ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

ALMABuild, an open-source Simulink tool for buildings and HVAC systems modeling

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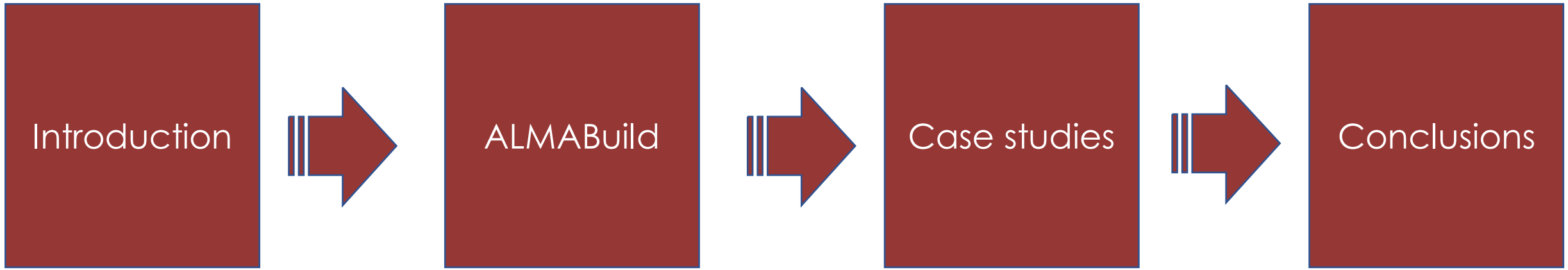
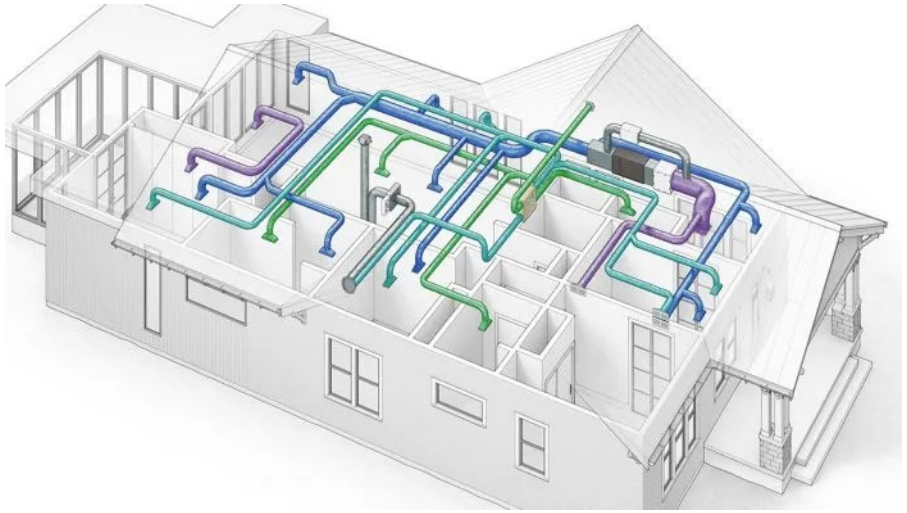
Contents

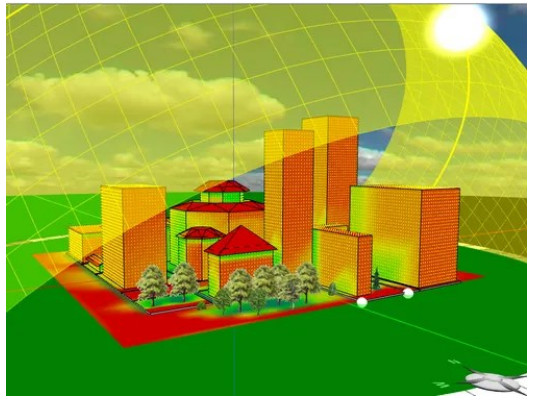


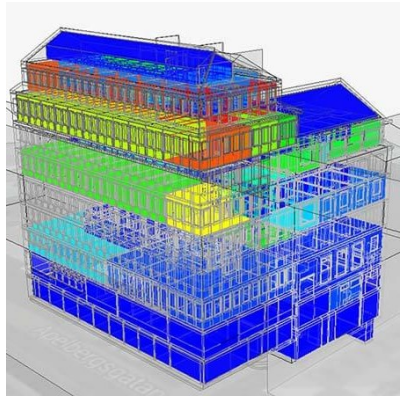
Introduction

Features expected from a building and HVAC plant modeling software:

- **Quick and easy implementation**;
- Possibility to select **different levels** of **detail**;
- **Low execution time** required for simulation.







Introduction

CARNOT
+
Building model

Co-simulation with a Whole Building Energy Software (**WBES**)

ESP-r
EnergyPlus
TRNSYS

- **Graphic implementation** of the building **geometry** (e.g., SketchUp, CAD)
- **Graphical user interfaces** for **input** implementation
- **Accurate building modelling** (e.g., shadings, humidity)

BUT

- **Long simulation times**
- **Compatibility problems** and difficulties in **data exchanges**
- **Time-steps** not suitable for accurate HVAC systems simulation

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Introduction

CARNOT

+

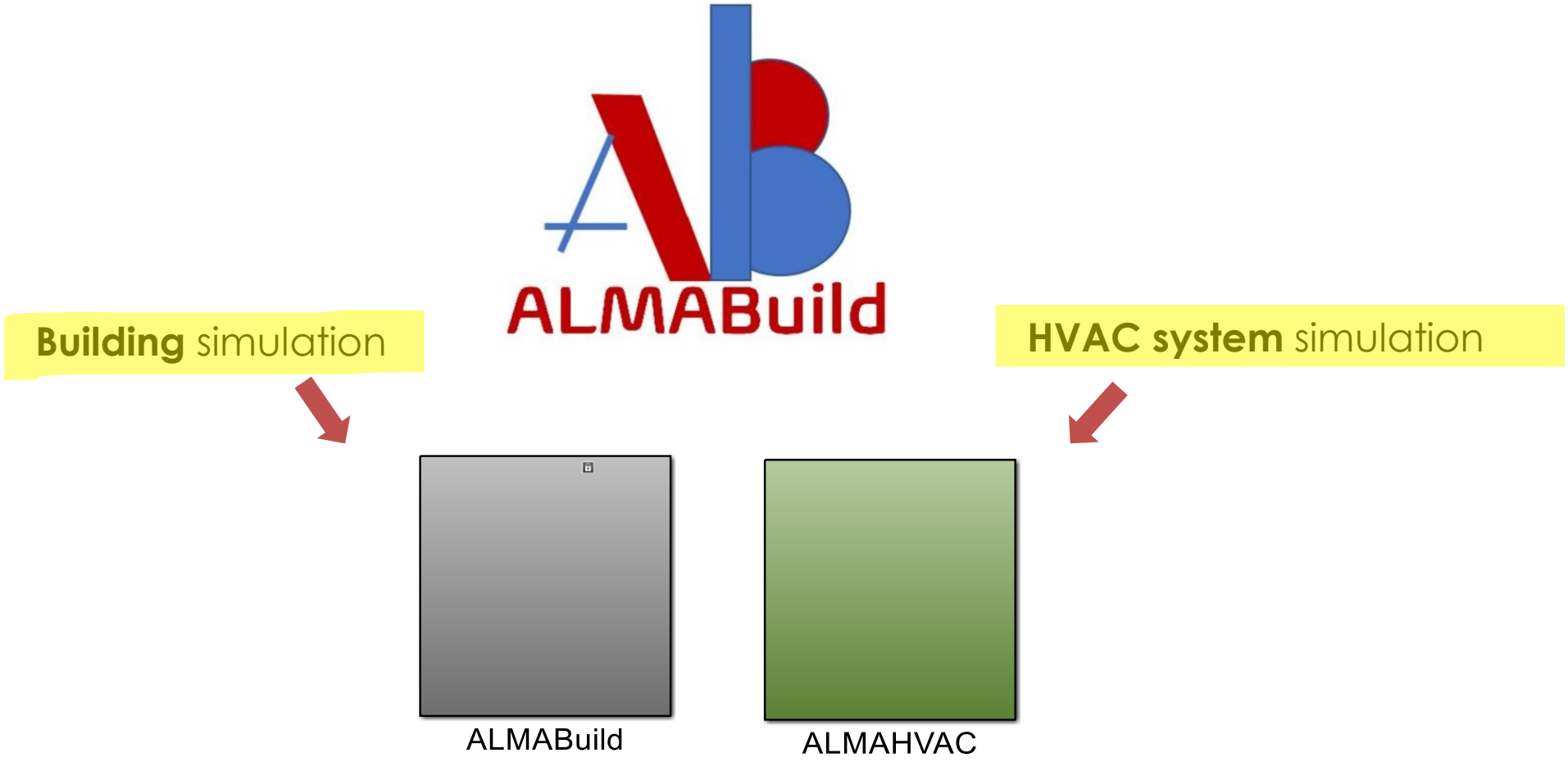
Building model

Adoption of another **Simulink-based tool**

ALMABuild

ALMABuild

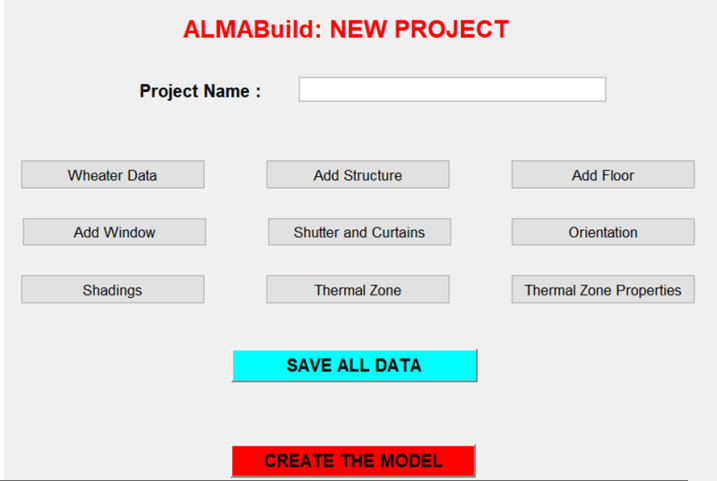
Tool operating in the Simulink (MATLAB) environment for the simulation of coupled **building-HVAC systems** under dynamic operating conditions.

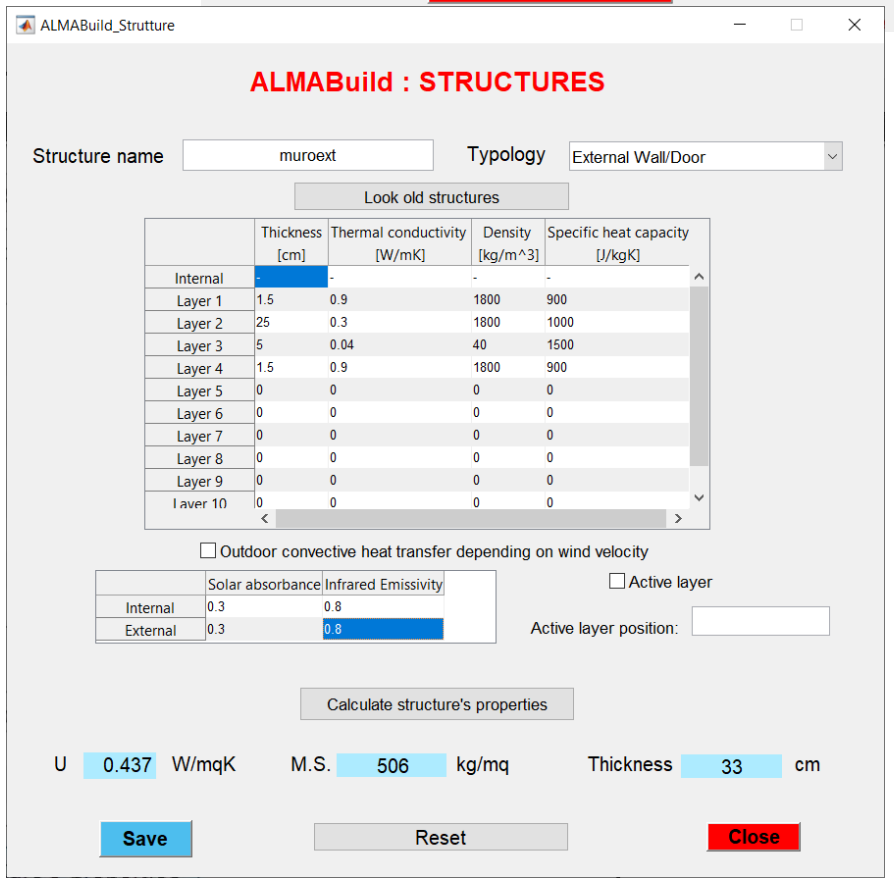


ALMABuild

Automatic building **implementation** in Simulink through Graphical User Interfaces (**GUIs**)

- **Fast** process
- **Limitation** of users' **errors**
- **No experience** required in Simulink or building modelling
- **No** need of **co-simulation**
- Building model **validated**
- **Variable time-step** suitable for HVAC systems (seconds)
- **Full compatibility** with **CARNOT**
- **Selection** of **the level of detail** in simulations

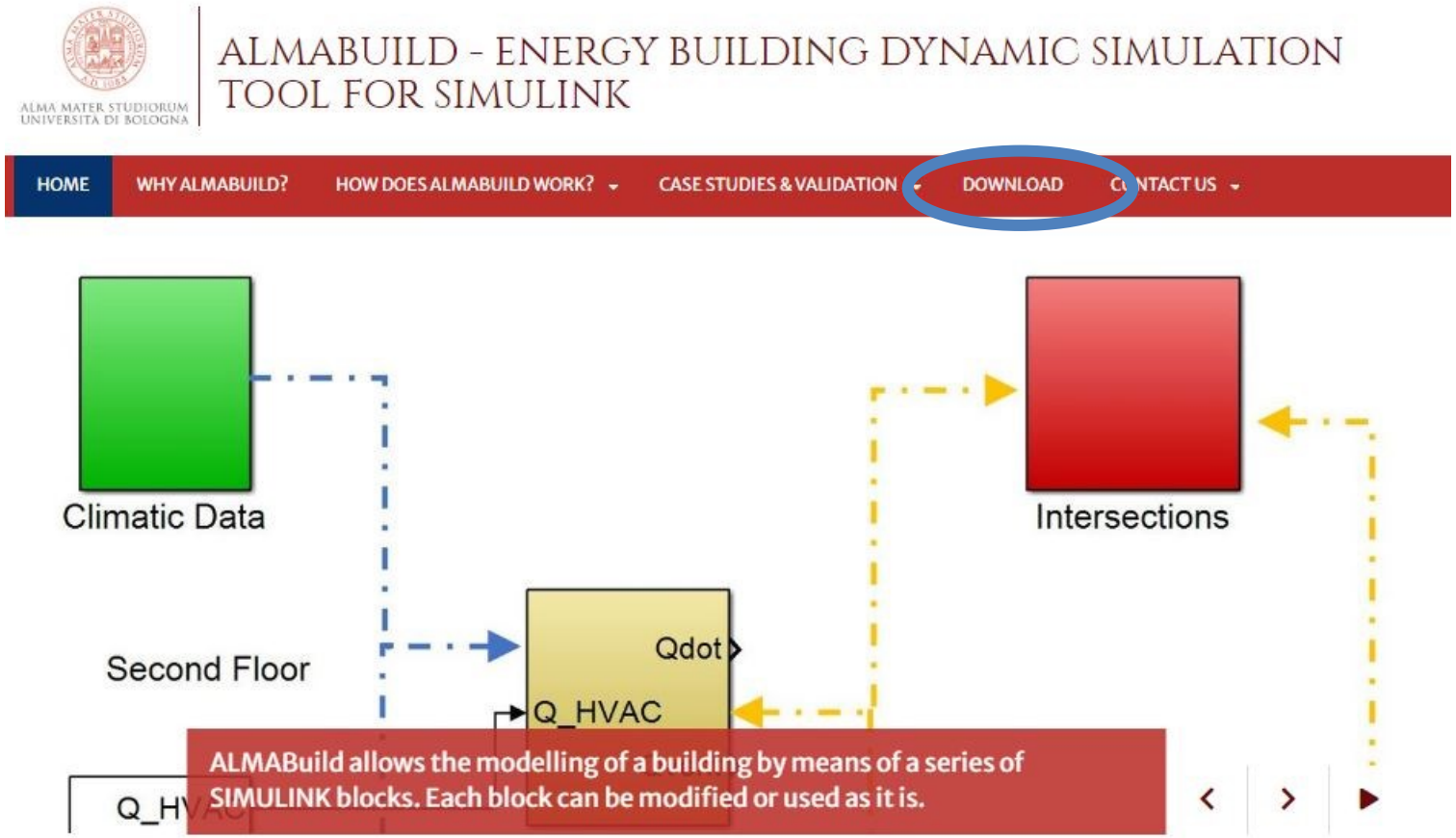




ALMABuild

Tool operating in the Simulink (MATLAB) environment for the simulation of coupled **building-HVAC systems** under dynamic operating conditions.

https://site.unibo.it/almabuild/it



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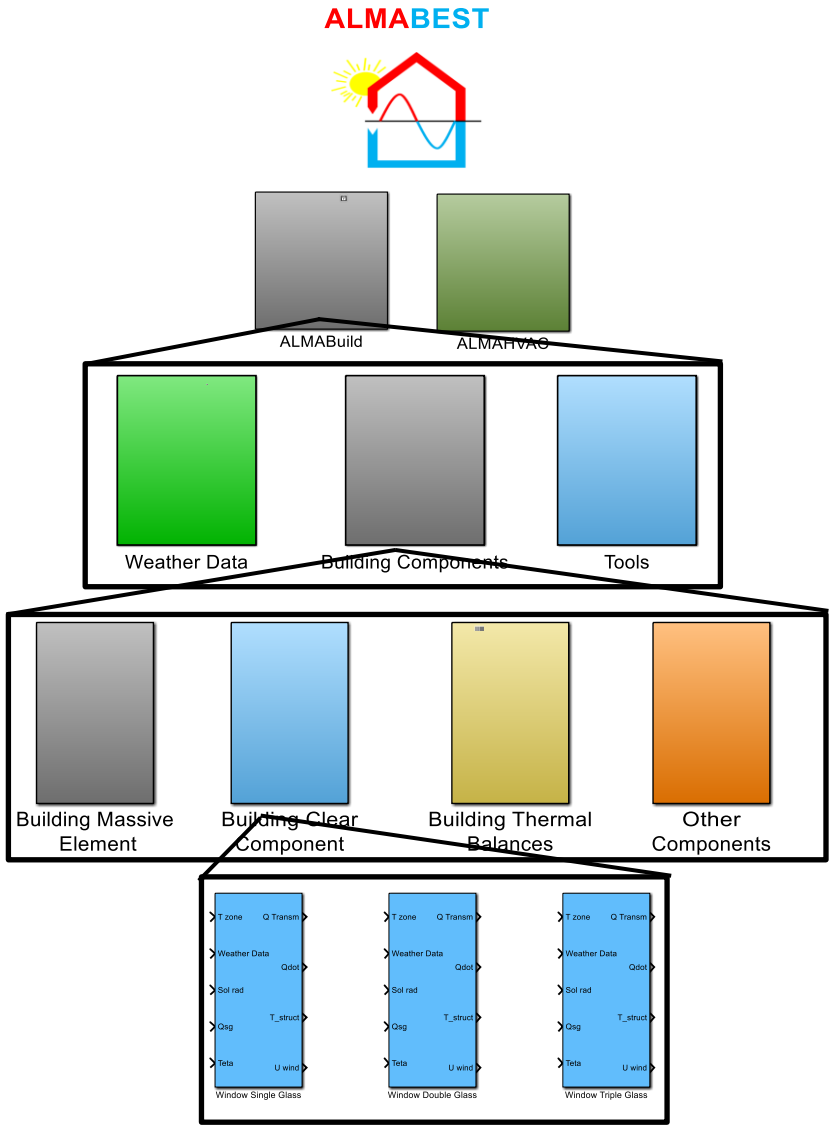


Library

Blockset

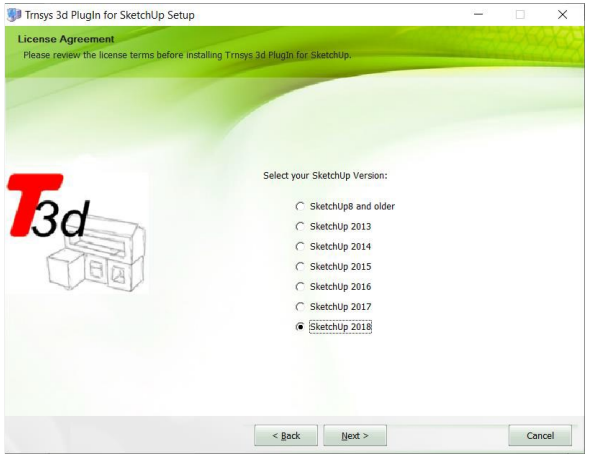
Subsystem

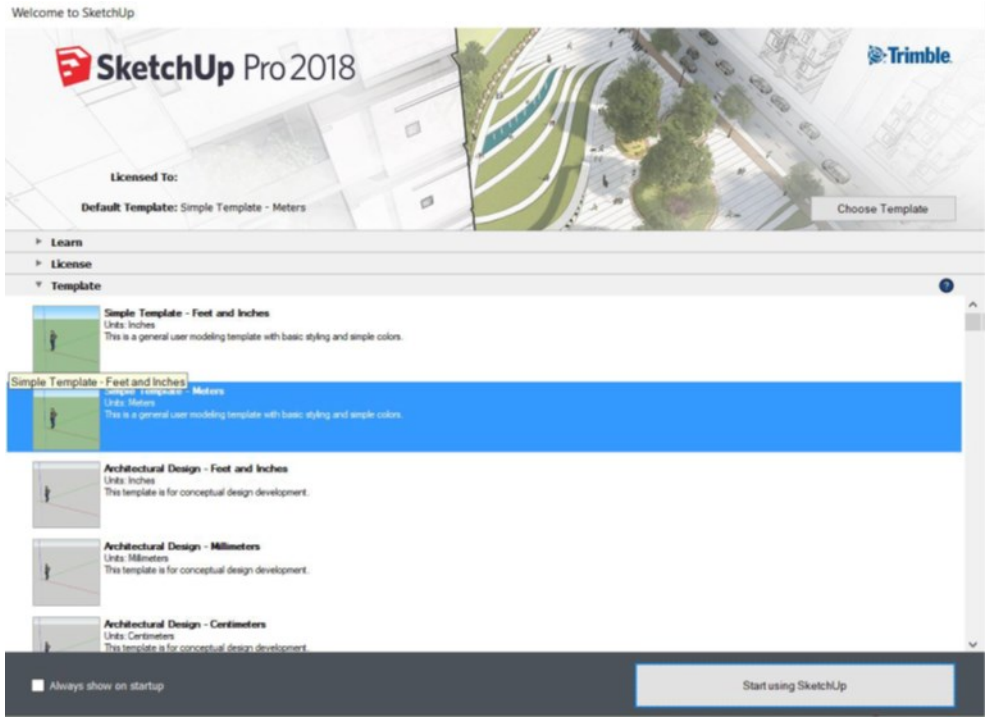
Elementary blocks

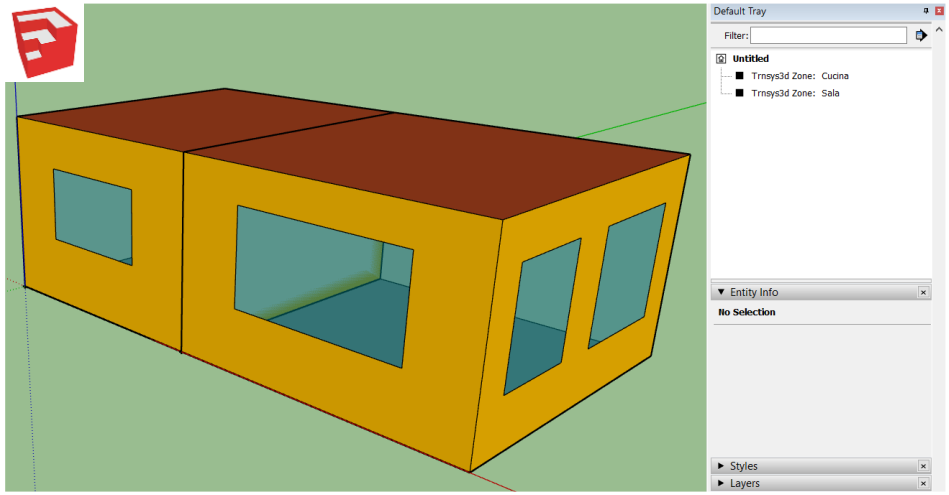
Hierarchical levels

ALMABuild

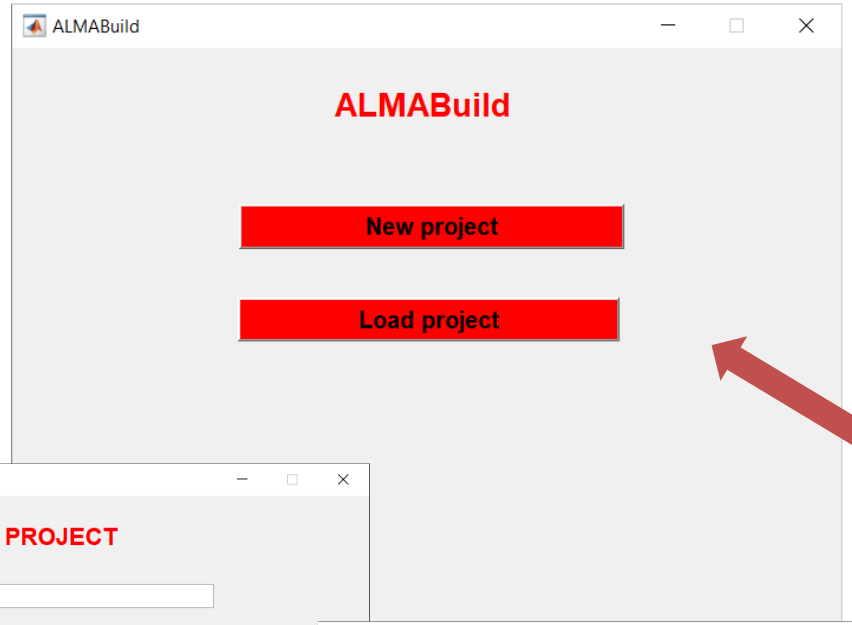
- 3D modeling of the building through **Google SketchUp** and plugIn **Trnsys3D** (free)
- Modeling of Multizone building and **automated geometry export** from Google SketchUp to ALMABuild

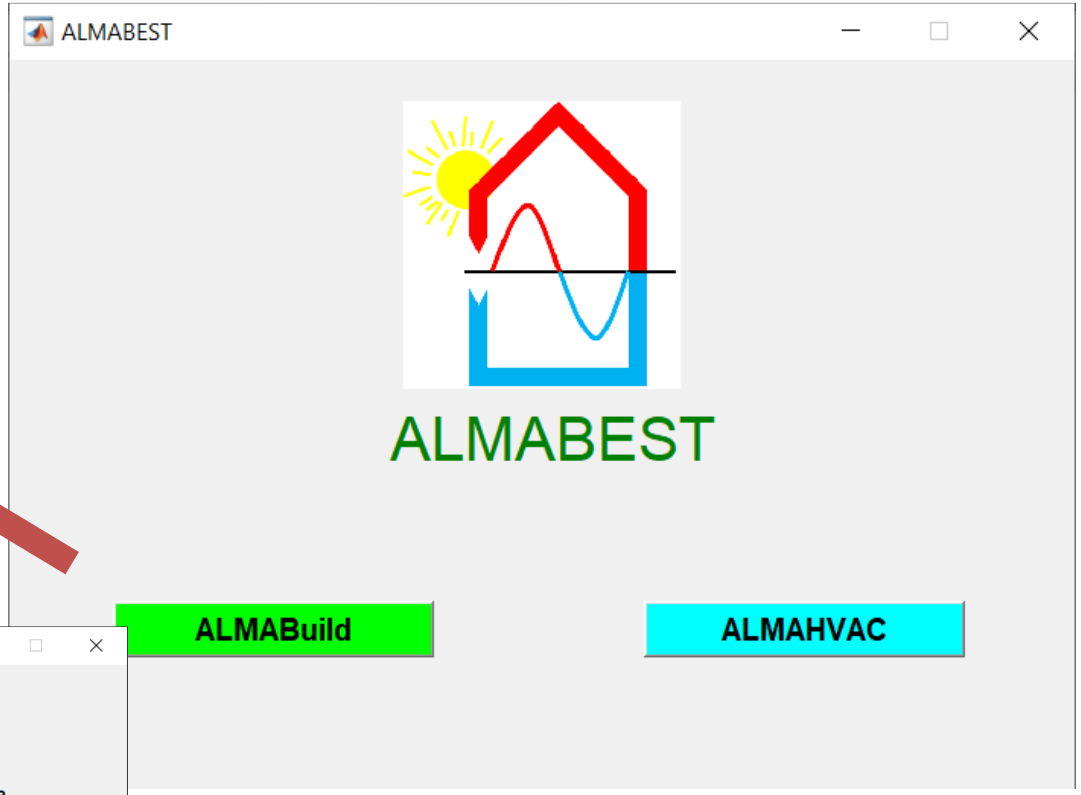


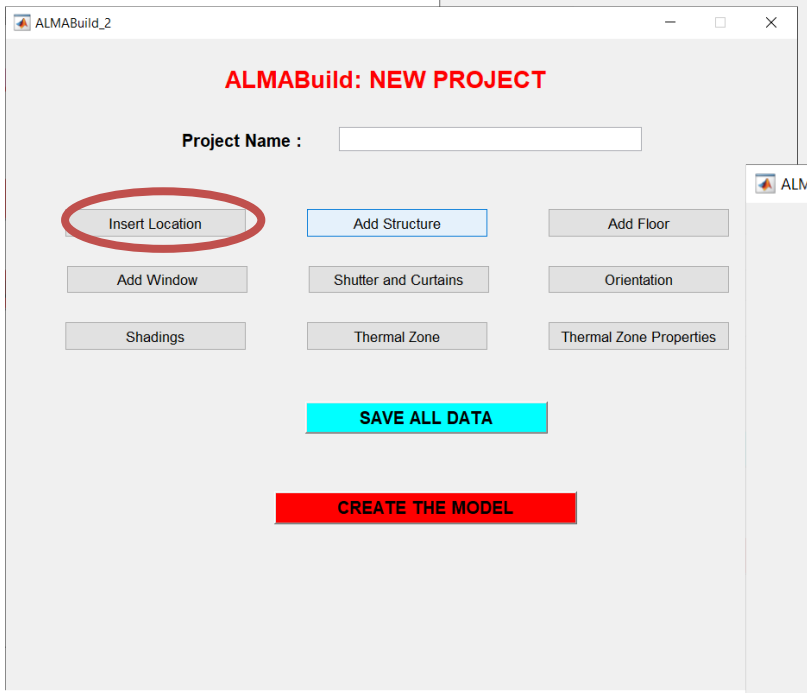


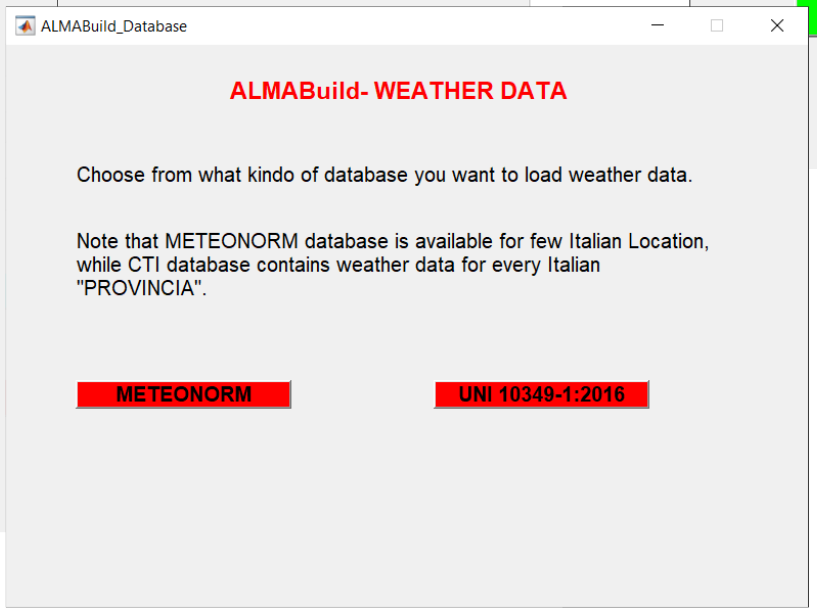


ALMABuild: Graphical User Interfaces (GUIs)









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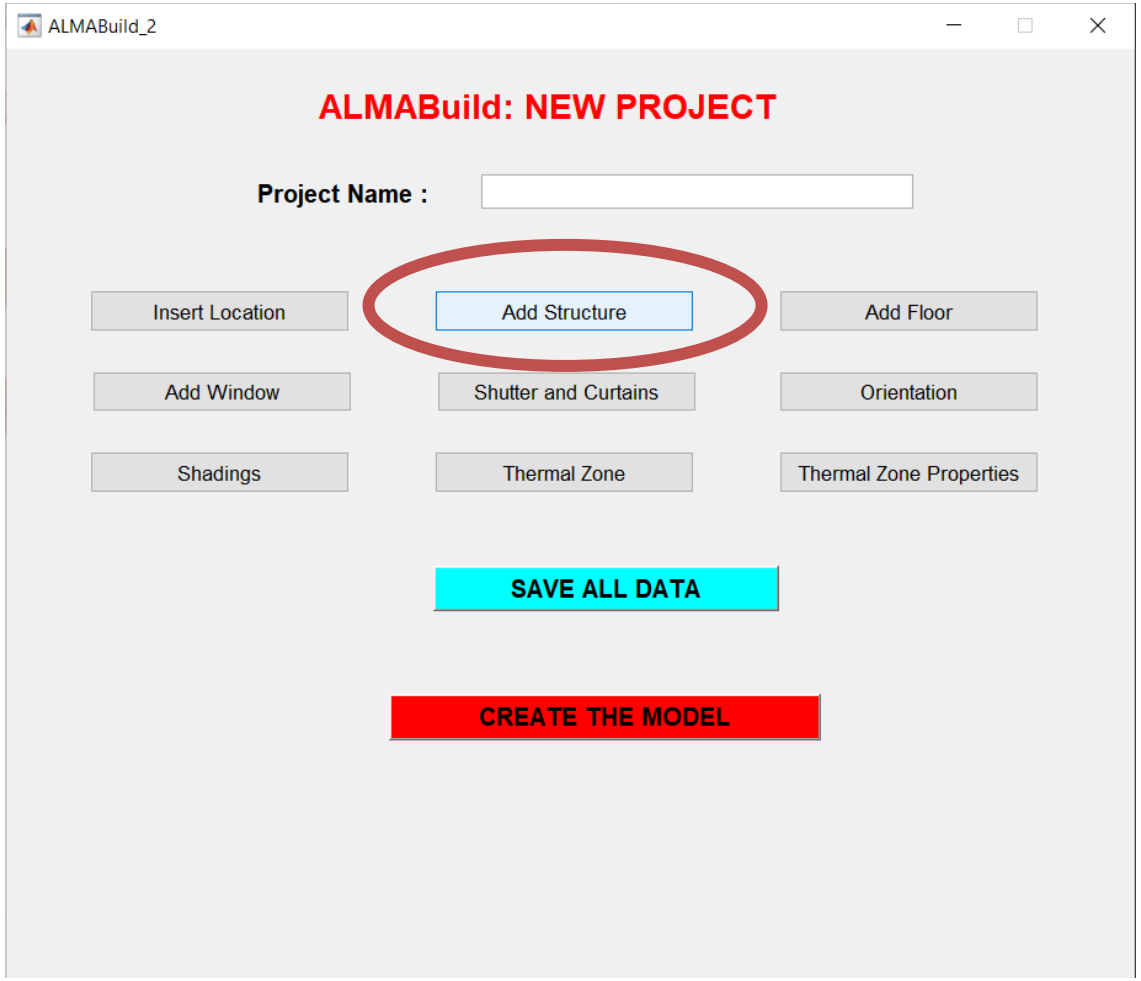

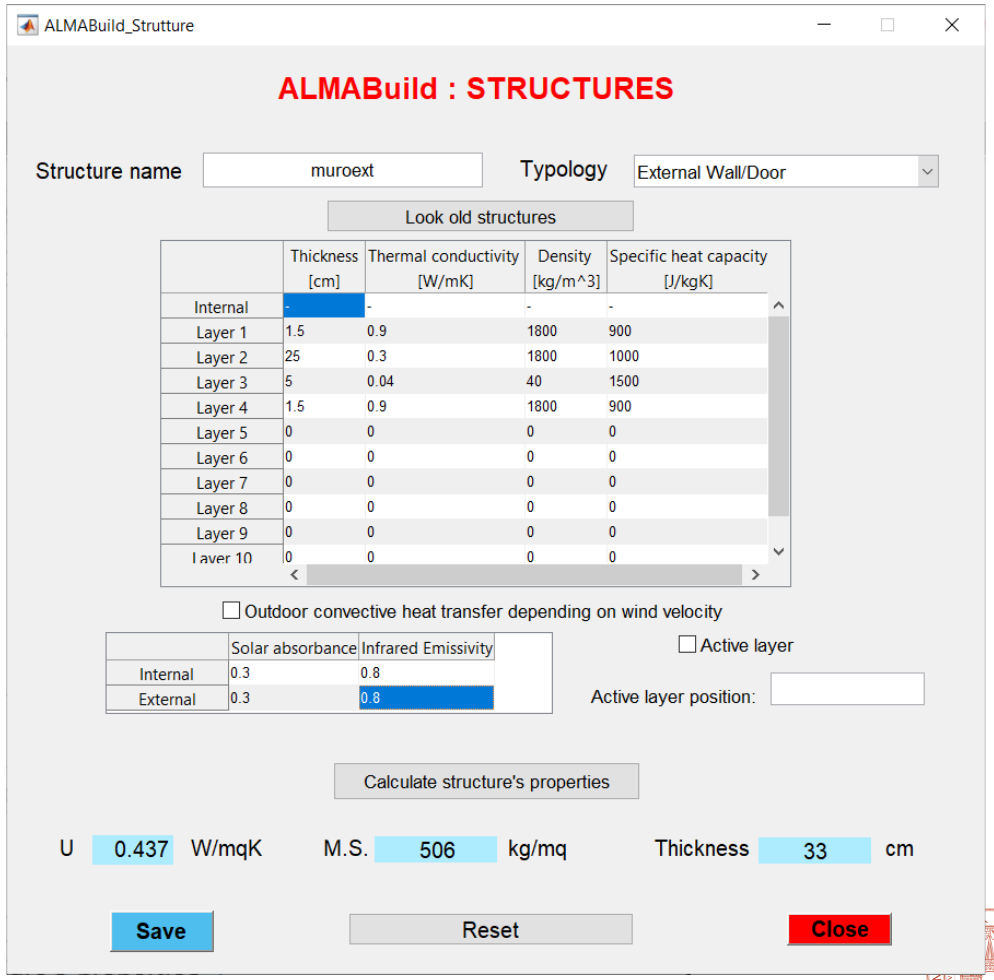

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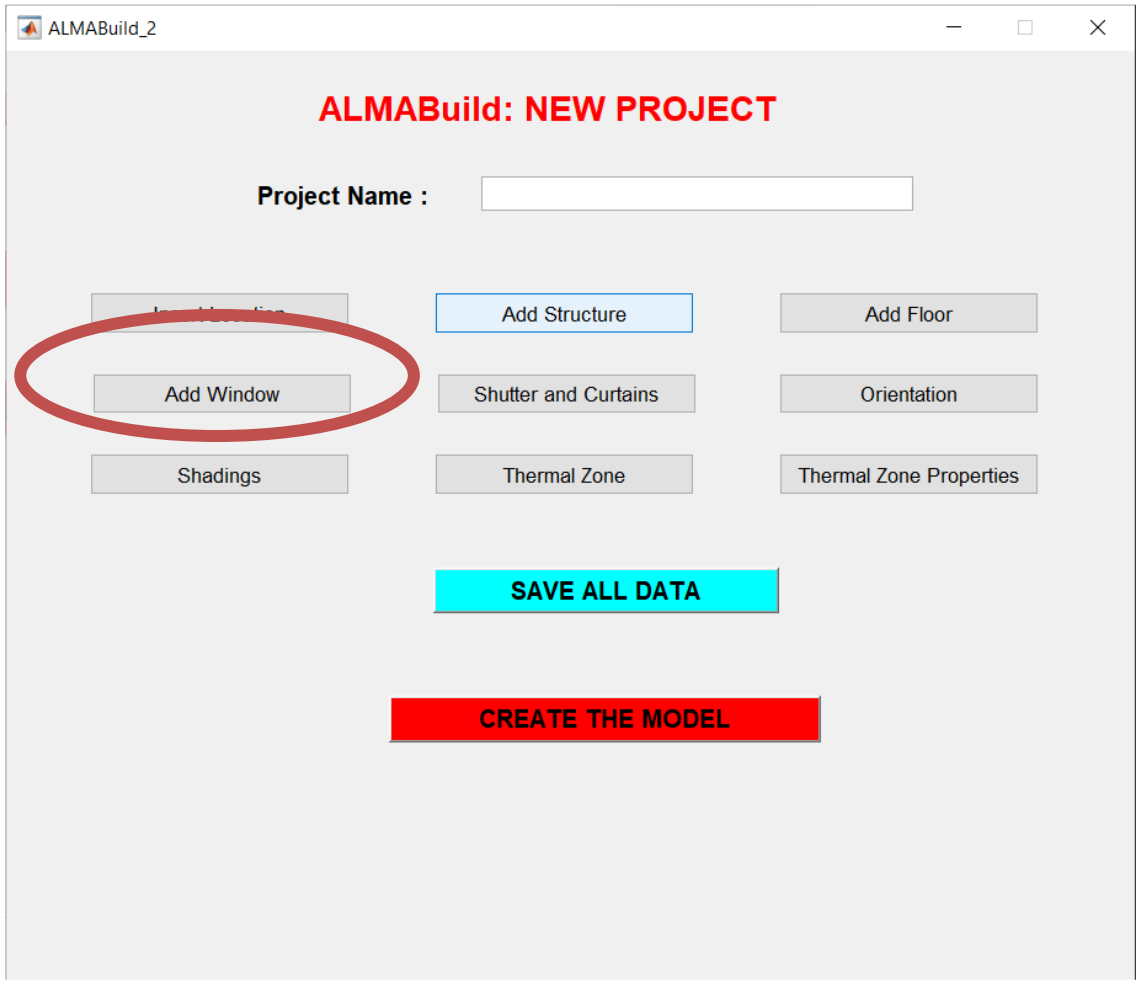

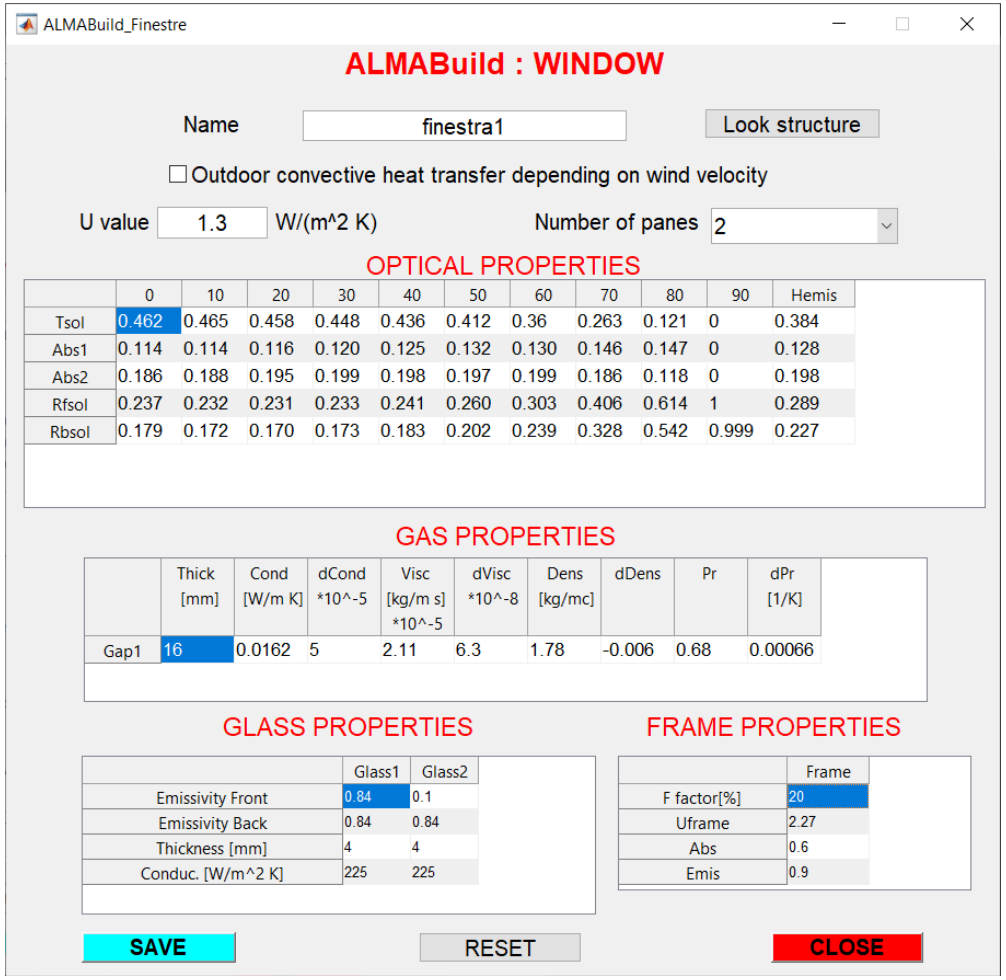

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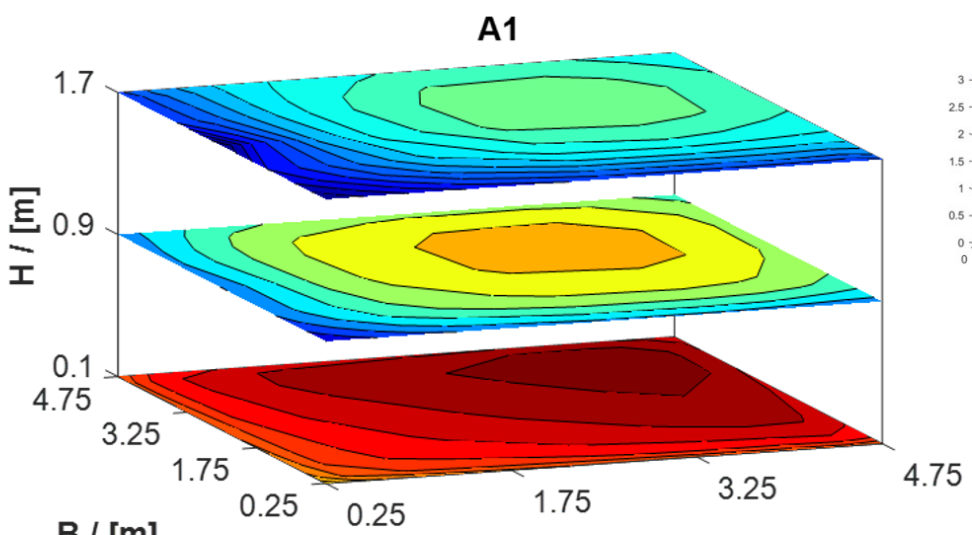

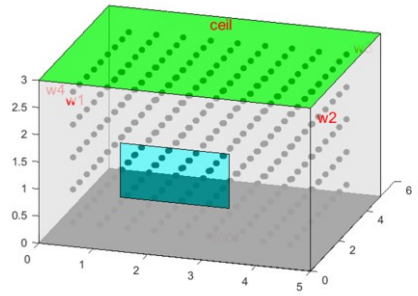

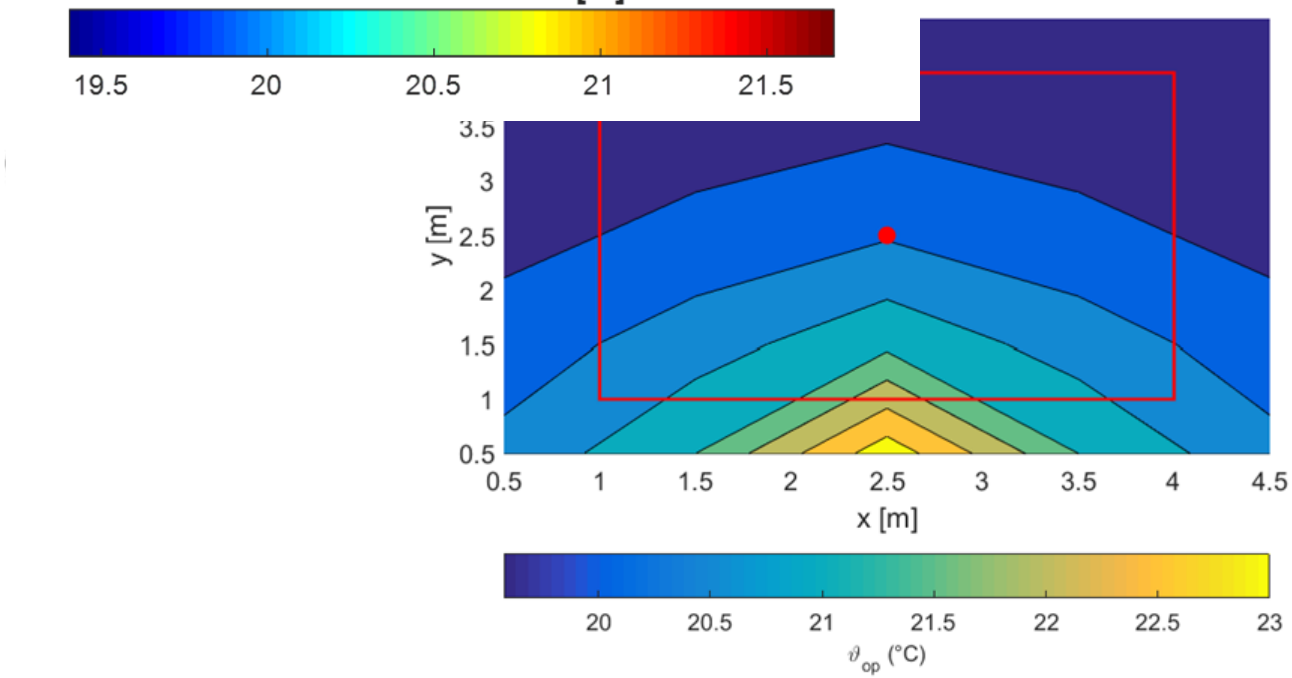

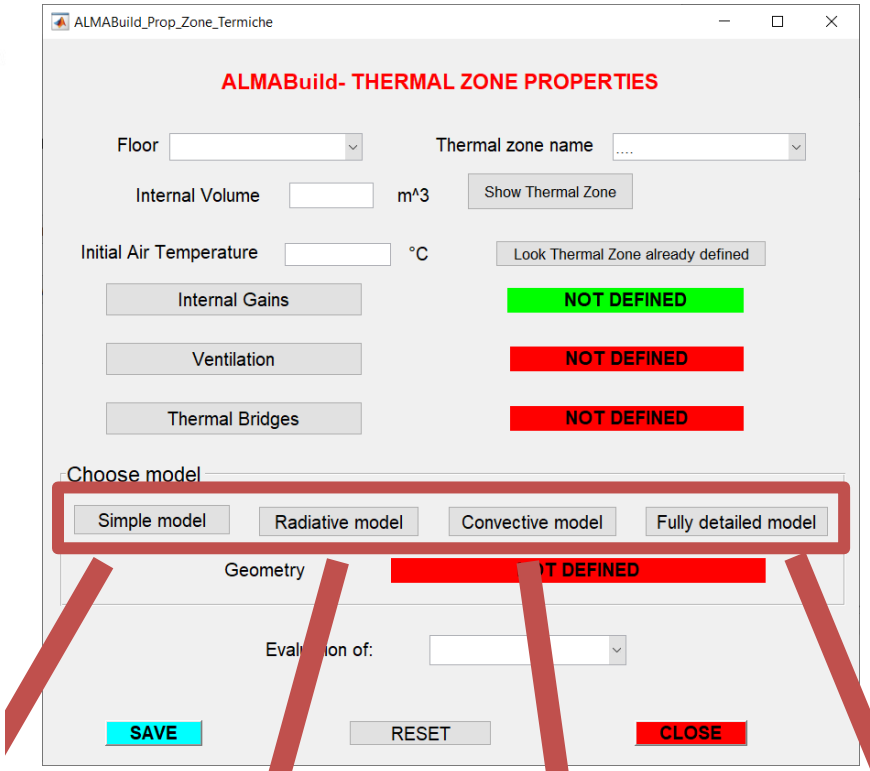

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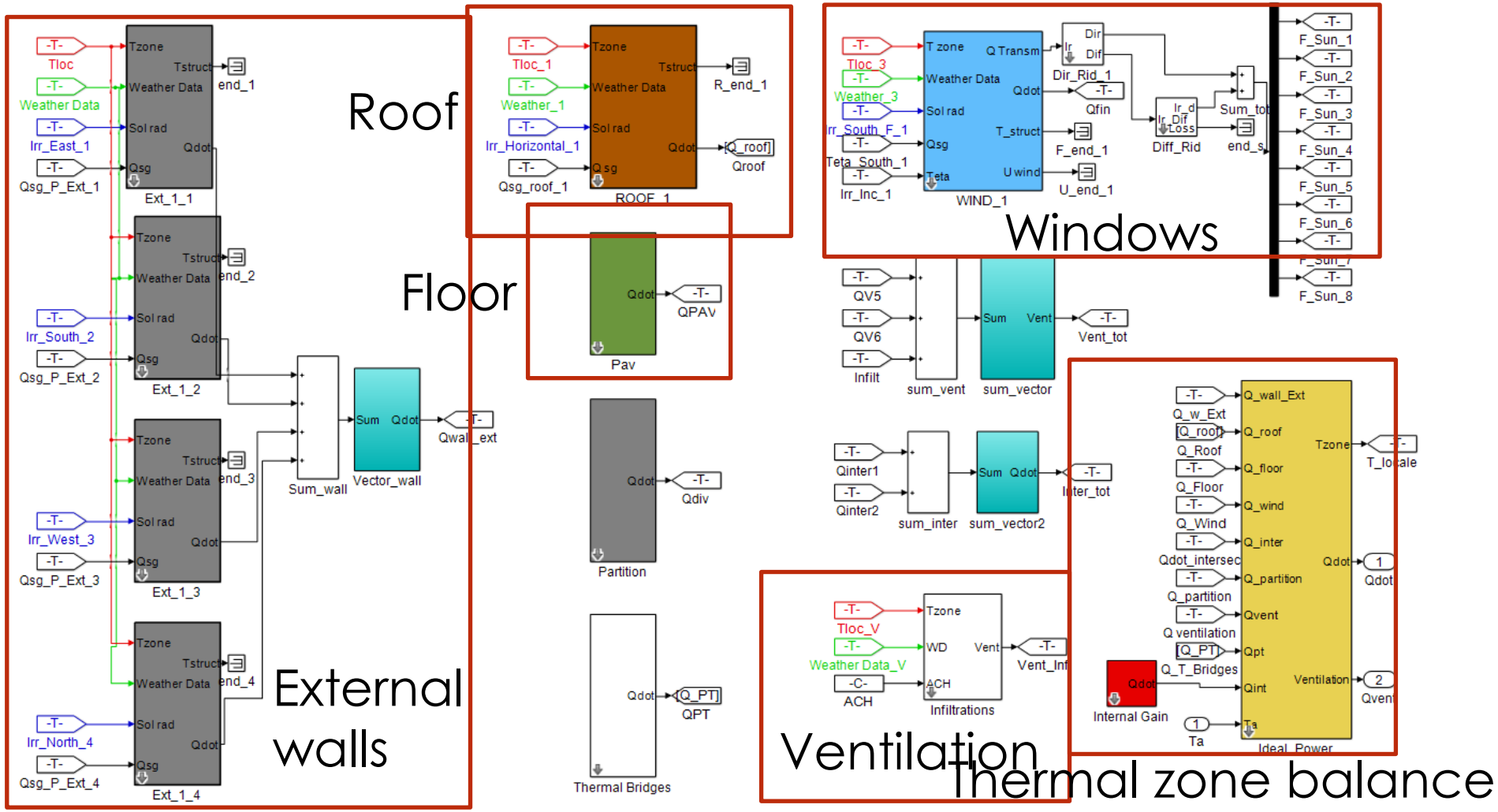
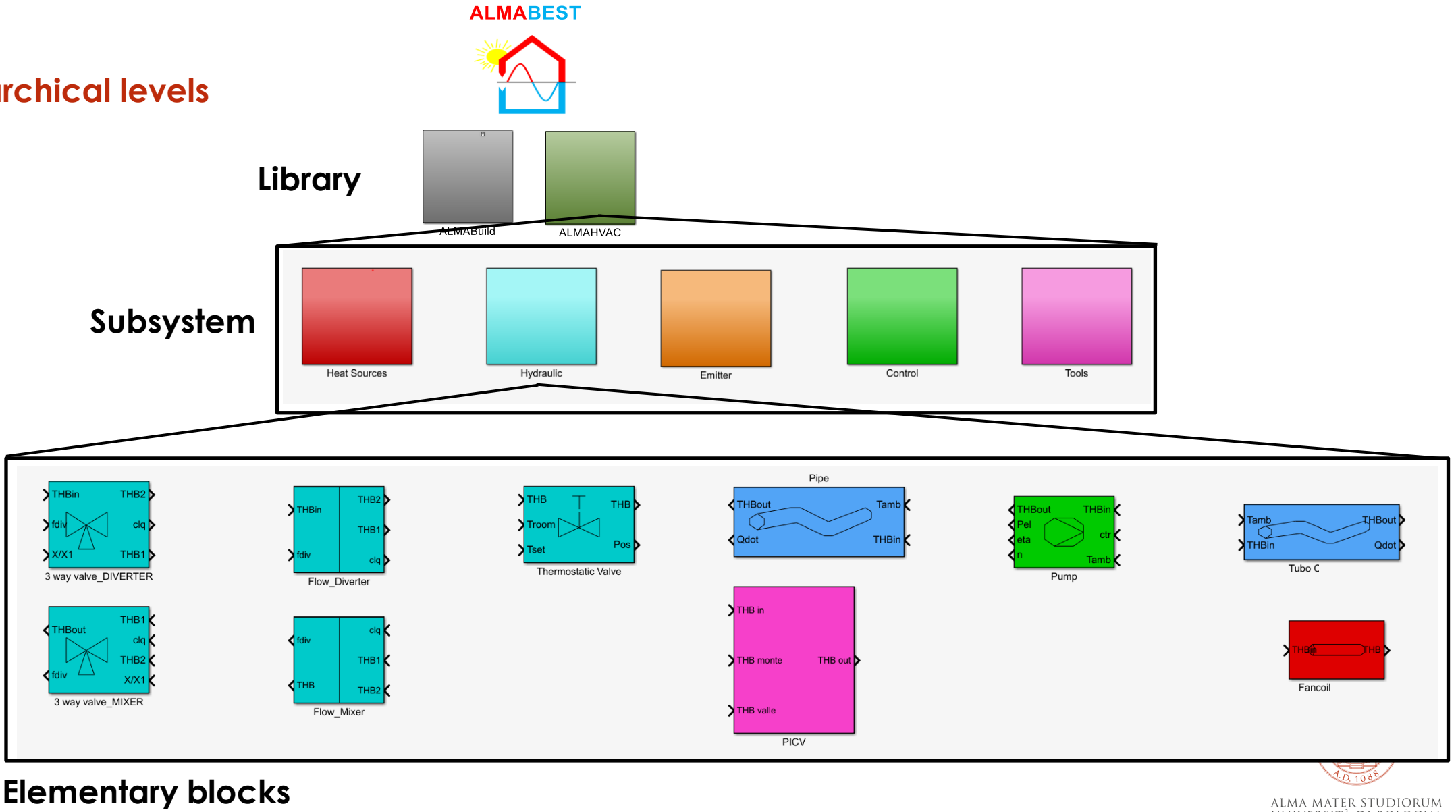
ALMABuild: automatic implementation in Simulink



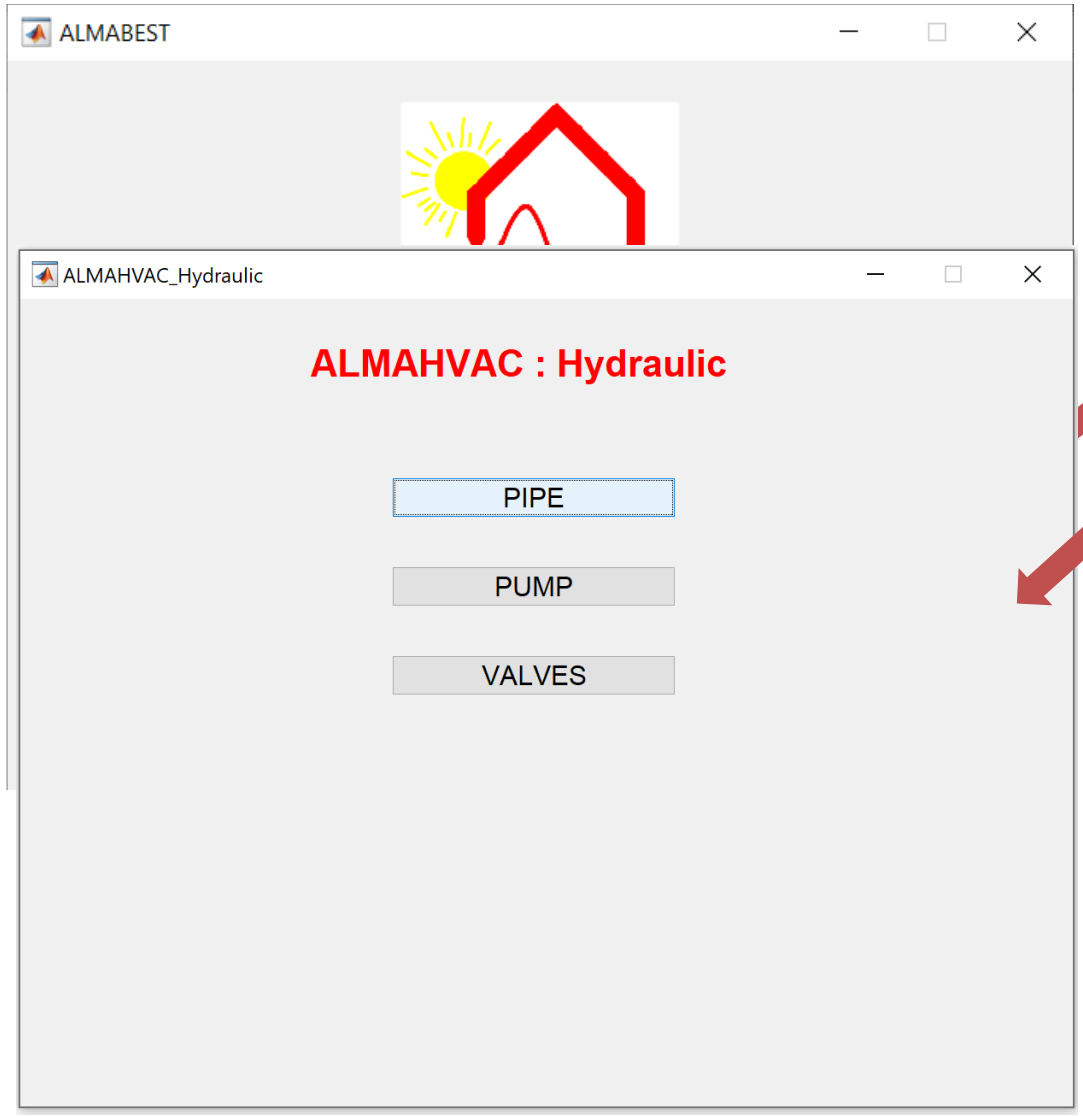
ALMAHVAC

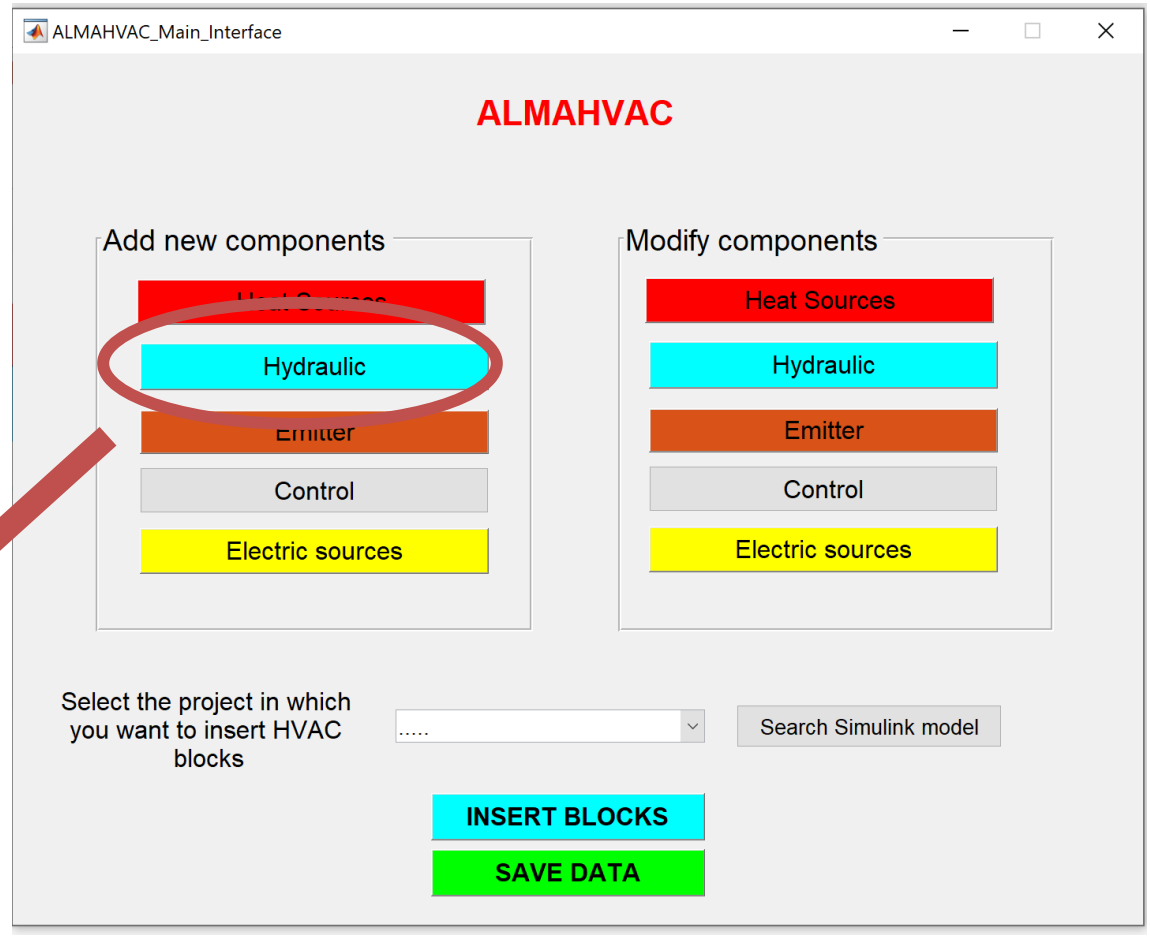
Hierarchical levels



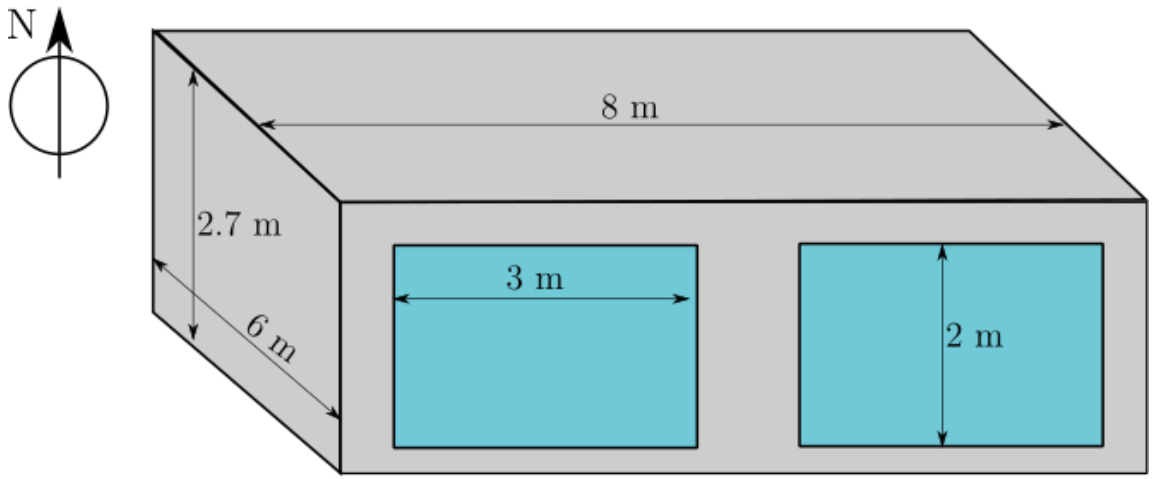
Elementary blocks

ALMAHVAC: Graphical User Interfaces (GUIs)





Case study: Optimization problem



Building characteristics

- 2 windows: South
- Set-point temperatures: 20 °C; 26 °C

Parameters to be optimized

- **Insulation layer thickness**: 0 – 30 cm
- **Windows total area**: 6 – 21 m^2.

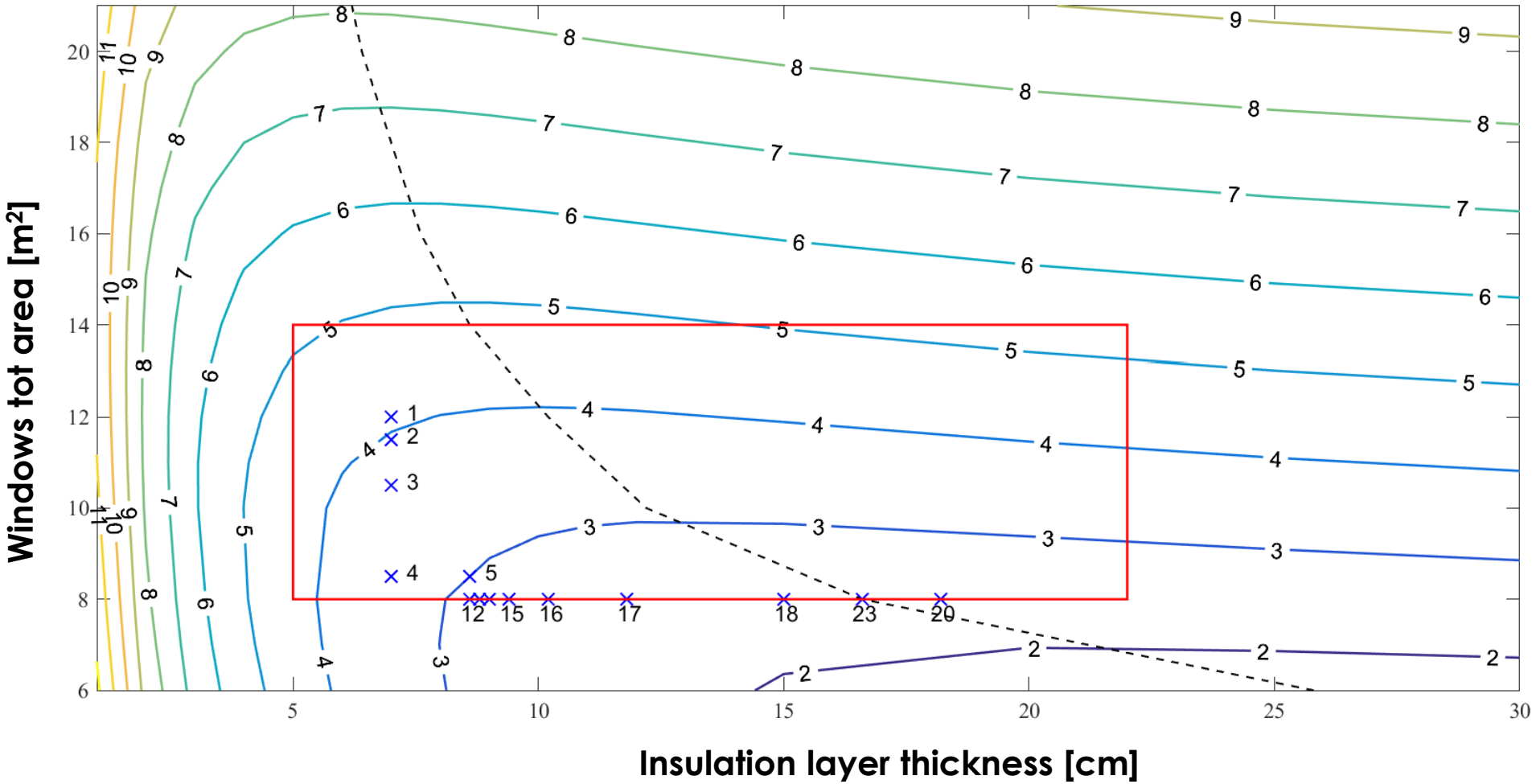
Objective function

Minimum total energy need (heating and cooling)

Case study: Optimization problem

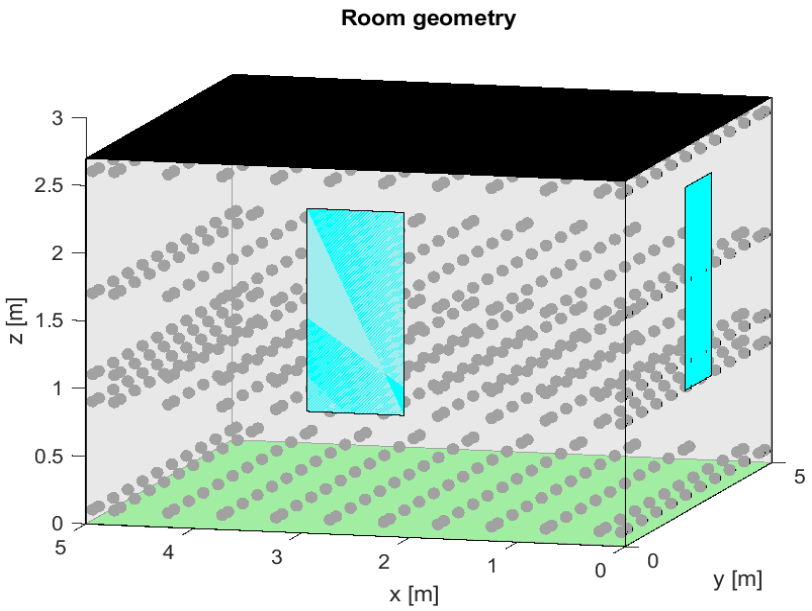
Matlab Optimization Toolbox

Tot energy need [MWh]

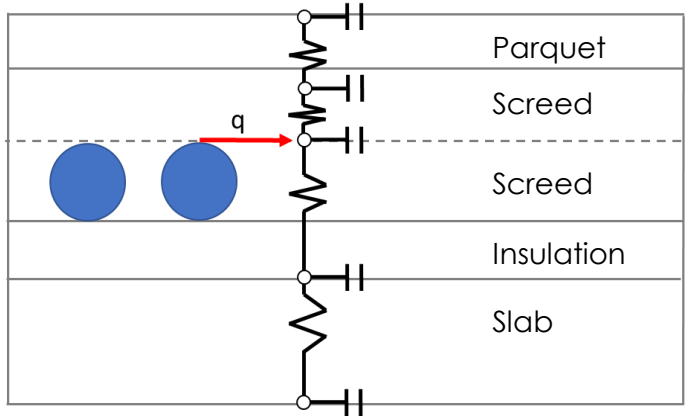


Only **64** simulated configurations instead of **988**!
Sim time saved: **94%.**

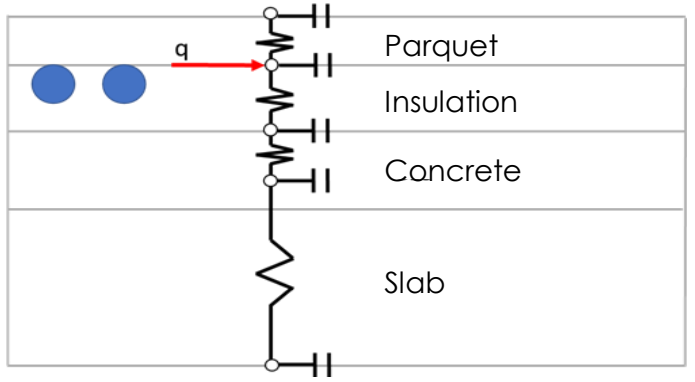
Case study: Radiant floor heating



- Location: **Bologna**
- Thermal design load: **756 W**
- Set-point temperature: **20 °C** (DB=0.5 K)
- 5 typologies of emitter:
  - ***Radiator***
  - ***Radiant ceiling***
  - ***Radiant floor***



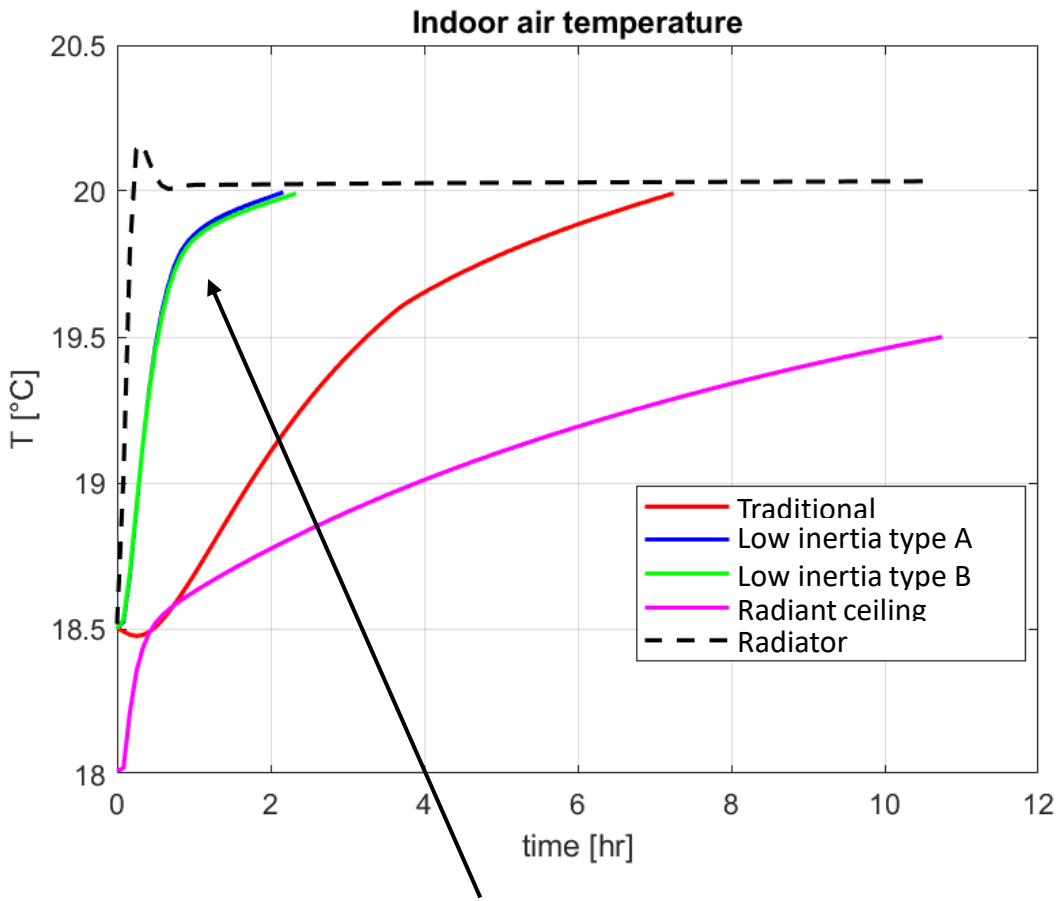
Traditional radiant floor heating (**high inertia**)



Low-inertia radiant floor heating

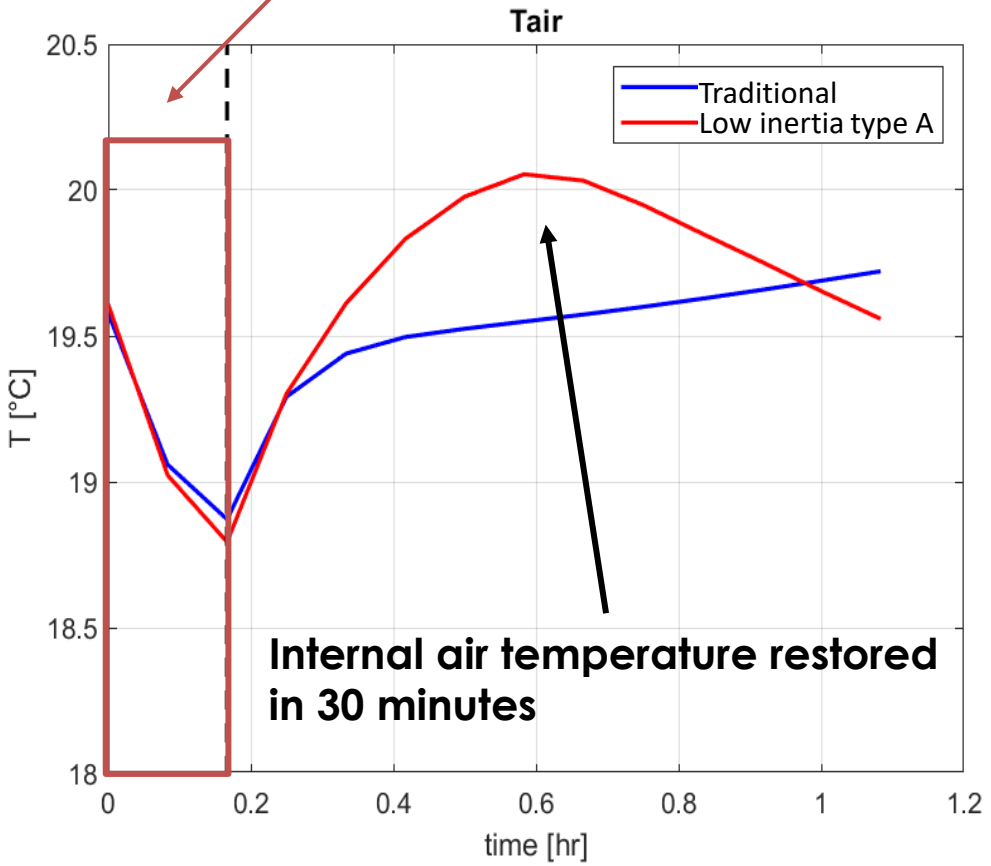
Case study: Radiant floor heating

Start-up transient



Very fast response for low-inertia radiant floor

Windows opening (10 min)



Conclusions

- **ALMABuild** is a **free Simulink tool** for **building-HAVC system** modeling
- **Detailed building 3D model**
- **Automatic implementation** of the **inputs** by means of GUIs
- **Automatic links** between blocks in **Simulink**
- **Compatibility with CARNOT**

ALMABuild

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Thank you for your attention

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