

FMI 3.0: Effektive Modellkopplung über Terminals

**Was bringt FMI 3.0 für die thermische
Gebäudemodellierung?**

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esi-group.com

Inhalt

- Was ist das Functional Mock-up Interface (FMI)?
- Was ist neu in FMI 3.0?
- Terminals
- Zusammenfassung
- Ausblick

Functional Mock-up Interface

Was ist das?

- Ein herstellerneutrales Austauschformat für Simulationsmodelle und zur Co-Simulation.
- Seit 2011 herausgegeben und gepflegt von der Modelica Association: fmi-standard.org.
- Unterstützt von mehr als 170 Tools weltweit: fmi-standard.org/tools.
- Angewendet in allen Industriezweigen, in denen cross-domain, cross-tool bzw. cross-company Systemsimulation betrieben wird.
- Modellaustausch erfolgt über Functional Mock-up Units (FMUs):
 - zip-file mit festgelegter Struktur
 - Modellbeschreibung in modelDescription.xml
 - Funktionalität im Binärformat (für eine oder mehrere Plattformen) und/oder C-code

ESI and FMI

FMI 3.0 und SimulationX

- FMI ist die Schlüsseltechnologie für Modellaustausch und Co-Simulation:
 - ESI stellte den Project Leader / Deputy Project Leader für mehr als 10 Jahre
 - ESI ist key-contributor zum Standard von Anfang an
- SimulationX und FMI:
 - SimulationX lieferte Test Implementierungen, die vor den Standard Releases notwendig waren
 - Voller Support (Export, Import, Model Exchange, Co-Simulation) von Version FMI 1.0 und 2.0
 - FMI 3.0:
 - Beta Version für Export und Import von FMUs for Co-Simulation im aktuellen SimulationX Release
 - Unterstützung aller obligatorischer Features bis Ende 2022
 - Weitere optionale Features je nach Kundenanforderung

FMI 3.0

Was ist neu?

- Neben FMI for Model Exchange und FMI for Co-Simulation: FMI for Scheduled Execution zur Aktivierung individueller Modellpartitionen (tasks) über einen externen Scheduler
- Neue Datentypen (verschiedene integers, 32 bit floating point, `binary` für nicht-numerische Daten)
- Nativer support für mehrdimensionale Variablen (Vektoren, Matrizen)
- Einführung struktureller Parameter zur Definition veränderlicher Array Dimensionen
- Einführung von `Clocks` zur exakten Kommunikation von Ereignissen zur synchronen Ausführung von Ereignis-getriggerten Modellpartitionen über mehrere FMUs hinweg

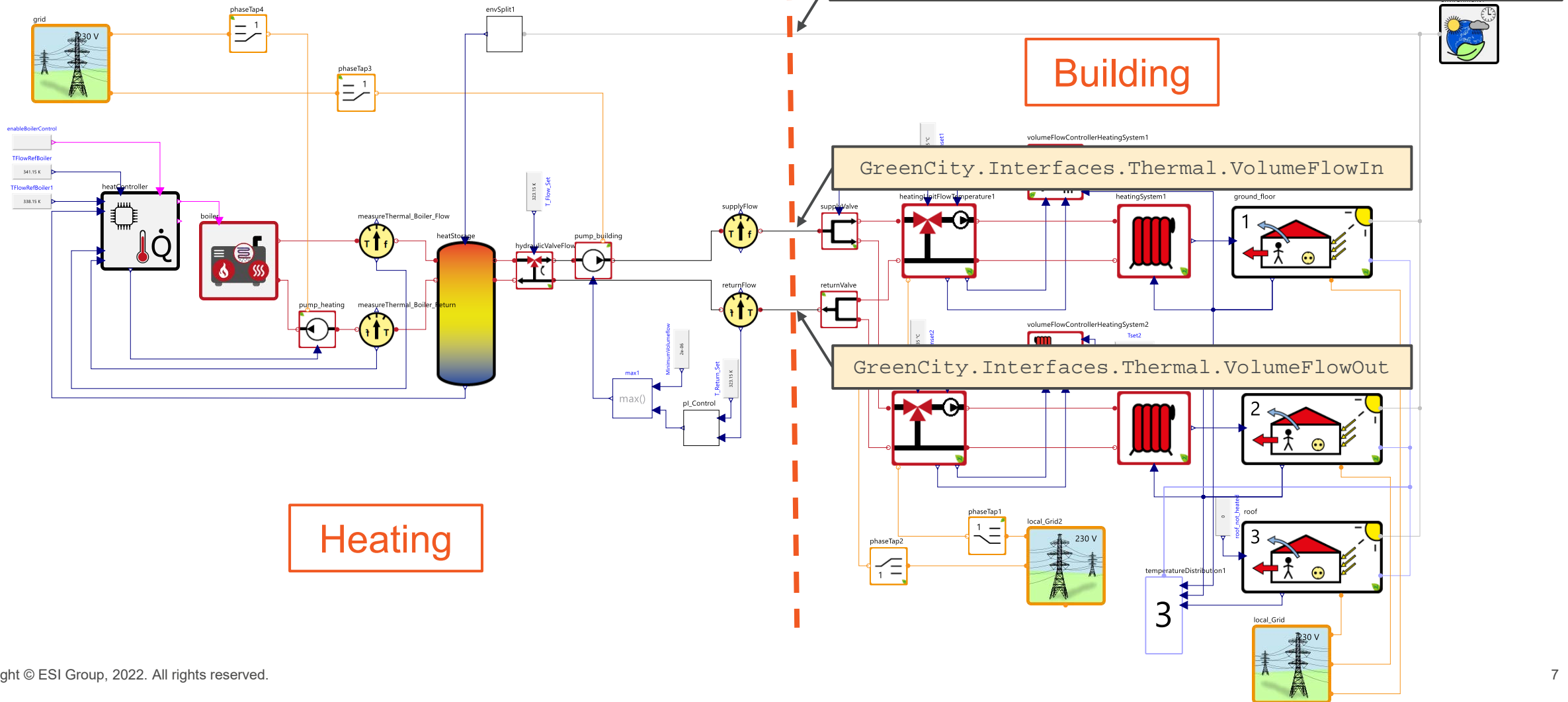
FMI 3.0

Was ist neu?

- „Early Return“ aus `fmi3DoStep`
- Event Mode und Intermediate Update Mode für FMI for Co-Simulation
- Definition von `Terminals` zur Gruppierung von Ein- und Ausgängen zu physikalischen bzw. Bus Konnektoren
- Einführung von `Icons` für FMUs und deren `Terminals`
- Konzept für Layered Standards
- Siehe auch:
 - Andreas Junghanns et. al.: [The Functional Mock-up Interface 3.0 - New Features Enabling New Applications.](#) 14th Modelica Conference 2021, Linköping, Sweden, September 20-24, 2021
 - [YouTube](#)

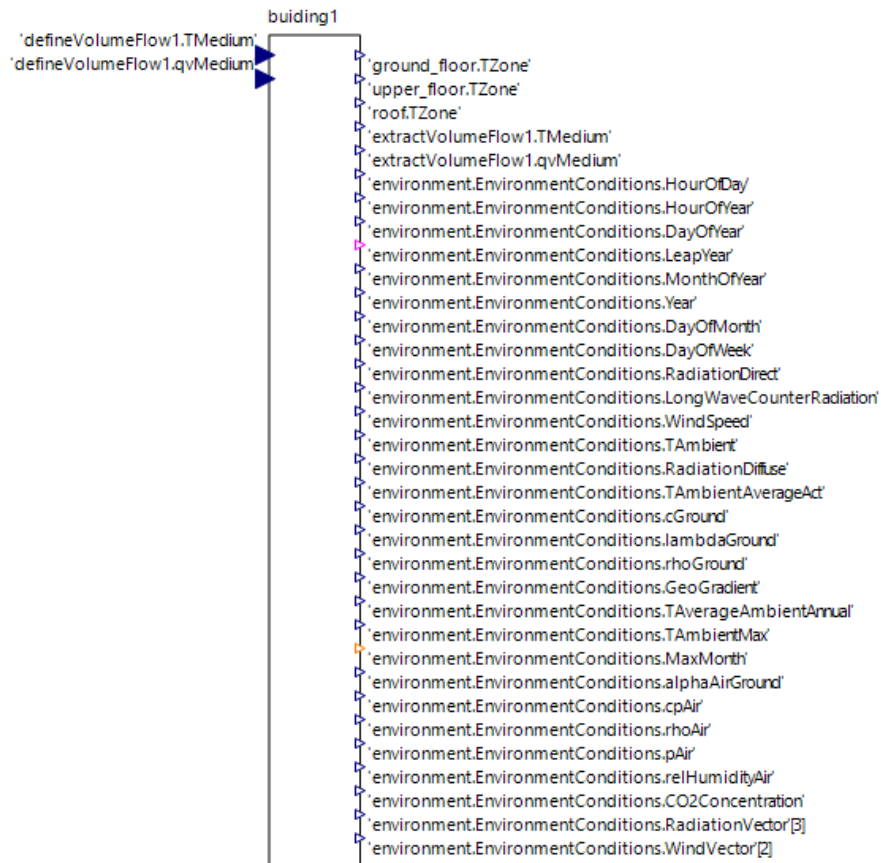
Terminals

Beispiel



Terminals: Beispiel

- FMI 2.0:
 - Nur Signalein- bzw. ausgänge



Code Export Wizard - Building_Demo20

Outputs
Select the outputs for generated model by using double click or drag&drop.

Project
FMI-Configuration
Inputs
Outputs
Parameters
External Resources
Generate and Build

Elements:

- environment (Environment)
 - TimeBase (Set output signal to a time varying Real e)
 - solarRadiation (Table look-up in one dimension (mat
 - DiffRadiation (Table look-up in one dimension (matri
 - DirRadiation (Table look-up in one dimension (matrix
 - windSpeed (Table look-up in one dimension (matrix/
 - windDirection (Table look-up in one dimension (matr
 - ambientTemperature (Table look-up in one dimension
 - HourOfDay (Time of day)
 - HourOfYear (Time of year)
 - DayOfYear (Day of year)
 - DayOfWeek (Day of week (1: Mo, 2: Tue, 3: We, 4
 - DayOfMonth (Day of Month)
 - MonthOfYear (Simulated Month (1: Jan, 2: Feb, 3: I
 - Year (Simulated year)
 - RadiationVector (3-dimensional radiation direction v
 - EnvironmentConditions (Environment Conditions Co
 - HourOfDay (Time of Day)
 - HourOfYear (Time of Year)
 - DayOfYear (Day of Year)
 - LeapYear (Leap Year)
 - MonthOfYear (Month of Year)
 - Year (Current Year)
 - DayOfMonth (Day of Month)
 - DayOfWeek (Day of Week)
 - RadiationVector (3-dimensional direction vector
 - RadiationDirect (Direct solar radiation in Radiat
 - LongWaveCounterRadiation (Longwave count
 - WindSpeed (Actual wind speed in WindVector c
 - WindVector (2-dimensional direction vector for
 - TAmbient (Actual ambient temperature)
 - RadiationDiffuse (Diffuse solar radiation)
 - TAmbientAverageAct (Average ambient tempe
 - cGround (Specific heat capacity of the ground)

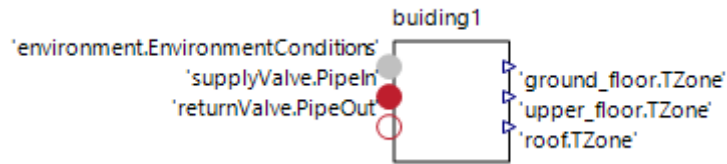
Selection:

Output	Element
TZone (Zone temperature)	ground_floor
TZone (Zone temperature)	upper_floor
TZone (Zone temperature)	roof
TMedium (Medium tempe...	extractVolumeFlow1
qvMedium (Medium volu...	extractVolumeFlow1
HourOfDay (Time of Day)	environment.EnvironmentConditions
HourOfYear (Time of Year)	environment.EnvironmentConditions
DayOfYear (Day of Year)	environment.EnvironmentConditions
LeapYear (Leap Year)	environment.EnvironmentConditions
MonthOfYear (Month of Y...	environment.EnvironmentConditions
Year (Current Year)	environment.EnvironmentConditions
DayOfMonth (Day of Mon...	environment.EnvironmentConditions
DayOfWeek (Day of We...	environment.EnvironmentConditions
RadiationVector (3-dimen...	environment.EnvironmentConditions
RadiationDirect (Direct so...	environment.EnvironmentConditions
LongWaveCounterRadiat...	environment.EnvironmentConditions
WindSpeed (Actual wind ...	environment.EnvironmentConditions
WindVector (2-dimension...	environment.EnvironmentConditions
TAmbient (Actual ambient...	environment.EnvironmentConditions
RadiationDiffuse (Diffuse ...	environment.EnvironmentConditions
TAmbientAverageAct (Av...	environment.EnvironmentConditions
cGround (Specific heat c...	environment.EnvironmentConditions
lambdaGround (Heat con...	environment.EnvironmentConditions
rhoGround (Density of gro...	environment.EnvironmentConditions
GeoGradient (Geothermal...	environment.EnvironmentConditions
TAverageAmbientAnnual ...	environment.EnvironmentConditions
TAmbientMax (Maximum ...	environment.EnvironmentConditions
MaxMonth (Month with m...	environment.EnvironmentConditions
alphaAirGround (Heat tra...	environment.EnvironmentConditions
cpAir (Specific heat capa...	environment.EnvironmentConditions
rhoAir (Density of Air)	environment.EnvironmentConditions
pAir (Air pressure)	environment.EnvironmentConditions
relHumidityAir (Relative h...	environment.EnvironmentConditions
CO2Concentration (CO2 ...	environment.EnvironmentConditions

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Terminals: Beispiel

- FMI 3.0:
 - Terminals können direkt ausgewählt werden



Code Export Wizard - Buiding_Demo

Terminals
Select the terminals (connectors) for generated model by using double click or drag&drop.

Project
FMI-Configuration
Inputs
Outputs
Terminals
Parameters
External Resources
Generate and Build

Elements:

- supplyValve (Controllable valve for volum...
- PipeIn (Input pipe)
- PipeOutRegulated (Output pipe with rer...
- PipeOutRemain (Output pipe with rer...
- returnValve (Valve for volume flow mergin...
- PipeOut (Output pipe)
- PipeIn1 (Input pipe 1)
- PipeIn2 (Input pipe 2)
- heatingSystem1 (Heating system)
- local_Grid (Electrical power grid for conn...
- ground_floor (Building zone including inne...
- upper_floor (Building zone including inner ...)
- roof (Building zone including inner heat los...
- temperatureDistribution1 (Zone temperat...
- heatingUnitFlowTemperature1 (Flow temp...
- phaseTap2 (Connection of 1-phase to 3-p...
- local_Grid2 (Electrical power grid for conn...
- heatingSystem2 (Heating system)
- heatingUnitFlowTemperature2 (Flow temp...
- phaseTap1 (Connection of 1-phase to 3-p...
- environment (Environment)
- EnvironmentConditions (Environment)
- extractVolumeFlow1 (Extracts the charac...

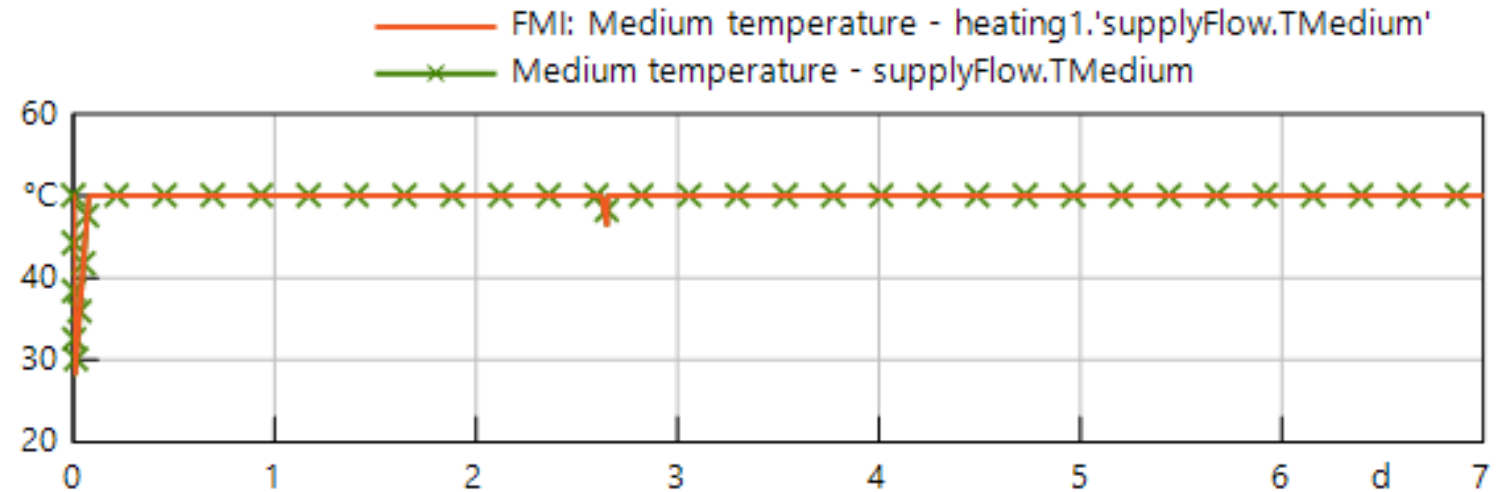
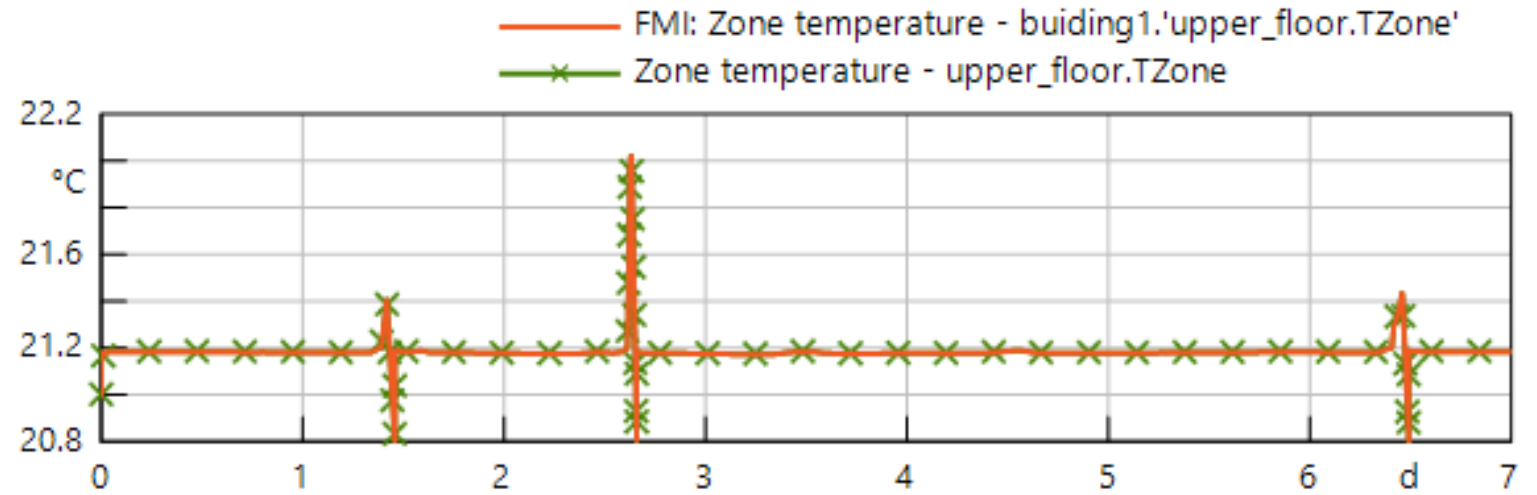
Selection:

Connector	Description	In-/Output	Matching Rule
PipeIn (Input pipe)	supplyValve		plug
qv	Volume flow	Input	
T	temperature	Input	
PipeOut (Output pipe)	returnValve		plug
qv	Volume flow	Output	
T	temperature	Output	
EnvironmentConditions (Environment Conditions Connection)	environment		plug
HourOfDay	Time of Day	Output	
HourOfYear	Time of Year	Output	
DayOfYear	Day of Year	Output	
LeapYear	Leap Year	Output	
MonthOfYear	Month of Year	Output	
Year	Current Year	Output	
DayOfMonth	Day of Month	Output	
DayOfWeek	Day of Week	Output	
RadiationVector	3-dimensional direction vector for direct solar radiation	Not used	
RadiationDirect	Direct solar radiation in RadiationVector direction	Output	
LongWaveCounterRadiation	Longwave counter radiation	Output	
WindSpeed	Actual wind speed in WindVector direction	Output	
WindVector	2-dimensional direction vector for wind speed direction	Not used	
TAmbient	Actual ambient temperature	Output	
RadiationDiffuse	Diffuse solar radiation	Output	
TAmbientAverageAct	Average ambient temperature	Output	
cGround	Specific heat capacity of the ground	Output	
lambdaGround	Heat conductivity of the ground	Output	
rhoGround	Density of ground	Output	
GeoGradient	Geothermal gradient	Output	
TAverageAmbientAnnual	Average ambient temperature in a year	Output	
TAmbientMax	Maximum monthly averaged ambient temperature during a year	Output	
MaxMonth	Month with maximum average temperature	Output	
alphaAirGround	Heat transmission coefficient between ground and air	Output	
cpAir	Specific heat capacity of air	Output	
rhoAir	Density of Air	Output	
pAir	Air pressure	Output	
relHumidityAir	Relative humidity	Output	
CO2Concentration	CO2 Concentration	Output	

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Terminals: Beispiel

- Simulationsergebnisse:



Zusammenfassung

- FMI 3.0 Erweiterungen verbessern die Genauigkeit und die Performance von Co-Simulationen:
 - `Clocks`, `Early Return`, `Event Mode`, `Intermediate Update Mode`
- Terminals und Icons:
 - Verbessern die Nutzerfreundlichkeit immens
 - Verringern die Fehleranfälligkeit

Ausblick

- Layered Standard Konzept erlaubt FMI-Erweiterungen:
 - Definition von anwendungsspezifischen Terminal Types
 - Menge, Name und Semantik von Bussignalen
 - Vorzeichendefinitionen
 - Physikalische Einheiten
 - **Ermöglicht den nahtlosen Modellaustausch zwischen unterschiedlichen Bibliotheken bzw. Tools**
- Definition von Minimalschnittstellen (Terminals, Parameter), die bestimmte Geräte haben müssen
 - Beispiel: eine Pumpe hat zwei physikalische Flusskonnektoren und einen Steuereingang
 - **Ermöglicht den nahtlosen Austausch von Komponenten z.B. aus Herstellerbibliotheken**

Any Questions?