From **BIM** to **Building Real-time simulation** (and light implications)

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light+building autumn edition

SPHERE BIM DIGITAL TWIN PLATFORM

THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION´S H2020 PROGRAM UNDER GRANT AGREEMENT NO. 820805

BUILDING DIGITAL TWIN ASSOCIATION

CONTENTS

- Why Real-Time Simulation IN A BUILDING?
- HOW is BIM representation for SIMULATION
- Translating BIM to simulation (3D to schematics)
- How is the simulation schematic of a building?
- Some Mathematics behind
- Software in the Loop embedded .exe
- How is the way round? From simulation to BIM/Digital Twin
- Some CONCLUSIONS/MESSAGES/OPINNIONS

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Why Real-Time Simulation IN A BUILDING?

- SPHERE EU PROJECT ABOUT BUILDING DIGITAL TWINS
- Reusing EC&LSS technology of aerospace, nuclear
- The same simulation DECK for design, commissioning and advance control
- Simulation in real time embedded in the edge in small electronics and connected with BMS
- TO GET: Supervision of sensors, advance control (predictive), humans interaction, SRI´s, commissioning
- From BIM/as-built to simulation model, DECK, and .exe interacting in OPC/UA with BMS

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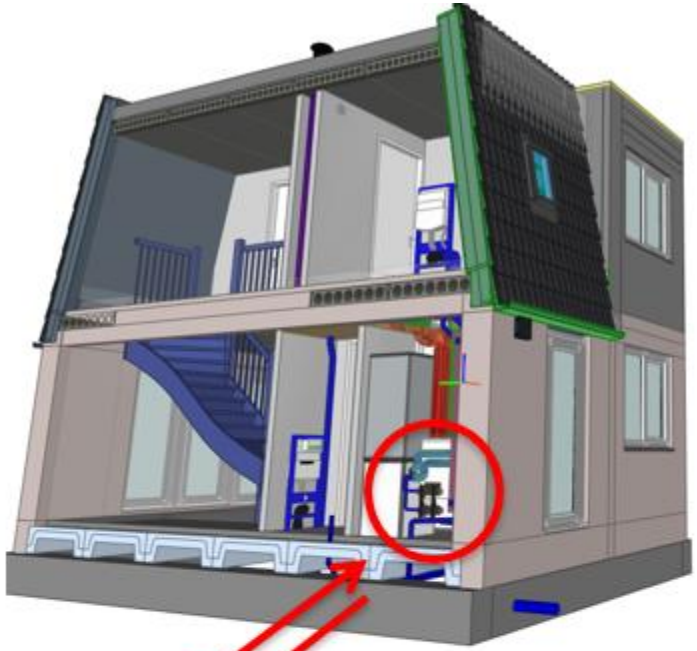
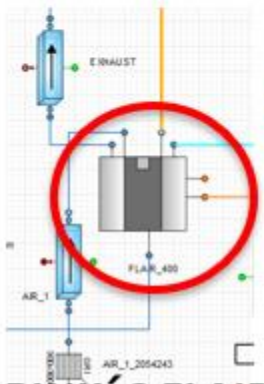
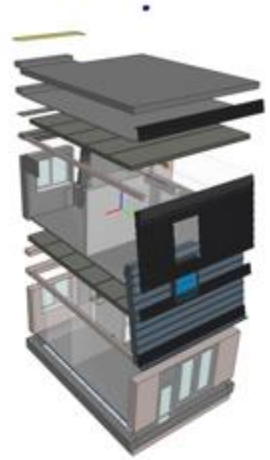


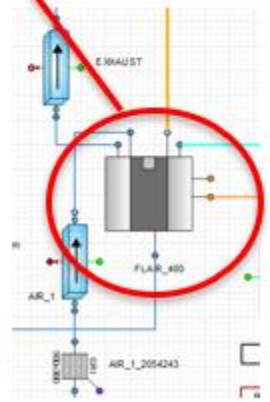


PROJECT

BRINK´S FLAIR 400 SIMBOT

The same MACHINE model but packed as DECK/OPC,
Working INSITE, with many potential uses





REAL TIME

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HOW is BIM representation for SIMULATION

- Equipments: 1 to 1
- Networks: XX to 1
- Consistency problems in the design:
  - SPACES
  - FITTINGS
  - BAD NETWORK DESIGN!

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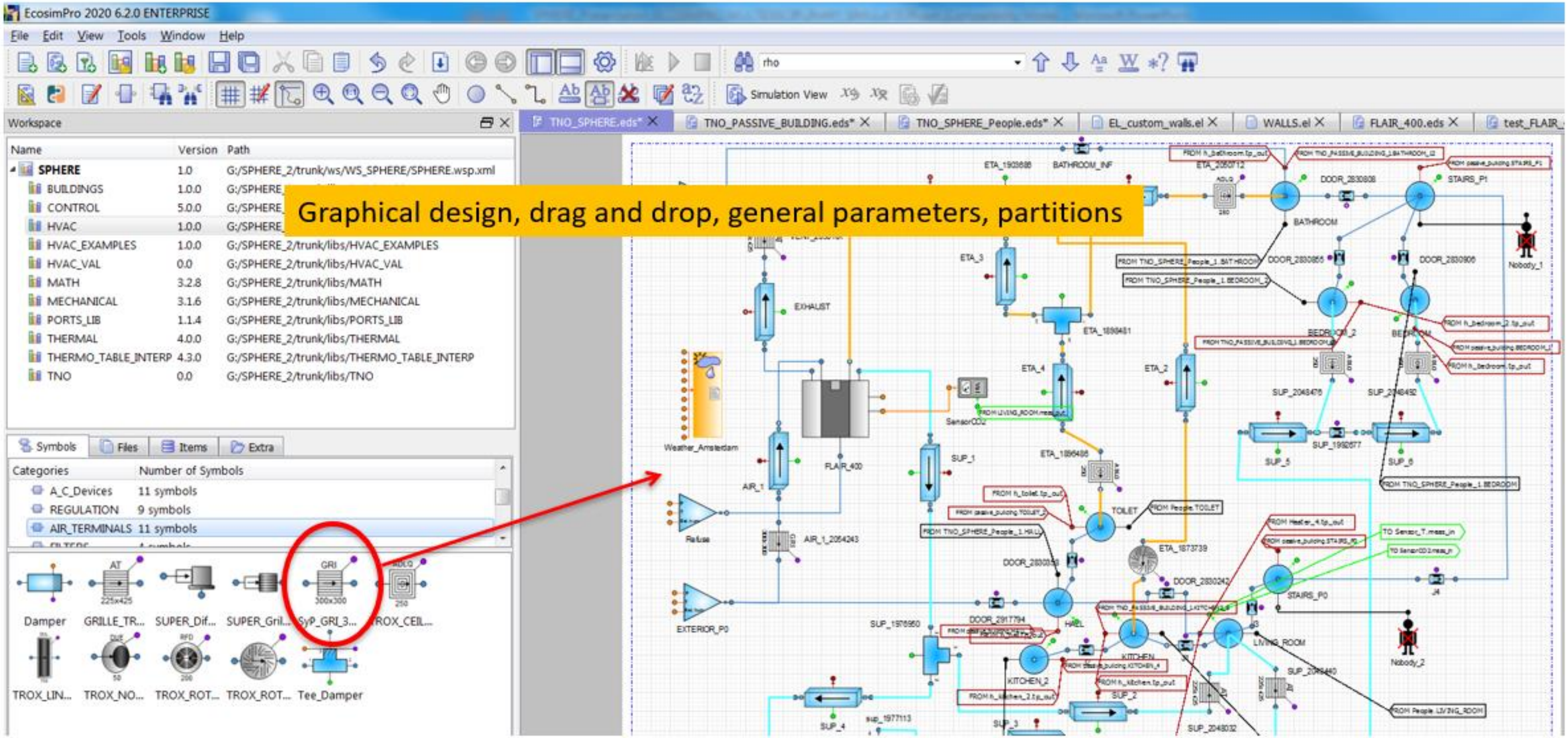
Graphical design, drag and drop, general parameters, partitions
EcosimPro 2020 6.2.0 ENTERPRISE
File Edit View Tools Window Help
Workspace
Name Version Path
SPHERE 1.0 G:/SPHERE_2/trunk/ws/WS_SPHERE/SPHERE.wsp.xml
BUILDINGS 1.0.0
CONTROL 5.0.0
HVAC 1.0.0
HVAC_EXAMPLES 1.0.0 G:/SPHERE_2/trunk/libs/HVAC_EXAMPLES
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MECHANICAL 3.1.6 G:/SPHERE_2/trunk/libs/MECHANICAL
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TNO 0.0 G:/SPHERE_2/trunk/libs/TNO
Symbols Files Items Extra
Categories Number of Symbols
A_C_Devices 11 symbols
REGULATION 9 symbols
AIR_TERMINALS 11 symbols
Damper GRILLE_TR... SUPER_Dif... SUPER_Gril... SyP_GRI_3... TROX_CEIL...
TROX_LIN... TROX_NO... TROX_ROT... TROX_ROT... Tee_Damper
Simulation View
TNO_SPHERE.eds* TNO_PASSIVE_BUILDING.eds* TNO_SPHERE_People.eds* EL_custom_walls.el WALLS.el FLAIR_400.eds test_FLAIR
EXHAUST
Weather_Amsterdam
FLAIR_400
SensorCO2
AIR_1
SUP_1
Refuse
EXTERIOR_P0
BATHROOM
BEDROOM_2
TOILET
HALL
KITCHEN
KITCHEN_2
LIVING_ROOM
STAIRS_P0
Nobody_1
Nobody_2

Translating BIM to simulation (3D to schematics)

- Simulation interface is like 2D schematics (P&ID diagrams), BUT

- We use connectors
- Boundary conditions
- Mathematical partitions, experiments, decks…

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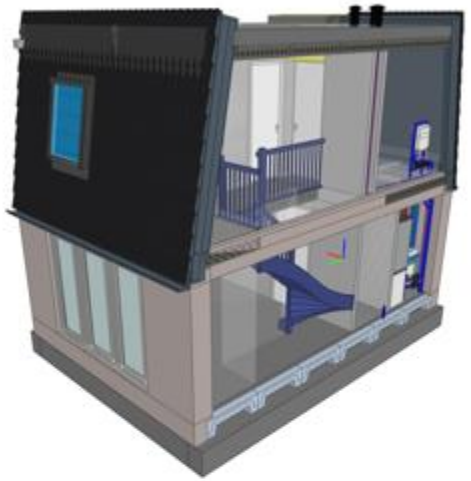
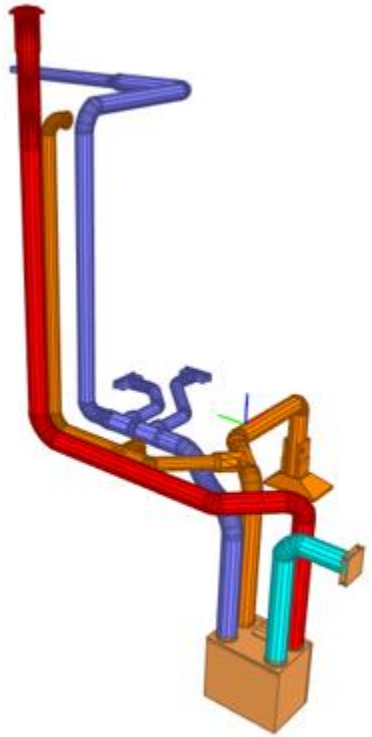
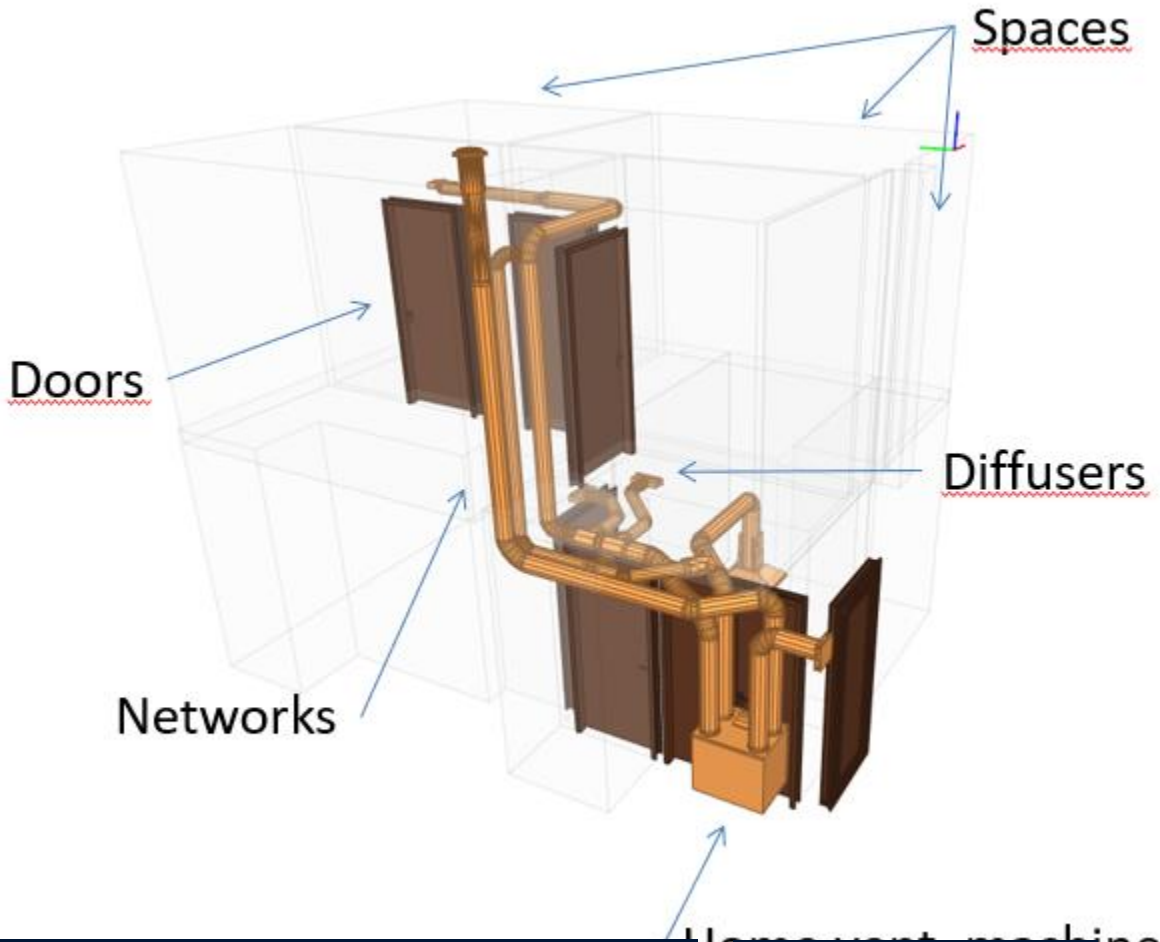
BIM MODEL OF TNO PILOT (HOLLAND): VENTILATION SYSTEM







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How is the simulation schematic of a building?

- Connectors (arrows)
- Passive building, systems, humans, meteo and BCs
- The human multiplexor
- Spaces to 2D plan presentation in XY position, with name and properties (m3)

- Importance of libraries. SIMBOT concept

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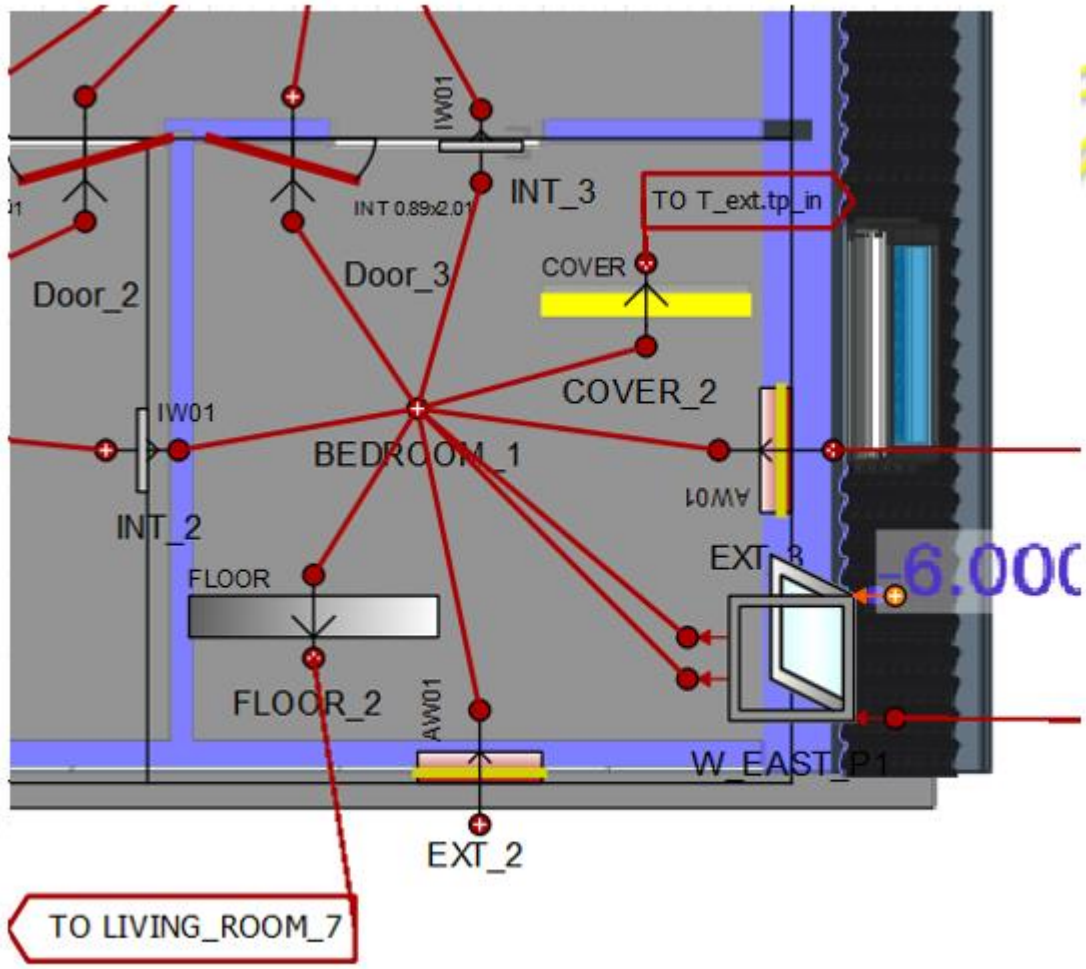
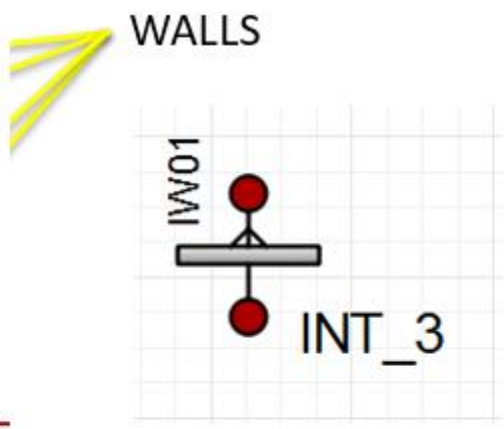
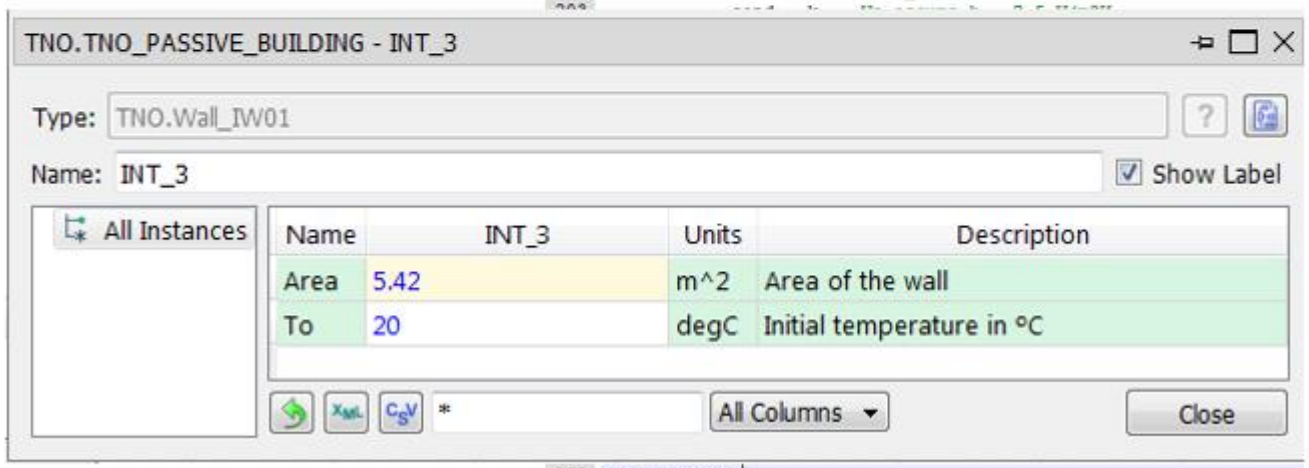
EXAMPLE: (PASSIVE) MODEL OF A ROOM






```
COMPONENT Wall_IW01
    PORTS
        IN thermal (n = 1) tp_in  "Thermal inlet port"
        OUT thermal (n = 1) tp_out  "Thermal outlet port"
    DATA
        REAL Area = 1 UNITS u_m2   "Area of the wall"
        REAL To = 20 UNITS u_C "Initial temperature in °C"
    DECLS
        DISCR REAL T_in[5]
        DISCR REAL k
    TOPOLOGY
        BUILDINGS.ExternalWallRC( n=5 ) Wall(
            --Boundary = FALSE,
            mat = {None, None, None, None, None },
            rho = {1600, 875, 40, 875, 1600},
            cp = {1000, 1700, 1000, 1700, 1000},
            To = T_in,
            A = Area,
            d = {0.02, 0.003, 0.02, 0.03, 0.02},
            k = {0.8, 0.2, 0.031, 0.2, 0.8}
            )
        THERMAL.GL(n=1) conv_in(
```




```
END COMPONENT
```

Some Mathematics behind

- Equations and the big solver
- (super) Time step (10 min), convergence
- SIMBOTs (equipment components) for real time (tested and certified!)
- Mathematical Partitions
- Experiments and DECKS

BARRIERS/STEPS FROM SIMULATION TO REAL TIME (!) … “not any software is useful”

- GOOD SCHEMATICS/library interface/BIM integration
- Good debugging and testing of models
- Good COMPONENT libraries. Components designed for real time! Open library components (user independence!). NO black boxes
- Enough granularity (control valve, … fluids, mechanical, control)
- Mathematical management: partitions, experiments, decks (SOLVERS!!!)
- Good programming practices (user counts)
- OPCUA, MODBUS, OTHER INTEGRATIONS FOR REAL TIME

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Software in the Loop embedded .exe

- The same DECK for excel, exe for BMS
- Implementation of complex SRIs
- Understandable output for end user at DT interface
- Virtual building working as “alive”
- Testing before, during commissioning and along all life

- We can control health levels, not only comfort!

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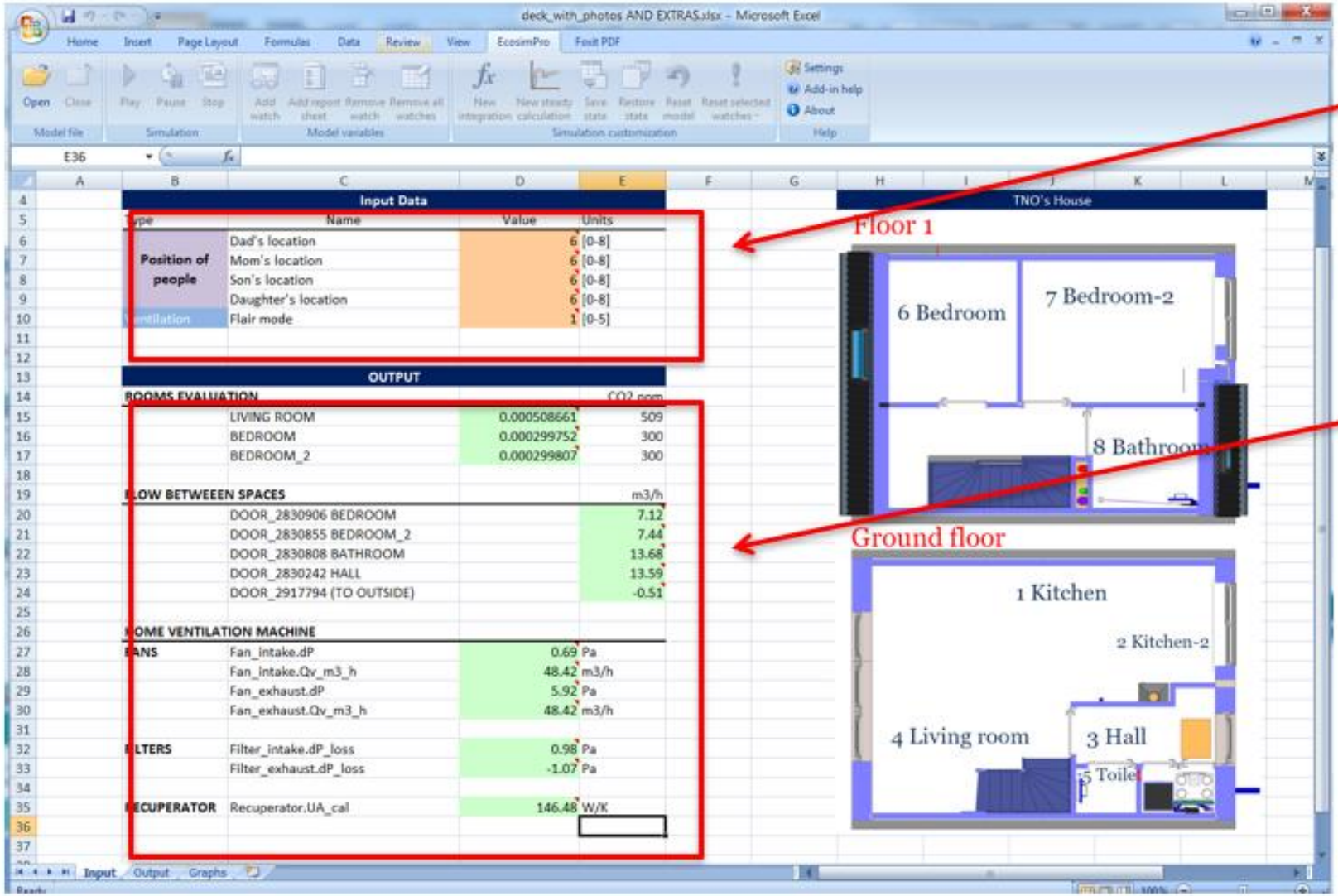
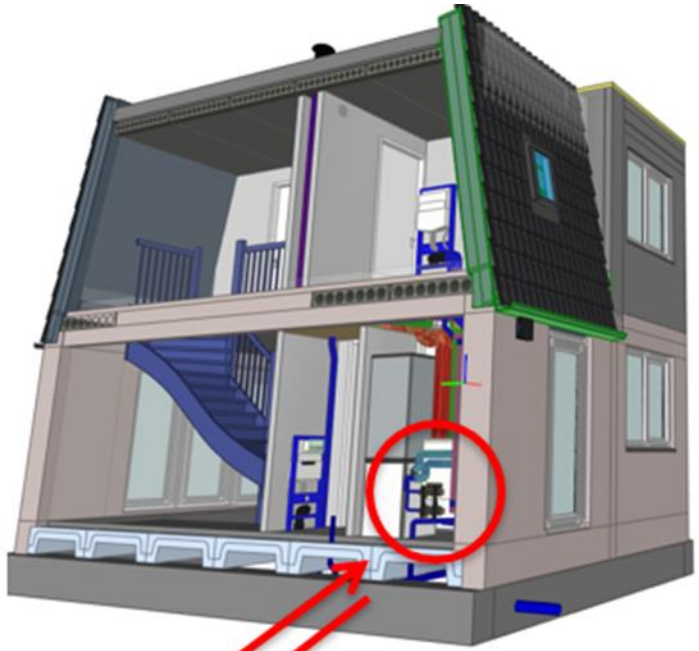
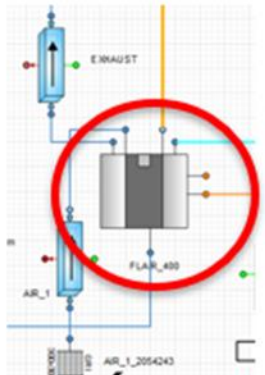
THIS IS A DECK







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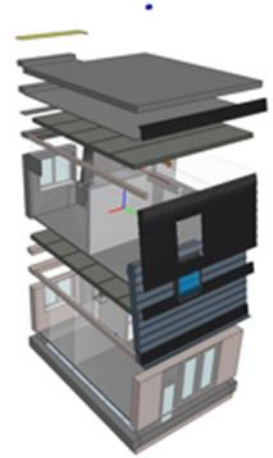

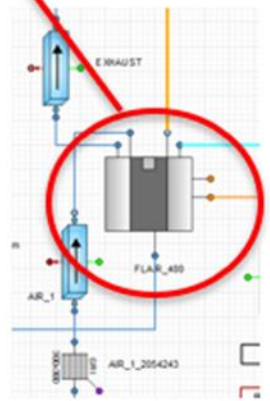

REAL TIME

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How is the way round? From simulation to BIM/Digital Twin

- Simulation outputs can be treated as sensors, but we design our interface with DT and we can change it easily
- We can check consistency and validation of our model against BIM information
- We can feed/enrich the 3D BIM models with information from simulation

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Some CONCLUSIONS/MESSAGES/OPINNIONS

- **BIM schema (IFC) must "understand and collaborate" with real time disciplines**. We don´t work with the same information. Simulation works with equations, dynamics. With BIM we have geometry, properties. And NOT 1-1 relationship sometimes.
  - NOTE 1: A simulation model is much simpler than a BIM model (if we have the SIMBOTs ready)
  - NOTE 2: A BIM model is part of a Digital Twin, but NOT a digital twin
- For HVAC equipment's (functional!) BIM representation is static, geometric – Perhaps **SIMBOTs** is a better way to be described
- **Combined concept of light+sensor+actuators**: power points in the building to complete advanced control tasks (human interaction), not only lights
- Great **future challenge and an opportunity** to reduce price in implementation

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THANK YOU! DANKE SEHR!

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