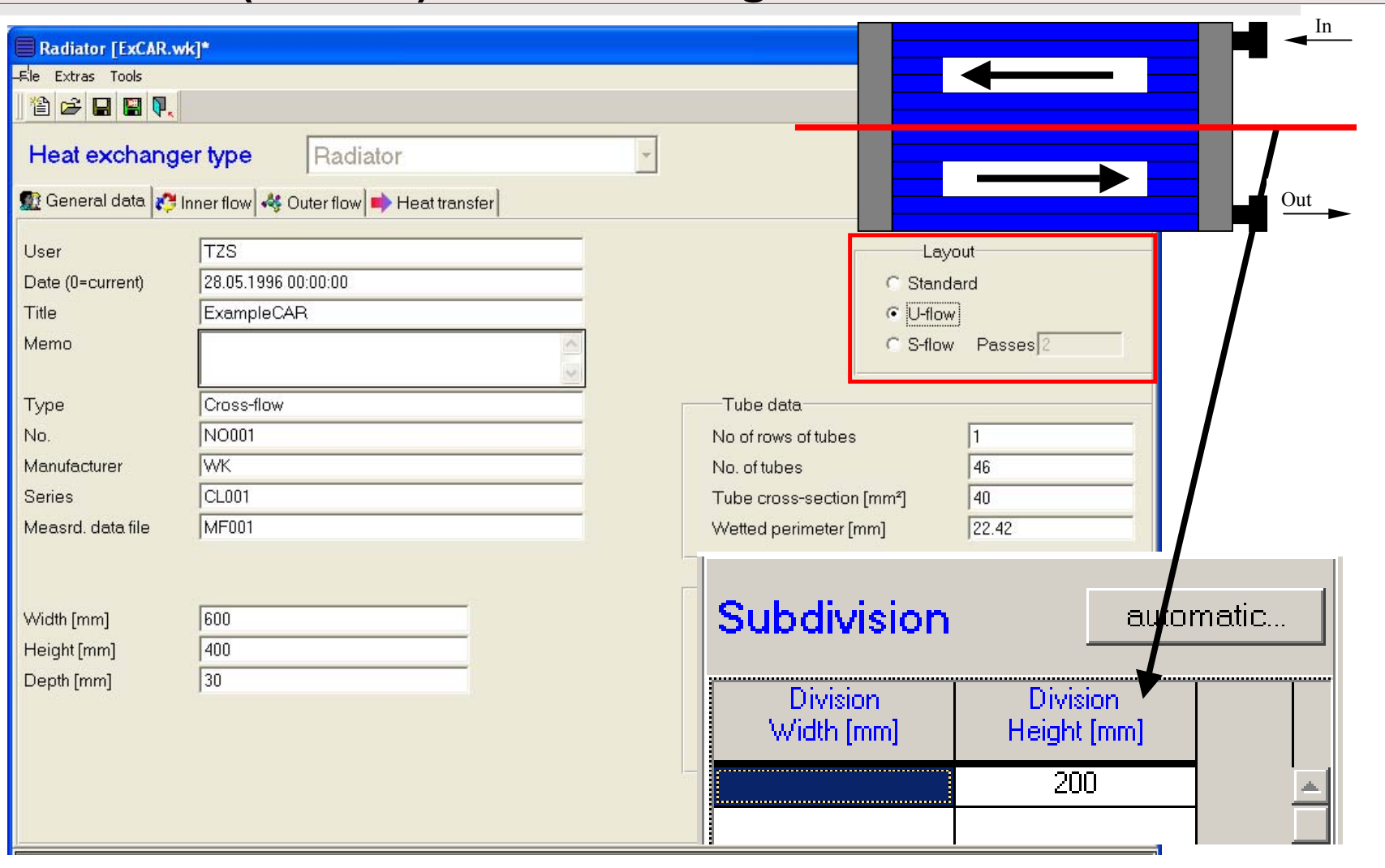
☒ Gain

1.5

1.Constant



Two-Pass (U-Flow) Heat Exchanger



Heat exchanger type Radiator

General data Inner flow Outer flow Heat transfer

User: TZS
 Date (0=current): 28.05.1996 00:00:00
 Title: ExampleCAR
 Memo:
 Type: Cross-flow
 No.: NO001
 Manufacturer: WK
 Series: CL001
 Measrd. data file: MF001

Width [mm]: 600
 Height [mm]: 400
 Depth [mm]: 30

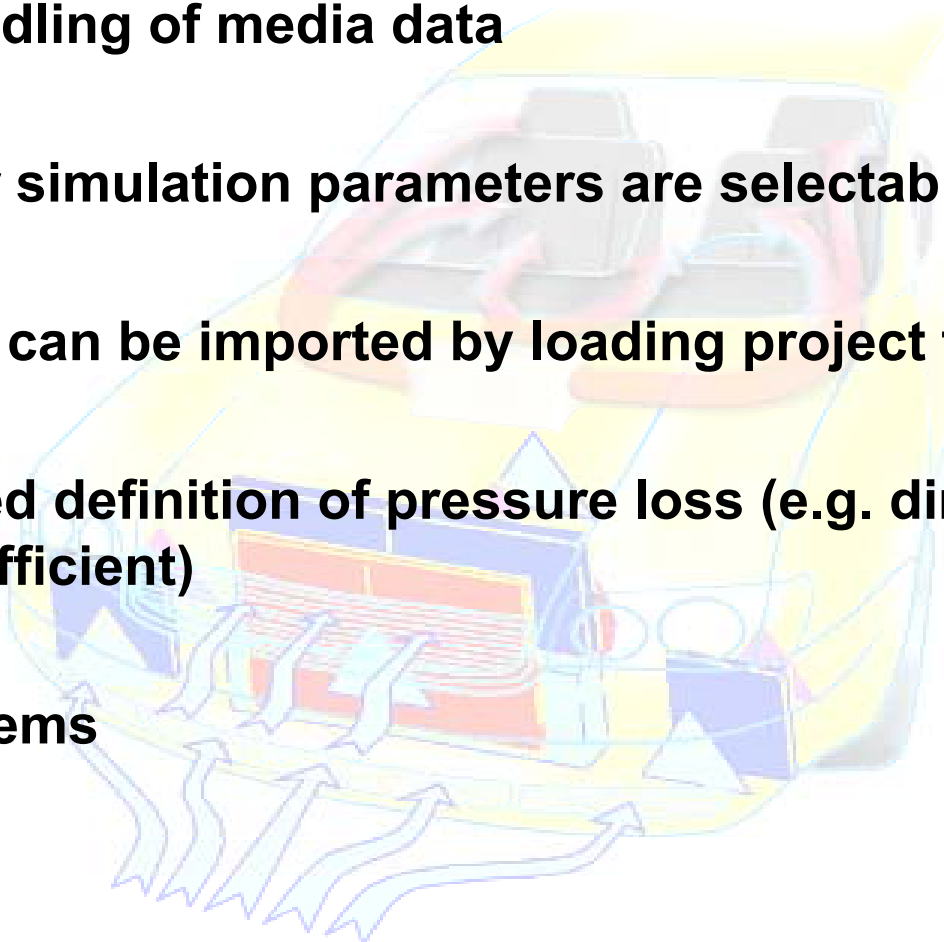
Layout
☐ Standard
☒ U-flow
☐ S-flow Passes: 2

Tube data
 No of rows of tubes: 1
 No. of tubes: 46
 Tube cross-section [mm²]: 40
 Wetted perimeter [mm]: 22.42

Subdivision
 automatic...

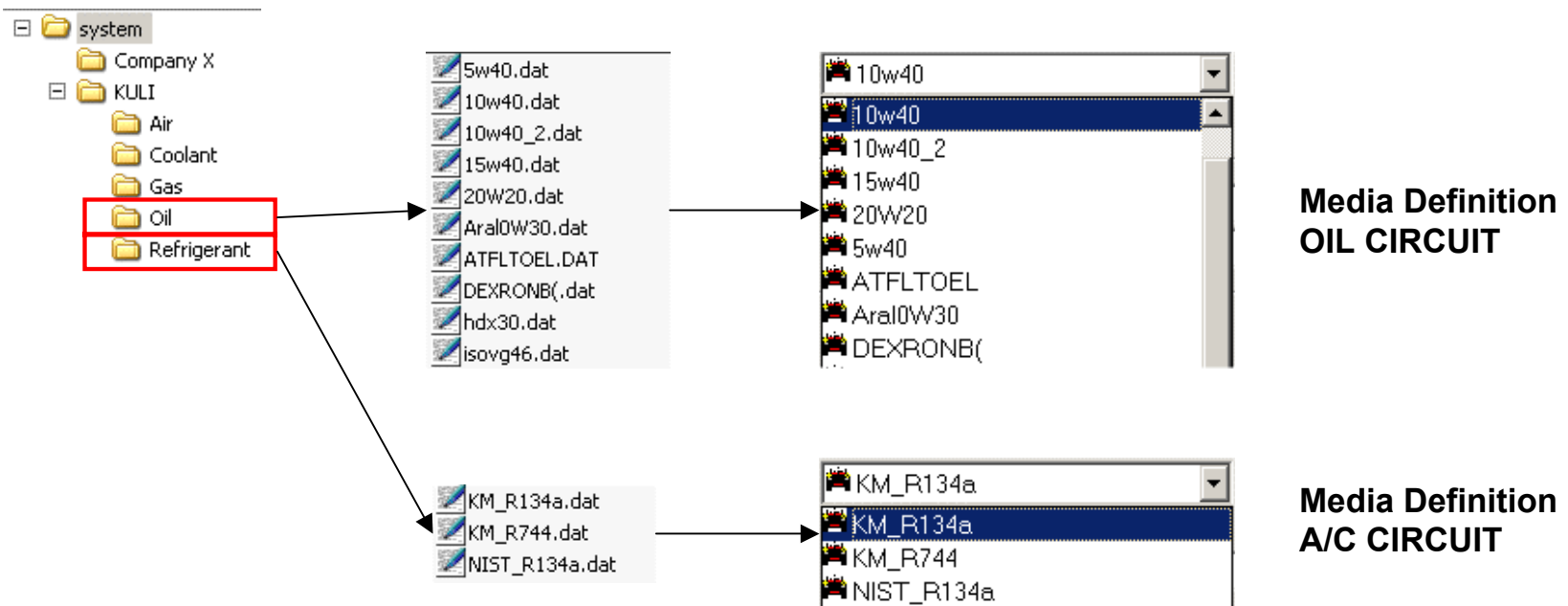
Division Width [mm]	Division Height [mm]
200	

KULI base - Improvements

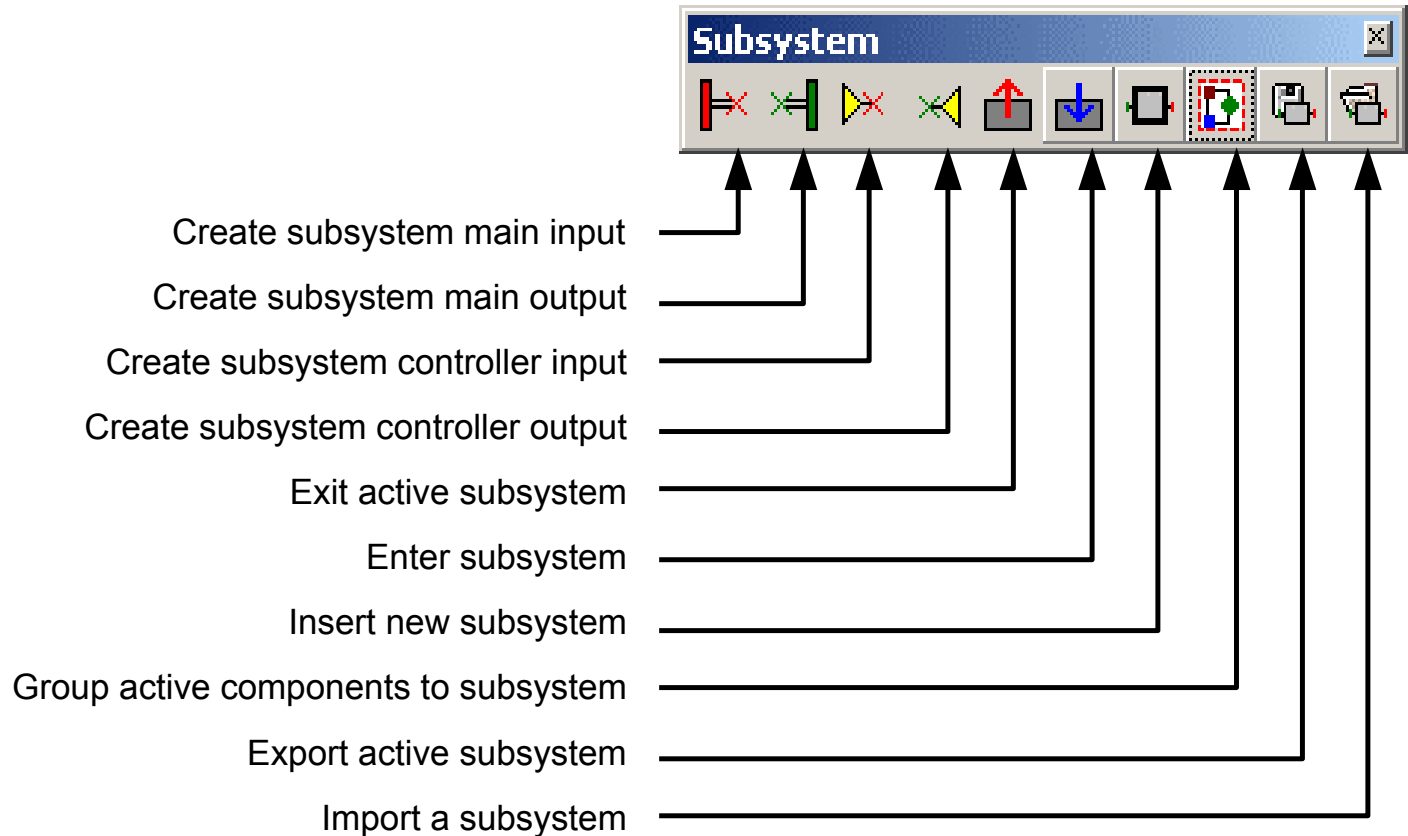
- New handling of media data
 - Units for simulation parameters are selectable
 - Settings can be imported by loading project file
 - Enhanced definition of pressure loss (e.g. dimensionless loss coefficient)
 - Subsystems
- 

New Handling of Media Data

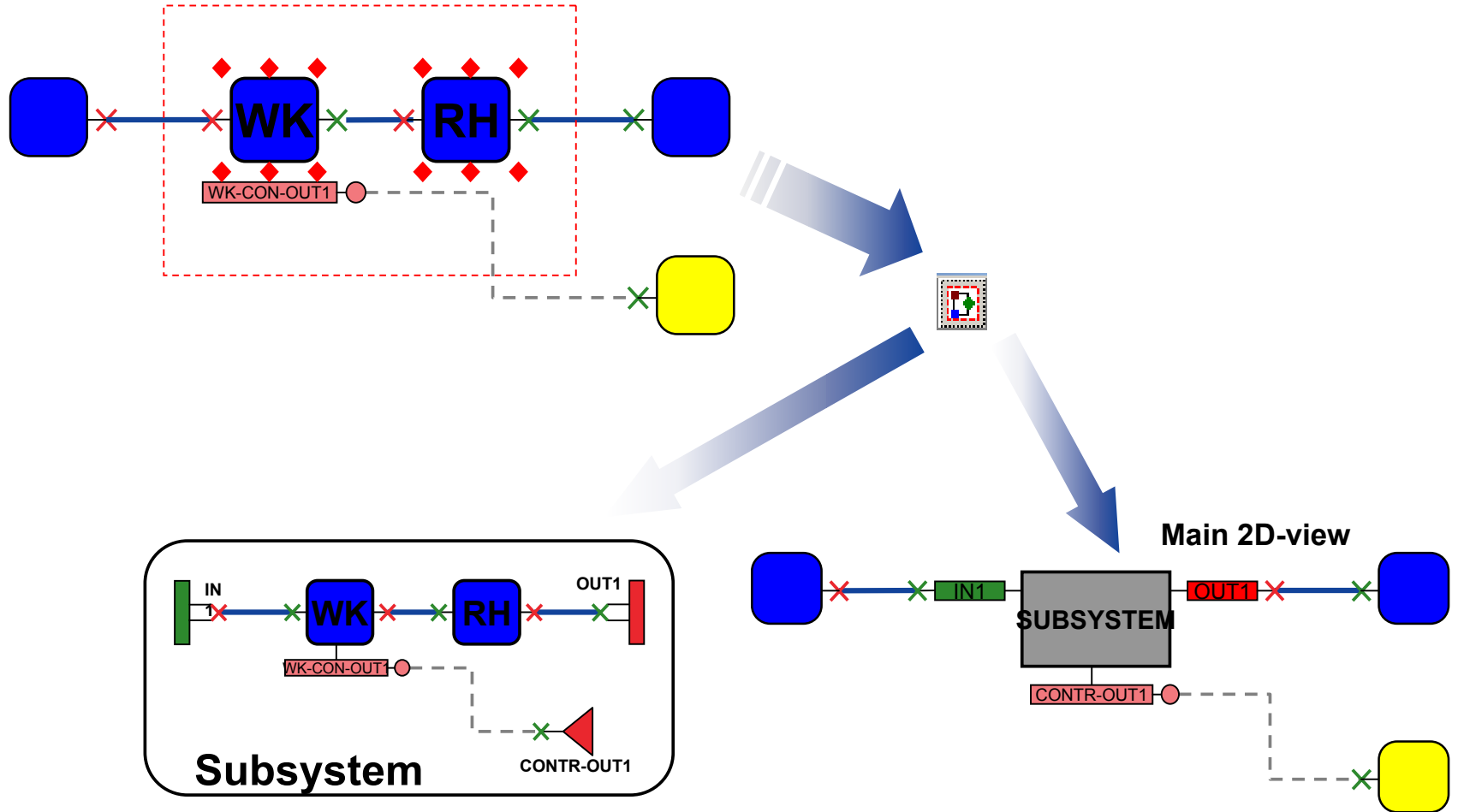
- Media combined to groups (Air, Coolant, ...)
- Company specific Media Folders
- User defined Identifiers supported



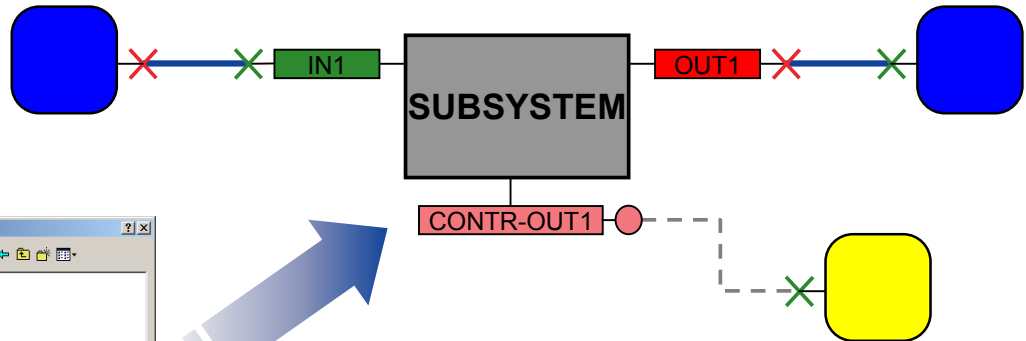
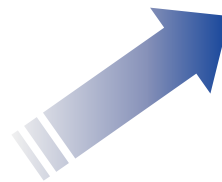
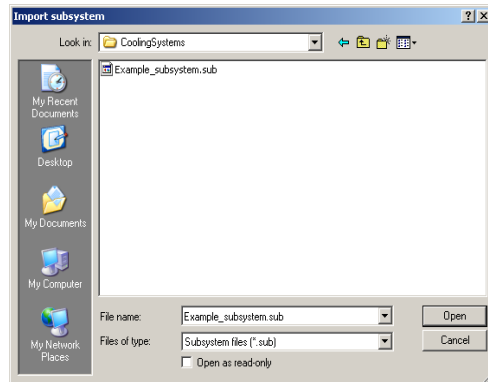
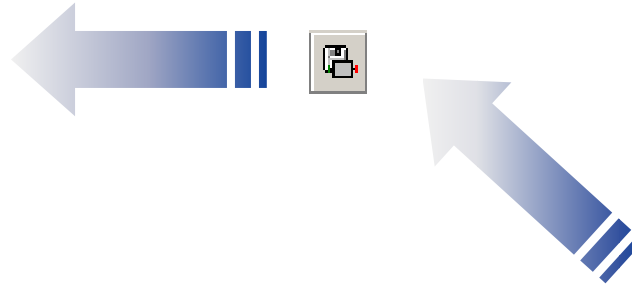
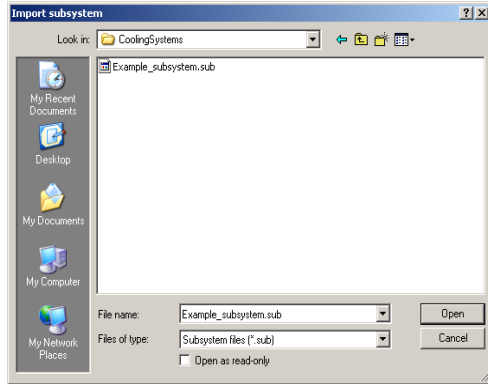
Subsystems Toolbar



Group Components to Subsystem



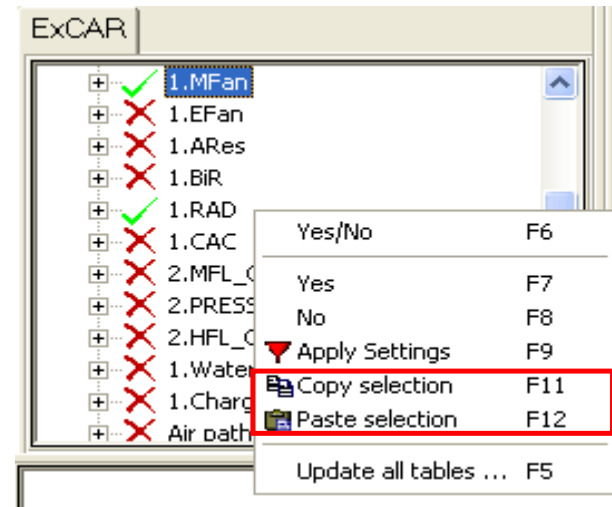
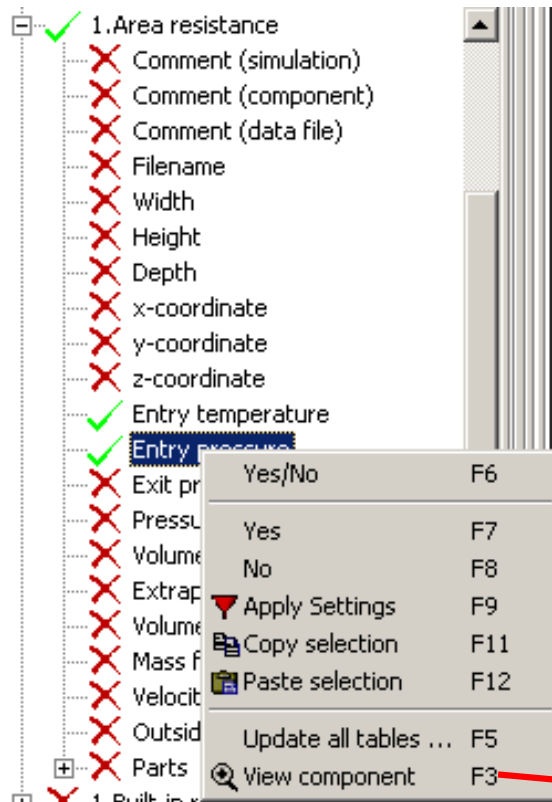
Import / Export Subsystem



KULI postprocessor - Improvements

- Improved data management for transient data (performance improvements)
- More result values are shown
- Double-click for selecting of value (in tree)
- Easy navigating to components' values
- Settings can be copied from one component to another (use context menu)
- Automatic export to Excel (normal, transposed, summary or one datasheet for each component, optional with diagrams)
- Loading of more output files at once

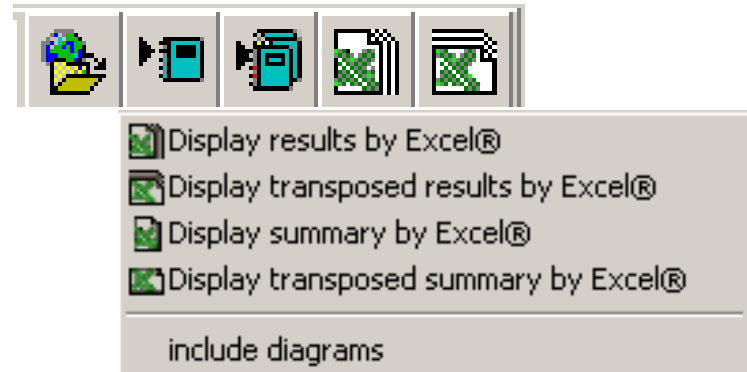
Easy navigating to components' values



Selected simulation results		Diagrams		
Resistance		Cross flow HX		
1.Area resistance		ExCAR		
Label / stationary	1	2	3	
Entry temperature [°C]	22	20	35	
Entry pressure [hPa]	1013.5	1016.72	1025.76	

Interface Postprocessor – Excel (1)

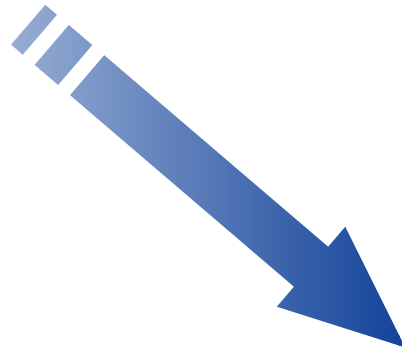
- Different types of export
- Display results
 - each component in the postprocessor is displayed on its own page in Excel
- Display summary
 - all exported data is displayed on a single sheet
 - separate sheets for multiple files
- Option to transpose data
- Option to include diagrams



Interface Postprocessor – Excel (2)

Selected simulation results			
Diagrams			
Cross flow HX			
1.Radiator	ExCAR		
Label / stationary	1	2	3
Entry temp. IM [°C]	99.6597	88.3788	105.7
Mass flow IM [kg/s]	1.09167	1.00814	1.54715
Cooling air mass flow [kg/s]	0.594118	0.884697	1.61756

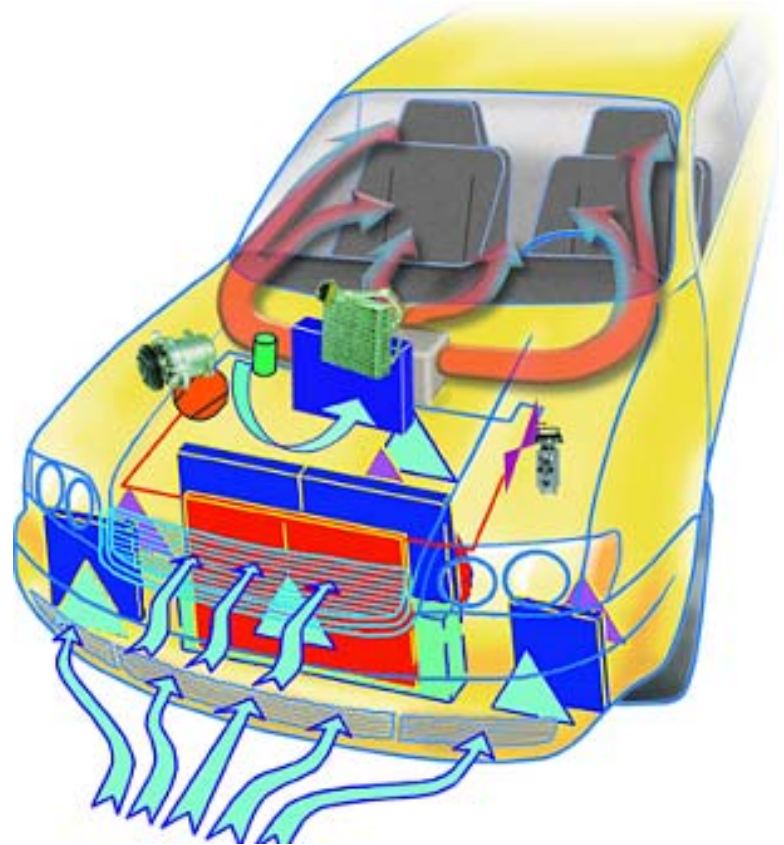
KULI 5.1



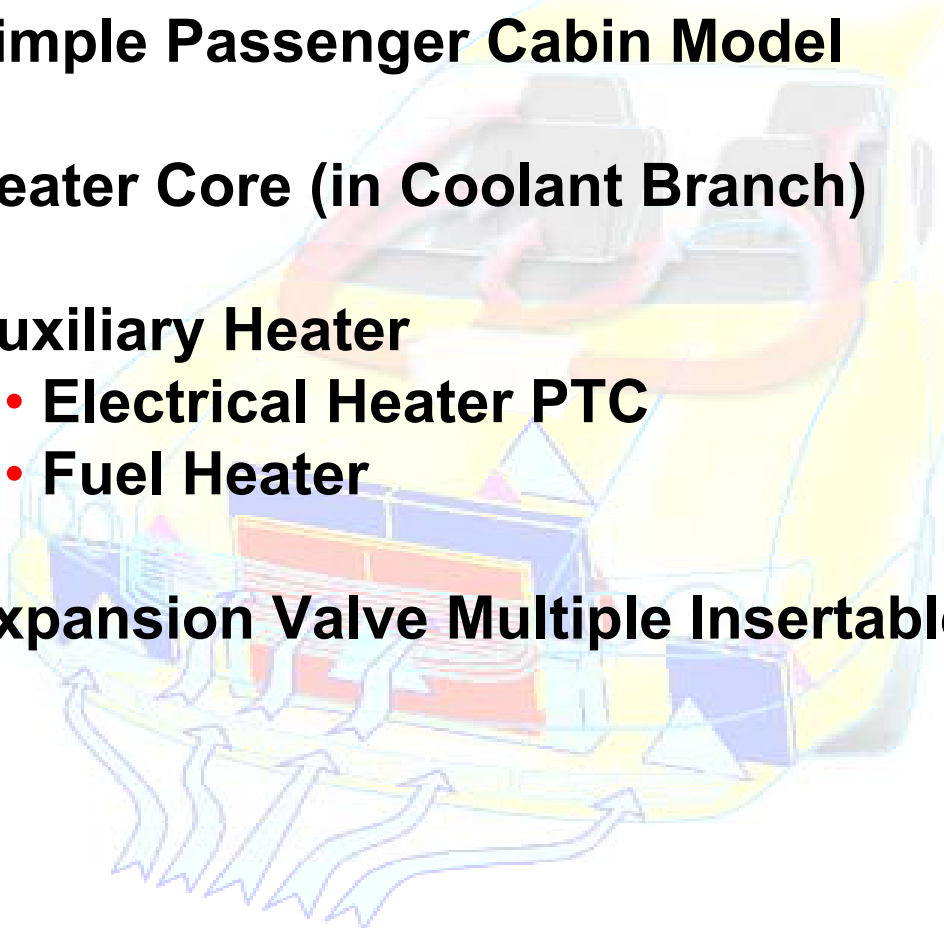
Microsoft Excel - ExCAR.xls					
Datei Bearbeiten Ansicht Einfügen Format Extras Daten Fenster ?					
<div> <div>Arial 8 F K U</div> <div> <div>F28</div> <div>=</div> </div> </div>					
1	1.Radiator				
2	Label / stationary	1	2	3	
3	Entry temp. IM [°C]	99.6597	88.3788	105.7	
4	Mass flow IM [kg/s]	1.09167	1.00814	1.54715	
5	Cooling air mass flow [kg/s]	0.594118	0.884697	1.61756	
35					
36					
37					
1.RAD / 1.CAC /					

KULI hvac – New Features

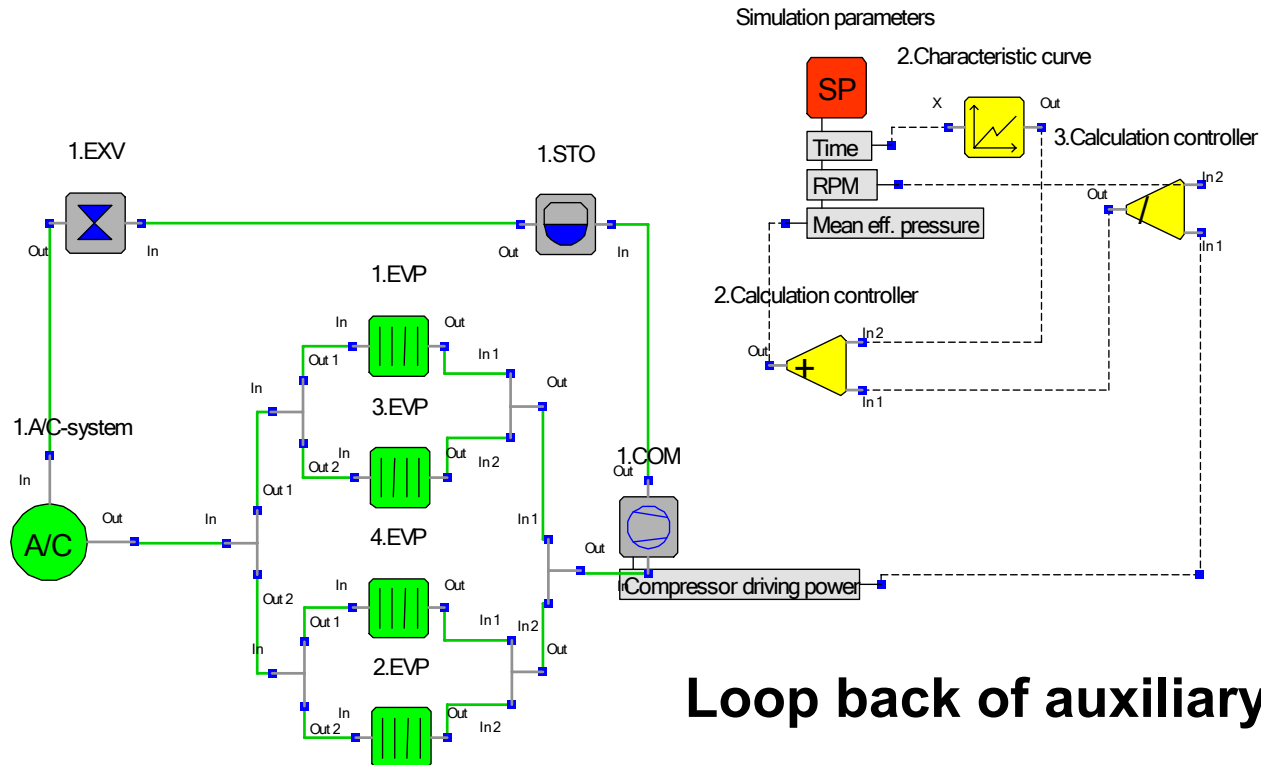
- New Components
- Additional Refrigerant Circuit Layouts
- Triangle Process
- Heat Pump Mode
- Warming Up / Cooling Down Simulation



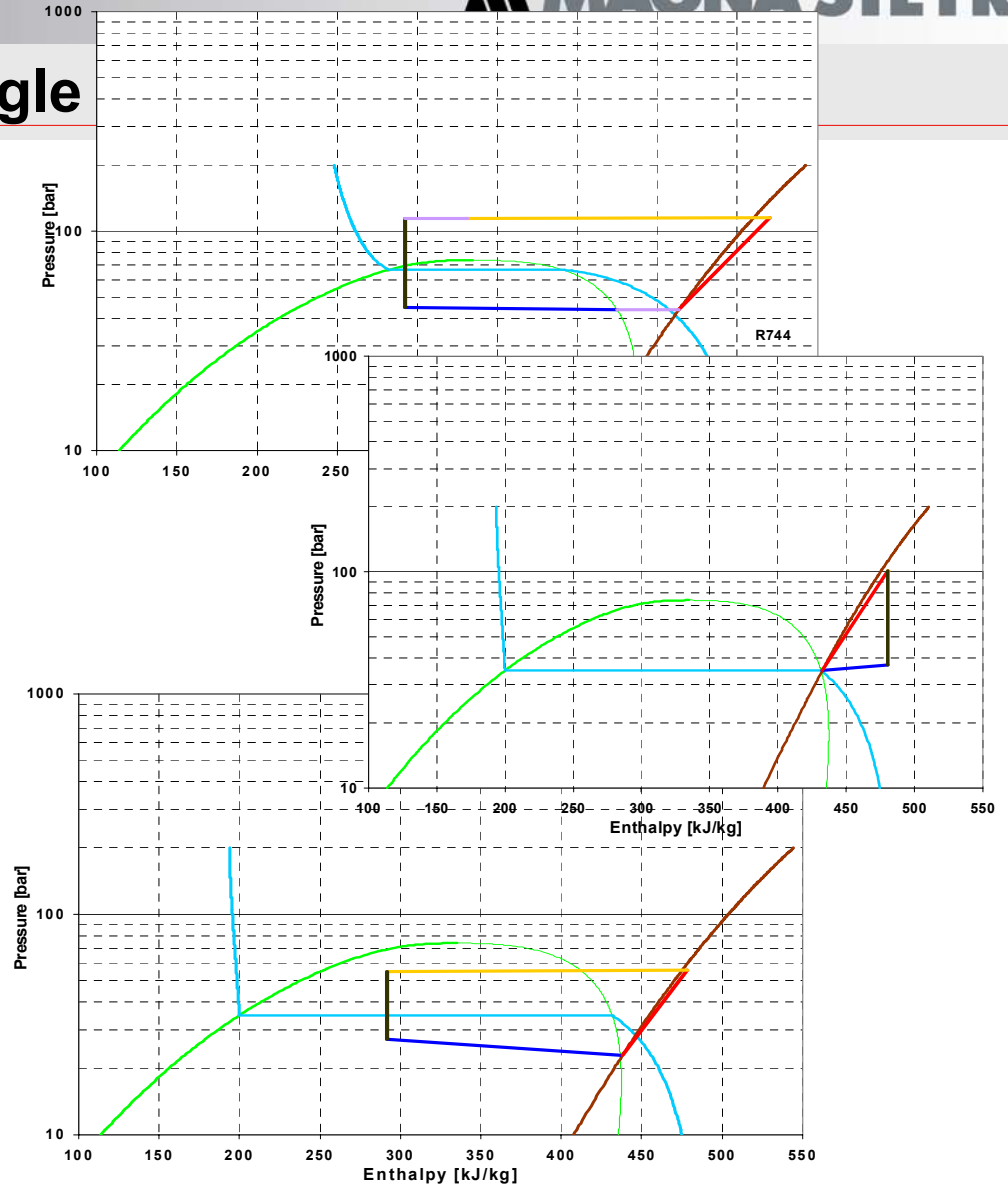
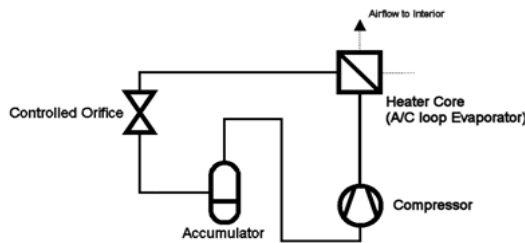
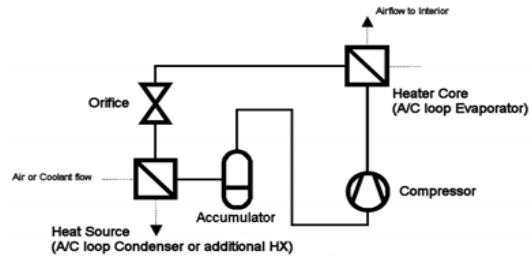
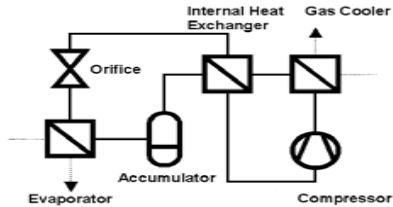
KULI hvac – New Components

- **Simple Passenger Cabin Model**
 - **Heater Core (in Coolant Branch)**
 - **Auxiliary Heater**
 - **Electrical Heater PTC**
 - **Fuel Heater**
 - **Expansion Valve Multiple Insertable**
- 

Triangle Process – Simulation Model



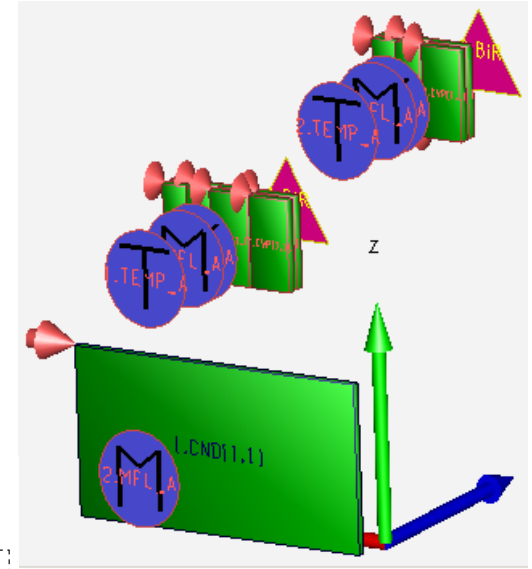
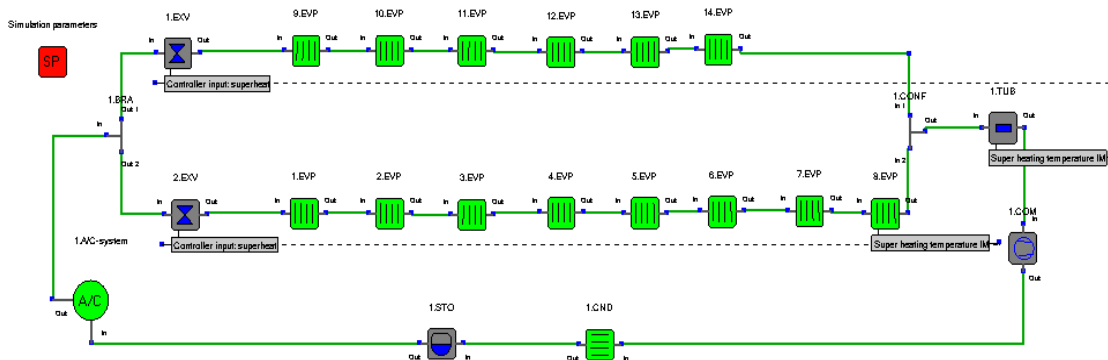
R744 Refrigerant – Triangle



A/C System With 2 Branches

AC Circuit

- 2 Expansion Valves
- Evaporator 1: 8 Sections
- Evaporator 2: 6 Sections

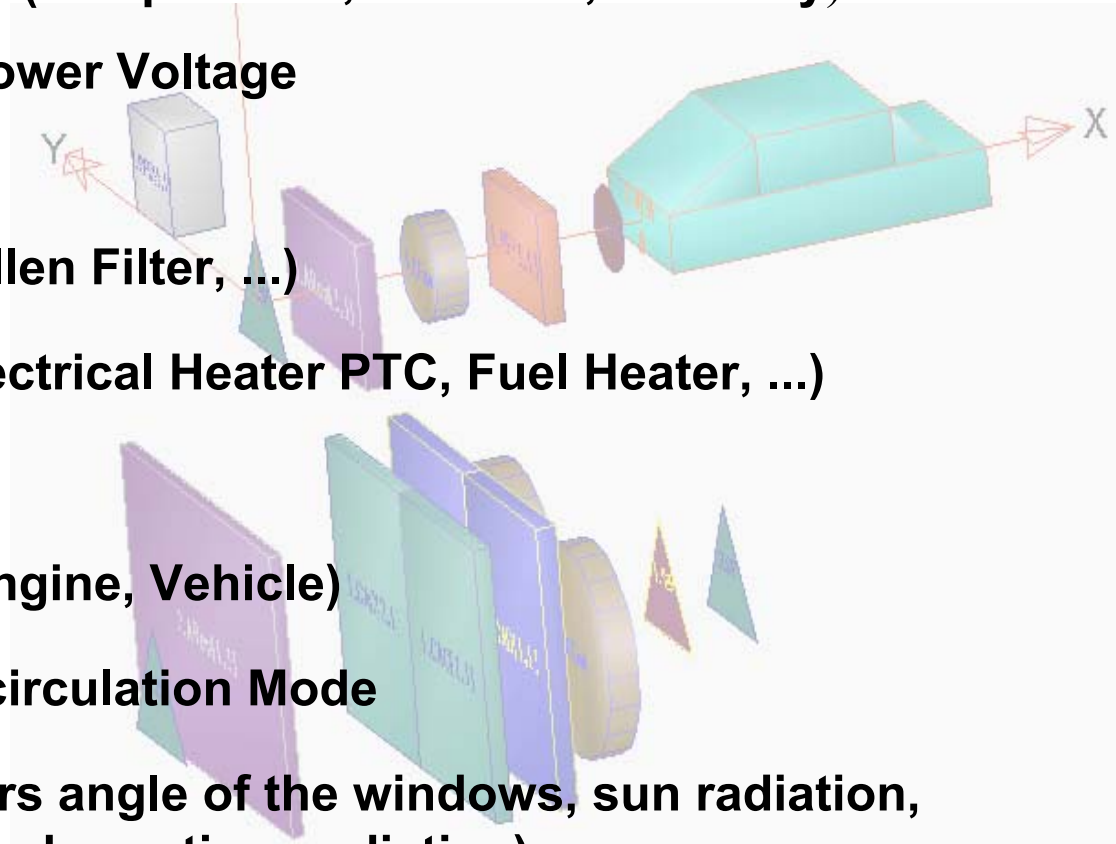


3D Component Arrangement

Warming-Up/Cooling-Down of Passenger Compartment

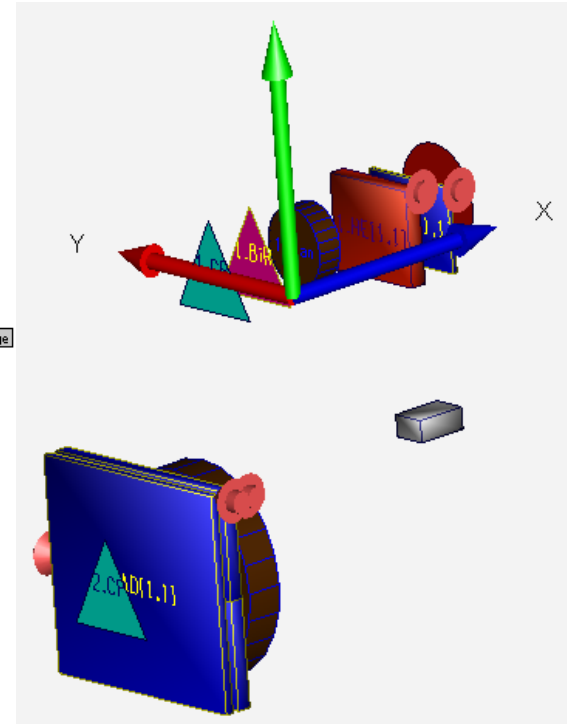
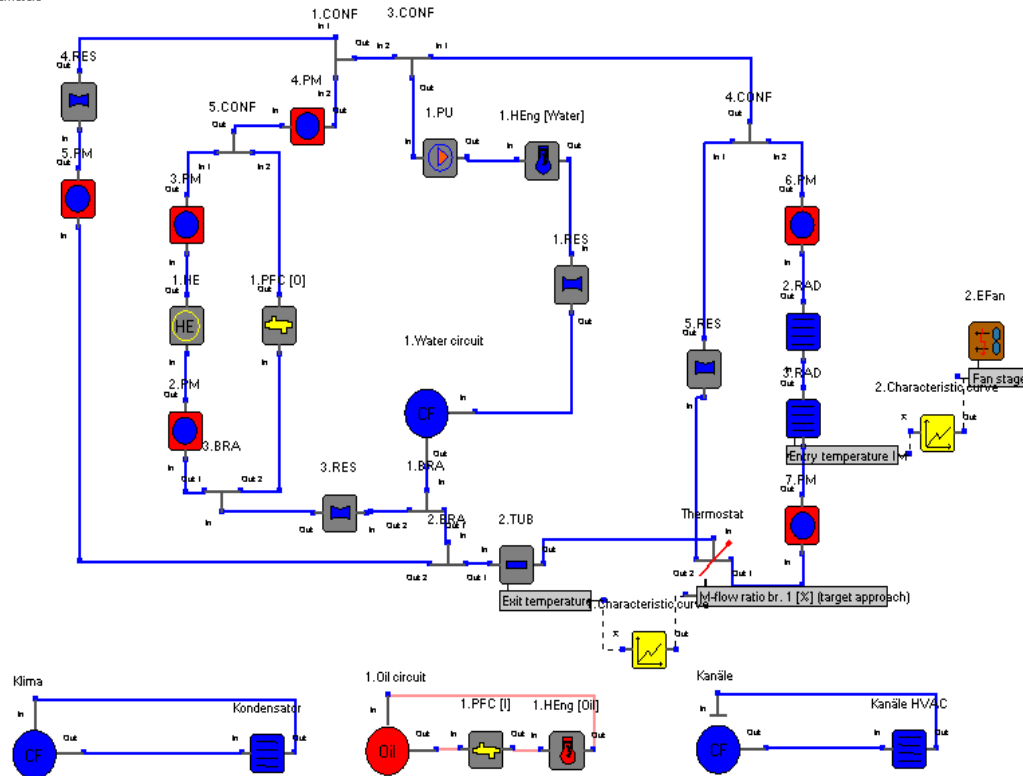
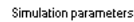
Simulation Parameters

- Ambient Parameters (Temperature, Pressure, Humidity)
- Blower Type and Blower Voltage
- Heater Matrix
- Air Resistances (Pollen Filter, ...)
- Auxiliary Heater (Electrical Heater PTC, Fuel Heater, ...)
- Engine Type
- Operation Points (Engine, Vehicle)
- Fresh-Air Mode, Recirculation Mode
- Body Type (considers angle of the windows, sun radiation, volume of the cabin, absorption, radiation)



Simulation Model - Warm Up

Coolant Circuit

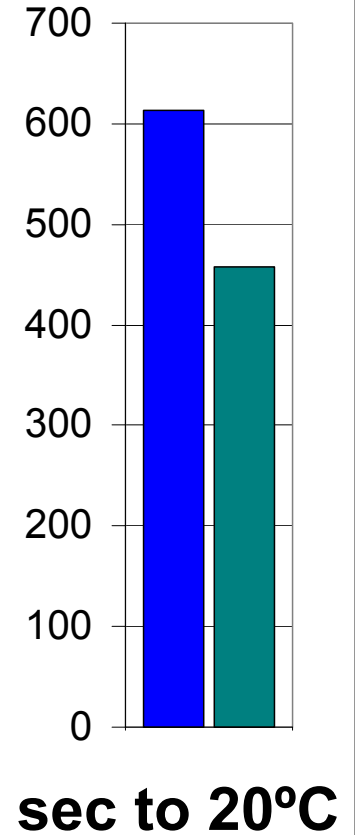
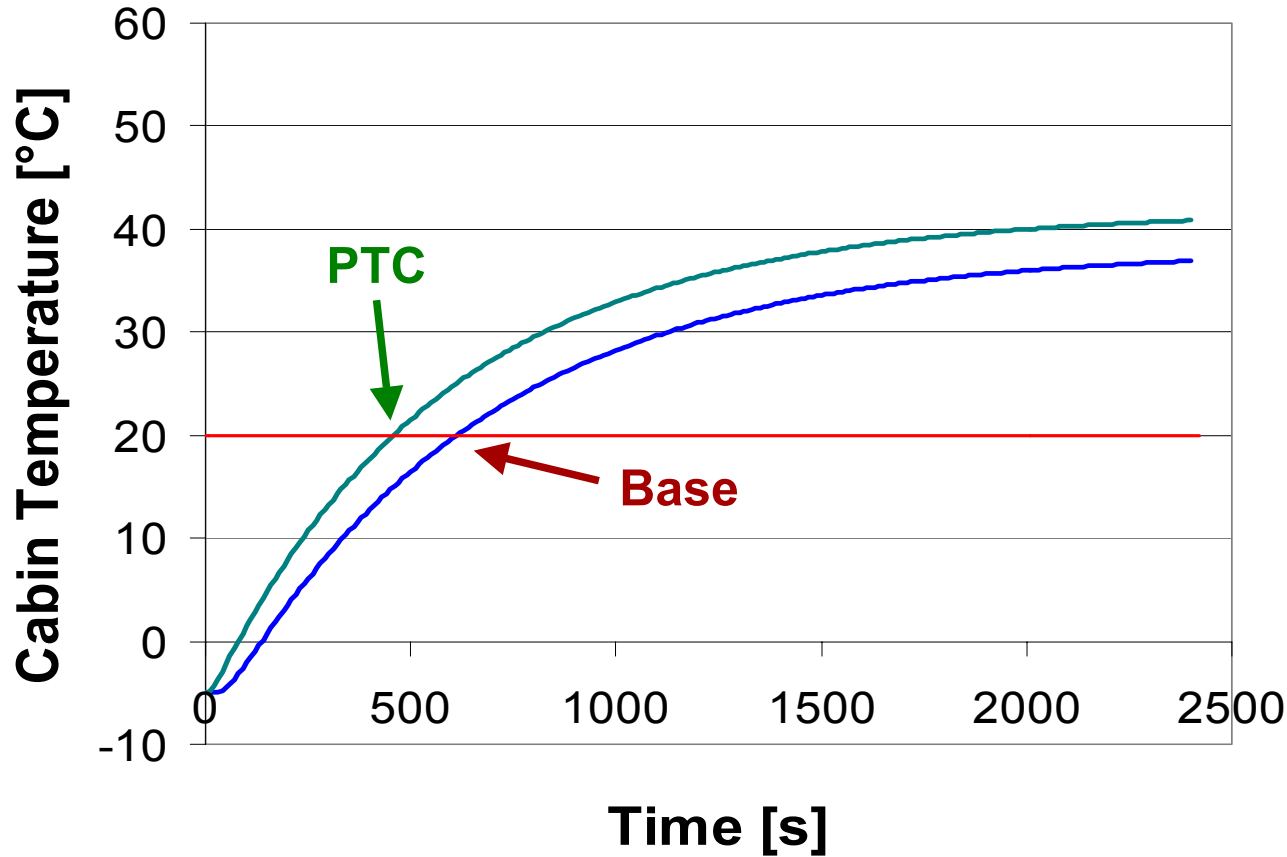


Condenser

Oil Circuit

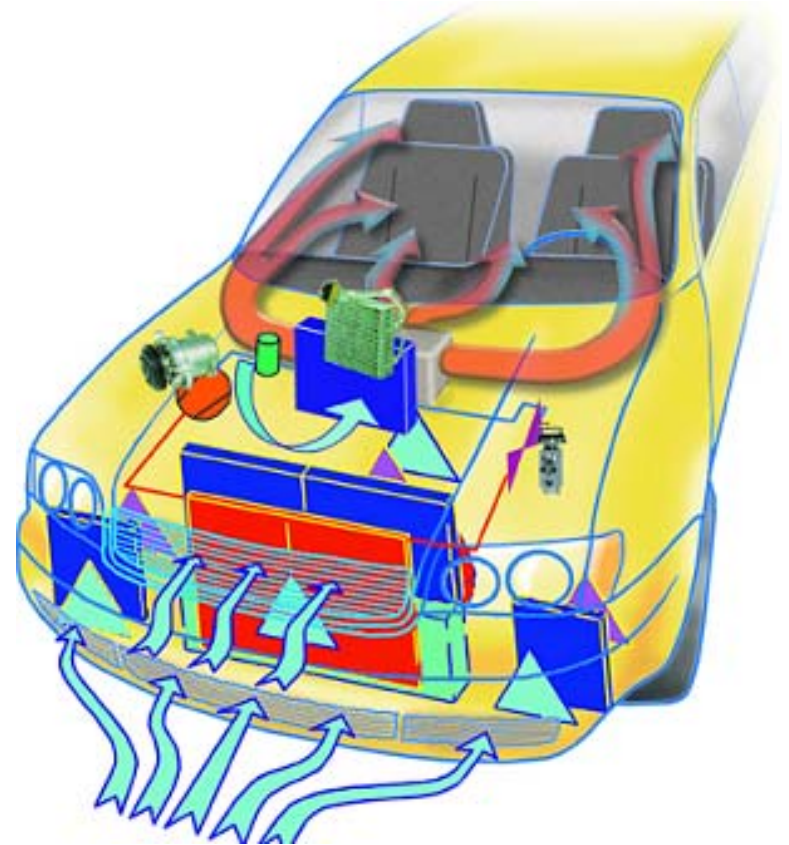
Air Ducts

Passenger Compartment Warm-up: PTC 600 W



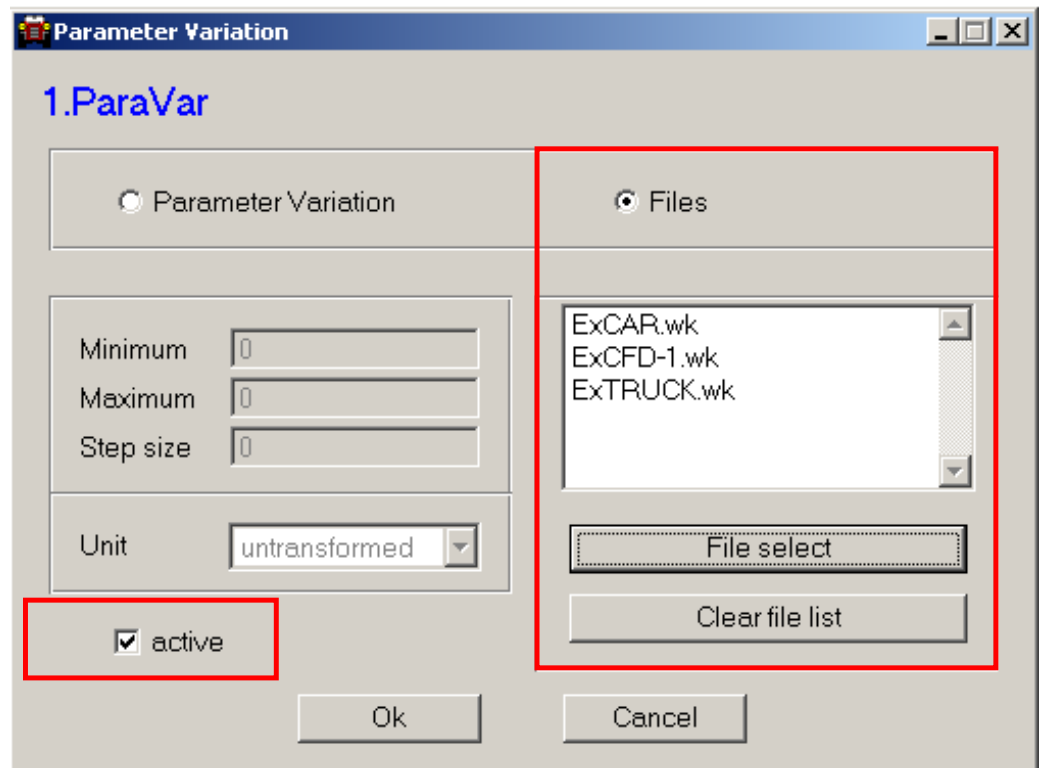
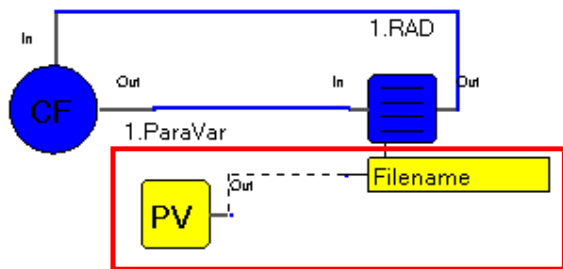
KULI advanced

- **Variation of Parameters including Components**
- **Enhanced Optimization**
- **Interface to Flowmaster[®] with COM-objects**
- **COM-Interface improved (changes in VBA-script)**
- **Sensitivity analysis**
- **Enight[®] to KULI converter**



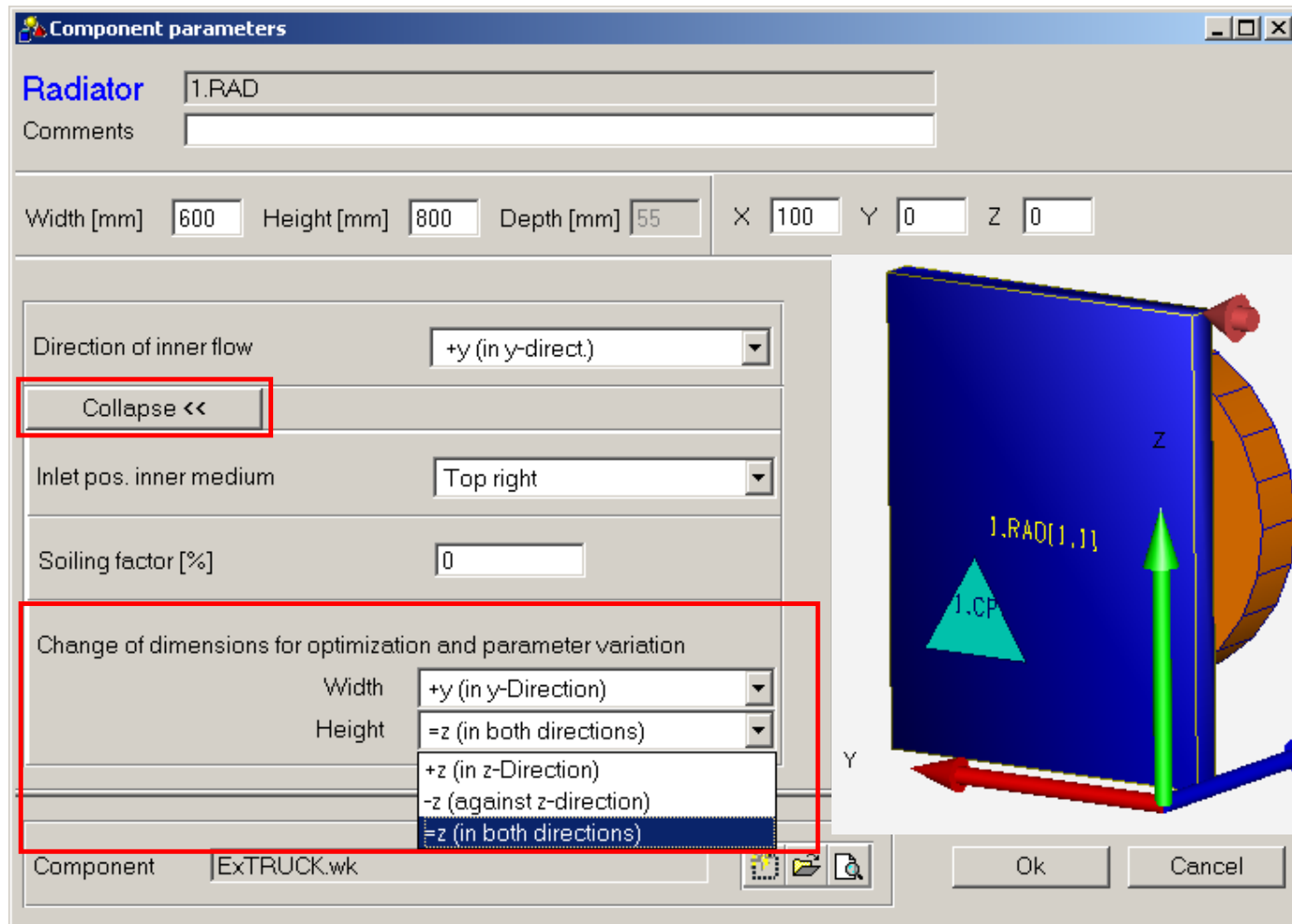
Variation of Parameters

1. Water circuit

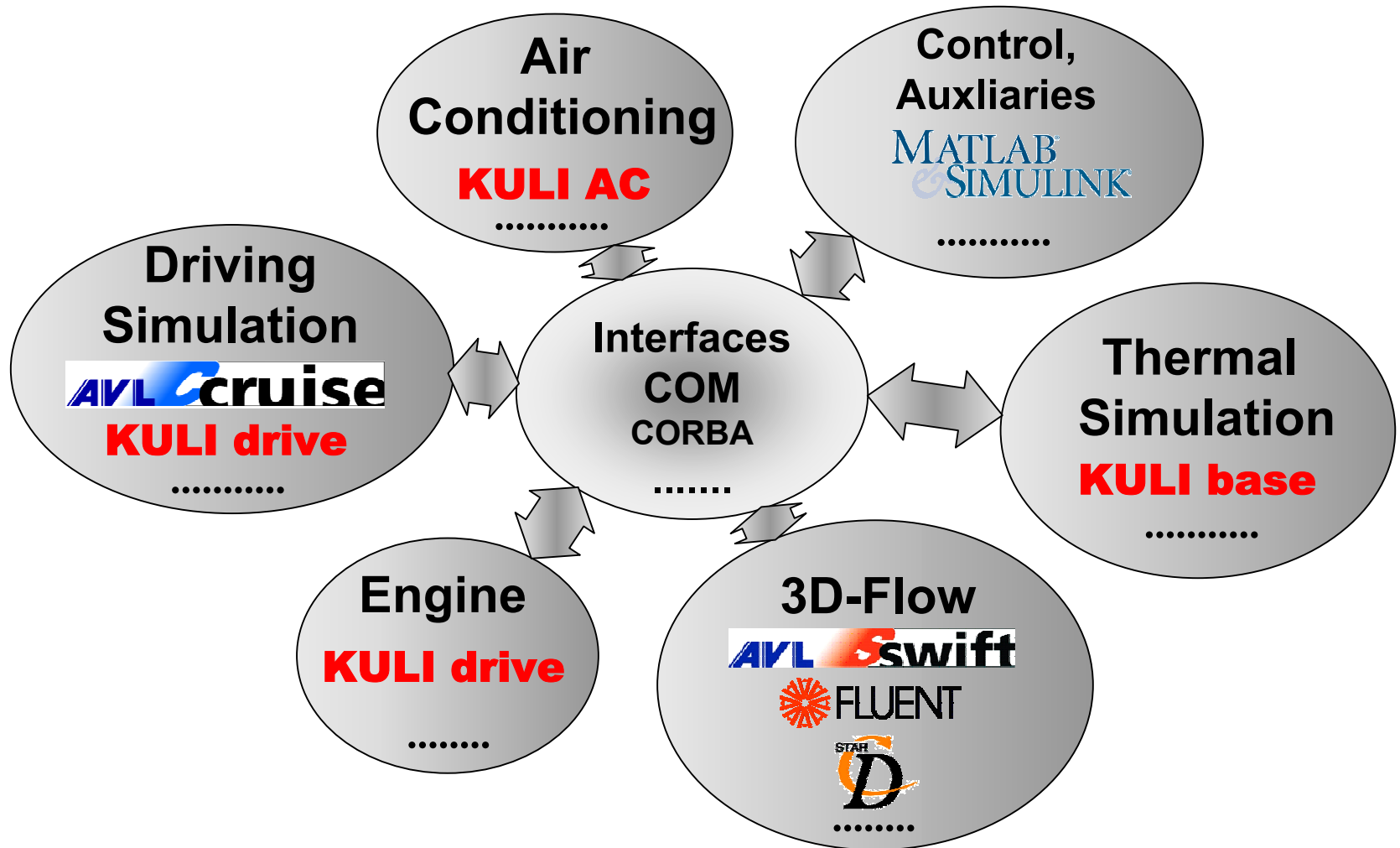


KULI 4.0 optimization stopped

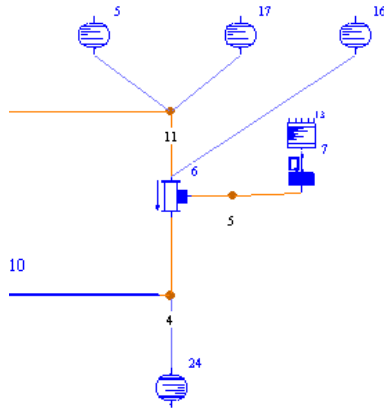
Direction of Optimization



Coupling of Simulation Software



Interface Flowmaster® to KULI with COM Objects



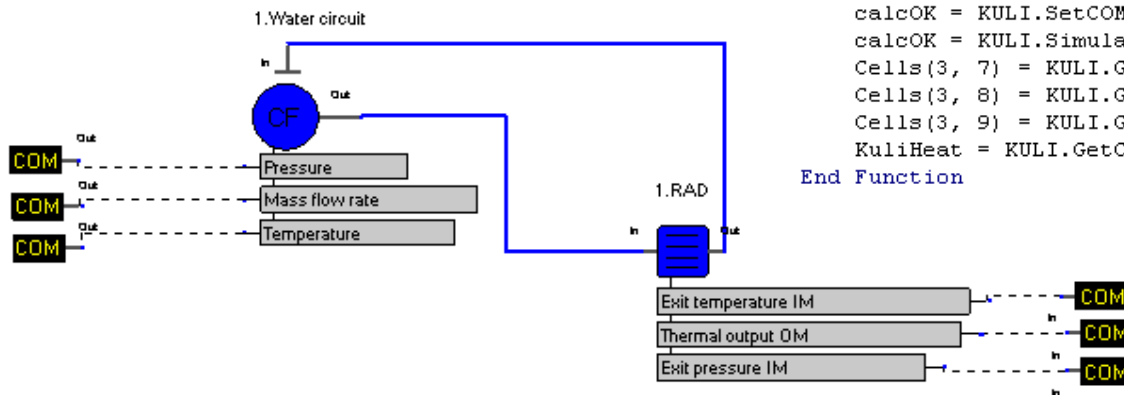
```
Set gauge_temp = Analysis.GetGauge(5)
Set gauge_press = Analysis.GetGauge(17)
Set gauge_press_2 = Analysis.GetGauge(24)
Set gauge_massFlow = Analysis.GetGauge(16)
If (gauge_temp Is Nothing) Or (gauge_press Is Nothing) Or (gauge_massFlow :
```

FLOWMASTER



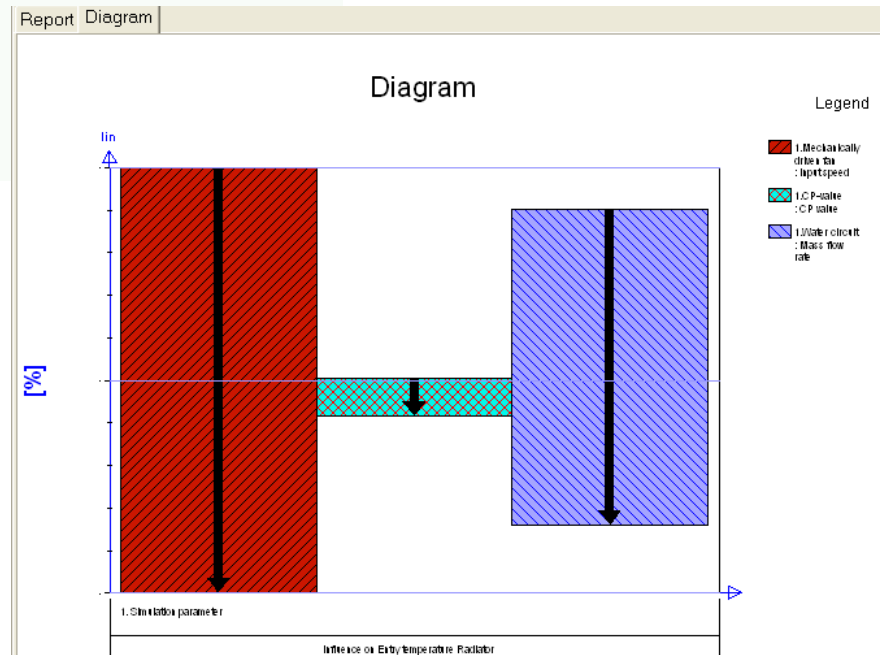
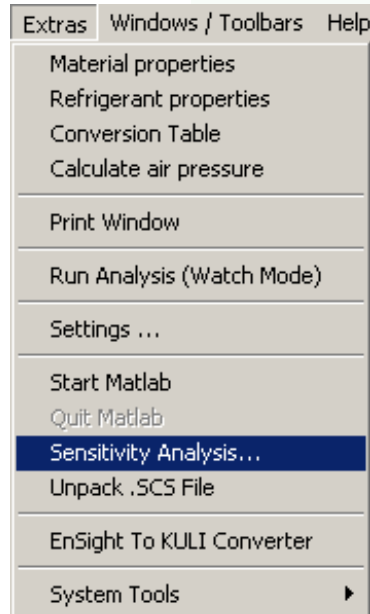
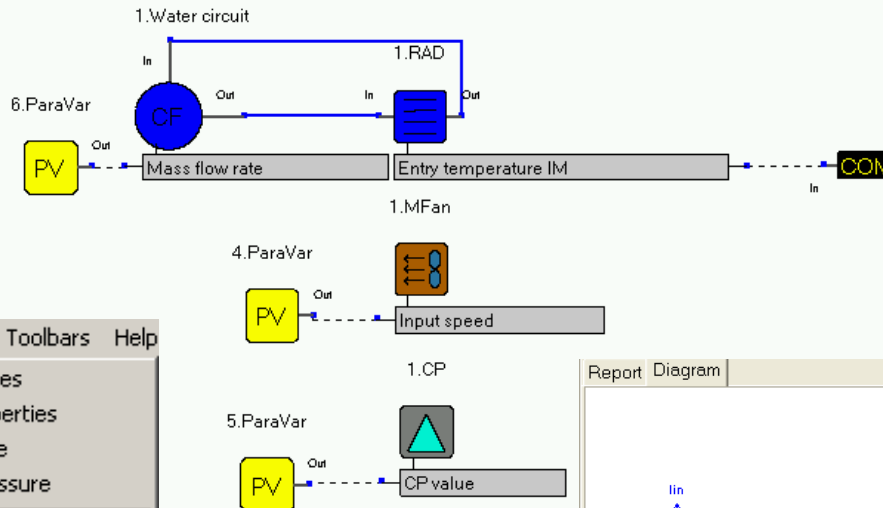
```
Public Function KuliHeat(temp, press, massFlow As Double)
```

```
'start KULI-analysis to enable iteration
calcOK = KULI.SetCOMValueByID("SetMassFlowKuli", massFlow)
calcOK = KULI.SetCOMValueByID("SetPressureKuli", press)
calcOK = KULI.SetCOMValueByID("SetTempKuli", temp)
calcOK = KULI.SimulateOperatingPoint(1)
Cells(3, 7) = KULI.GetCOMValueByID("GetPressureKuli")
Cells(3, 8) = KULI.GetCOMValueByID("GetTempKuli")
Cells(3, 9) = KULI.GetCOMValueByID("GetHeatFlowKuli")
KuliHeat = KULI.GetCOMValueByID("GetHeatFlowKuli")
Function
```

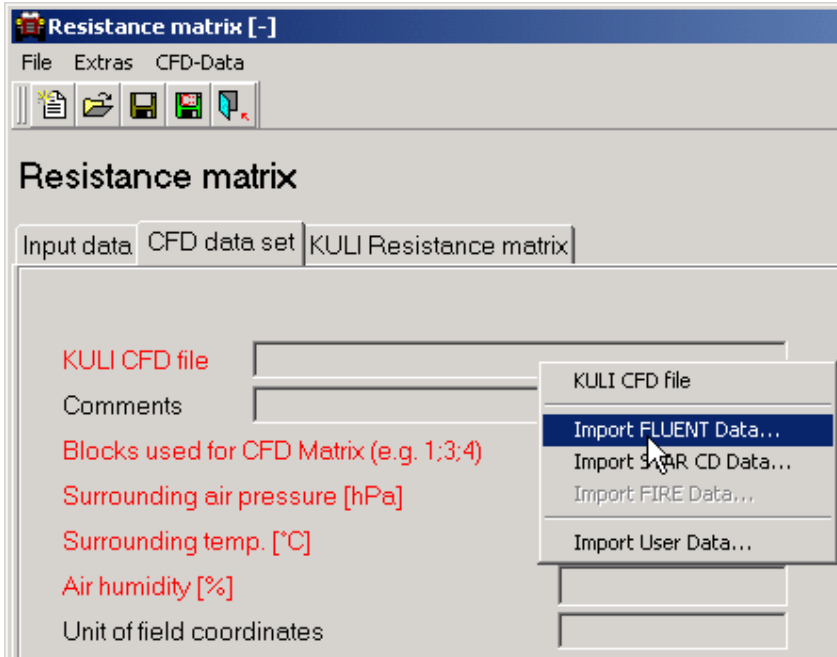


KULI 5.1

Sensitivity Analysis



Facelift for the CFD-interface (1)



- **direct CFD data import**
 - **accessible via context menu**
 - **conversion to KULI cfd file and import into resistance matrix dialog in one step**

Facelift for the CFD-interface (2)

File Extras CFD-Data

Resistance matrix

Input data | CFD data set | KULI Resistance matrix

Status: generated

ATTENTION: The resistance matrix will be generated for the first active simulation point.

Generate resistance matrix

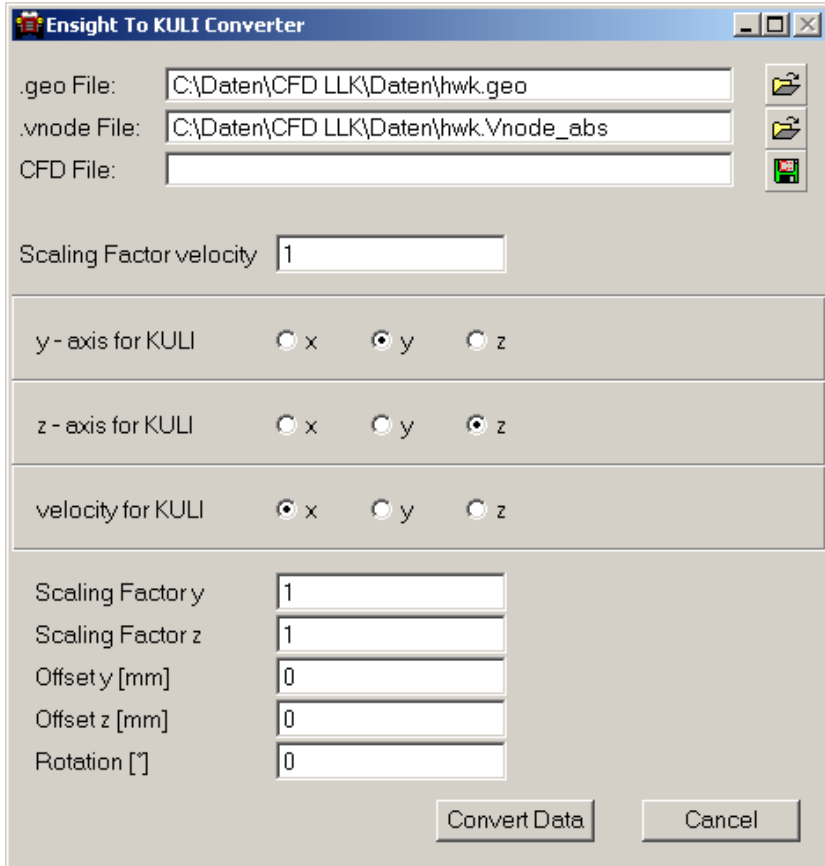
„Generate“-button on tab „Resistance matrix“ => more logical behavior

Output of volume and mass flow rates from CFD data

y-coordinate [mm]	z-coordinate [mm]	Zeta-values
-328	-59	4.01291
-328	-24	16.4688
-328	183	1.36247
-328	218	1.80557
-328	253	3.2545
-328	286	3.84506
-328	321	5.27357
-328	357	9.07016
-294	50	2.07605

	Sum absolute	Vector sum
Air mass flow rate from CFD data [kg/s]	1.16841	0.817147
Air vol. flow rate from CFD data [m³/s]	0.971417	0.679378

Ensignt to KULI Converter



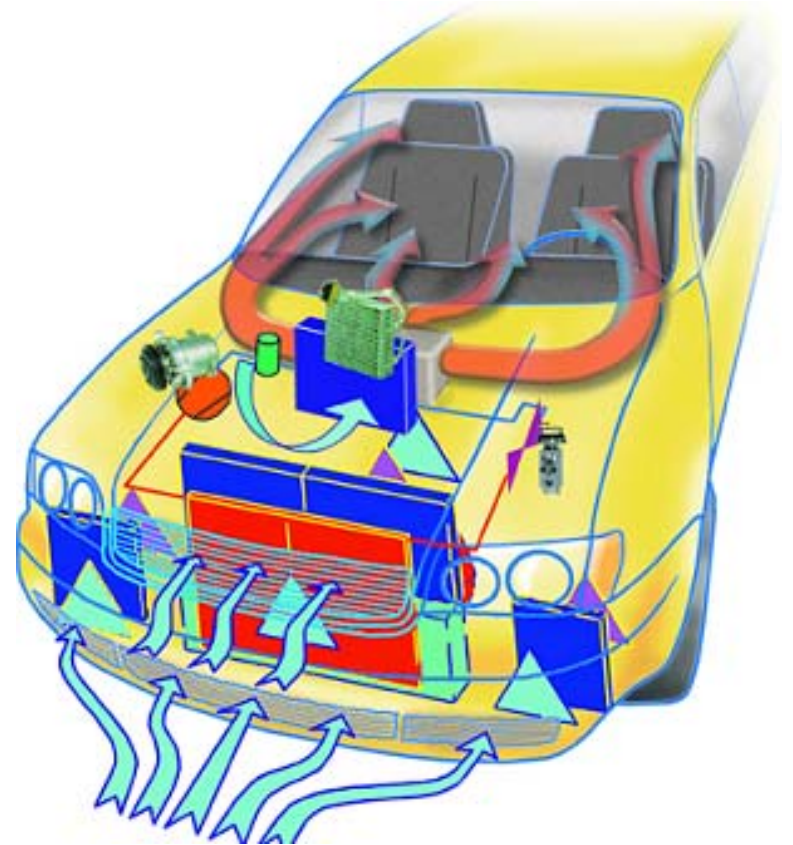
The screenshot shows the 'Ensignt To KULI Converter' dialog box. It contains the following fields and options:

- .geo File:** C:\Daten\CFD LLK\Daten\hwk.geo
- .vnode File:** C:\Daten\CFD LLK\Daten\hwk.Vnode_abs
- CFD File:** (empty)
- Scaling Factor velocity:** 1
- y - axis for KULI:** ☐ x ☒ y ☐ z
- z - axis for KULI:** ☐ x ☐ y ☒ z
- velocity for KULI:** ☒ x ☐ y ☐ z
- Scaling Factor y:** 1
- Scaling Factor z:** 1
- Offset y [mm]:** 0
- Offset z [mm]:** 0
- Rotation [°]:** 0
- Buttons:** Convert Data, Cancel

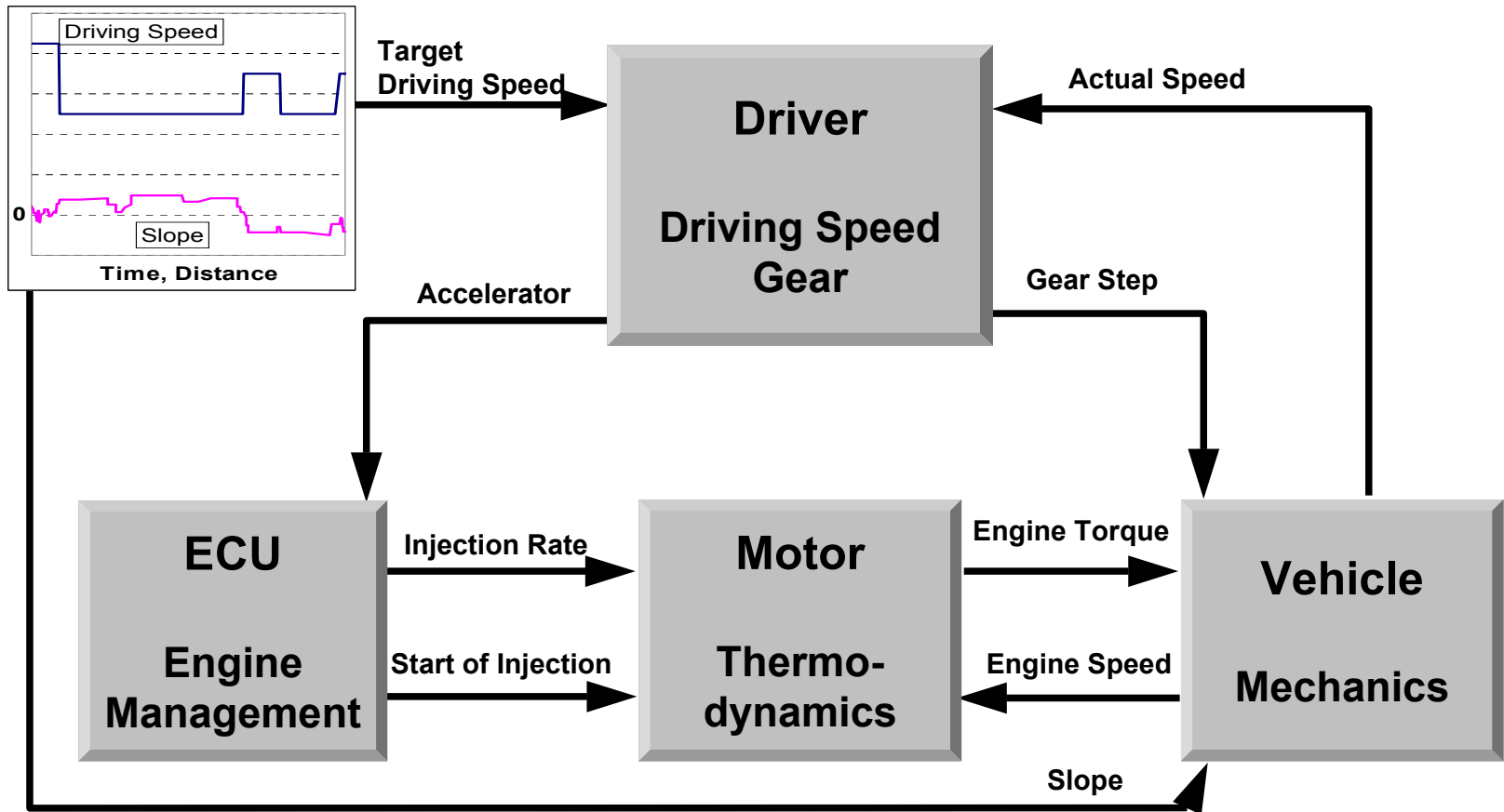
- **Ensignt To KULI Converter**
 - converts Ensignt output to KULI cfd files
 - several options for scaling, moving, rotating

KULI drive

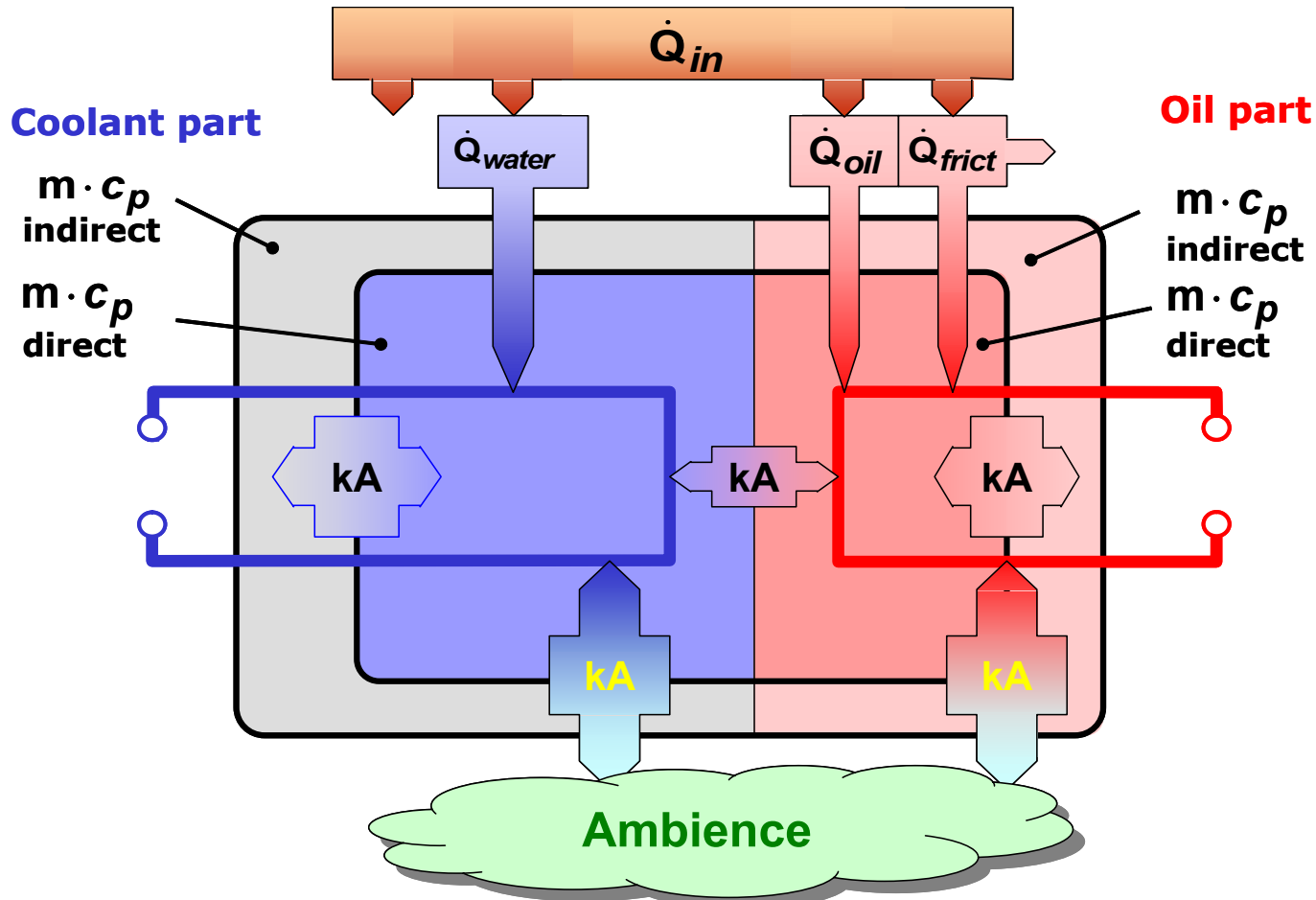
- **Transient Operation**
- **Driving Simulation**
- **Standard Driving Profiles**
- **Multi-mass Engine Model**
- **Transient Control Using Sensors & Actuators**



Transient Simulation – Driving Cycle Specification

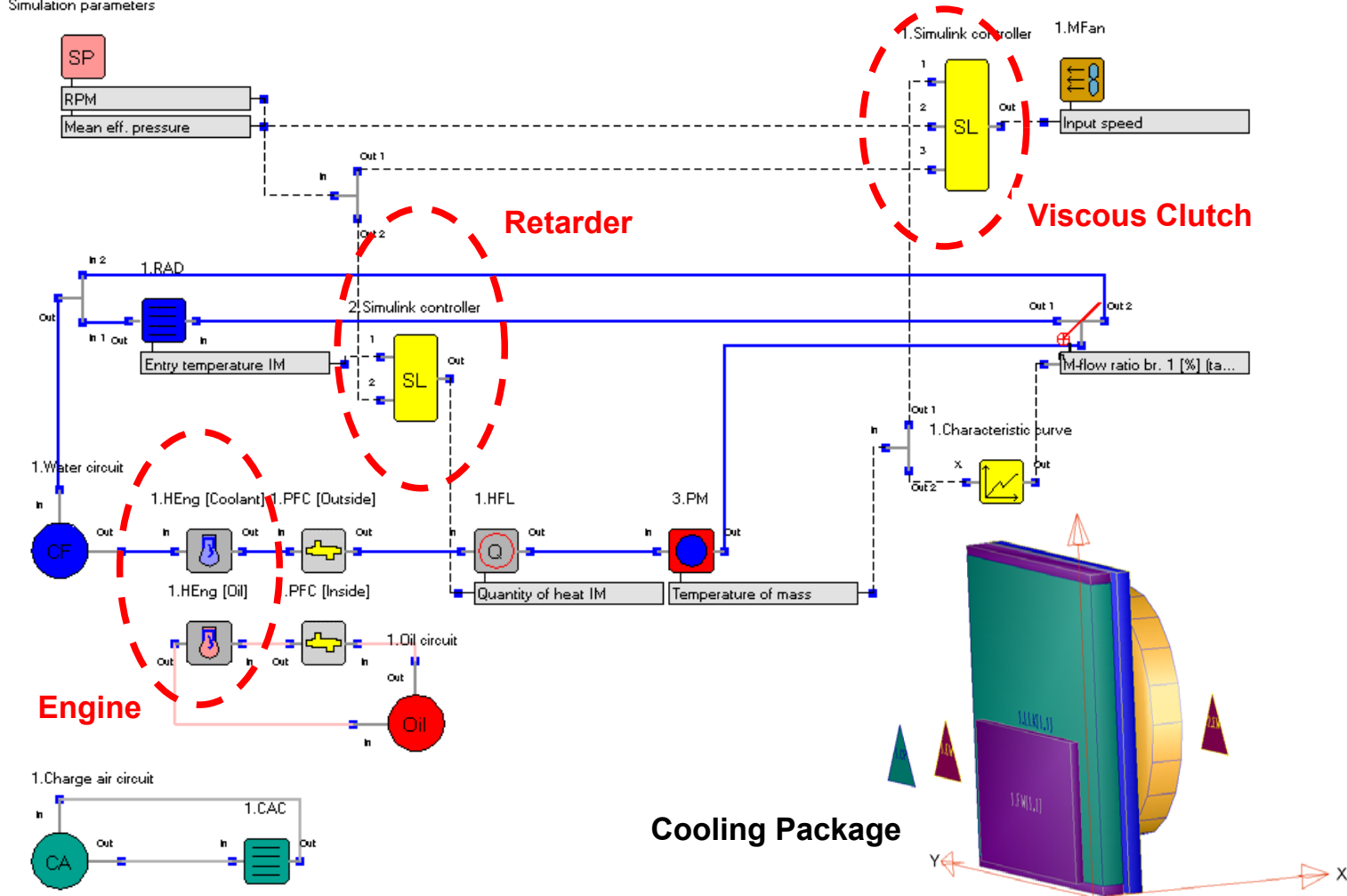


Engine Simulation Model

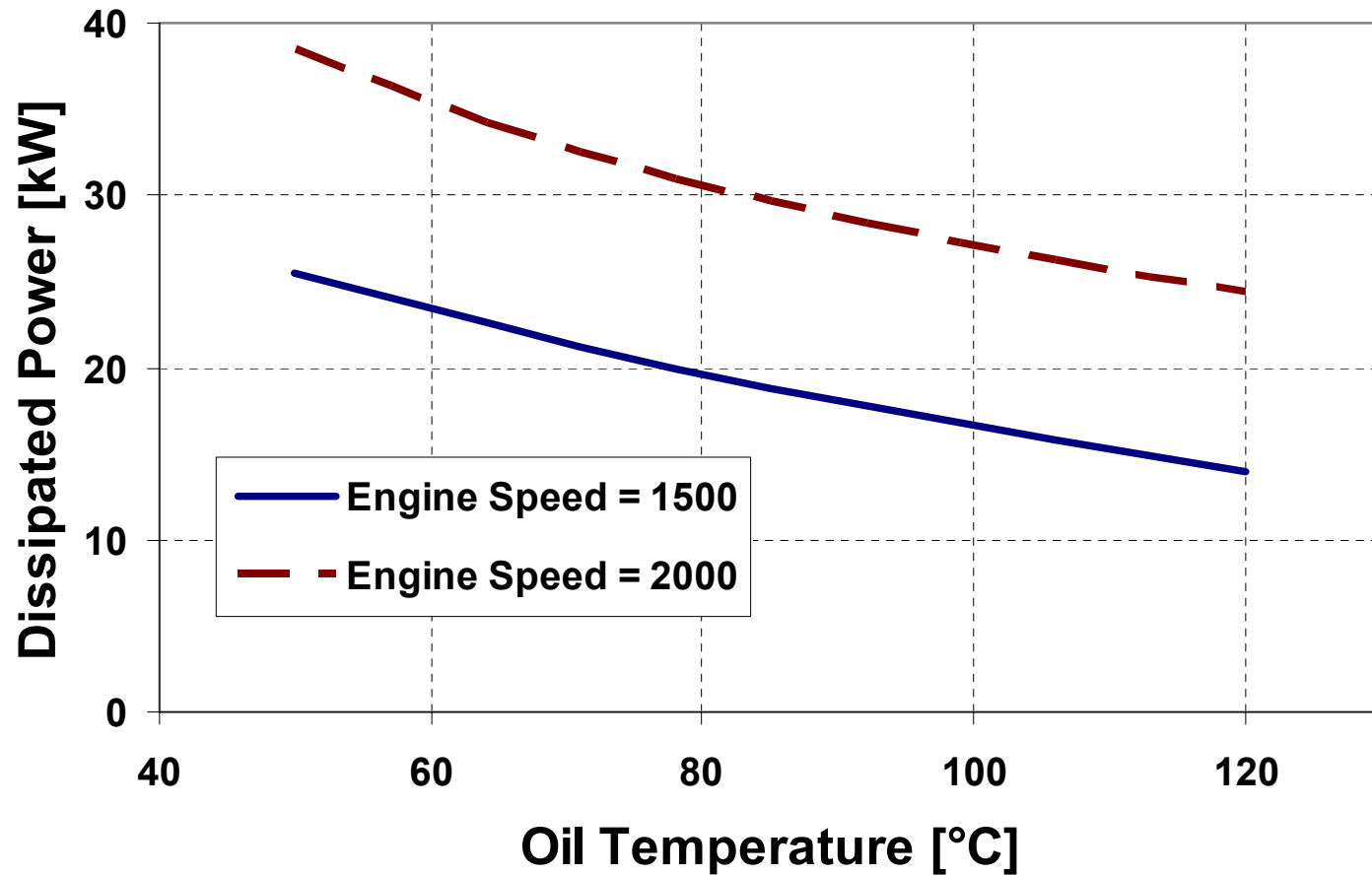


Simulation Model for a Commercial Truck

Simulation parameters



Dissipated Engine Power Correlated with Oil Temperature



Relative Energy Consumption – 2 Temperature Levels

