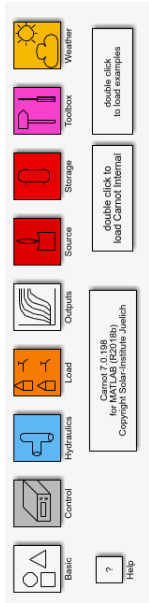


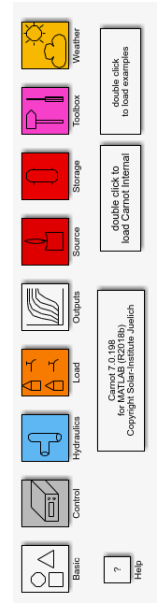
New developments in Carnot

Carnot User Meeting Bologna 23/06/2023

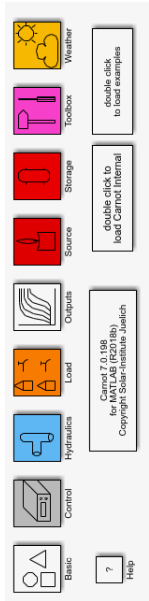
Bernd Hafner

Carnot

- Major application
- Where to find it
- Development group
- Bug fixes and new features



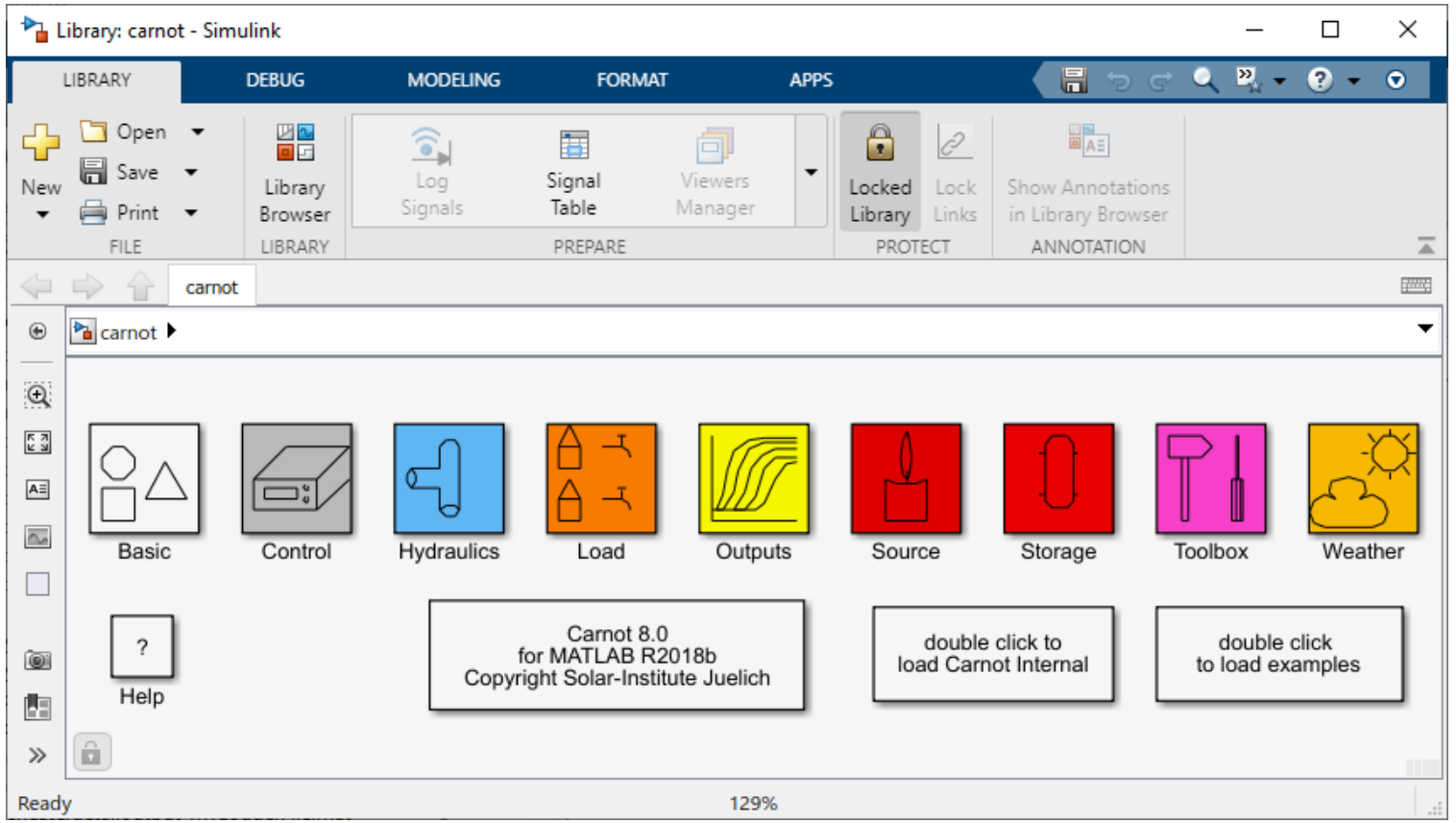
Carnot : Major Application

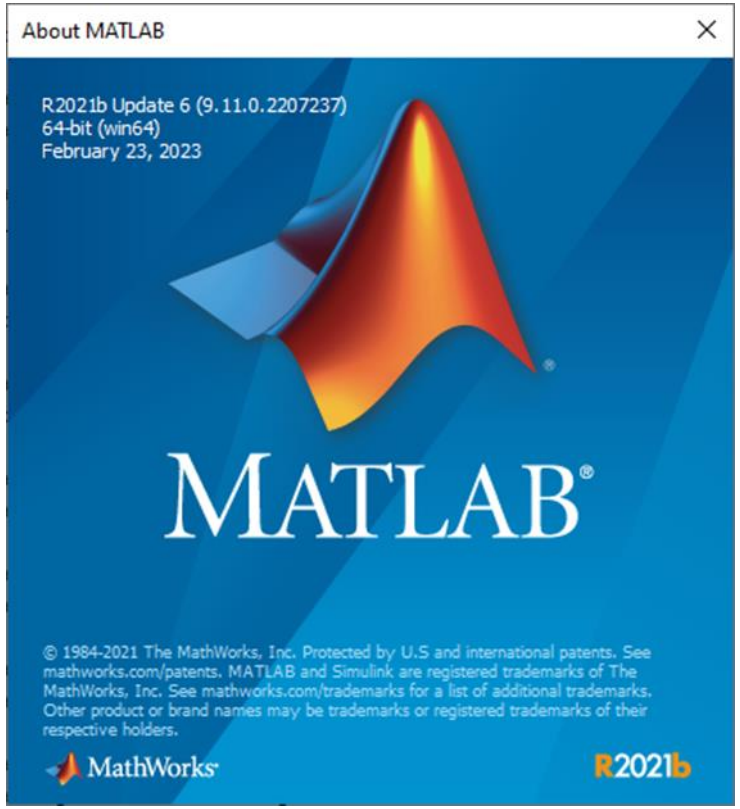


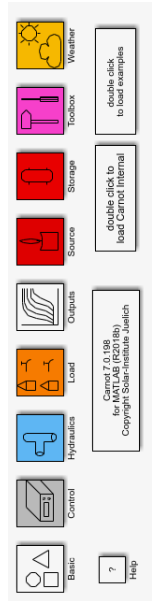
- Simulation of solar systems (thermal & electric)
- Simulation of HVAC systems
- Calculation of fluid properties, solar position, fluid flow and heat transfer characteristics (Reynolds, Grashof, Prandtl, …)
- A quite powerful tool for Model Based Development using the Matlab features for requirement engineering, MIL / HIL / SIL, code generation and testing

- Published by FH Aachen as open source under BSD license

Carnot 8.0 for Matlab R2021b

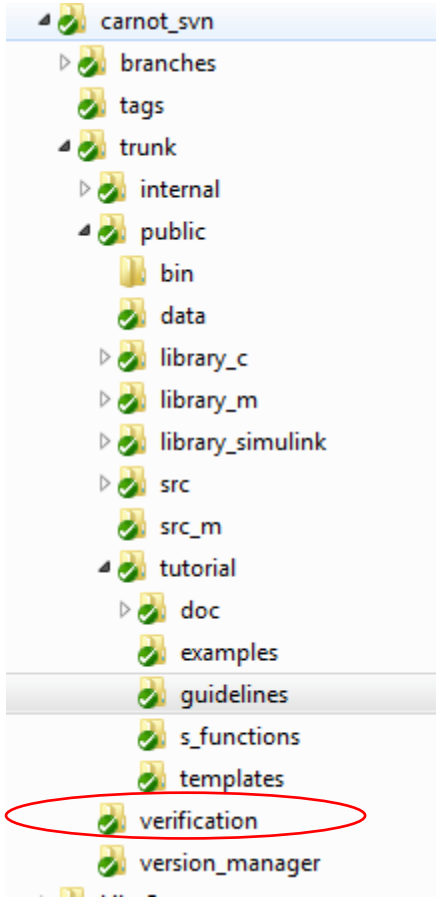






… available since 20/06/2023

Verification



Command Window

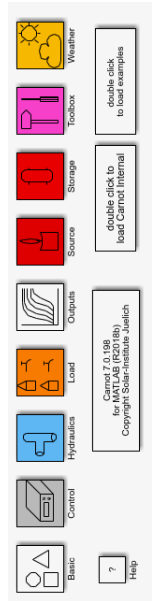
```
>> run('C:\repos\Lib_Carnot\verification\verification_carnot.m')
--- starting verification of CARNOT library and functions ---
    density of Water OK: error 0.000
    heat_capacity of Water OK: error 0.003
    thermal_conductivity of Water OK: error 0.011
```

verification_carnot_results.txt - Editor

Datei Bearbeiten Format Ansicht Hilfe

```
327 of 333: FixedSurface OK: error   0

328 of 333: RadiationOnInclinedSurface OK: error 3.59e-12°

329 of 333: RadiationOnInclinedSurface OK: error 0.0296°

330 of 333: TrackedSurface OK: error 0.000

331 of 333: verify_WeatherDatafile_mdl OK: error   0

332 of 333: WeatherSimpleModel OK: error   0

333 of 333: validating WeatherFromWorkspace OK: error   0
```

Zeile 1, Spalte 1 | 100% | Unix (LF) | UTF-8

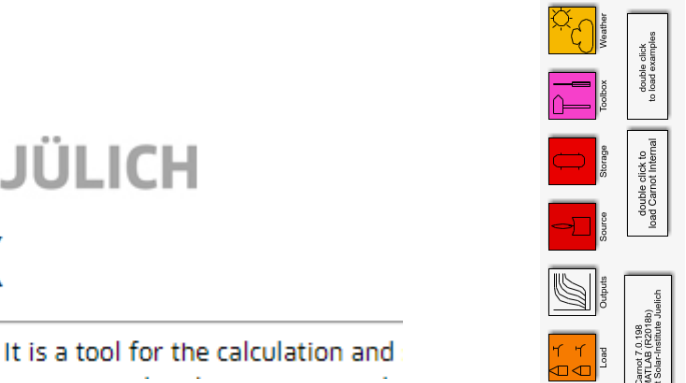


verification is correct for Matlab R2021b
… for R2022b and R2023a still to be done

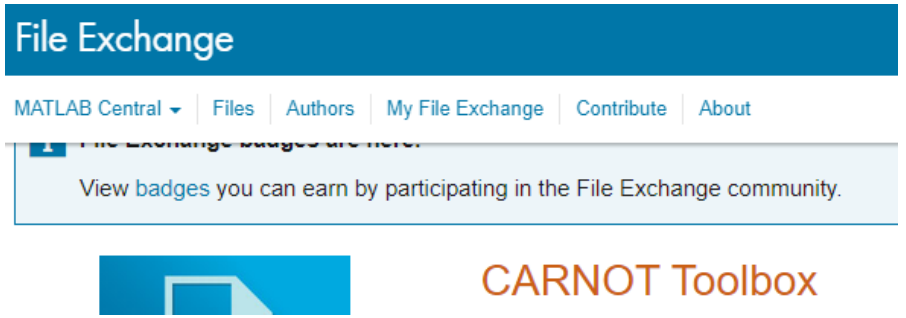
Carnot – Where to find it?

https://www.fh-aachen.de/forschung/solar-institut-juelich/carnot/

Email: carnot@sij.fh-aachen.de

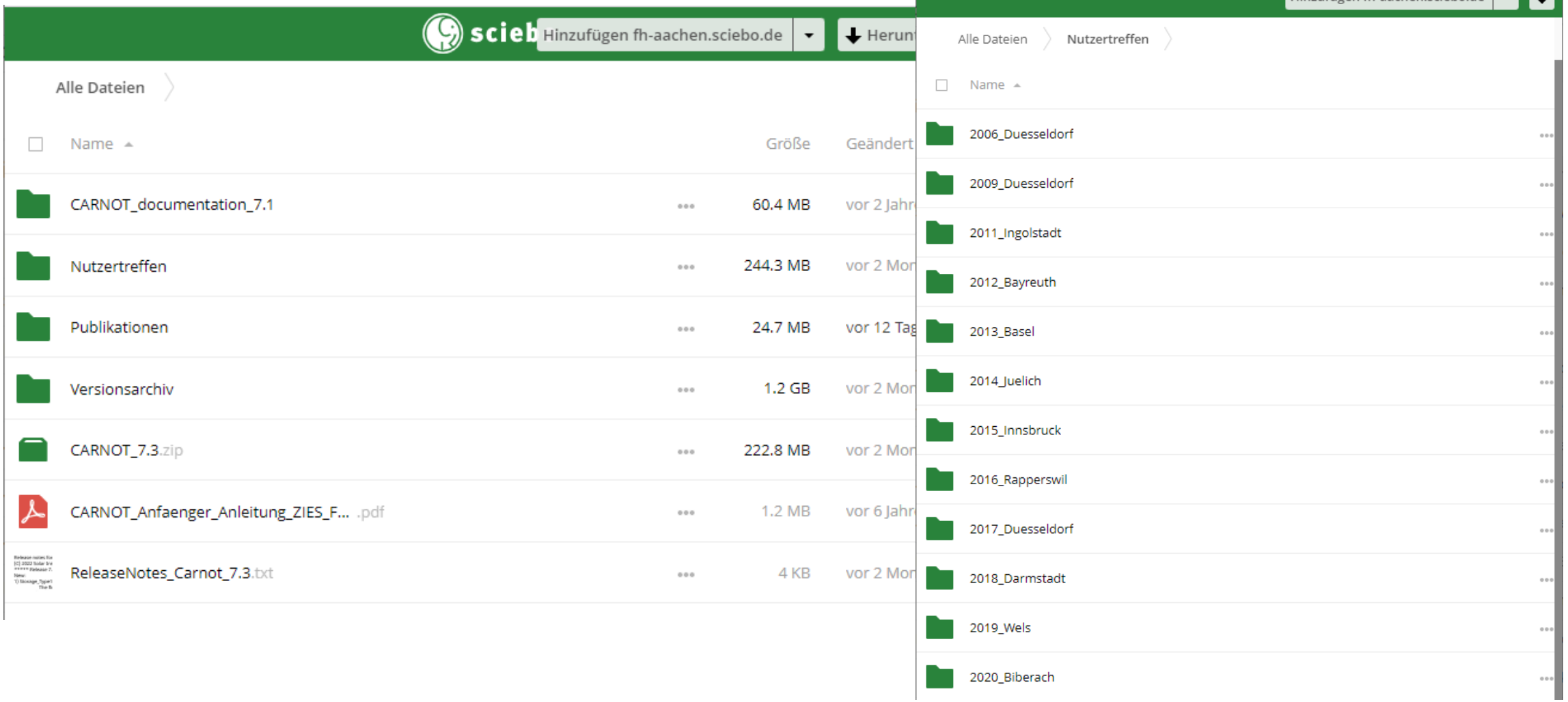


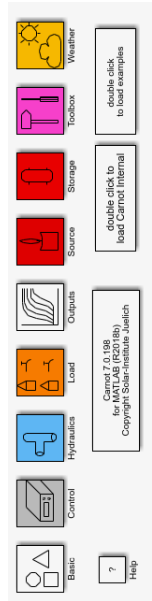
https://de.mathworks.com/matlabcentral/fileexchange/68890-carnot-toolbox



User Group: https://www.gomatlab.de/carnot-toolbox-f108.html

Carnot – Documentation https://fh-aachen.sciebo.de/index.php/s/0hxub0iIJrui3ED?path=%2F



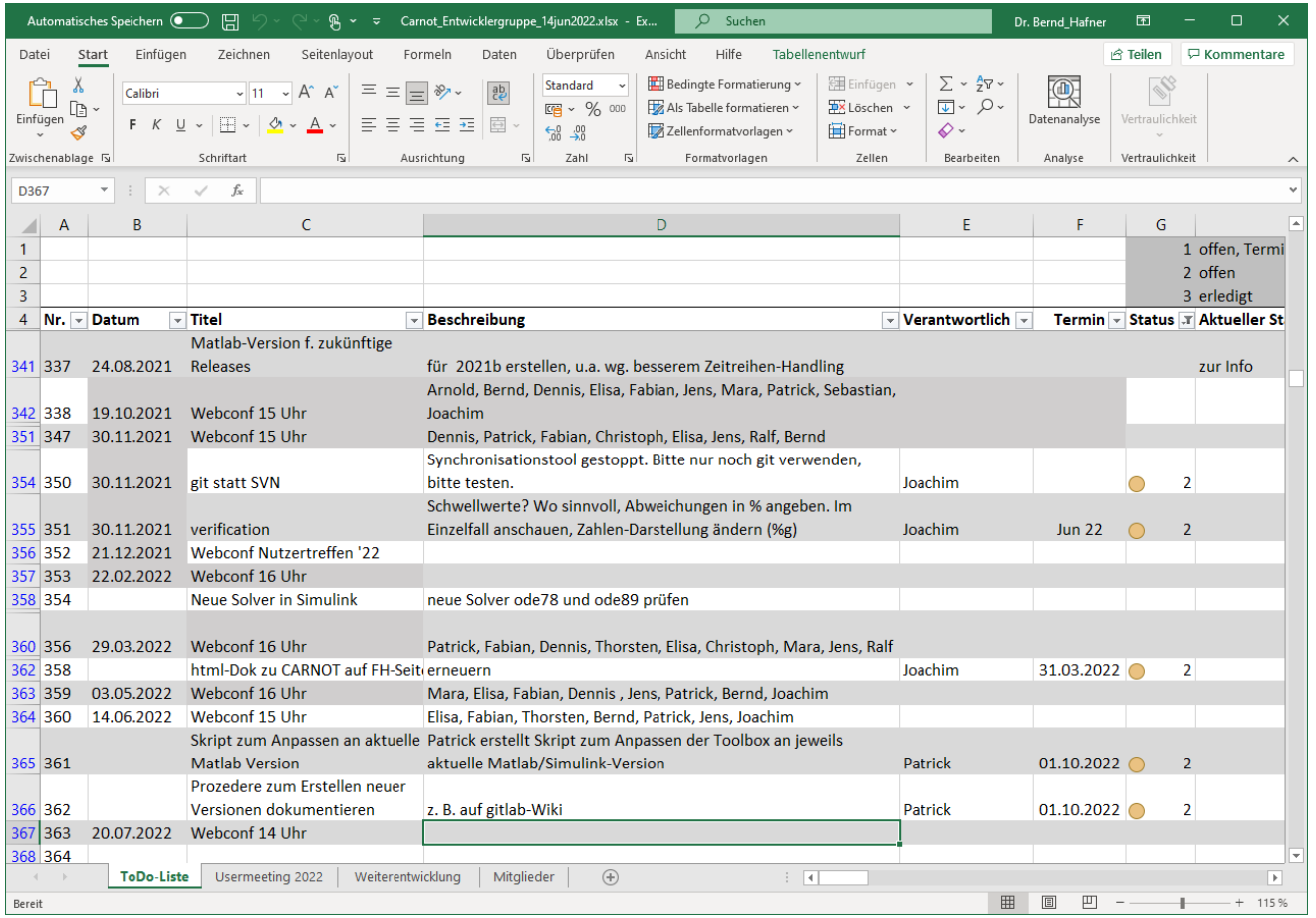


CARNOT development group

Sorted members list:

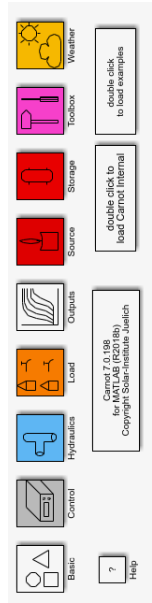
Mara Magni, Elisa Venturi, Fabian Ochs,
Christoph Messmer, Stephan Volkmer,
Patrick Kefer, Thorsten Summ,
Marco Griesbach, Jens Schaumann,
Bernd Hafner, Tobias Blanke,
Joachim Göttsche, Ralf Dott,
Arnold Wohlfeil, Dennis Götzelmann

- Web-conference every 4-8 weeks
- New features
- Bug reporting
- Organize the user meeting



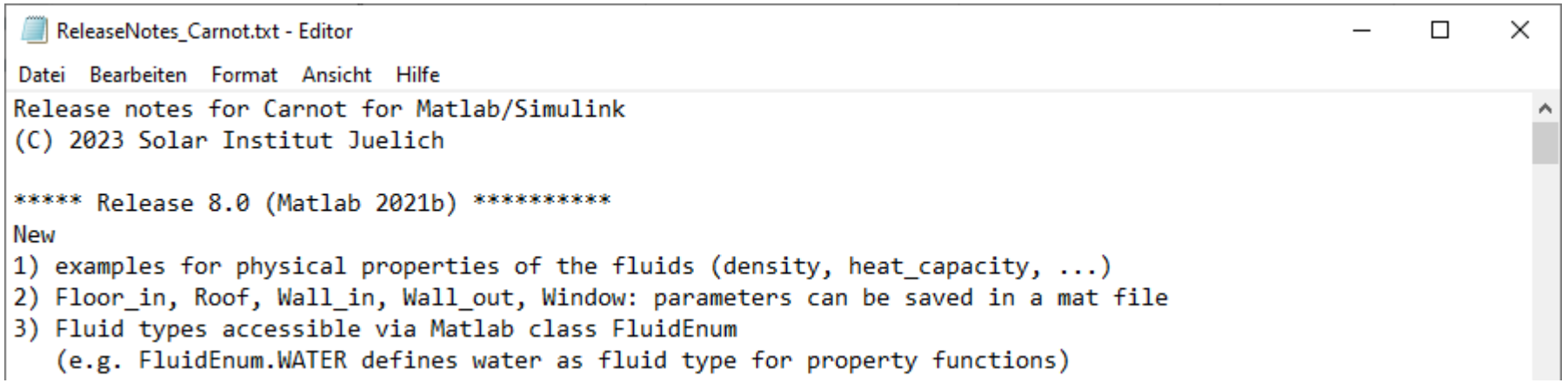
Nr.	Datum	Titel	Beschreibung	Verantwortlich	Termin	Status	Aktueller St
						1	offen, Termi
						2	offen
						3	erledigt
337	24.08.2021	Matlab-Version f. zukünftige Releases	für 2021b erstellen, u.a. wg. besserem Zeitreihen-Handling				zur Info
338	19.10.2021	Webconf 15 Uhr	Arnold, Bernd, Dennis, Elisa, Fabian, Jens, Mara, Patrick, Sebastian, Joachim				
347	30.11.2021	Webconf 15 Uhr	Dennis, Patrick, Fabian, Christoph, Elisa, Jens, Ralf, Bernd				
350	30.11.2021	git statt SVN	Synchronisationstool gestoppt. Bitte nur noch git verwenden, bitte testen.	Joachim		2	
351	30.11.2021	verification	Schwellwerte? Wo sinnvoll, Abweichungen in % angeben. Im Einzelfall anschauen, Zahlen-Darstellung ändern (%g)	Joachim	Jun 22	2	
352	21.12.2021	Webconf Nutzertreffen '22					
353	22.02.2022	Webconf 16 Uhr					
354		Neue Solver in Simulink	neue Solver ode78 und ode89 prüfen				
356	29.03.2022	Webconf 16 Uhr	Patrick, Fabian, Dennis, Thorsten, Elisa, Christoph, Mara, Jens, Ralf				
358		html-Dok zu CARNOT auf FH-Seite	erneuern	Joachim	31.03.2022	2	
359	03.05.2022	Webconf 16 Uhr	Mara, Elisa, Fabian, Dennis , Jens, Patrick, Bernd, Joachim				
360	14.06.2022	Webconf 15 Uhr	Elisa, Fabian, Thorsten, Bernd, Patrick, Jens, Joachim				
361		Skript zum Anpassen an aktuelle Matlab Version	Patrick erstellt Skript zum Anpassen der Toolbox an jeweils aktuelle Matlab/Simulink-Version	Patrick	01.10.2022	2	
362		Prozedere zum Erstellen neuer Versionen dokumentieren	z. B. auf gitlab-Wiki	Patrick	01.10.2022	2	
363	20.07.2022	Webconf 14 Uhr					
364							

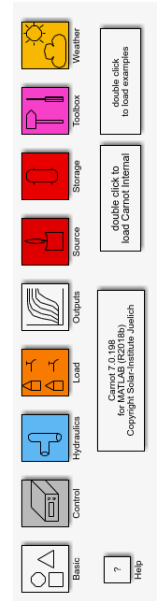
Carnot 8.0 : Improvements & New Features



Carnot 8.0: Bug fixes

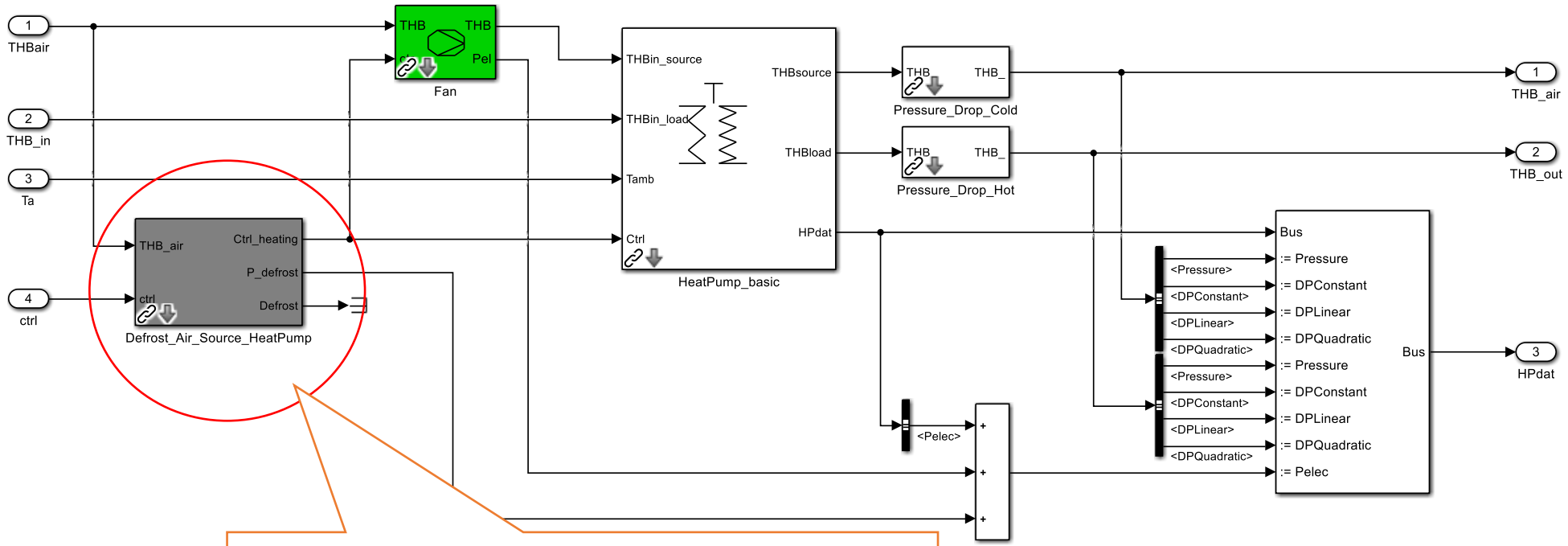
… refer to the release notes





Carnot 8.0 : new Features

HeatPump_Air_Source



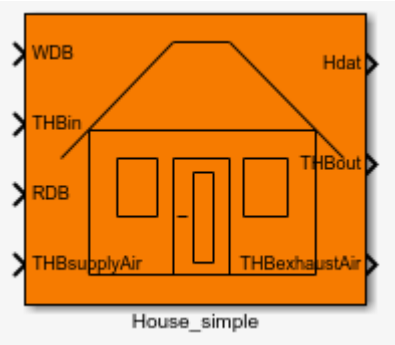
Defrost model: operation and defrost time from look-up table fitted to measurement

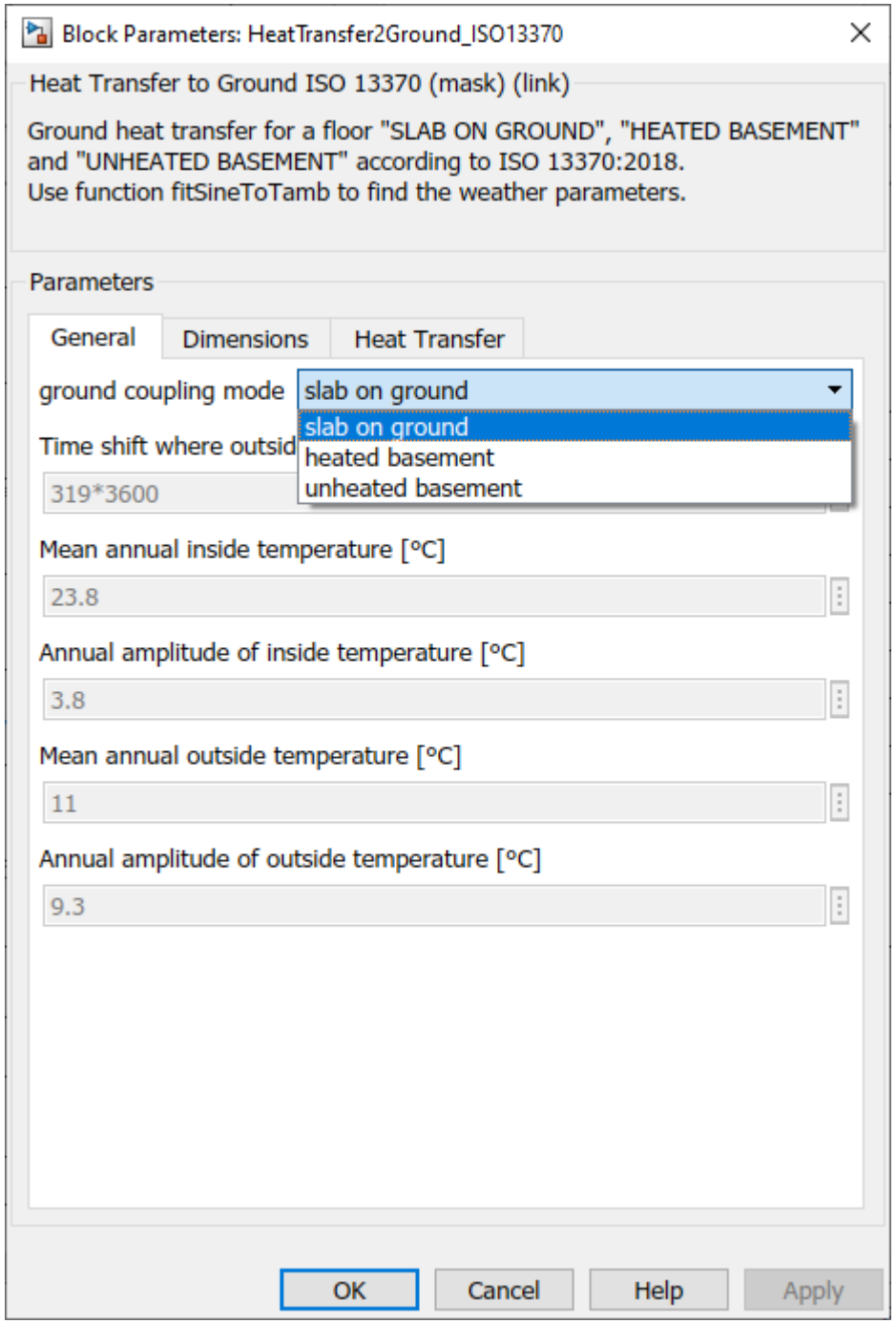
Carnot 8.0 : Improvements

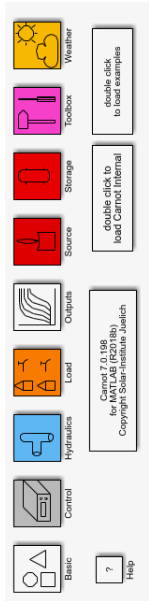
House_simple

TBH input for ventilation

HeatTransfer2Ground_ISO13370 with the options: slab on ground, heated basement, unheated basement

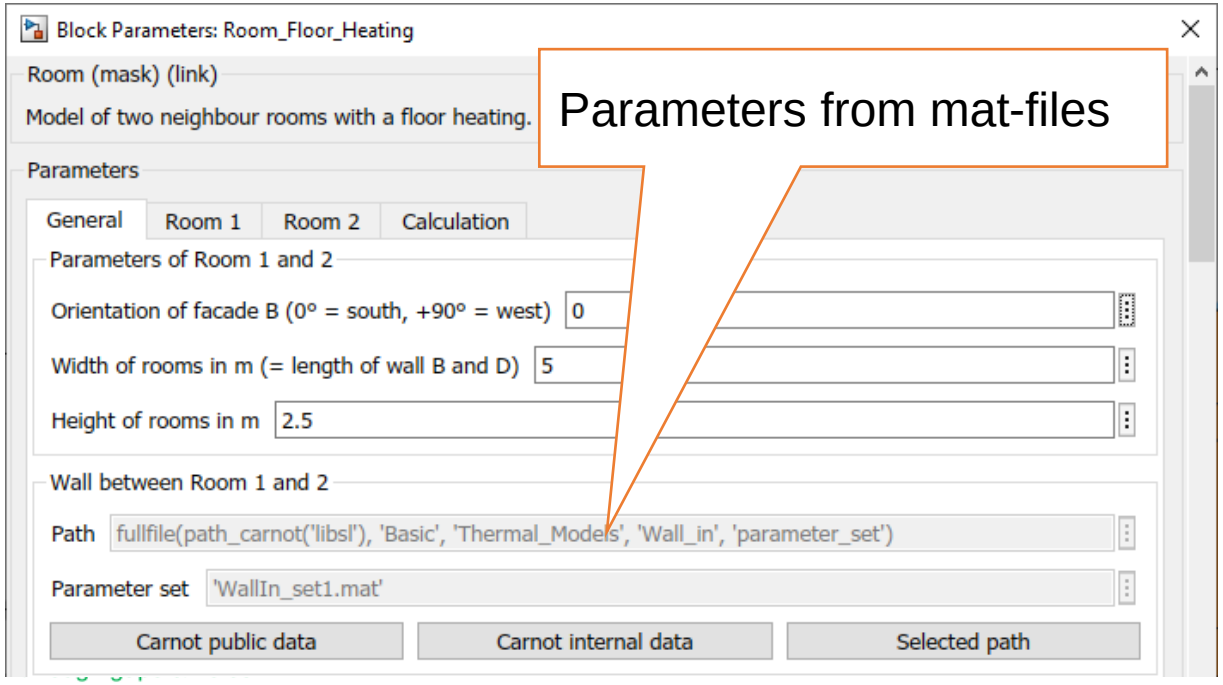






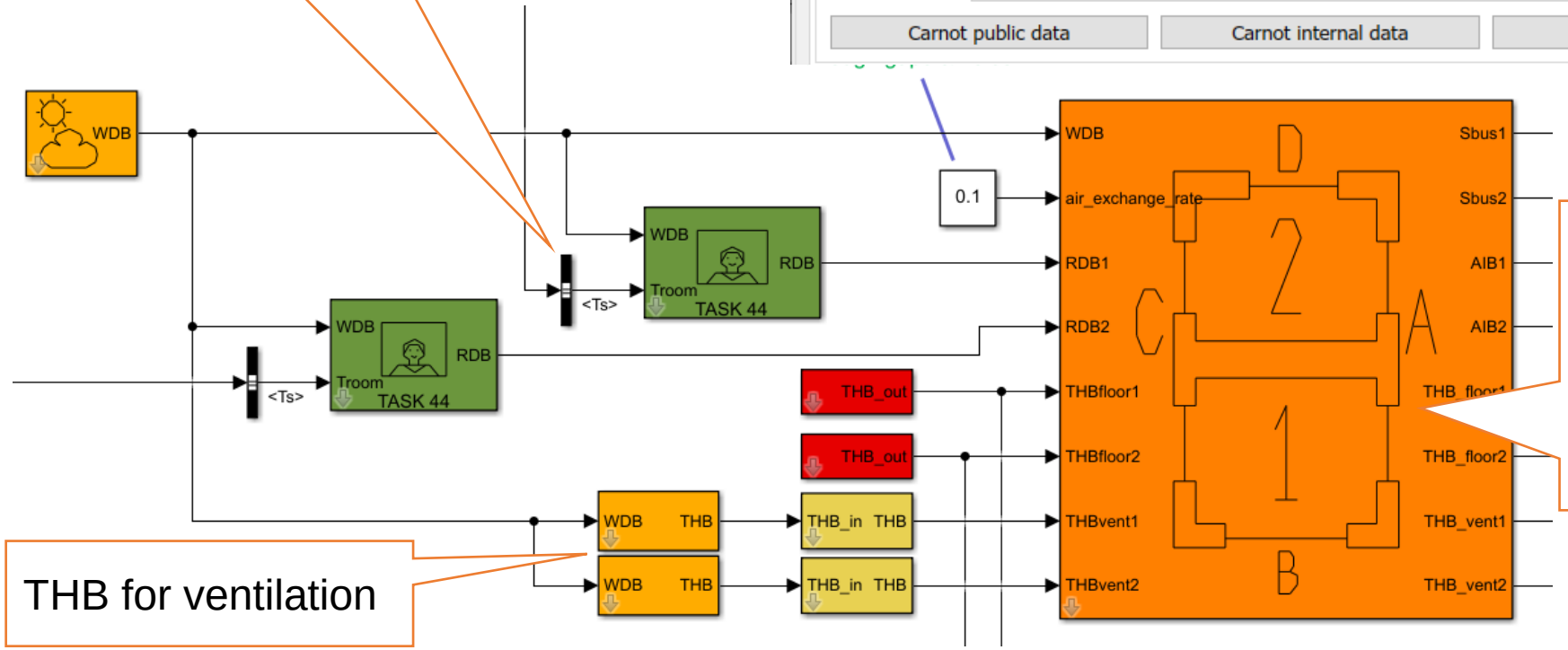
Carnot 8.0 : new Features

Room_radiatior, Room_floor_heating



Parameters from mat-files

Resident Data as input



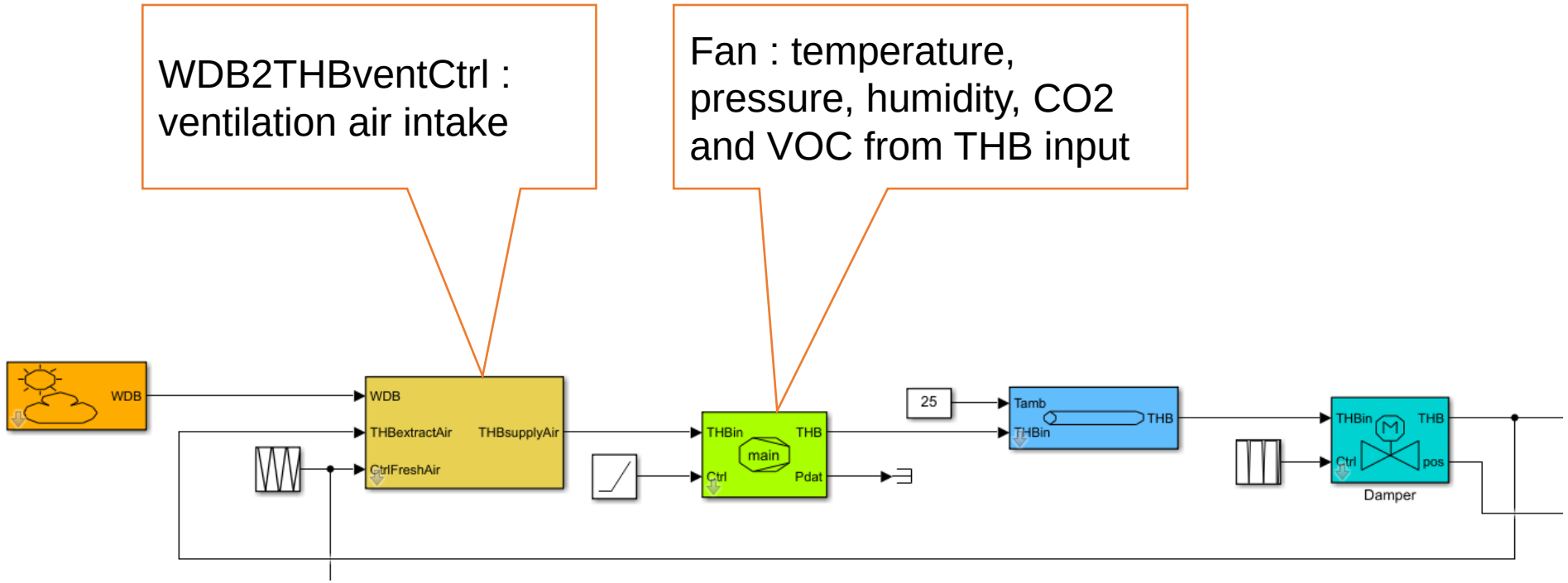
Concentration (CO2, VOC)

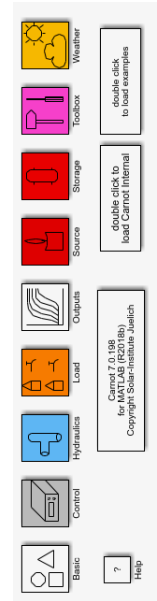
Window_ ventilation

THB for ventilation

Carnot 8.0 : new Features

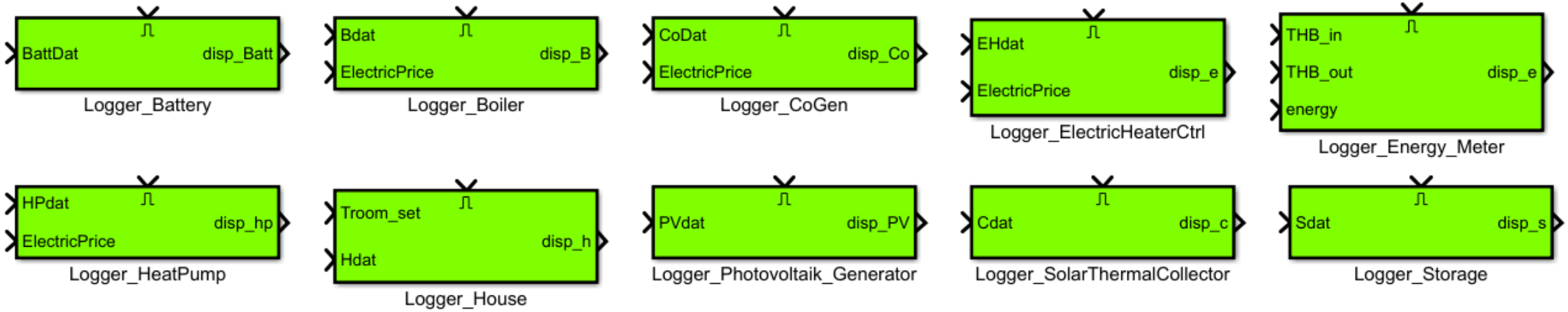
Fan models

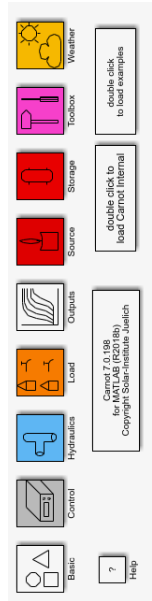




Carnot 8.0 : new Features

Data_Logger blocks



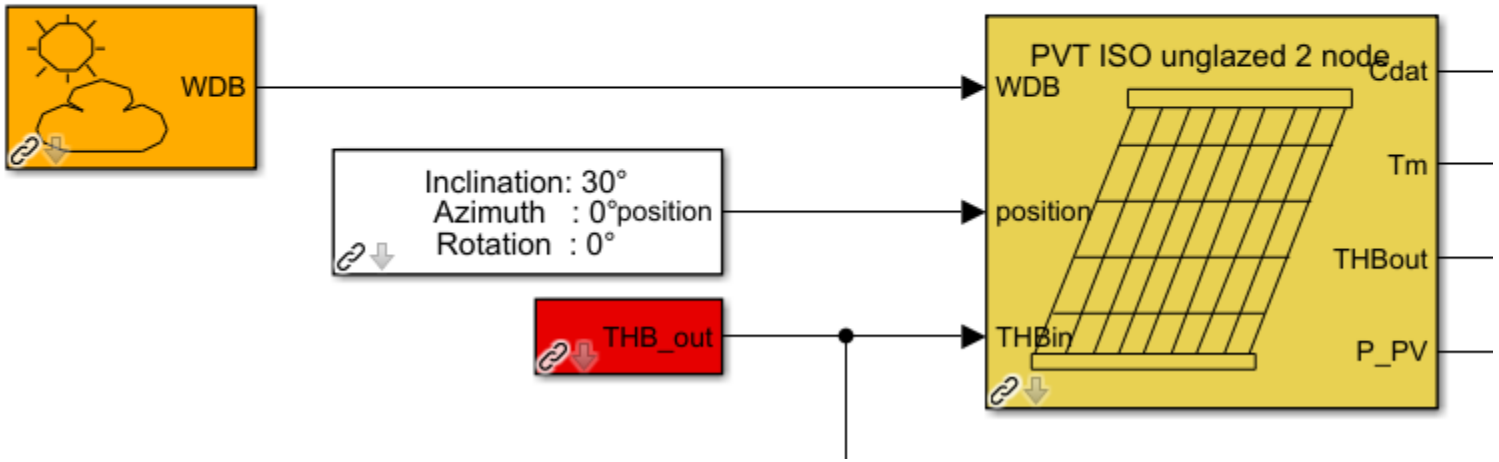


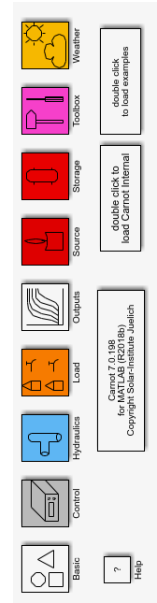
m-functions for evaluation of the data
e.g. the calculation of the seasonal performance factor of a heat pump
or the specific heating demand of a house in kWh/m²

Carnot 8.0 : new Features

PVT_Collector_Unglazed_ISO_2node

photovoltaic thermal collector based on the PV model and the ISO model of an unglazed collector



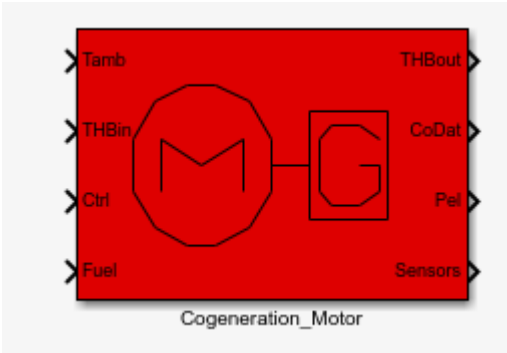


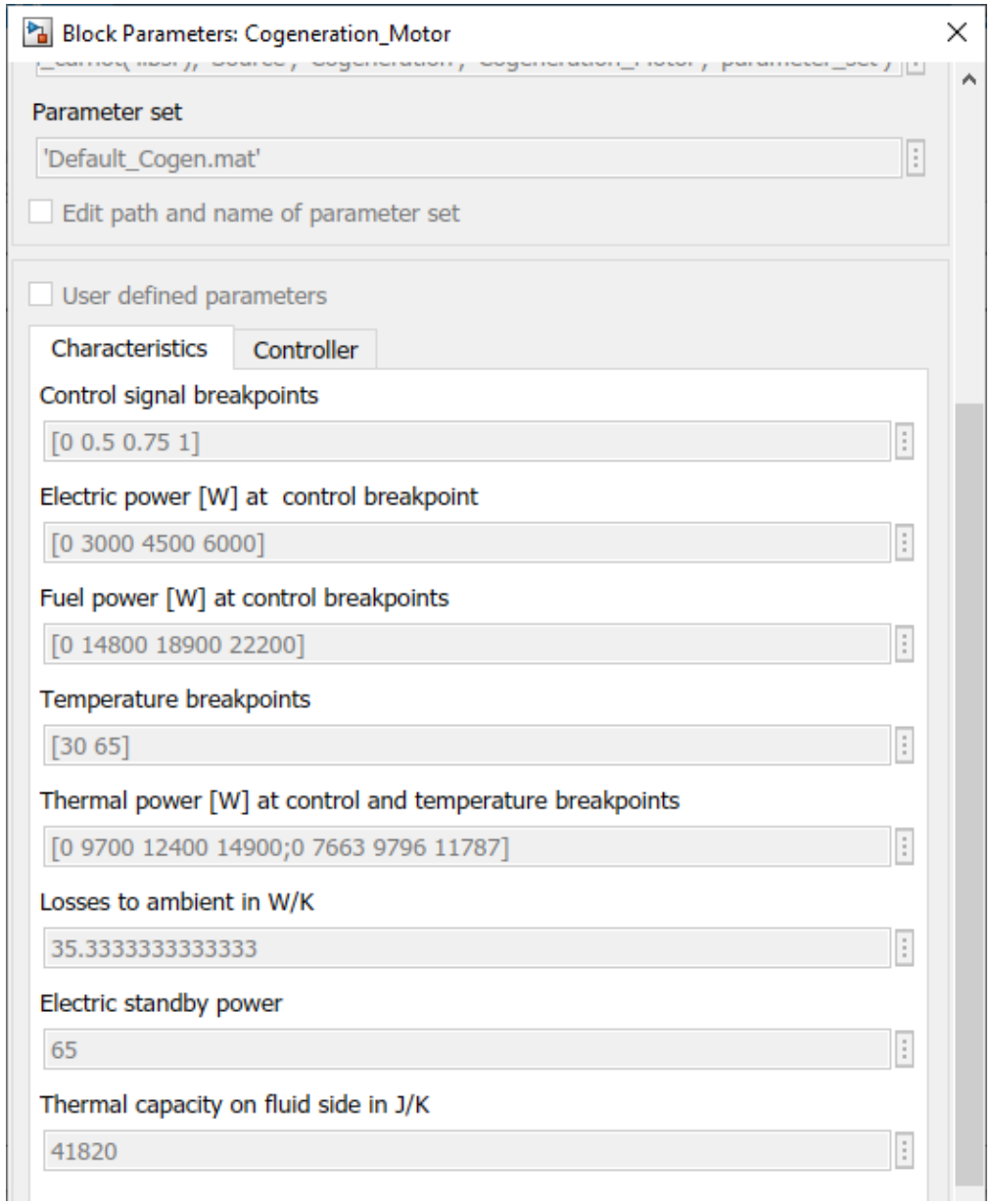
Carnot 8.0 : new Features

Cogeneration_Motor

model of a cogeneration unit with a gas motor

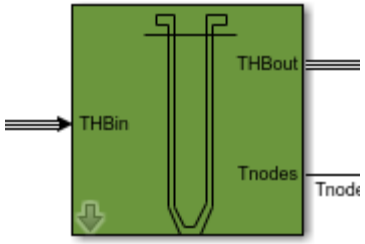
Based on Look-up Tables with some
basic control functions (temperature limits)

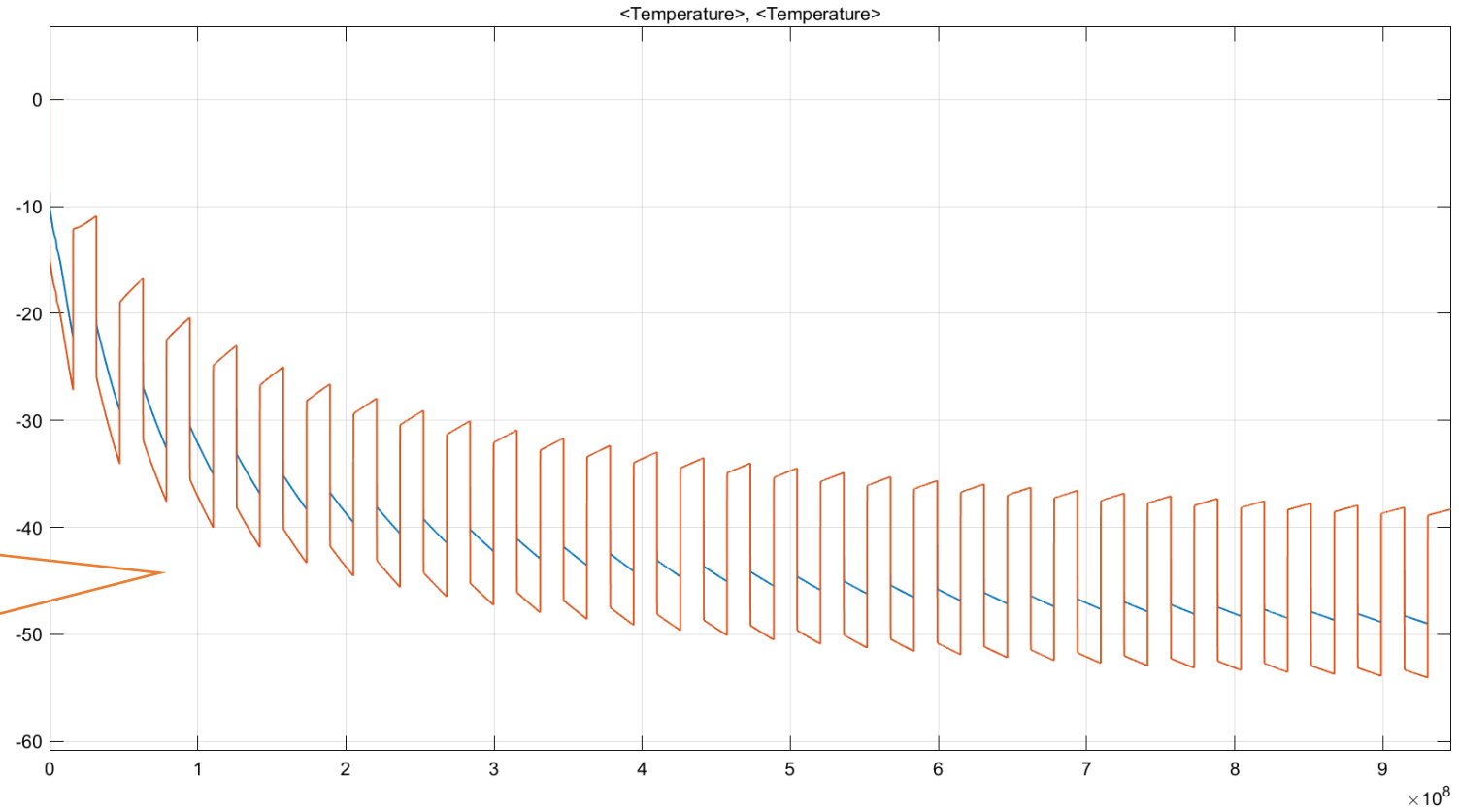




Carnot 8.0 : new Features

Ground_source_heat_exchanger – complete verification with literature and test data

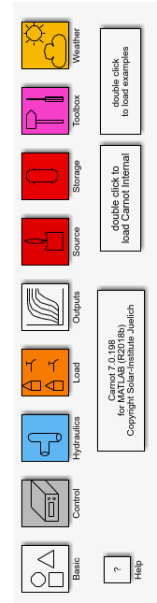


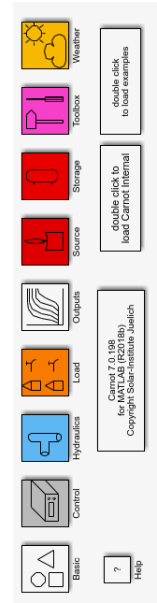


Testcase [Huber]
30 years operation time

Simulation time 2 s ☺

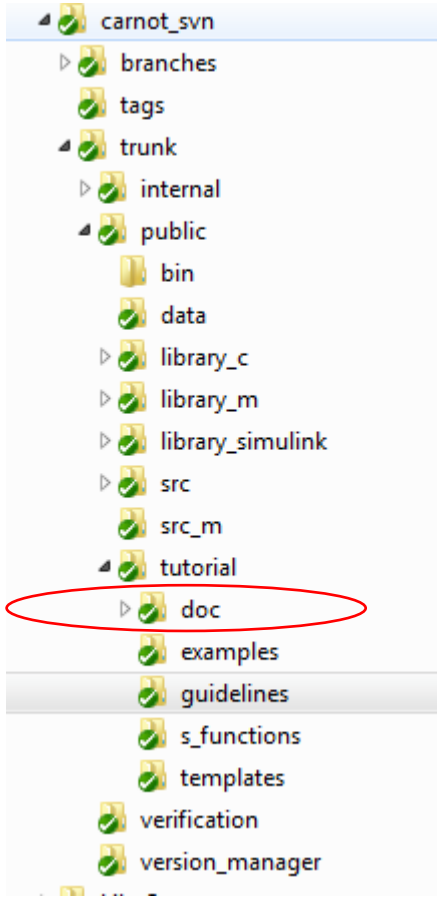
Model and validation data: Huber A, Schuler O.: Berechnungsmodul für Erdwärmesonden (EWS). ENET Bericht Nr. 9658807-1, 1997





Thank you for your attention

Carnot folders: Tutorial



Carnot m-Functions for Blocks Overview

Contents

- Basic / Electric
- Basic / Heat_Transfer
- Basic / Hydraulics
- Basic / Material_Properties
- Basic / Thermal_Models
- Hydraulics
- Load / General
- Load / Hot_Water_Tapping

Basic / Thermal_Models

hp_param

CarnotCallbacks_WindowWithShading

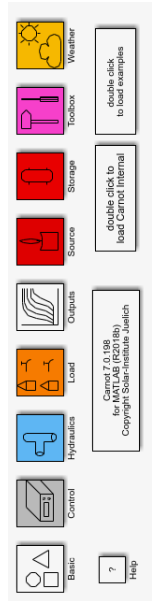
Hydraulics

CarnotCallbacks_PumpAdditional

Load / General

CarnotCallbacks_Data_from_File

createDatafile



Carnot m-Functions Overview

Contents

- carnot_library_tools
- comfort
- data_input
- economy
- hydraulics
- material_properties
- physical_units
- time_functions
- weather_and_sun

comfort

calculate_pmv

clothing_area_factor

clothing_surface_temperature

heat_transfer_clothing

calculate_ppd

Carnot 8.0 : new Features

ISO 7730 comfort rating

- WarmAndCoolFloor - comfort rating of temperature differences at the floor
- RadiantAsymmetryWall - comfort rating of different wall temperatures

Additional functions (data cannot be created with standard Carnot building models)

- VerticalAirTemperatureDifference - comfort rating of vertical temperature differences in the room
- DraughtRating - evaluation of air temperature and velocities