

SIMULATION TECHNOLOGY
GROUP



ESTONIAN SOCIETY
OF HEATING AND
VENTILATION ENGINEERS

Co-operative training session

An IDA ICE 5.1 demo 

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Tallinn, TalTech

Tech. Lic. Mika Vuolle

CEO, EQUA Simulation Finland Oy

Subjects and focus points

The most practical and efficiency-enhancing functions & options in IDA ICE 5th versions

- Full **optimization** suite
- Climate zone model with vertical thermal **stratification** and **view factors**
- **Table**-organized, accessible details across the case
- User-friendly **PV panel** design
- Additional options and components in **Plant modeling**

Automated Multi-Objective Optimization

- What should You know about AutoMOO?
 - **Integrated** into the already known Parametric Runs interface
 - **Automated** optimisation using an evolution-based genetic algorithm (NSGA2) among others
 - Parameters added as **Input** listing with given/defined ranges, distribution, number of variants and precision
 - Singular or multiobjective target **Outputs**: different simulation runs results addition to the outputs
 - Useful at: design sizing, annual energy or custom runs, daylight factor, simple cost calculations – **all of them in the same time!**
 - User-defined additional input and output options with **Graphical Script**
 - **Process control** with break-, model saving- and result retaining options

Stratified Zone Model

in nutshell

What is it and why it is not CFD?

- **Climate model with vertical thermal stratification**
- Best for **tall, large zone volumes** where extensive cold surfaces, draughts are present, and the location of loads and gains are critical
- Visualization above s default acceptable air speed (0.1 m/s, user-defined)
- Field values (see the image):
- No. of layer instead of no. of cell inputs
- Visualization upon a grid and additional volumes
- Terminal multiplicity possibility
- Biggest difference from CFD: these flow elements **DO NOT SEE and DO NOT INTERACT** with each other!!

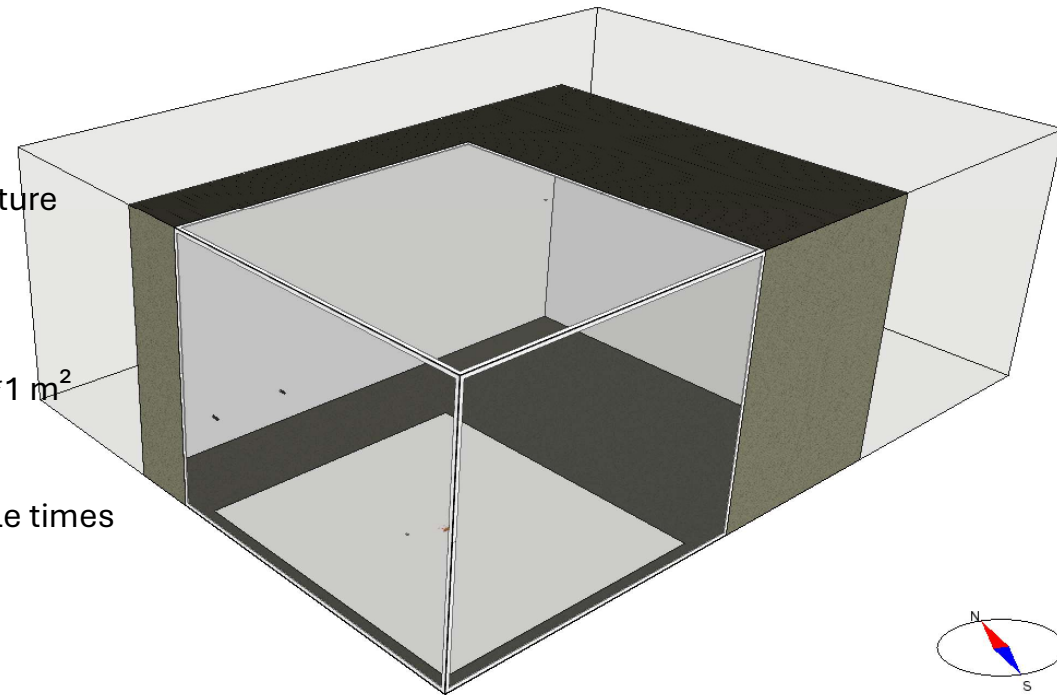
The screenshot displays the 'Conf hall: a zone in atrium_summer' software interface. The main window has tabs for General, Advanced, Outline, Results, and Annotations. The 'Advanced Parameters' tab is active, showing settings for 'Model fidelity' (Climate (with stratification)), 'Air velocity in the occupied zone' (0.1 m/s), 'Zone controller' (<controlled by setpoints>), and 'In use' (<when occupied>). A smaller 'Supply terminal' window is open in the foreground, showing 'Air source' (CENTRAL-AHU), 'Terminal area' (1 m²), 'Design air flow' (6666.66 L/s), 'Design air velocity (flow/area)' (6.67 m/s), and 'Flow element parameters' (k=1.6, Distance from surface=0.0 m, Multiplicity=4). To the right, the 'Air stratification' panel shows 'Layer height' (1 m). Below it, the 'Grid for results' panel shows 'Resolution' (Horizontal: 0.5 m, Vertical: 0.5 m, Time: 0.25 h). The 'Measures' panel lists various fields to be measured, including Air temperature, Air speed, Mean radiant temperature, Operative temperature, Predicted Mean Vote, Predicted Percentage of Dissatisfied, and Draught-Percentage of Dissatisfied. A 'Measuring volumes and planes' table is also visible.

Stratified Zone Model

large-scale comparison

Atrium example

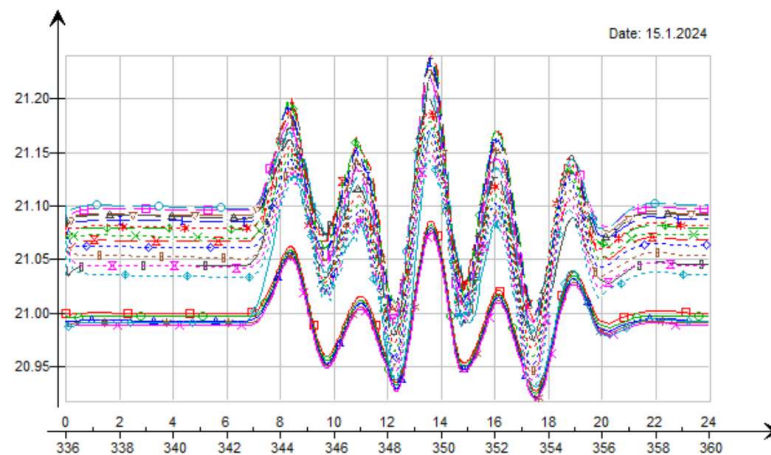
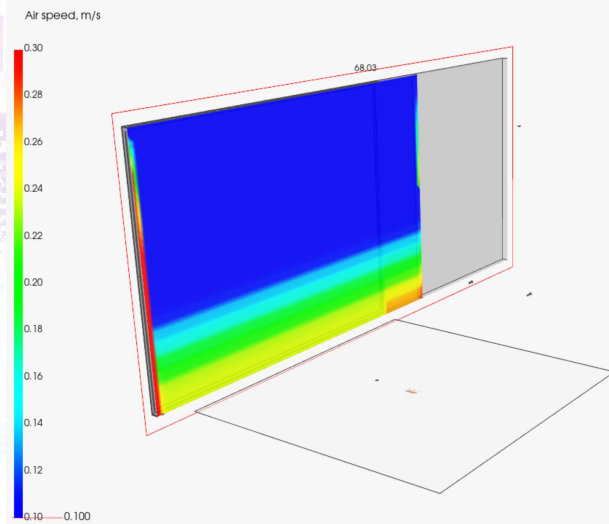
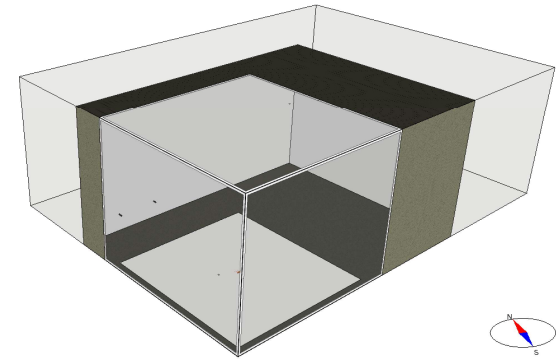
- Kalmar location, default weather file
- 1200 m², 24 000 m³, 1600 m² glazed surface
- $G = 0.25$, $U = 0.45$, external screens
- 15 kW UHF + 50 kW A2A HP (terminals: 10*1 m² @2.5m)
- Sensor in the coldest point of the corner, point air temperature
- Heating and cooling coil in the AHU
- No local cooling device
- CO₂-driven VAV ($T_{sup} = 18^{\circ}\text{C}$, 0.5 ... 7 l/s m²) (terminals: 5*1 m² @2.5m)
- The terminals use **multiplicity**, hence not modeled multiple times
- Simulated with 200 visitors (8*25), 8-12 and 13-17 present
- 1 meter/layer height, 0.5m cell resolution size, 4 laps/hour



Stratified Zone Model

Atrium example, results, winter case

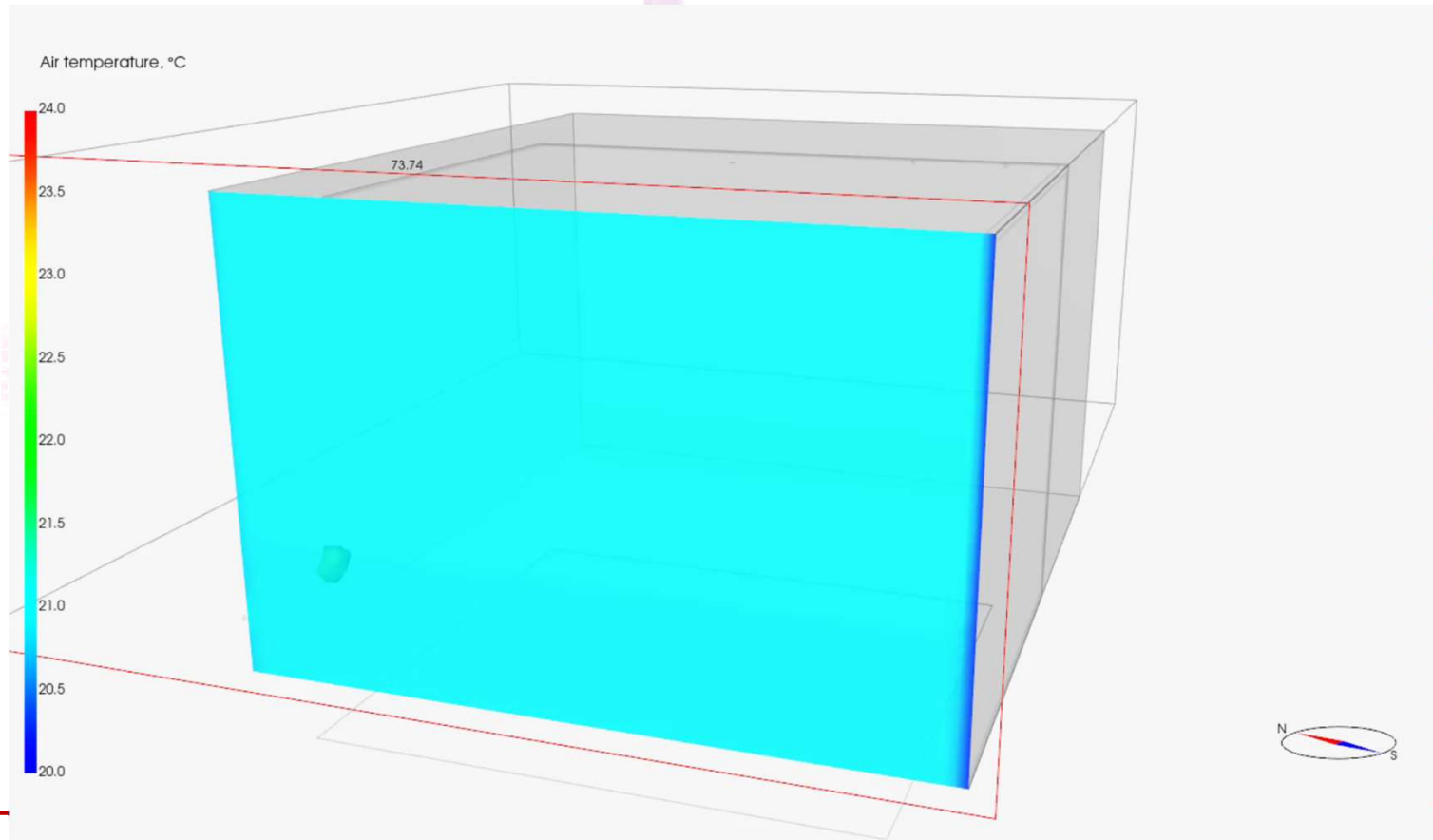
- Temperature distribution per layer:
- Draughts at 1m away from the glazed wall:



- Air temperature @ 0.5m, degC
- Air temperature @ 1.5m, degC
- Air temperature @ 2.5m, degC
- Air temperature @ 3.5m, degC
- Air temperature @ 4.5m, degC
- Air temperature @ 5.5m, degC
- Air temperature @ 6.5m, degC
- Air temperature @ 7.5m, degC
- Air temperature @ 8.5m, degC
- Air temperature @ 9.5m, degC
- Air temperature @ 10.5m, degC
- Air temperature @ 11.5m, degC
- Air temperature @ 12.5m, degC
- Air temperature @ 13.5m, degC
- Air temperature @ 14.5m, degC
- Air temperature @ 15.5m, degC
- Air temperature @ 16.5m, degC
- Air temperature @ 17.5m, degC
- Air temperature @ 18.5m, degC
- Air temperature @ 19.5m, degC

Stratified Zone Model

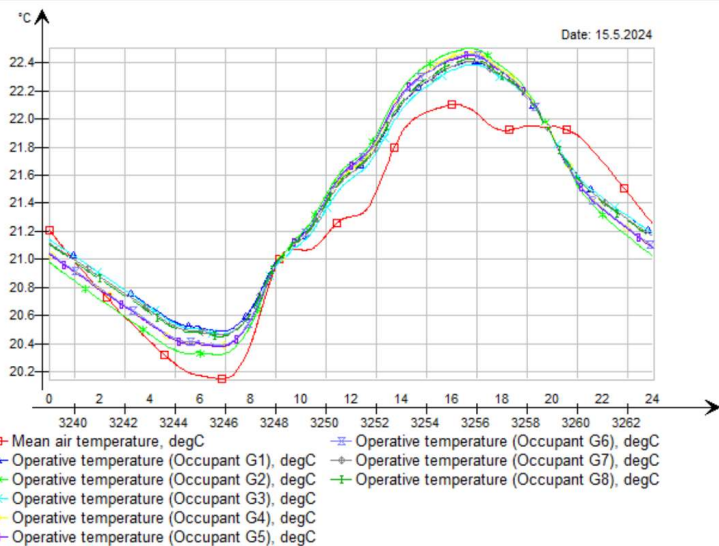
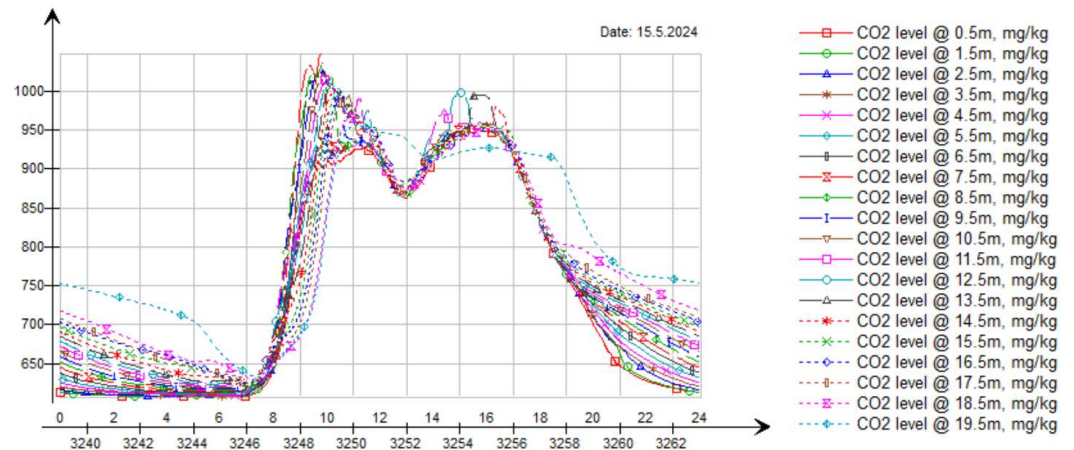
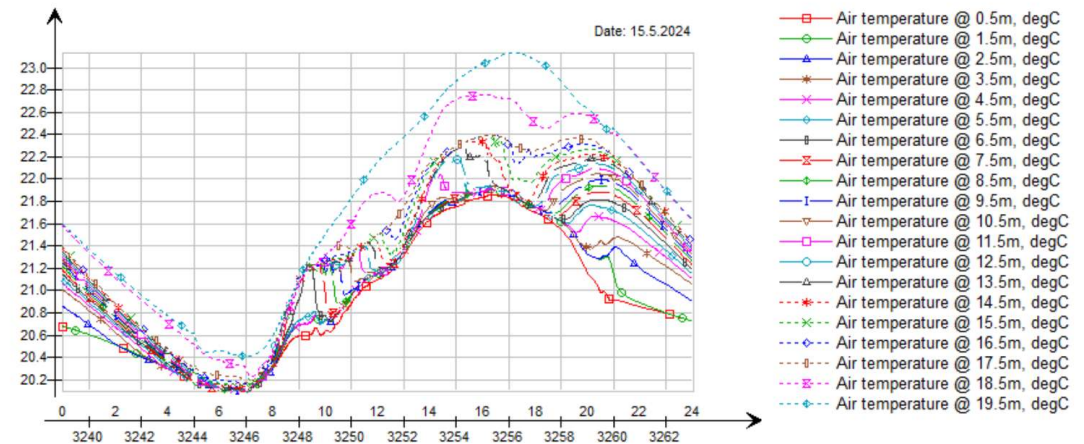
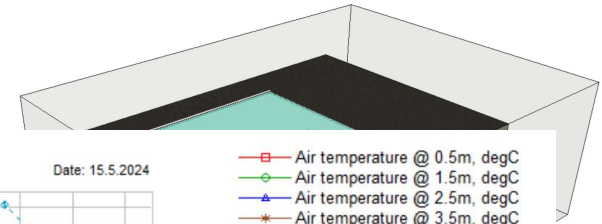
Wintertime temperature stratification at the occupant area



Stratified Zone Model

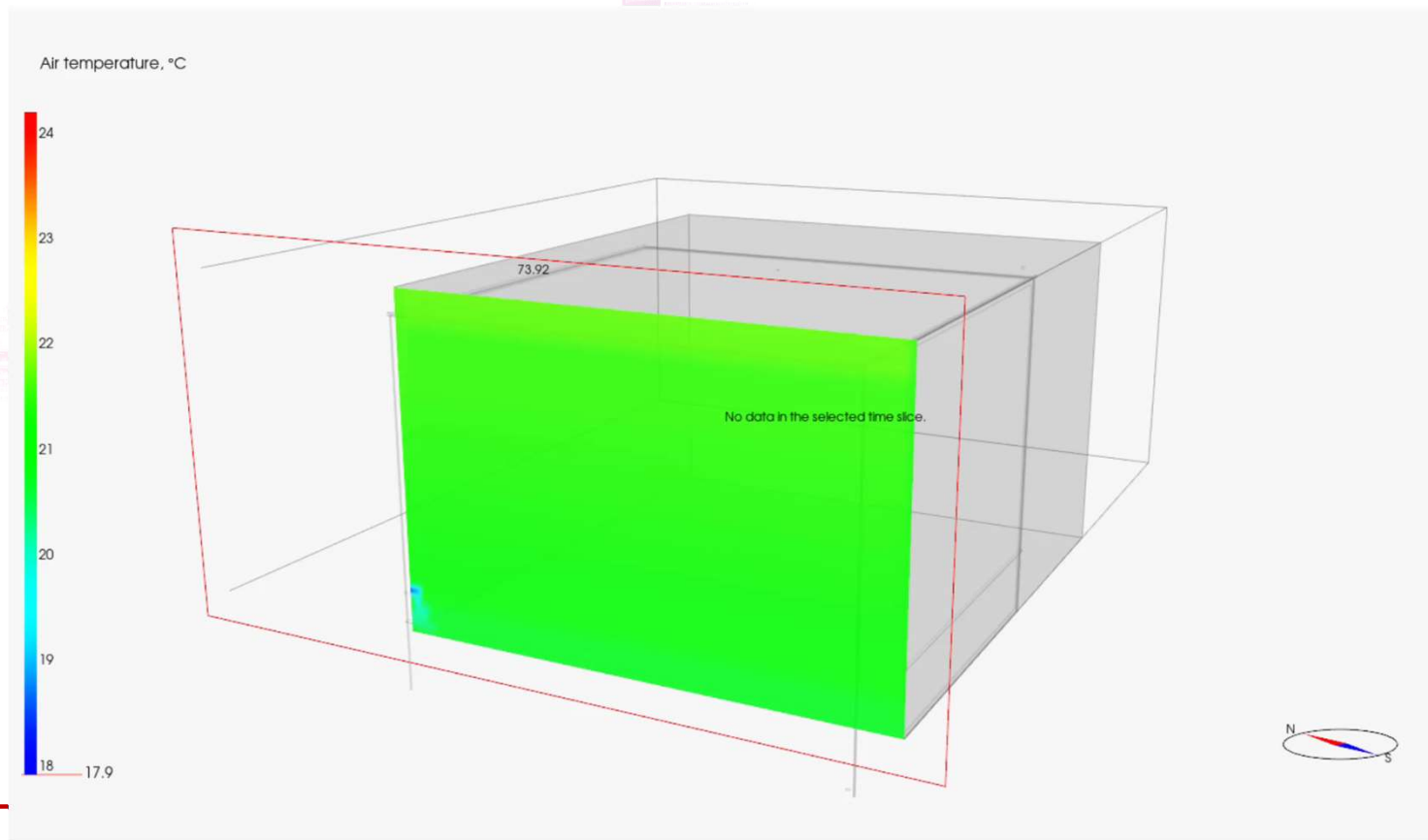
Atrium example, summer case

- Temperature distribution per layer:
- Local operative temperatures:
- CO2 level per layer:



Stratified Zone Model

Summertime temperature stratification at the occupant area:



Electrical system updates

battery

Available from the Electrical System

- 2 battery options
- Based on Tesla Powerwall
- Different connection options
- Simple controls, more to come
- Detailed outputs (from Requested Outputs)

The screenshot illustrates the workflow for adding a battery to an electrical system. It features three main windows:

- Load resource from database:** A dialog for selecting or creating a new battery resource. It includes a table of existing resources and a section for new resources.
- Electrical system: object in building1:** The main system diagram showing components like a Wind turbine and Photovoltaics. A red box highlights a 'Battery' component, with a red arrow pointing to its configuration window.
- Component: Battery: object in building1.Electrical system ...:** A configuration window for the selected battery, showing various settings and a schematic diagram.

Load resource from database - Select template

Name	Manufacturer	Technology	Total_Energy_KWh	Nominal_Voltage	Cell	Description	Url_Data_sheet	A_C
Tesla_Powerwall-268Ah(example)	TESLA	Li-ion	13.1 kWh	50V	Pana...	ESS ...	https:...	0.00
Tesla_Powerwall-134Ah(example)	TESLA	Li-ion	6.5 kWh	50V	Pana...	ESS f...	https:...	0.00

Component: Battery: object in building1.Electrical system ...

Electric battery

Battery model: Tesla_Powerwall-268Ah(example)

Number of batteries in series in each set of battery-string: 1

Number of battery-strings in parallel: 1

Initial state of charge (SOC): 0.75

(Example: a battery bank configured of 8 battery models, with 2 parallel battery-strings each has 4 batteries in series connection.)

Charger model: General Charger

Charging schedule (from grid): Always off

Discharging schedule: Always on

Energy meters

Energy meter (Battery): [Default] Electric battery

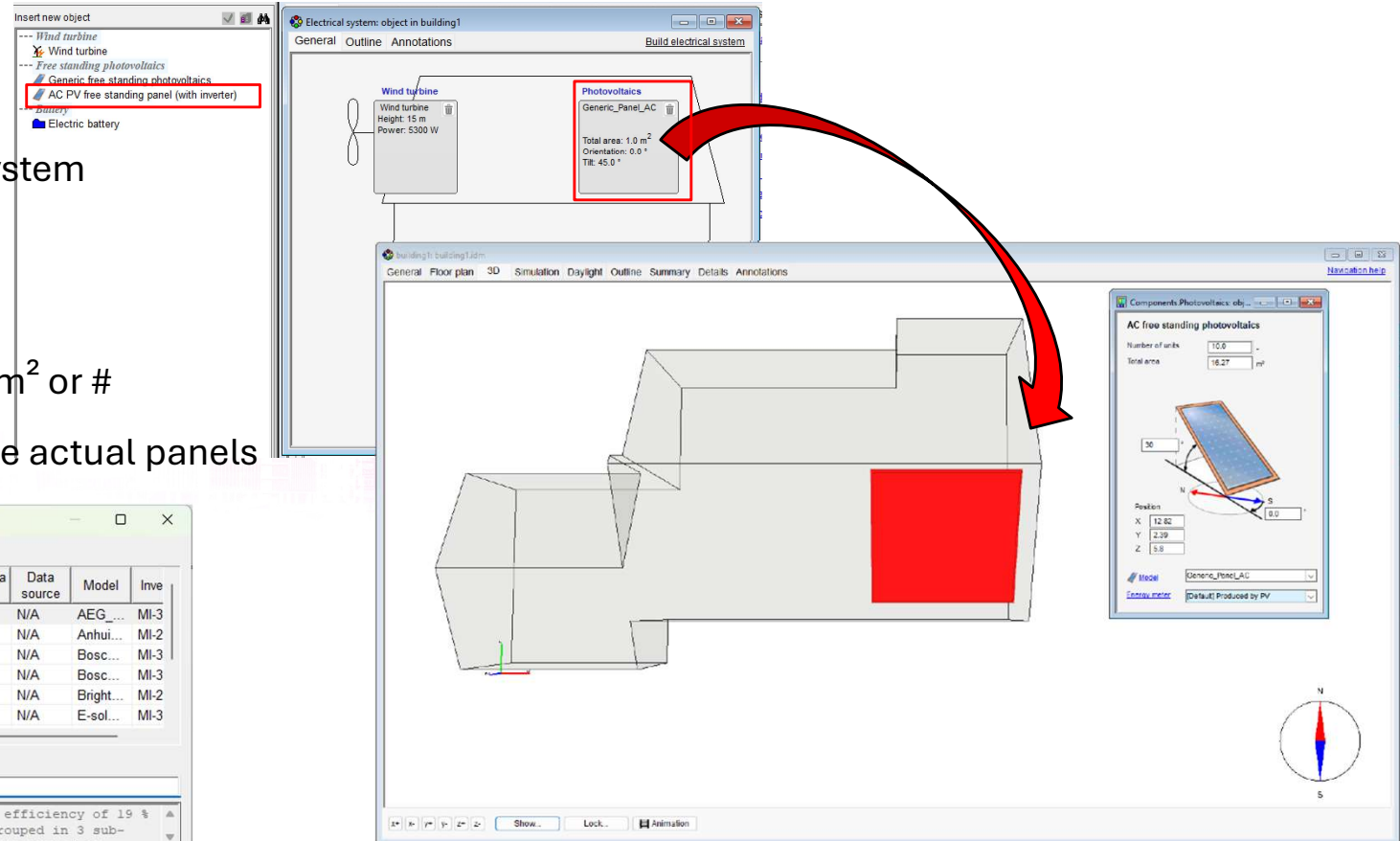
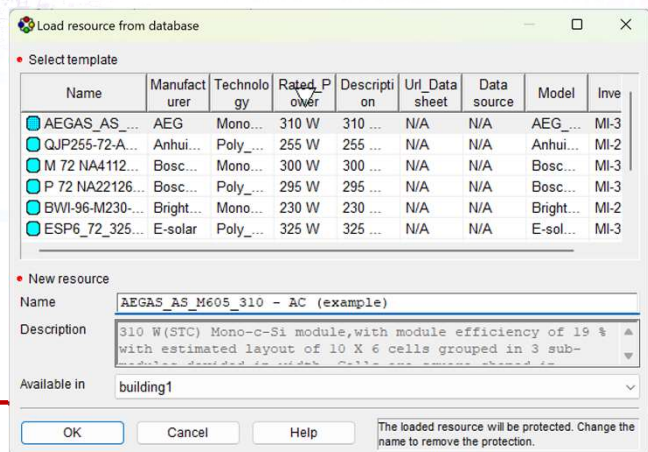
Energy meter (Fan): [Default] HVAC aux

Electrical system updates

generic AC

Generic free-size AC panel

- Available from Electrical System
 - Formerly from 3D
- Single piece only
- 2 input ways: representing m^2 or #
- AC panel types: same as the actual panels



Electrical system updates

AC editing

Detailed AC and DC panel array

- Input from 3D
- All panels in one table
- Fast and reliable estimation
- No additional electronics
- Single array
- Inbuilt inverter/each panel

Components: Photovoltaics: object in building1.Electrical system (General)

PV system

AC panels in the table:

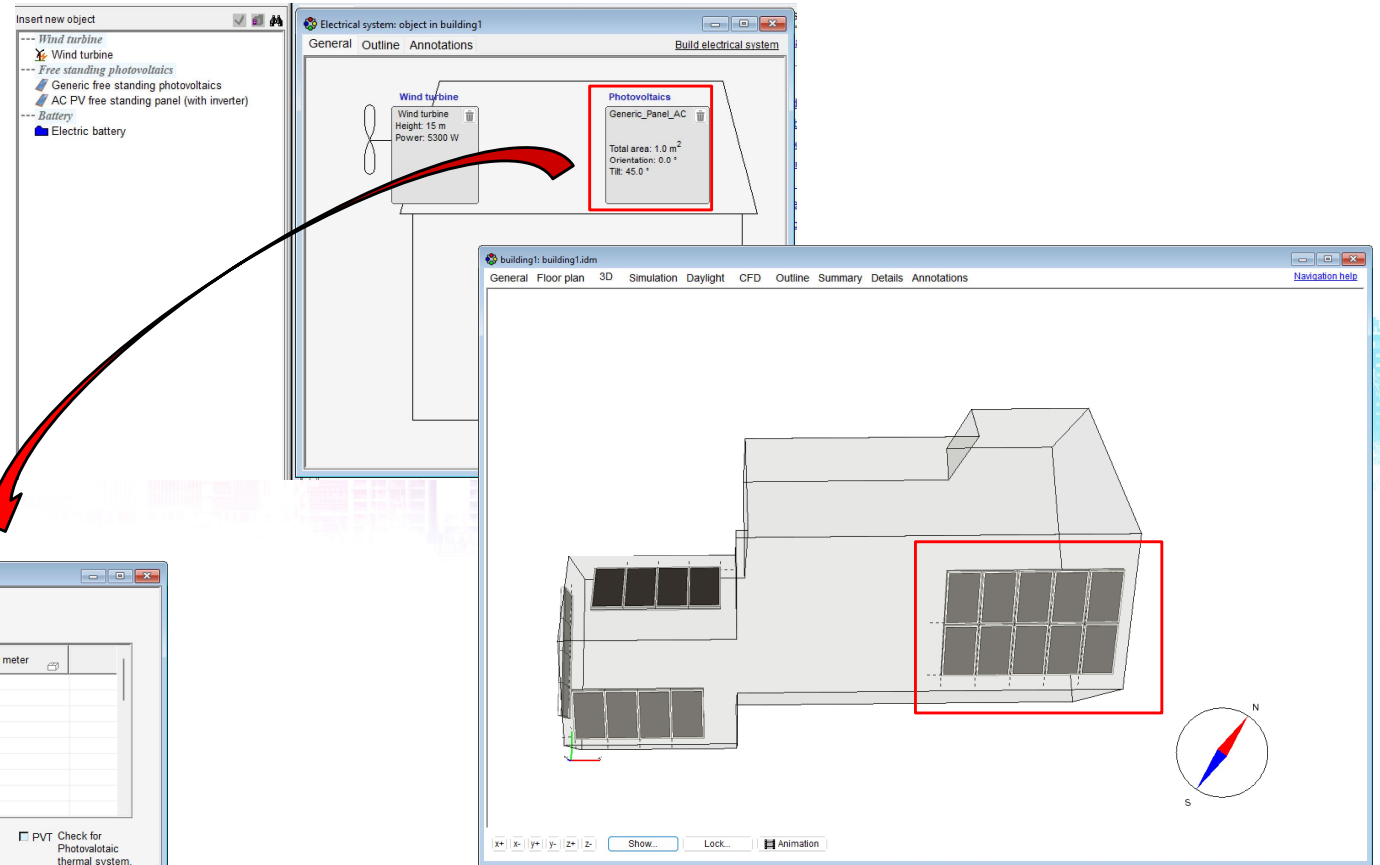
PV panels

Name	In string	Model	Optimizer	Energy meter
Building body Roof PV AC panel 1		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 2		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 3		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 4		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 5		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 6		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 7		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 8		© AEGAS_AS_M605_310 - AC ...		AC panels
Building body Roof PV AC panel 9		© AEGAS_AS_M605_310 - AC ...		AC panels

PV strings

Name	Type	Inverter	Power at ref. conditions, W	Energy meter

☐ PVT Check for Photovoltaic thermal system. Can only be used with the PVT Plant.



Electrical system updates

DC editing

DC with supporting electronics

- Strings
- Optimizers
- Energy meters

DC panels in the table:

Components: Photovoltaics: object in building1: Electrical system (General)

PV system

PV panels

Name	In string	Model	Optimizer	Energy meter
Ground Floor+1. Floor+2. Fl...	PV string 2	© AEGAS_AS_M605_310 ...	Maxim MAX20800T (MX)	
Ground Floor+1. Floor+2. Fl...	PV string 2	© AEGAS_AS_M605_310 ...	Maxim MAX20800T (MX)	
Ground Floor+1. Floor+2. Fl...	PV string 2	© AEGAS_AS_M605_310 ...	Maxim MAX20800T (MX)	
Ground Floor+1. Floor+2. Fl...	PV string 2	© AEGAS_AS_M605_310 ...	Maxim MAX20800T (MX)	
Ground Floor+1. Floor+2. Fl...	PV string 1	© AEGAS_AS_M605_310 ...	Tigo TS4_L (DC)	
Ground Floor+1. Floor+2. Fl...	PV string 1	© AEGAS_AS_M605_310 ...	Tigo TS4_L (DC)	
Ground Floor+1. Floor+2. Fl...	PV string 1	© AEGAS_AS_M605_310 ...	Tigo TS4_L (DC)	
Ground Floor+1. Floor+2. Fl...	PV string 1	© AEGAS_AS_M605_310 ...	Tigo TS4_L (DC)	

PV strings

Name	Type	Inverter	Power at ref. conditions, W	Energy meter
PV string 1	© AEGAS_AS_...	© SMA_Sun...	0.0	DC string1
PV string 2	© AEGAS_AS_...	© PIKO_IQ...	0.0	DC string2

Build electrical system

Photovoltaics

Generic_Panel_LAC

Total area: 1.0 m²
Orientation: 0.0 °
Tilt: 45.0 °

Properties

PV string 2

Model

© AEGAS_AS_M605_310 (example)

Inverter

© PIKO_IQ_4.2 (example)

Energy meter

DC string2

Power at ref. conditions

Selected panels 2480.2 W

Inverter load ratio 1.181

Voltage limit min max

Ref. temp 37.1 -11.8 °C

String volt 235.8 360.8 V

Inverter limit 180.0 1000.0 V

PV string

Set PV string = PV string 2 for selected PV panels

Click one or more PV panels to select in string 8 panels

Visualization help

Visualization

Close

Electrical system updates

PV multiplier

Multiplier for AC

- Avoid the modeling of identical PVs
- Much faster simulation time: several minutes to several seconds
- No grid of panels → can be used and varied in Parametric Runs

Used/Produced

	Total kWh
Produced by PV	-32215.5

Simulation time:
16 seconds
0.5% difference

Pvacinvert_1: equation object in PVbase2.Electrical system (Outline)

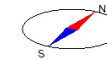
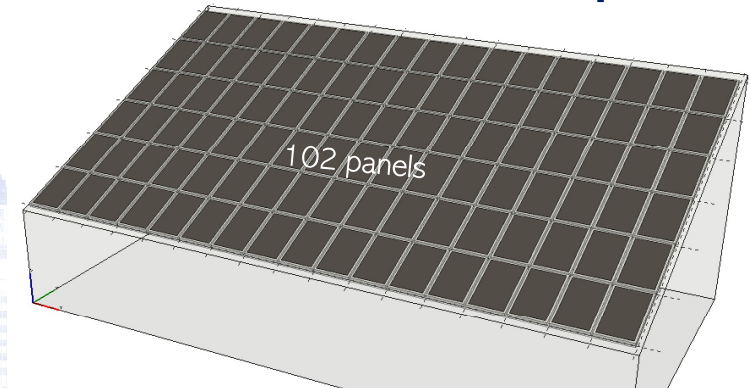
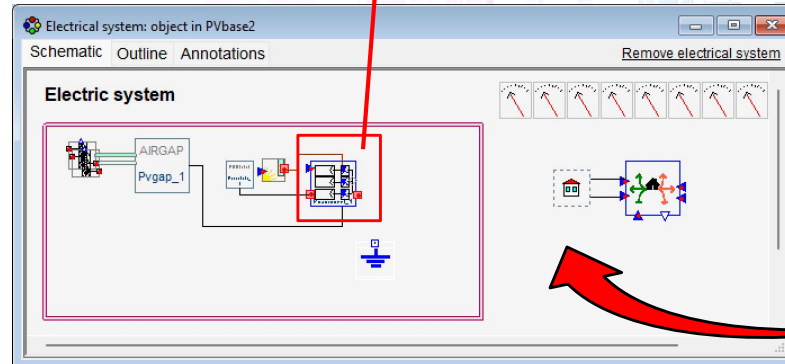
General Outline Code Annotations

Pvacinvert_1 (PVmi)

- Interfaces
- Variables
- Parameters

Name	Value	Start	Unit	Connected to
model	AEG_____			
MicroInv	MI-300			
Tau	30.0			
tolmc_gsm	0.008			
a_0	5.0E-4			
Ldc	0.9271			
MU	102.0			
a_ref_subM	0.52			
beta_oc_SunM	-0.04533			
N_s_SubM	20			
n_link	3			
N_s	60			
...	...			





Simulation time:
820 seconds

Used/Produced

	Total kWh
Produced by PV	-32075.9

INSTEAD

Build the electrical system of ONE panel

Energy Contracts and Traders

transactions

The screenshot shows the 'Energy Contracts and Traders: object in building2 (Energy-Info)' window. It has three tabs: General, Outline, and Annotations. The 'General' tab is active and contains three sections:

- All traders / Used traders:** A table with columns 'Name' and 'Type of trader'. It lists 'Facility' (Inside assessment boundary), 'Tenant' (Outside assessment boundary), and 'Utility' (Utility trader).
- Energy contracts:** A table with columns 'Name', 'Energy carrier', 'Contract rate plan', 'From', and 'To'. It lists various transactions like 'Purchased by ... Electricity', 'Exported by t... Electricity', 'Purchased by ... Fuel', 'Exported by t... Fuel', 'Purchased by ... District cooling', 'Exported by t... District cooling', 'Purchased by ... District heat', and 'Exported by t... District heat'.
- Contract rate plans:** A table with columns 'Name', 'Energy carrier', 'Currency', 'Fixed per kWh cost', 'Fixed cost per year', and 'Schedule, Cost/kWh'. It lists various rate plans like 'Purchased electricity', 'Exported electricity', 'Traded electricity', 'Purchased fuel', 'Exported fuel', 'Traded fuel', and 'Purchased district heat'.

Trader roles

Facility: INSIDE energy user, can consume and produce

Tenant: OUTSIDE user (in Finland also INSIDE)

Utility: grid type of supplier for any energy source, always available

Energy contracts

Purchase: buying from outside, unidirectional (e.g. electricity, fuel etc)

Export: selling to outside, unidirectional (e.g. PV electricity)

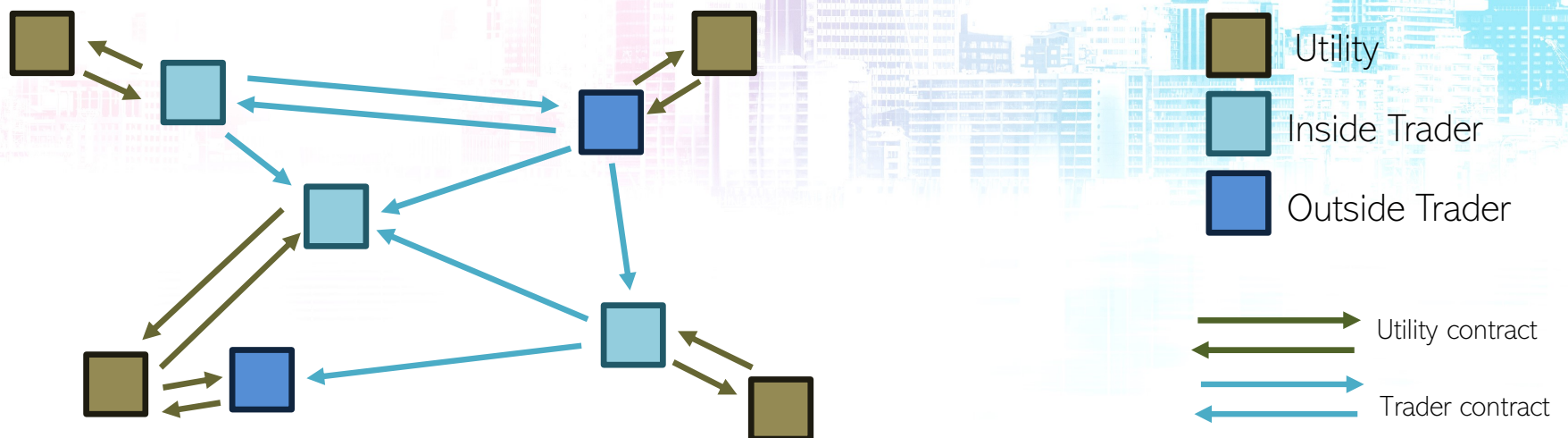
Trade: possibly bidirectional, within the boundary

Contract rate plans

Fixed costs: /kWh, /year, schedule input (e.g. from prn)

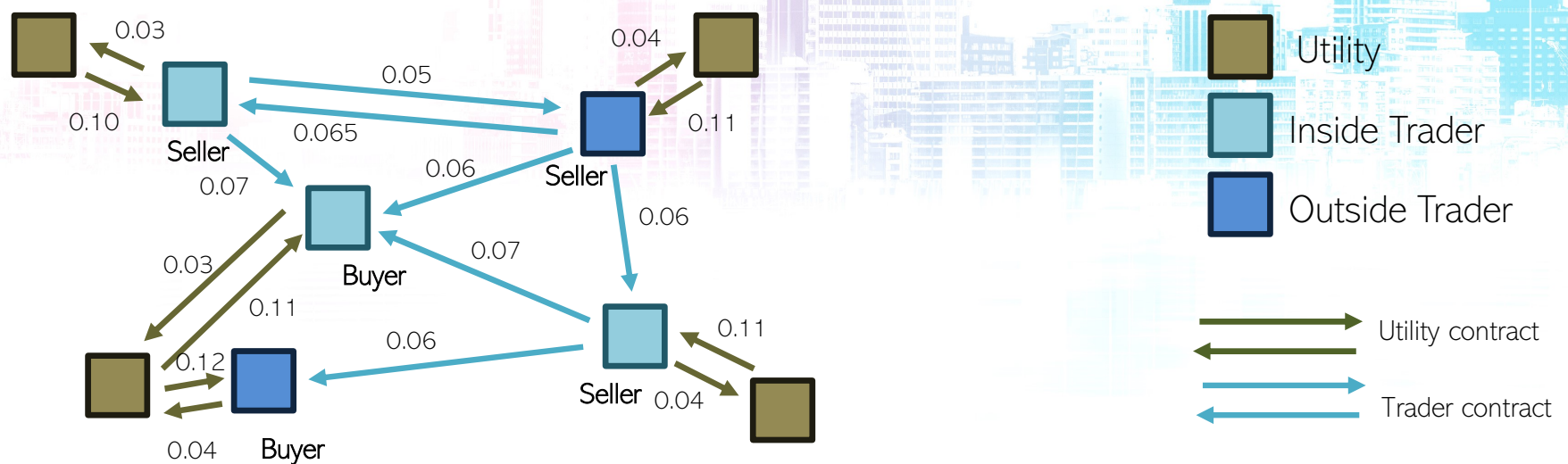
Trading algorithm - setup

- Utility and Non-Utility Traders
- Different energy Contracts
 - Utility → purchase/export (compulsory)
 - non-Utility → trading



Trading algorithm - setup

- Let's see the Contract rate plans = agreed prices [€]
- Energy needed/not needed → Trader becomes Buyer/Seller per energy carrier per timestep



Openings shape



Scandic Train Station, Helsinki

Same area (6m^2) but significant difference in DF% result

- Rectangular modeling: DFmed% = **2.70% (40 seconds)**
- Arched modeling: DFmed% = **3.07 % (35 seconds)**

editable frame

Results

☒ Daylight factor ☐ Illuminance ☐ Climate-based

Measuring plane	Group	Median daylight factor, %	Avg daylight factor, %
Café		2.705	3.651



Results

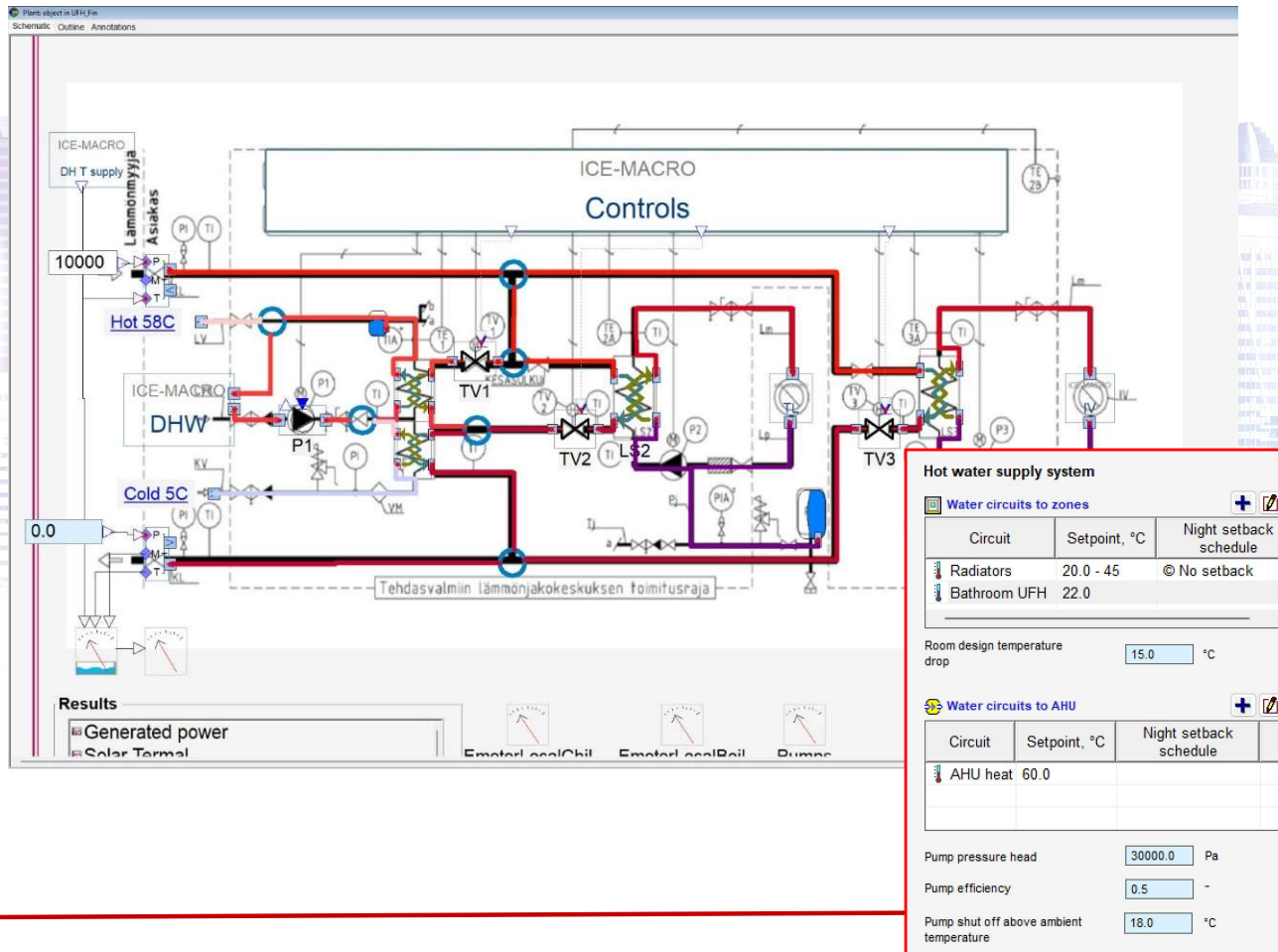
☒ Daylight factor ☐ Illuminance ☐ Climate-based

Measuring plane	Group	Median daylight factor, %	Avg daylight factor, %
Café		3.072	4.176



Updated plant modeling

new components



- Refined 1:1 modeling options
- **Multiple water circuits** (H&C)
- **BrineNodes**: mixing/diverting flows without additional mass flow definition
- **Variable speed heat pumps** with more numerical stability (A2B, B2B)
- New, extended **tank form**
- **New brine-filled stratified tank**
- **Circuit checking** before simulation
- **Easier access** to critical components e.g. 3-way valves

New borehole model

new functions

- GHX_MANY and a separate Pressure drop component
- Extended GUI for easier access to:
 - **Borehole pattern options** added
 - Examples provided
 - **Grouping** allows sectoral control (different mass flows at different times within the same borehole field)
 - **Coordinate system input** to the GUI
 - **Ground temperature sensors** added

GHX_MANY: a mathematical model in building1.Air Handling Unit (General)

General Outline Code Annotations

GHX_MANY Object type **GHX_MANY**

Multi holes, multi groups version of the IDAICE borehole model.

Parameters

ZHOLE 190.0 m Drilling (Borehole) Depth
 RHOLE 0.0575 m Drilling (Borehole) Radius
 RB 0.039 dimless Borehole heat resistance. If RB set to zero, give detailed heat resistances

Heat Resistances

Ground Temperature Sensors

NSENSORS 1 Number of temperature sensor in the ground.
 XSSENSORS (1) Position of the Sensors
 YSENSORS (1)
 ZSENSORS (1)

Ground

CPGRD 840.0 J/(kg K) Heat capacity of ground.
 LAMBGD 3.8 W/(m K) Heat transfer coefficient of ground.
 RHOGRD 2880.0 kg/m3 Density of ground.

Grout

CPGROUT 4180.0 J/(kg K) Heat capacity of grout.
 LAMBGROUT 0.6 W/(m K) Heat transfer coefficient of grout.
 RHOGRROUT 1000.0 kg/m3 Density of grout.

Pipe

RPIPE 0.016 m Radius of pipe.
 THICKPIPE 0.0026 m Thickness of Pipe wall.
 CPPPIPE 2200.0 J/(kg K) Heat capacity of pipe.
 LAMBPIPE 0.42 W/(m K) Heat transfer coefficient of pipe.

Liquid

LiqType Water /type of liquid.
 TFREEZE 0.0 Deg-C Freezing point of liquid.
 LAMBLIQ 0.42 W/(m K) Heat transfer coefficient of liquid.

Borehole patterns

NHOLES 1 Total number of boreholes.
 NGROUPS 1 number of groups.
 NG (1) Number of holes in each group Example
 X (1) Position of boreholes.
 Y (1)

Computational parameters

Computational Parameters Grid parameters, field logging and mirror parameter

Ground layer

LCASTING 2.0 Length of surface casting
 LAMBDA 0.1 Heat transfer coefficient of surface layer.
 RHOSURFLAY 1000.0 Density of surface layer.
 CPSURFLAY 4180.0 Heat capacity of surface layer

Background Ground Temperature Field

TMEAN 5.0 Deg-C Yearly mean temperature
 GEOTGRAD 0.0 K/m Temperature gradient in ground

Surface temperature

PMT Liquid out
 PMT Liquid in

Variables

Name	Value	Unit	Logged to	Logged as	Connected to	Description
TIN[1:1]	1.0	°C	Off			inlet liquid temperature of bore...