



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

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

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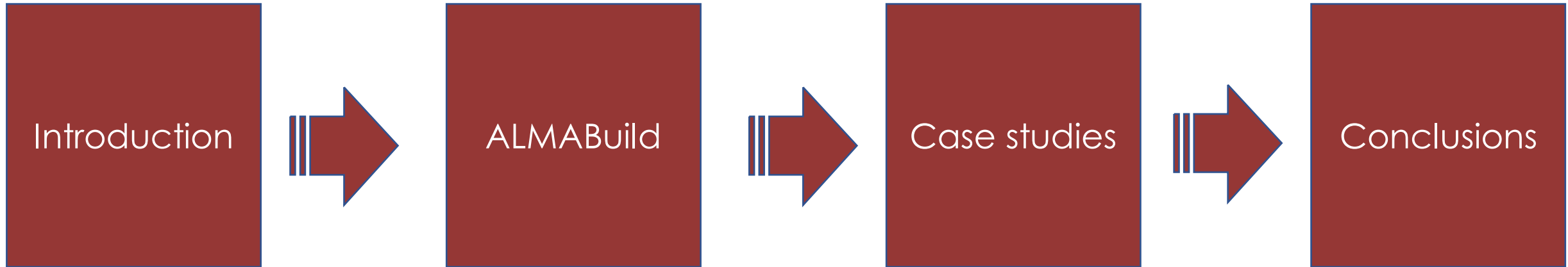
Christian Natale, MS

Prof. G.L. Morini

Department of Industrial Engineering

Alma Mater Studiorum - University of Bologna

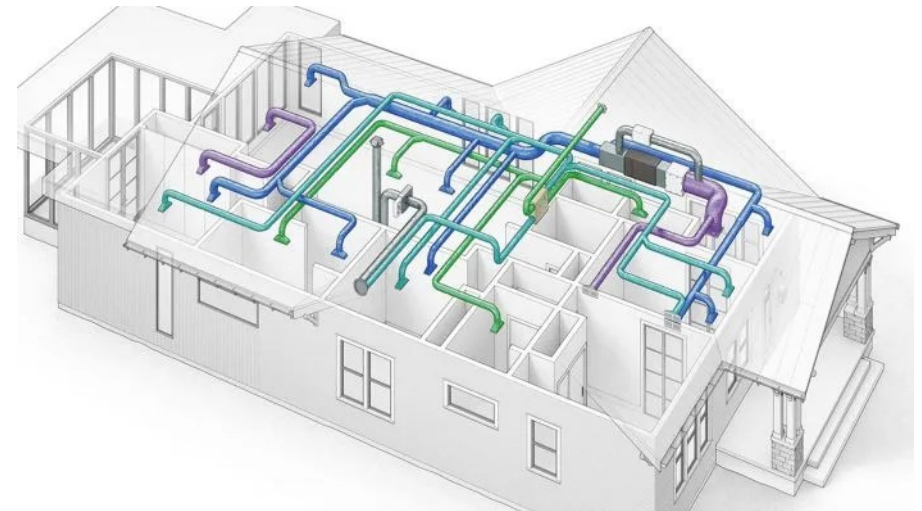
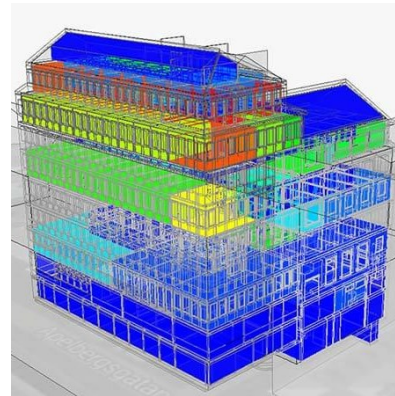
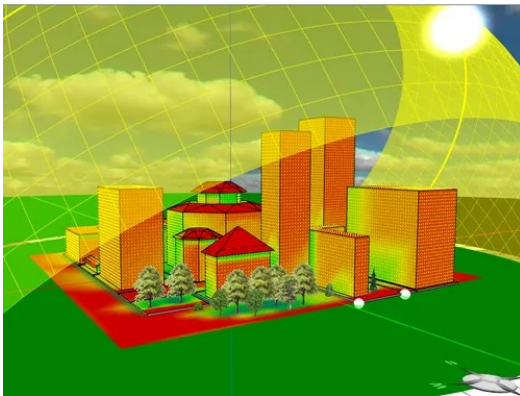
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Introduction

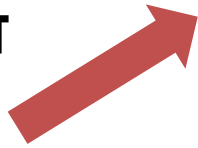
Features expected from a building and HVAC plant modeling software:

- **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



A

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

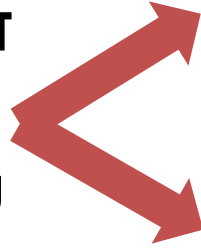
BUT

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

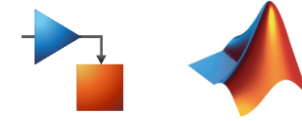


Introduction

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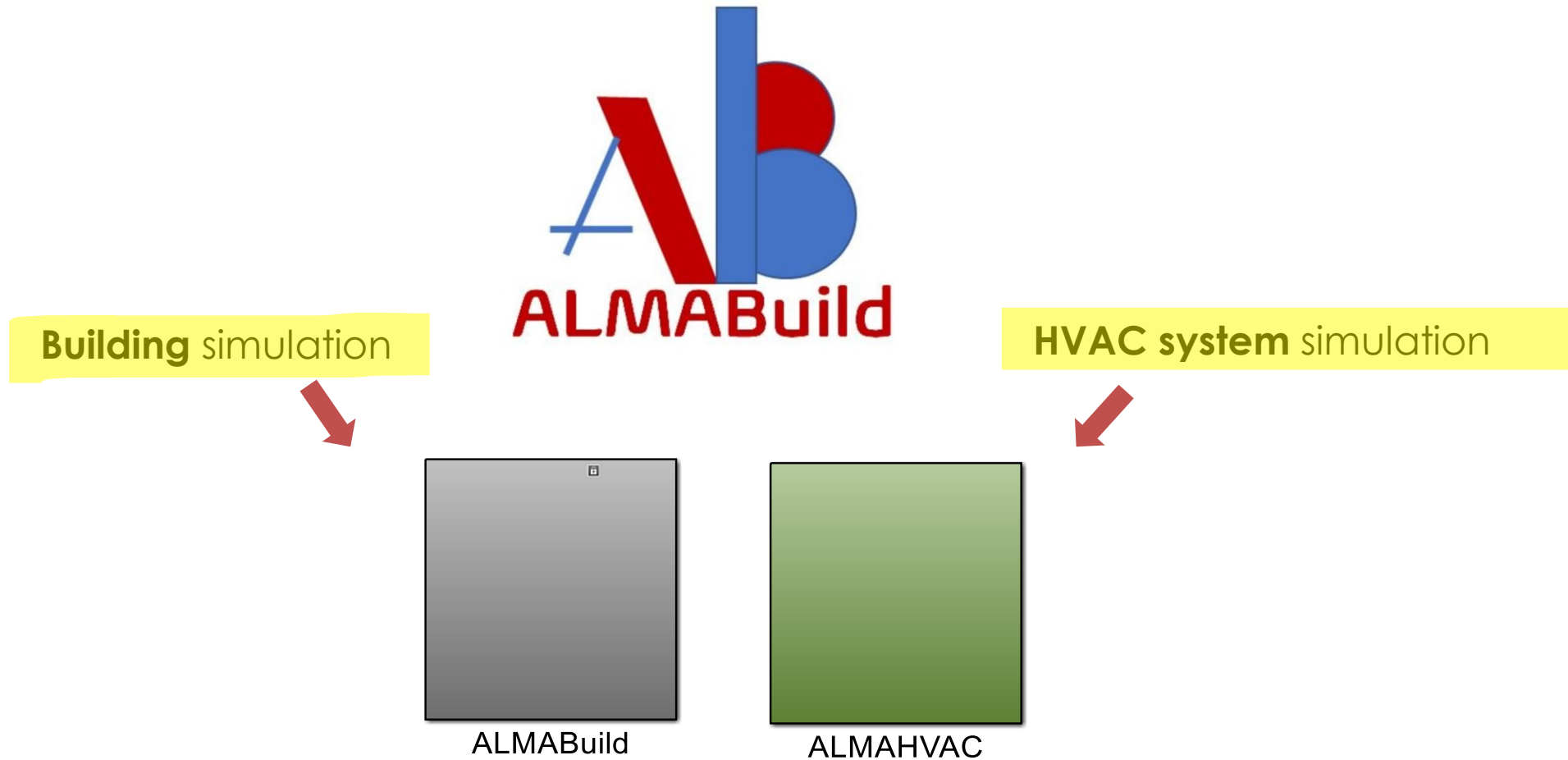


Adoption of another **Simulink-based tool**



ALMABuild

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

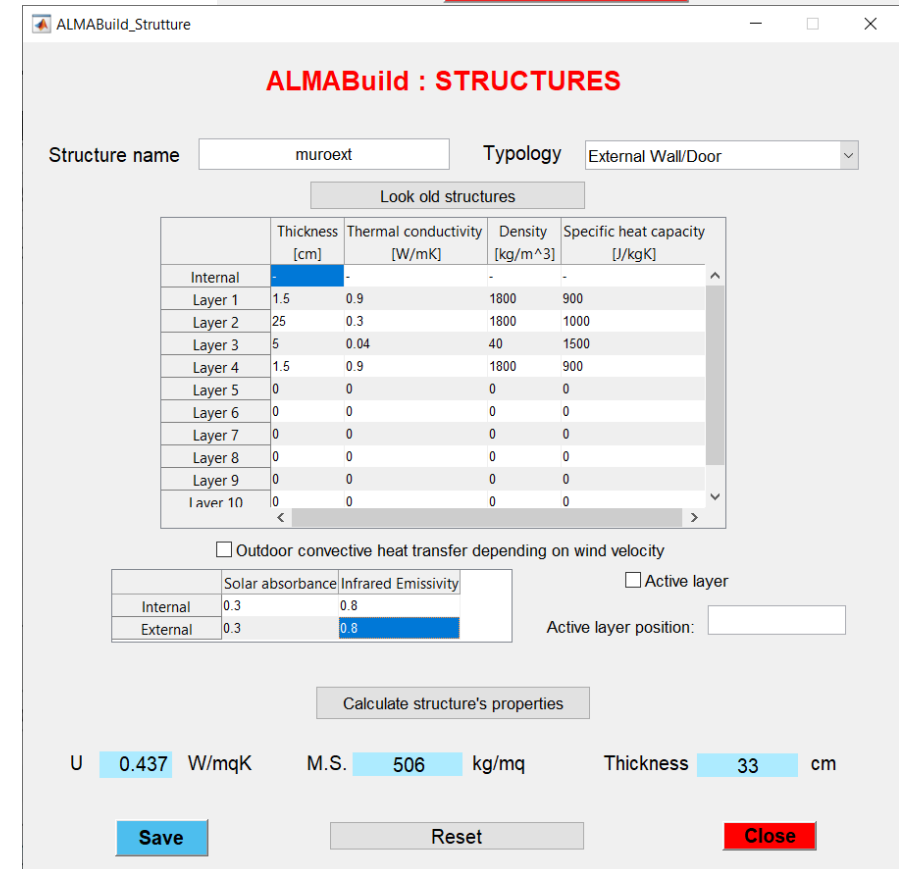
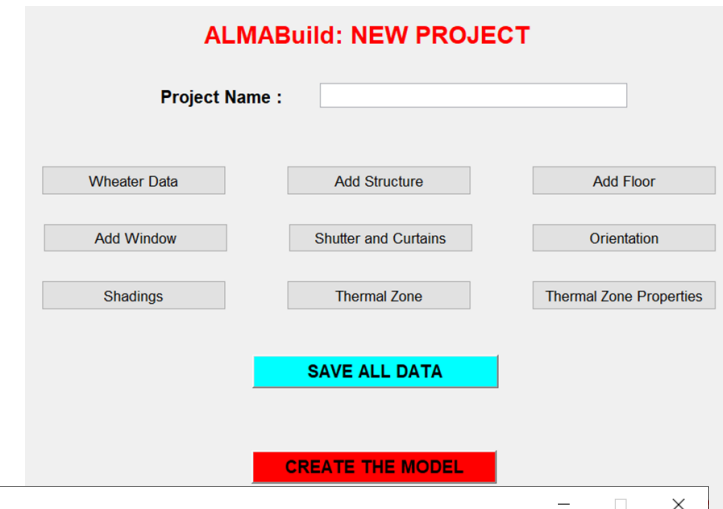


ALMABuild



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>

The screenshot shows the ALMABuild website interface. At the top left is the Alma Mater Studiorum University of Bologna logo. The main title is "ALMABUILD - ENERGY BUILDING DYNAMIC SIMULATION TOOL FOR SIMULINK". A navigation menu includes "HOME", "WHY ALMABUILD?", "HOW DOES ALMABUILD WORK?", "CASE STUDIES & VALIDATION", "DOWNLOAD" (circled in blue), and "CONTACT US". Below the menu is a diagram illustrating the simulation workflow. It features a green box for "Climatic Data", a yellow box for "Second Floor" (containing a "Qdot" block and a "Q_HVAC" block), and a red box for "Intersections". Dashed blue arrows show data flow from "Climatic Data" to "Second Floor". Dashed yellow arrows show bidirectional energy flow between "Second Floor" and "Intersections". A red banner at the bottom of the diagram contains the text: "ALMABuild allows the modelling of a building by means of a series of SIMULINK blocks. Each block can be modified or used as it is." Navigation arrows are visible at the bottom right of the diagram area.



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>

[Home](#) / [Download](#)

Download

ALMABUILD REQUEST FORM (IN PDF)

 [Request form \[pdf 196Kb\]](#)



ALMABuild is an open blockset of SIMULINK elements created by the Applied Thermal Engineering team of the University of Bologna.

ALMABuild is dedicated to students, researchers, architects, engineers and building management professionals.

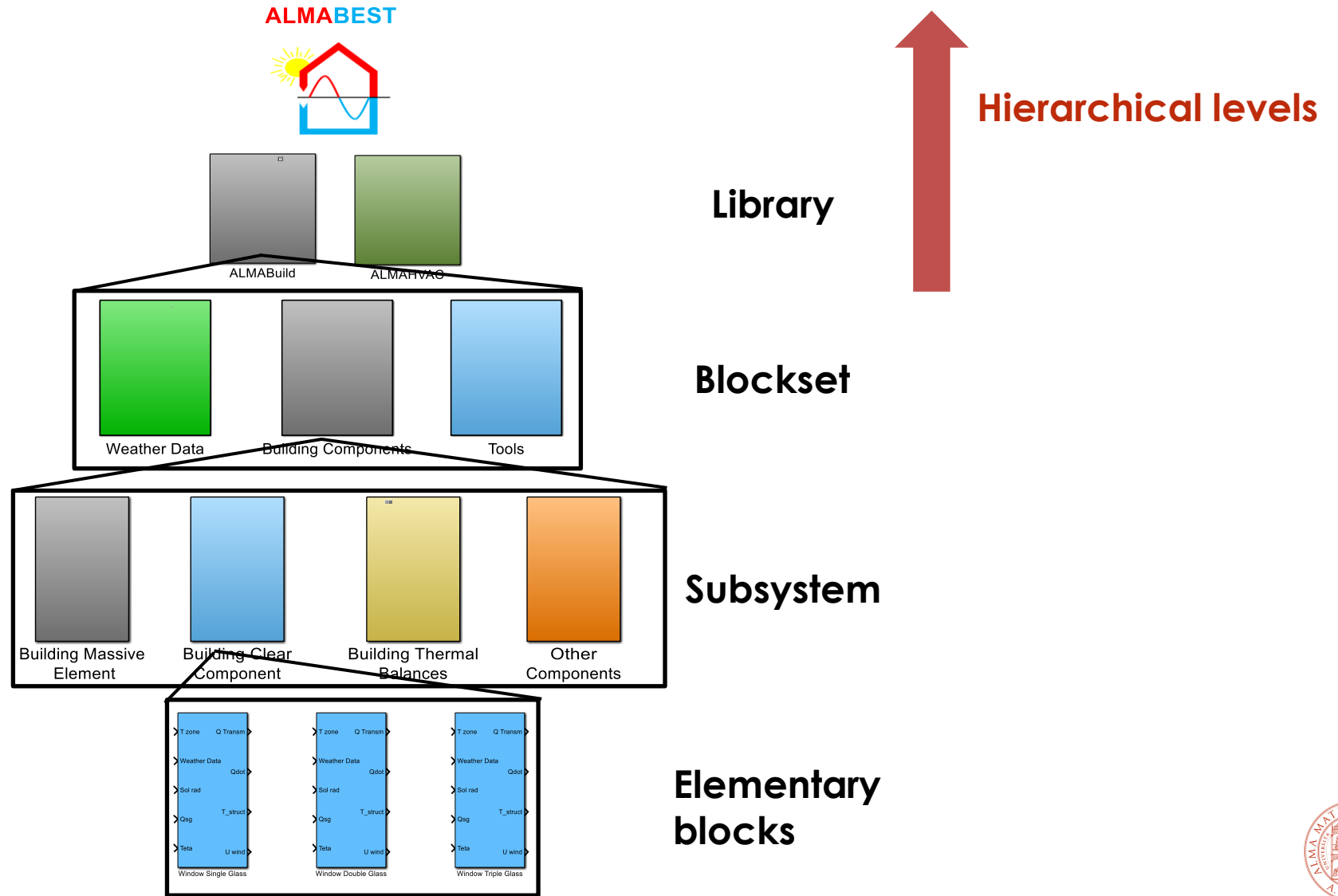
ALMABuild is freely available for users upon filling in the request form available from this page. At least MATLAB R2021a and a Simulink licence are required to run the tool!

The signed request form has to be sent by e-mail to:

Dr. Claudia Naldi (e-mail: claudia.naldi2@unibo.it)

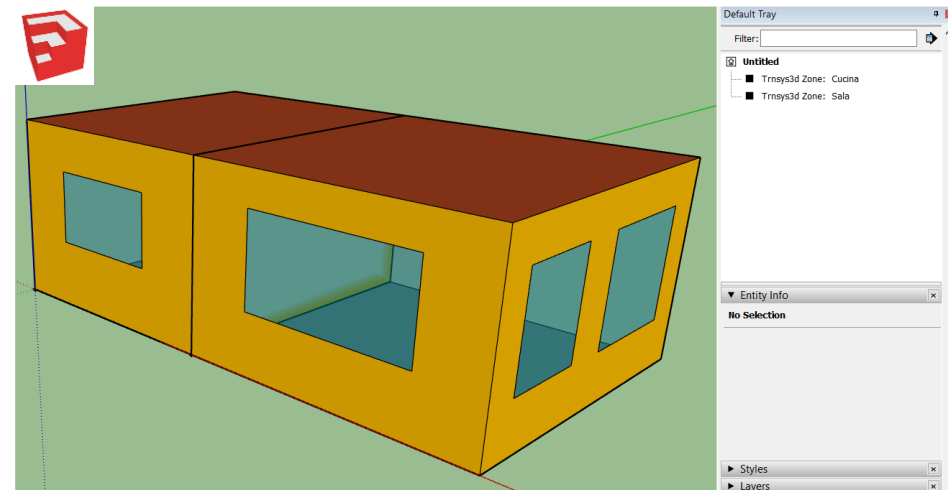
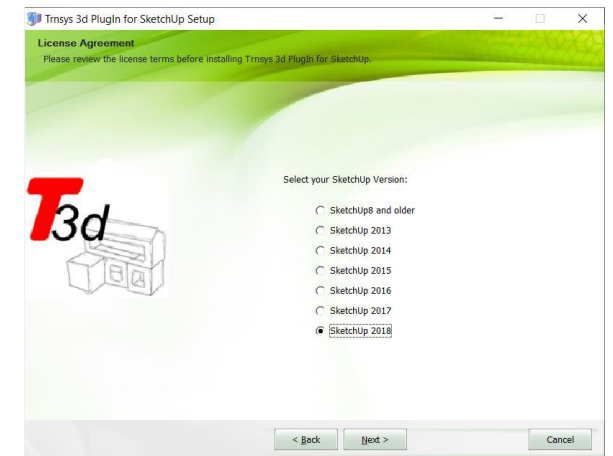
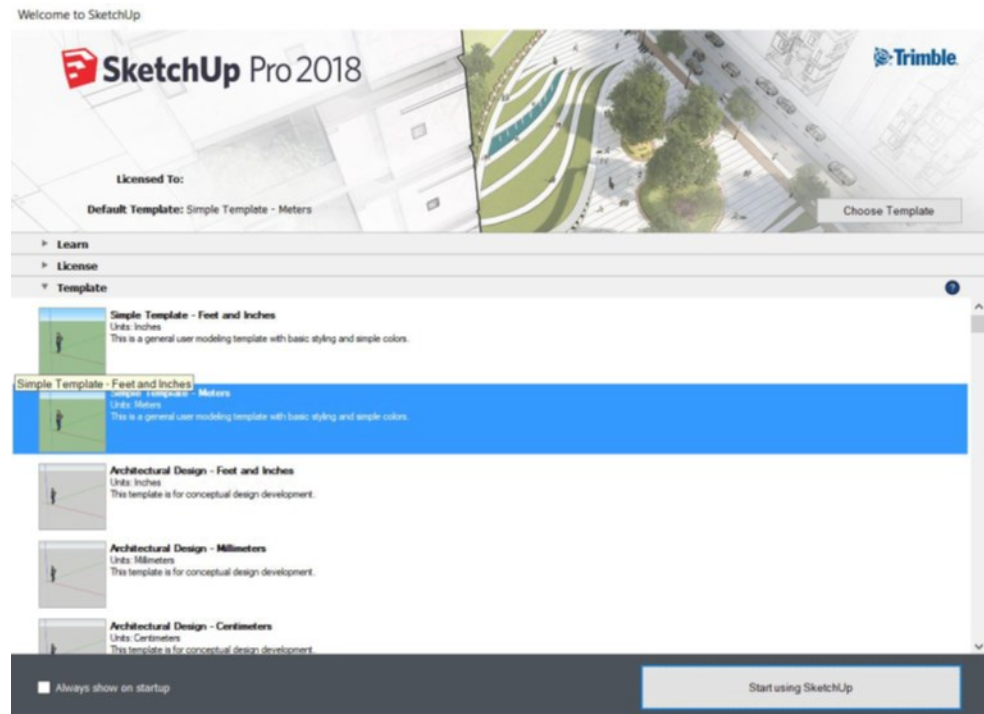


ALMABuild

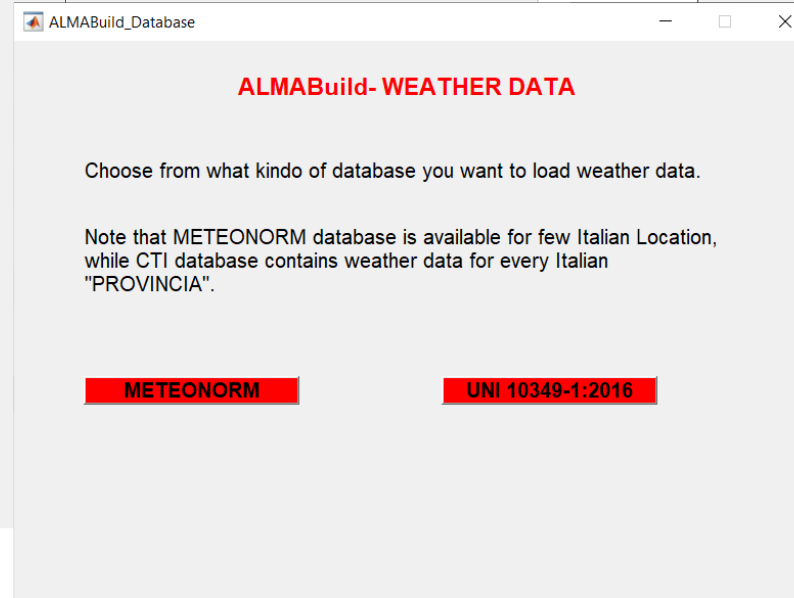
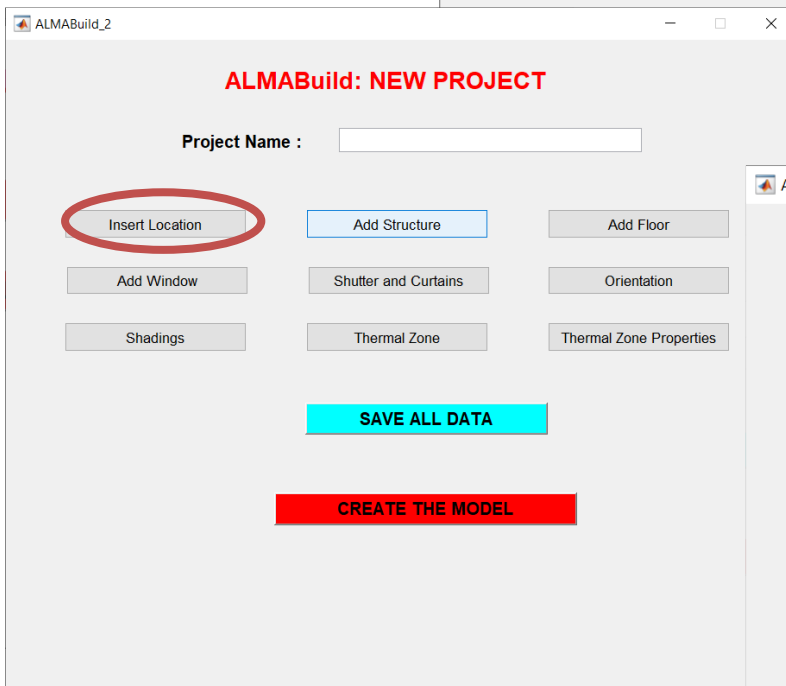
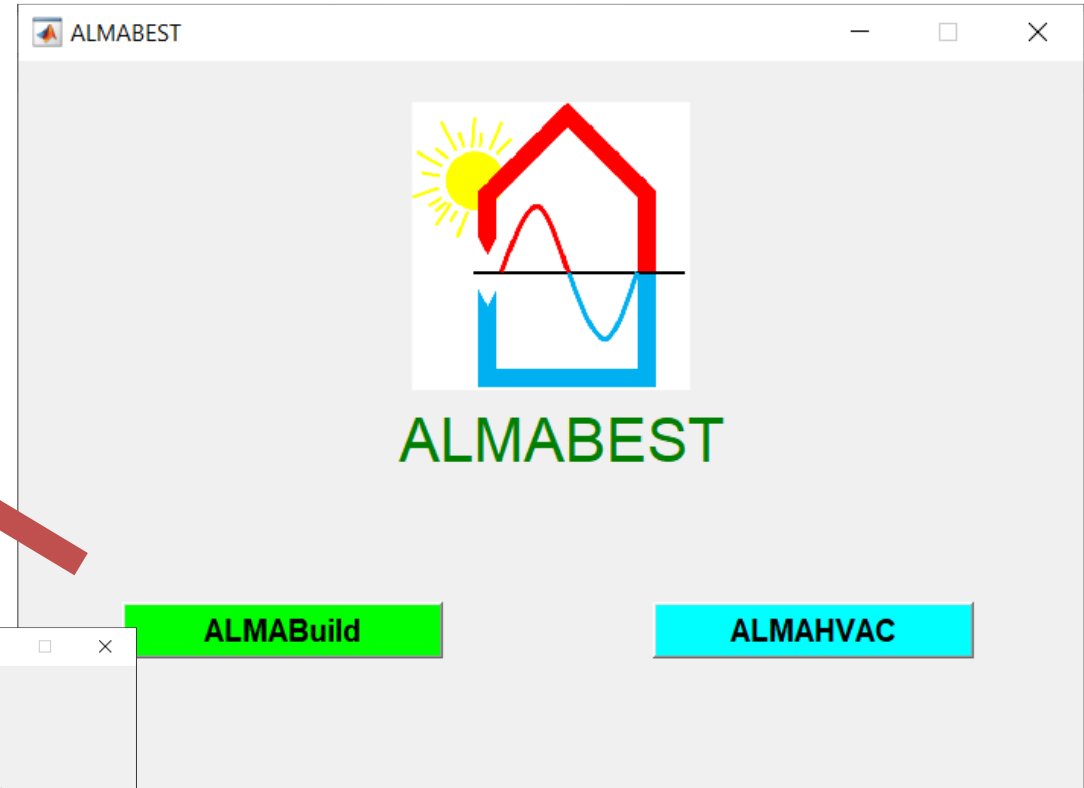
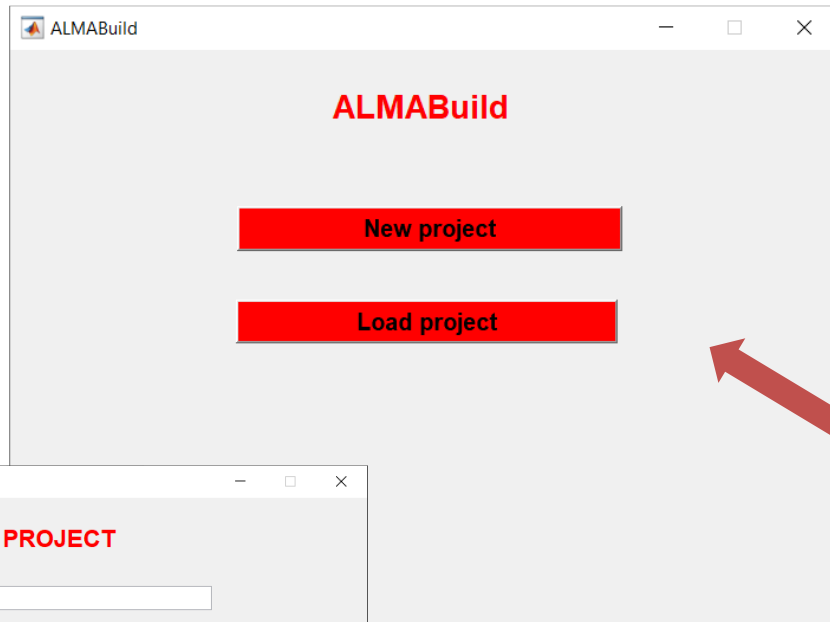


ALMABuild

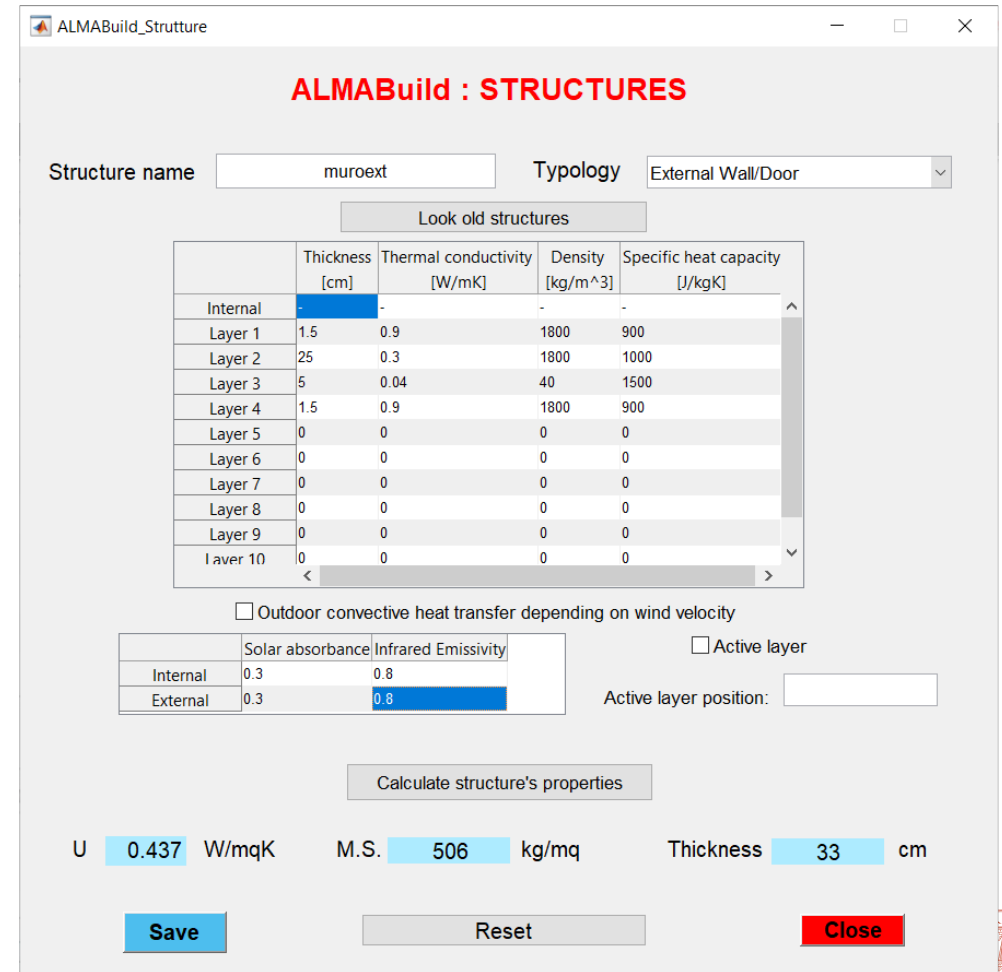
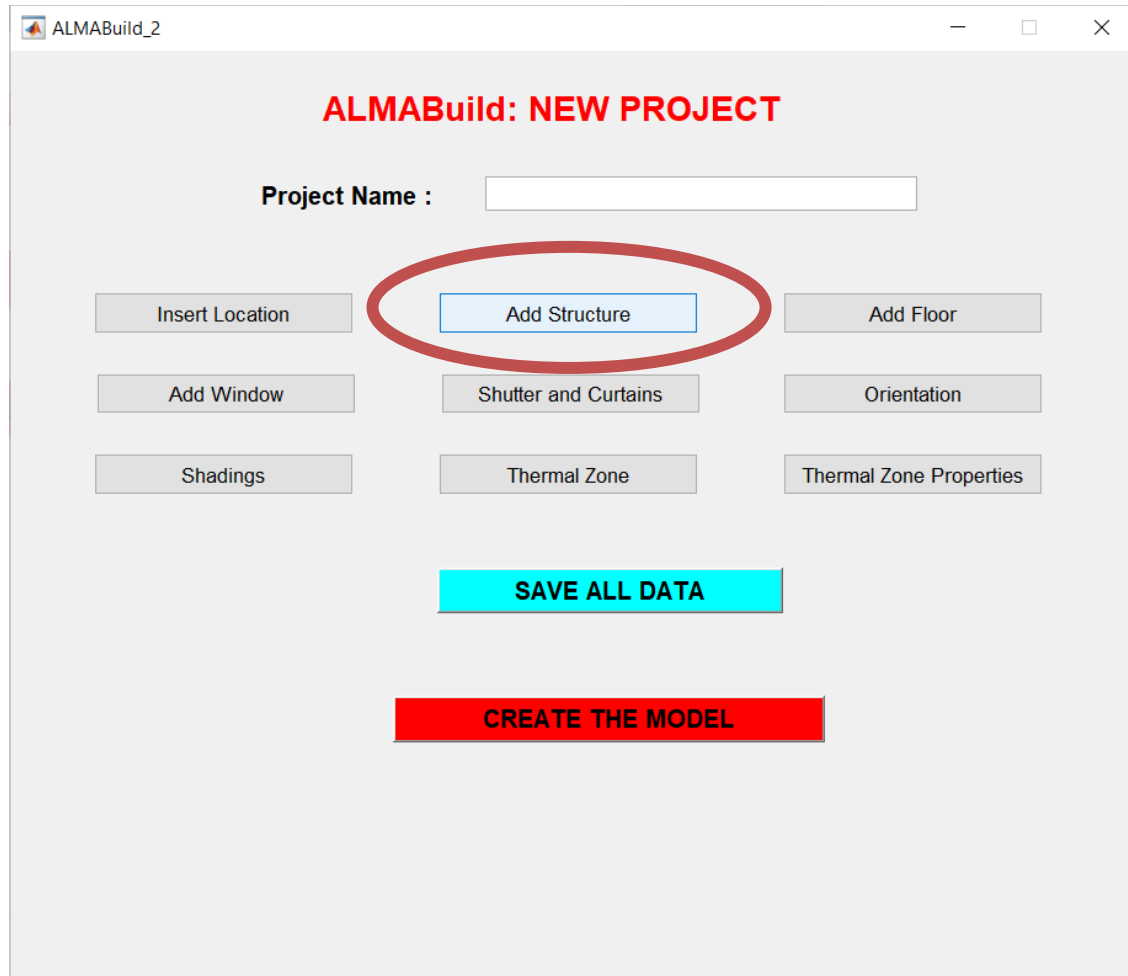
- 3D modeling of the building through **Google SketchUp** and plugin **Trnsys3D** (free)
- Modeling of Multizone building and **automated geometry export** from Google SketchUp to ALMABuild



ALMABuild: Graphical User Interfaces (GUIs)



ALMABuild: Graphical User Interfaces (GUIs)



ALMABuild: Graphical User Interfaces (GUIs)

ALMABuild_2

ALMABuild: NEW PROJECT

Project Name :

ALMABuild_Finestre

ALMABuild : WINDOW

Name

Outdoor convective heat transfer depending on wind velocity

U value W/(m² K) Number of panes

OPTICAL PROPERTIES

	0	10	20	30	40	50	60	70	80	90	Hemis
Tsol	0.462	0.465	0.458	0.448	0.436	0.412	0.36	0.263	0.121	0	0.384
Abs1	0.114	0.114	0.116	0.120	0.125	0.132	0.130	0.146	0.147	0	0.128
Abs2	0.186	0.188	0.195	0.199	0.198	0.197	0.199	0.186	0.118	0	0.198
Rfsol	0.237	0.232	0.231	0.233	0.241	0.260	0.303	0.406	0.614	1	0.289
Rbsol	0.179	0.172	0.170	0.173	0.183	0.202	0.239	0.328	0.542	0.999	0.227

GAS PROPERTIES

	Thick [mm]	Cond [W/m K]	dCond *10 ⁻⁵	Visc [kg/m s] *10 ⁻⁵	dVisc *10 ⁻⁸	Dens [kg/mc]	dDens	Pr	dPr [1/K]
Gap1	16	0.0162	5	2.11	6.3	1.78	-0.006	0.68	0.00066

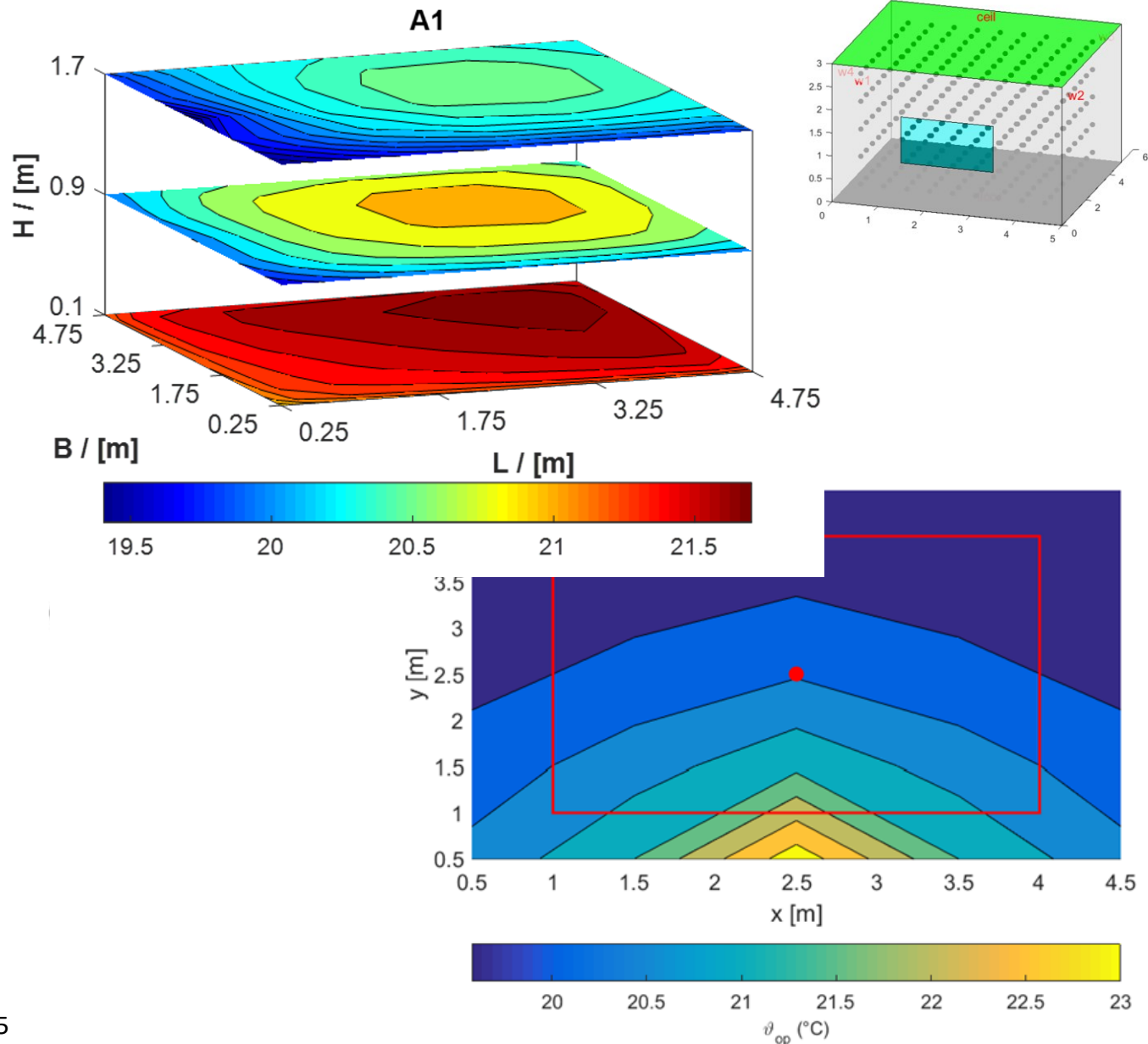
GLASS PROPERTIES

	Glass1	Glass2
Emissivity Front	0.84	0.1
Emissivity Back	0.84	0.84
Thickness [mm]	4	4
Conduc. [W/m ² K]	225	225

FRAME PROPERTIES

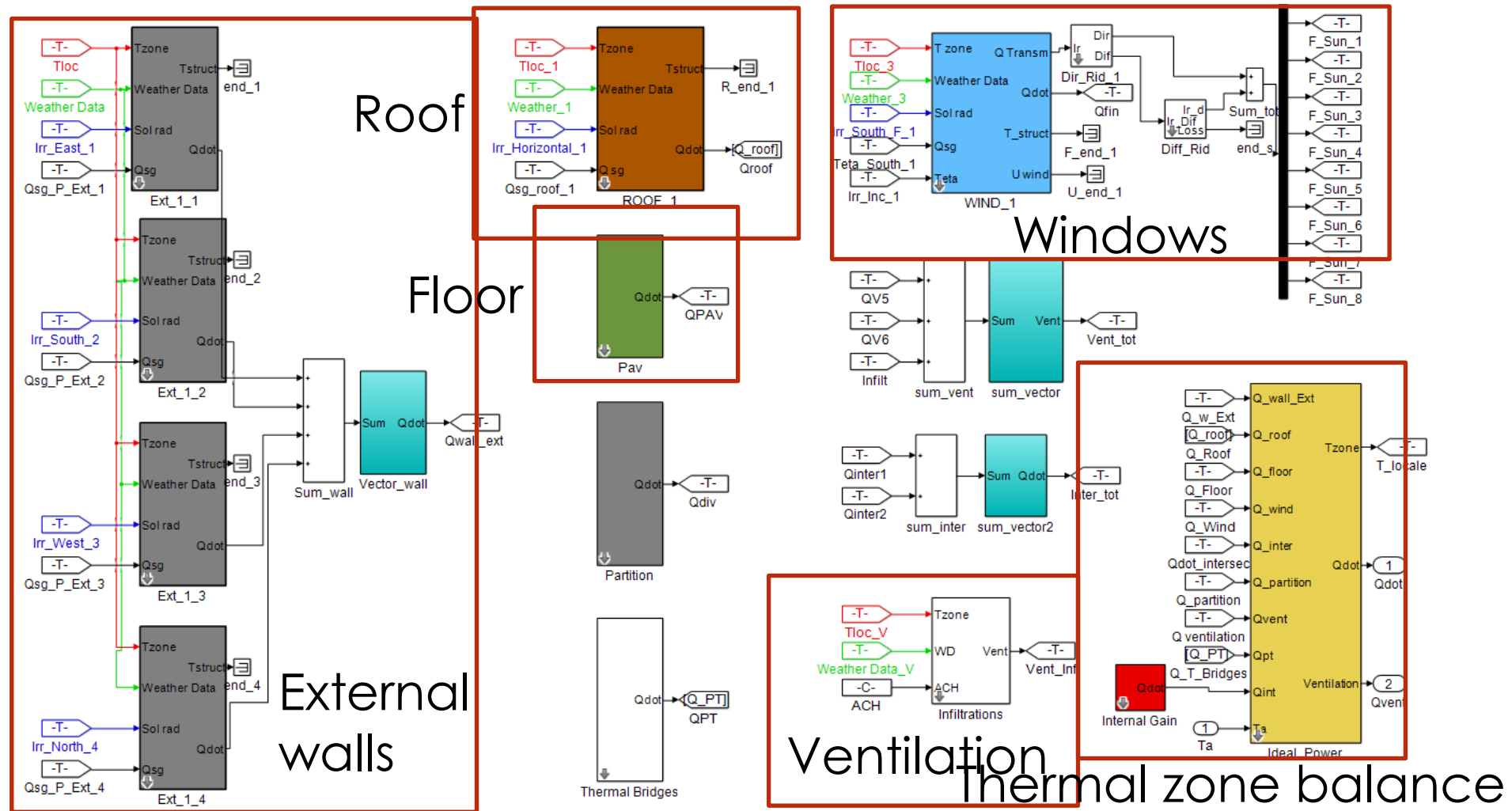
	Frame
F factor[%]	20
Uframe	2.27
Abs	0.6
Emis	0.9

ALMABuild: Graphical User Interfaces (GUIs)



The screenshot shows the 'ALMABuild- THERMAL ZONE PROPERTIES' window. It includes fields for 'Floor', 'Thermal zone name', 'Internal Volume' (m³), and 'Initial Air Temperature' (°C). There are buttons for 'Show Thermal Zone', 'Look Thermal Zone already defined', 'Internal Gains', 'Ventilation', and 'Thermal Bridges'. The 'Choose model' section has buttons for 'Simple model', 'Radiative model', 'Convective model', and 'Fully detailed model'. The 'Geometry' field is marked 'NOT DEFINED'. There are 'SAVE', 'RESET', and 'CLOSE' buttons. Red arrows point from the 'Simple model' button to the equation $1 T_{air} + 3D T_{rad}$, from the 'Radiative model' button to $3D T_{air} + 1 T_{rad}$, and from the 'Fully detailed model' button to $3D T_{air} + 3D T_{rad}$.

ALMABuild: automatic implementation in Simulink

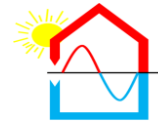


ALMAHVAC

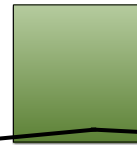
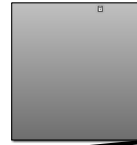


Hierarchical levels

ALMABEST



Library



Subsystem



Heat Sources



Hydraulic



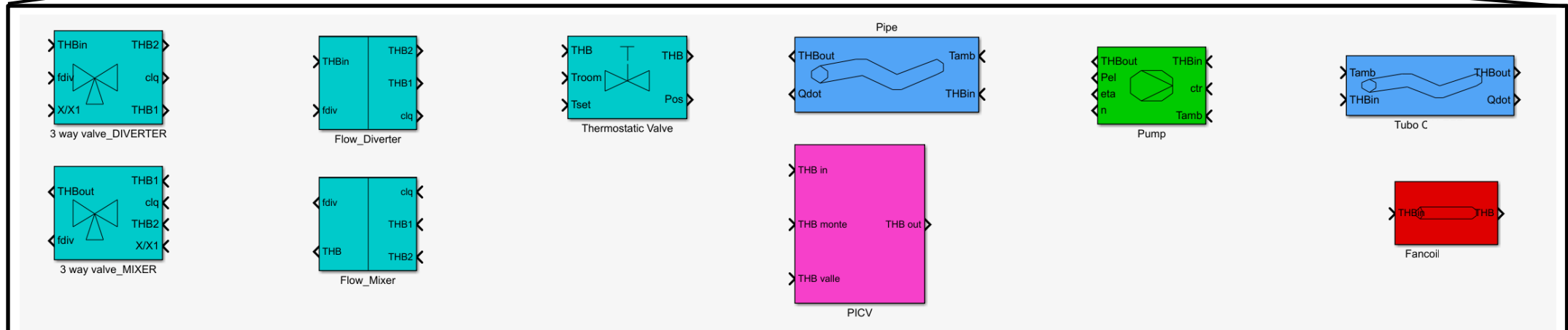
Emitter



Control

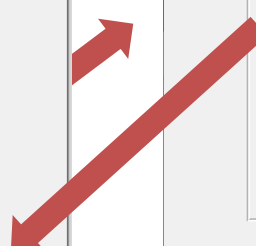
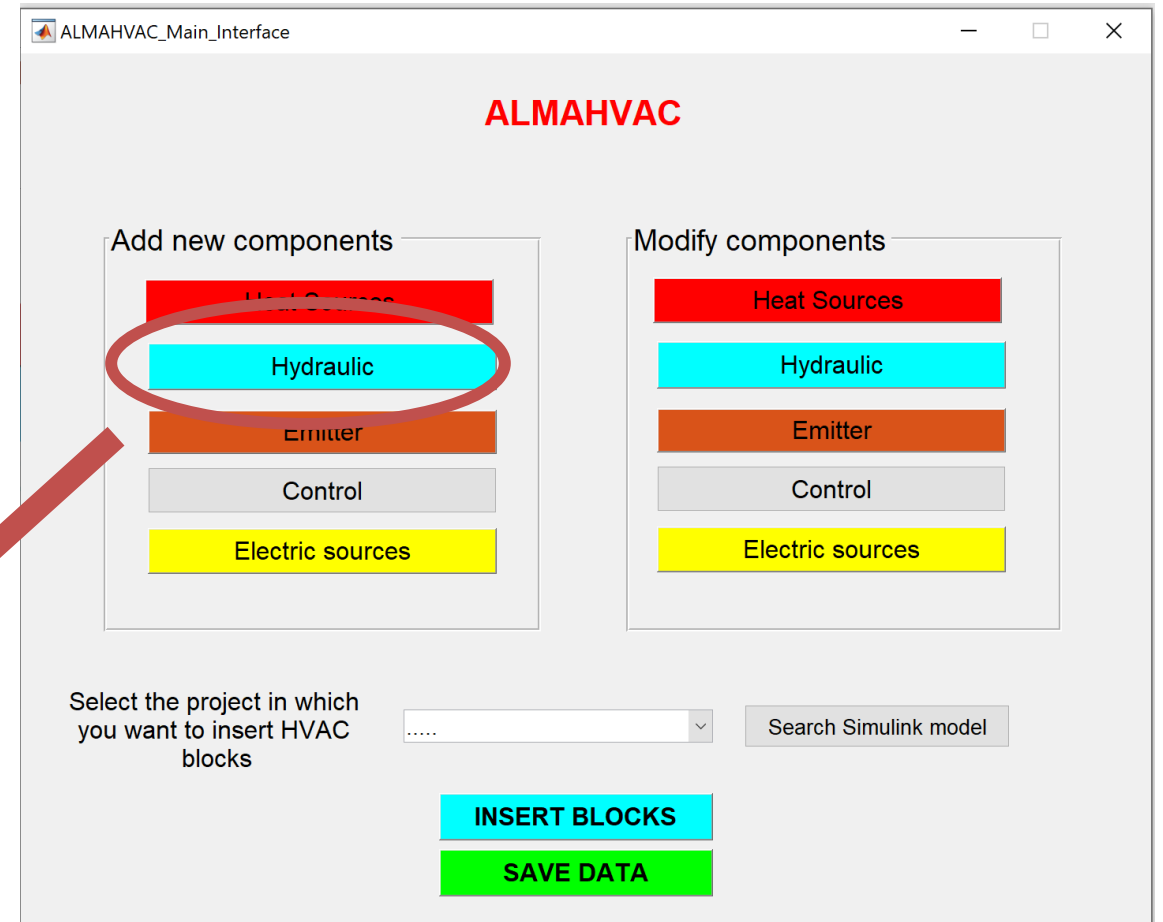
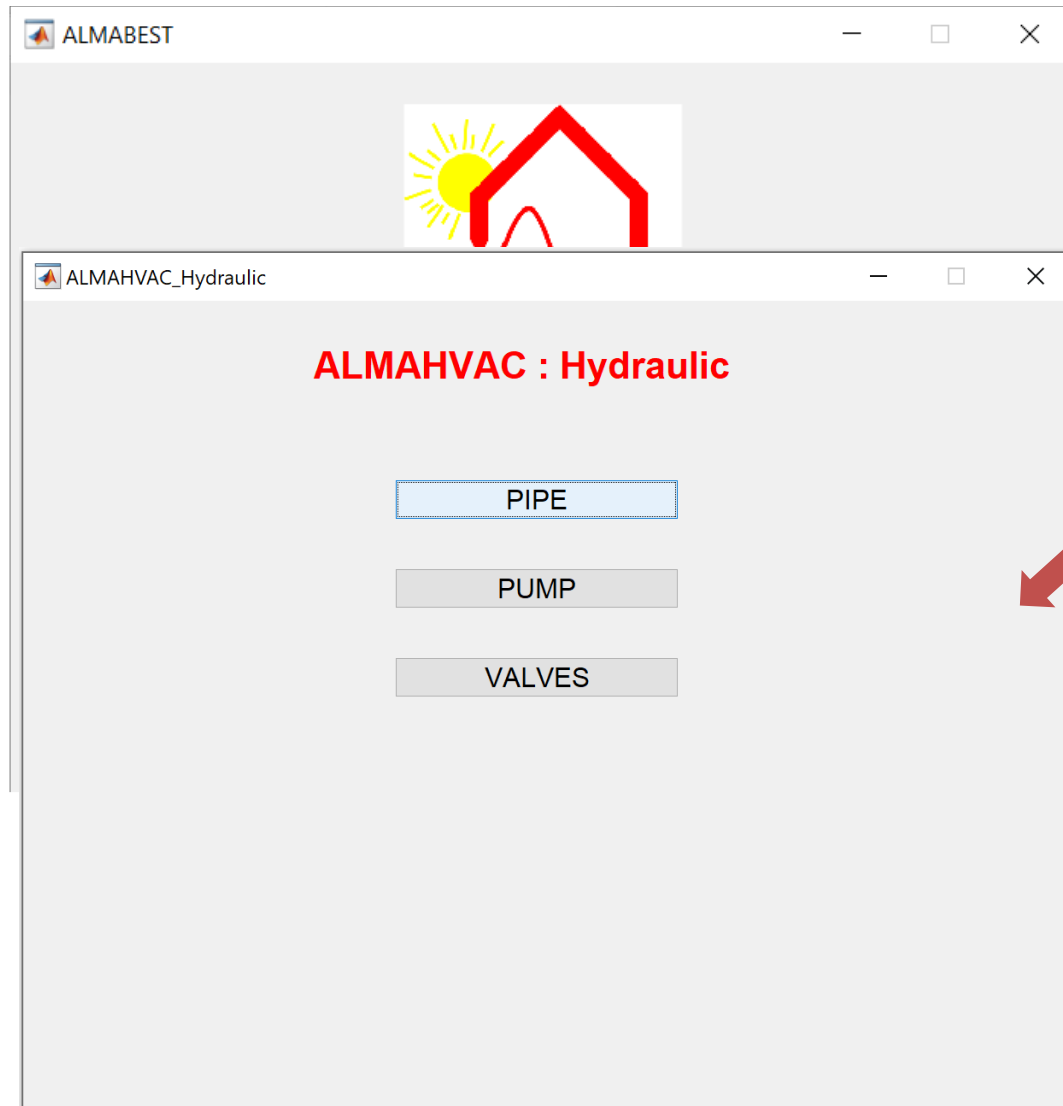


Tools



Elementary blocks

ALMAHVAC: Graphical User Interfaces (GUIs)



Case study: Optimization problem

Building characteristics

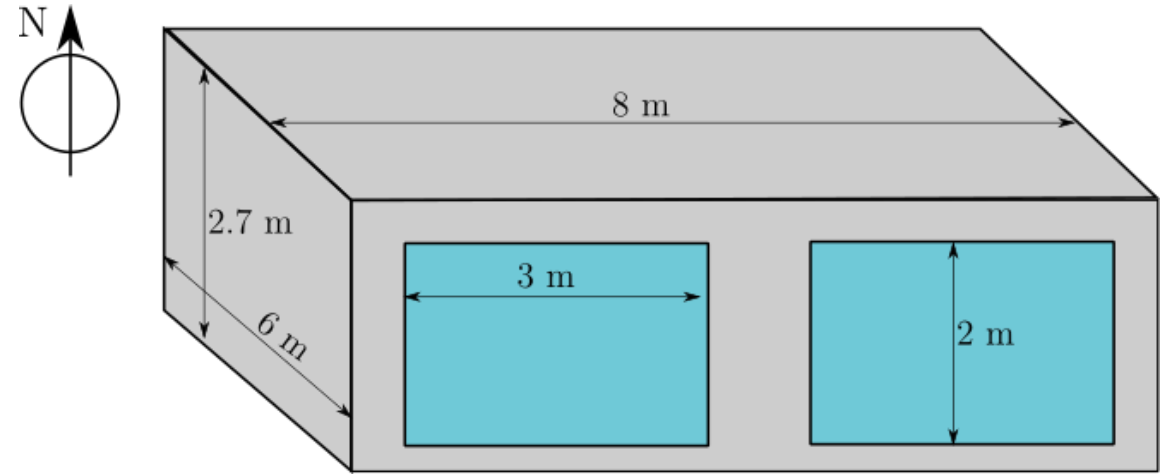
- 2 windows: South
- Set-point temperatures: 20 °C; 26 °C

Parameters to be optimized

- **Insulation layer thickness:** 0 – 30 cm
- **Windows total area:** 6 – 21 m².

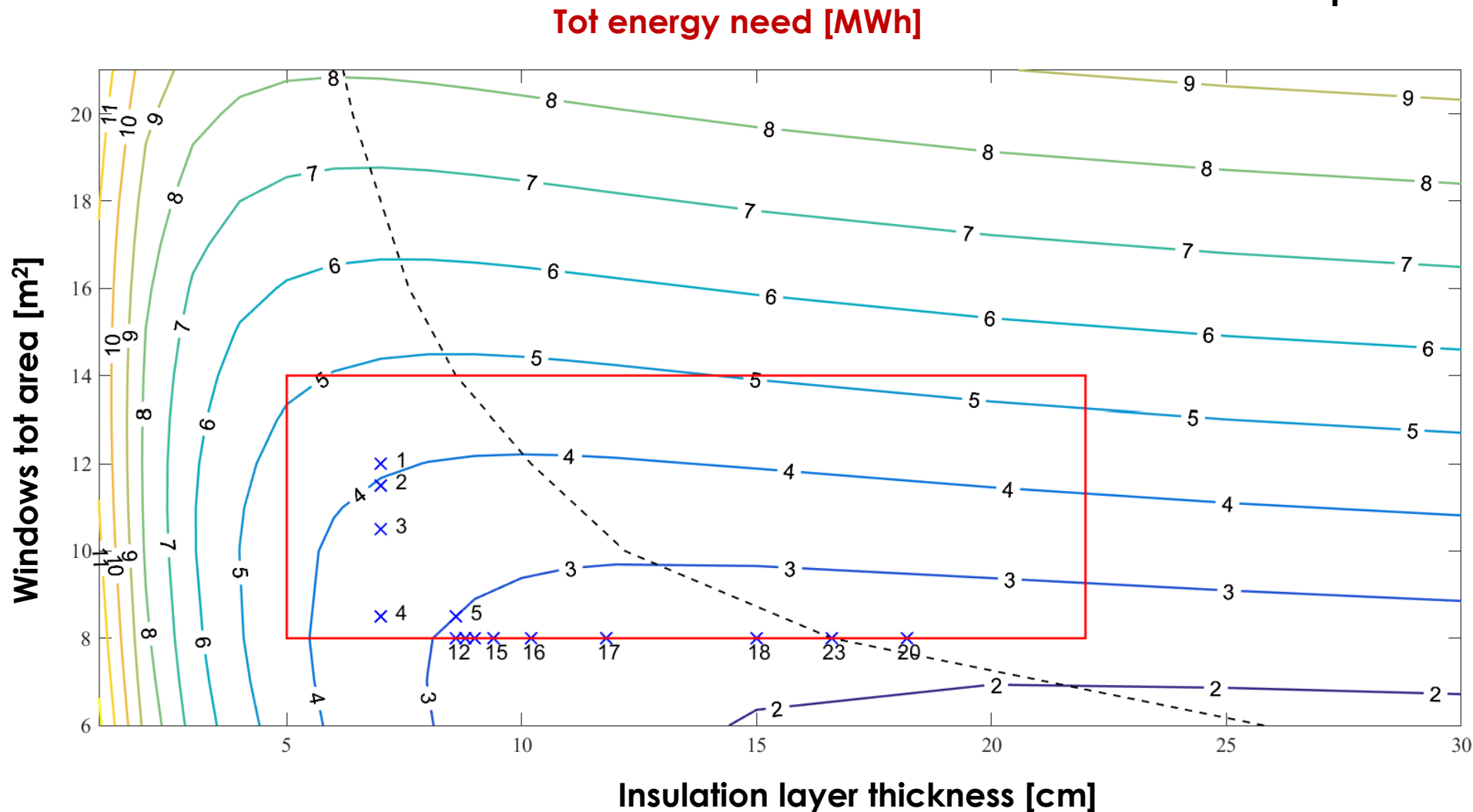
Objective function

Minimum total energy need (heating and cooling)



Case study: Optimization problem

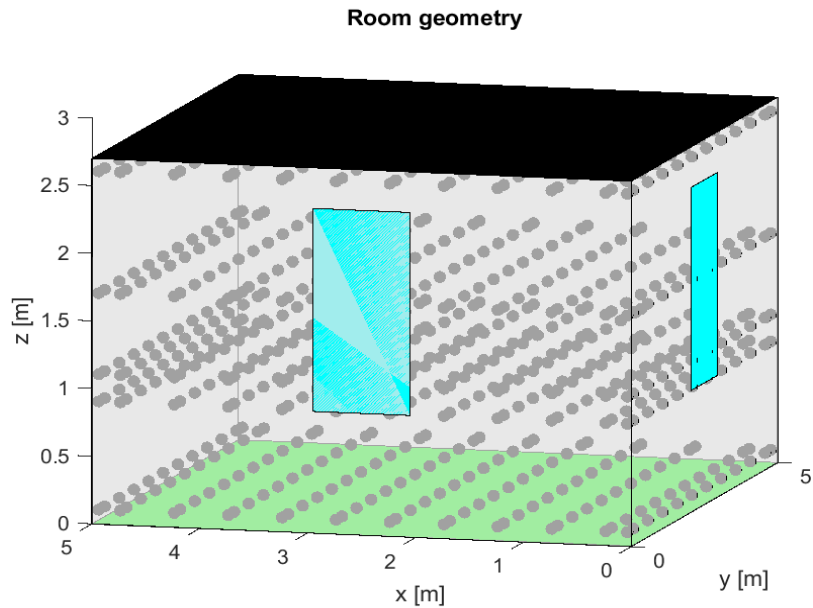
Matlab Optimization Toolbox



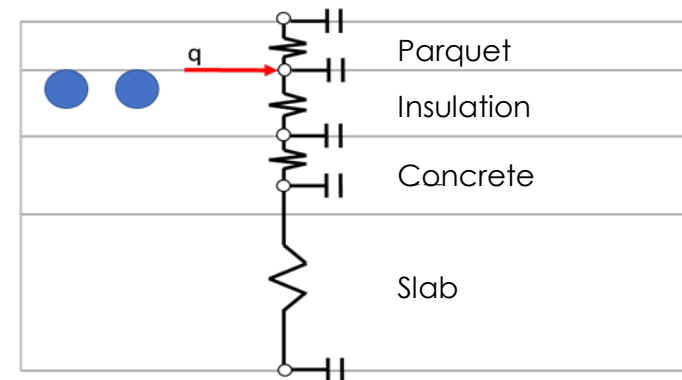
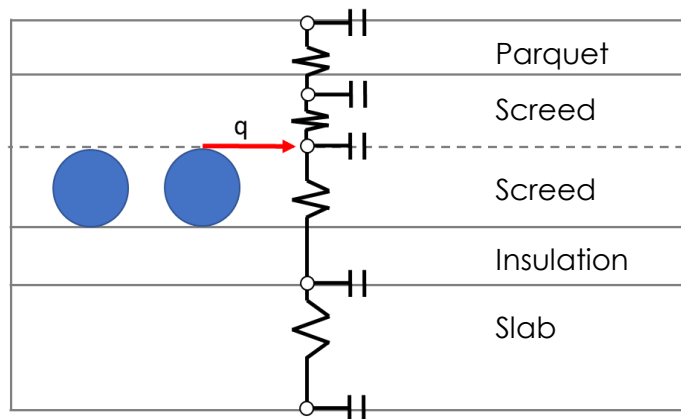
Only **64** simulated configurations instead of **988!**
Sim time saved: **94%**.



Case study: Radiant floor heating

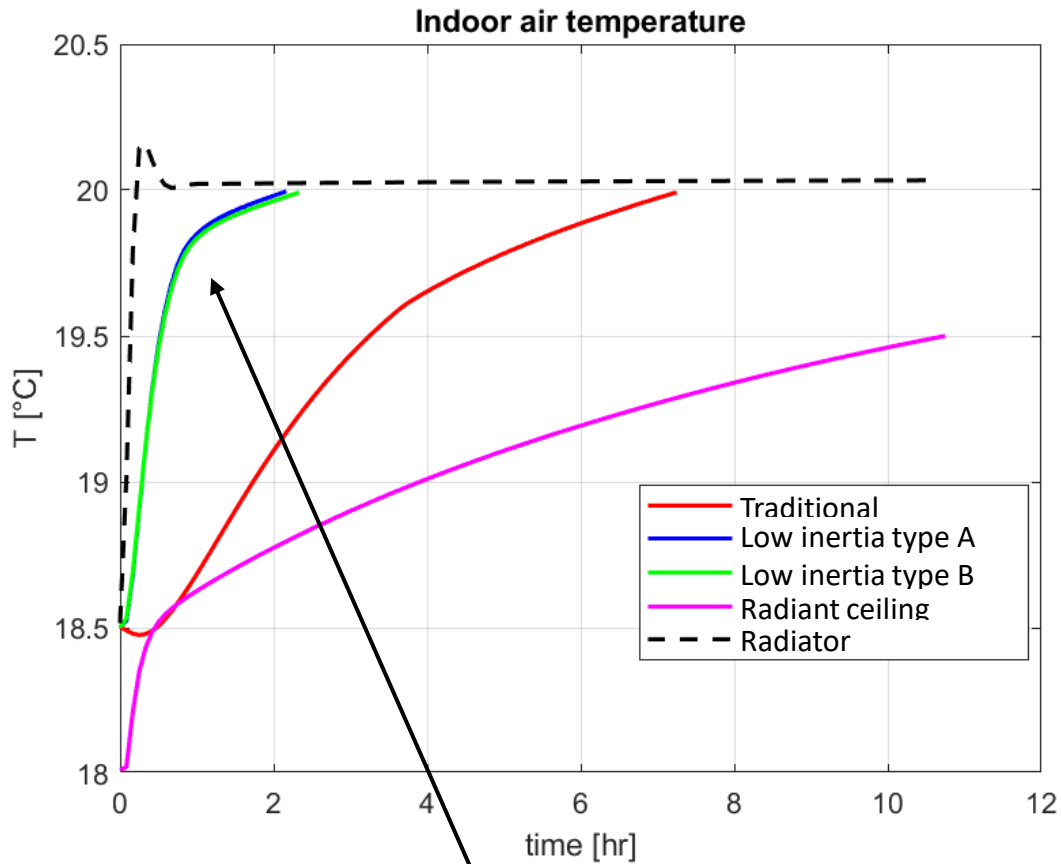


- Location: **Bologna**
- Thermal design load: **756 W**
- Set-point temperature: **20 °C** (DB=0.5 K)
- 5 typologies of emitter:
 - **Radiator**
 - **Radiant ceiling**
 - **Radiant floor**



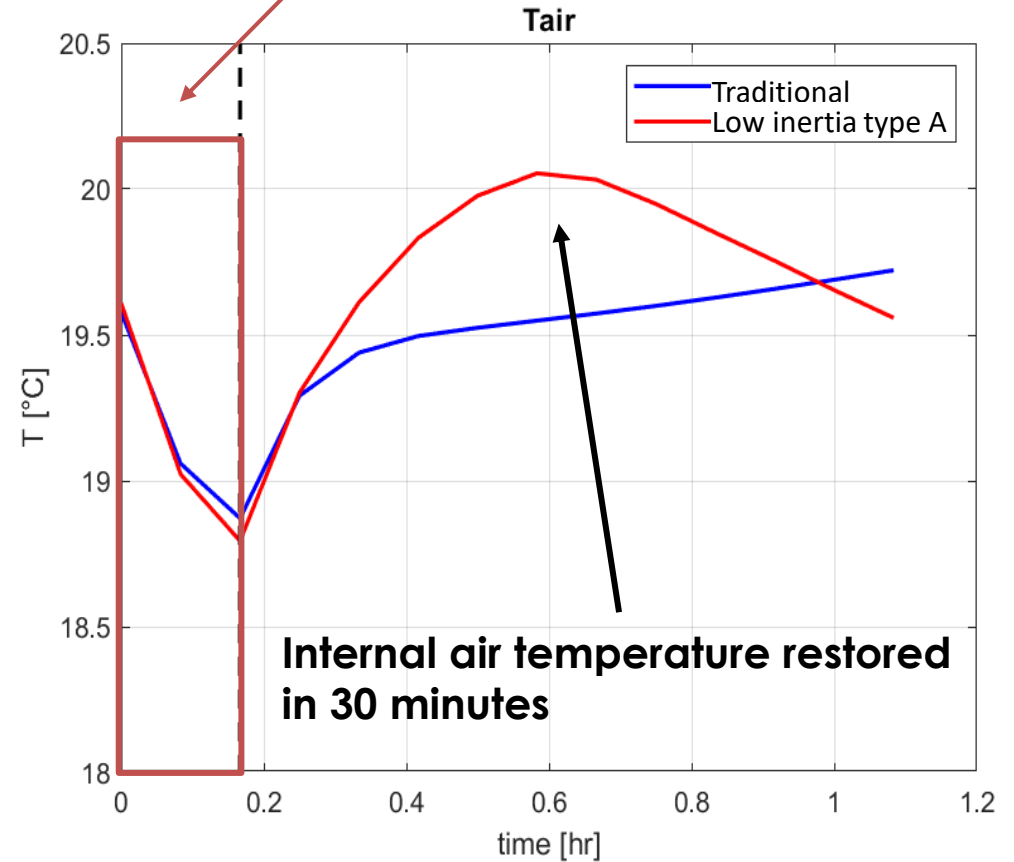
Case study: Radiant floor heating

Start-up transient



Very fast response for low-inertia radiant floor

Windows opening (10 min)



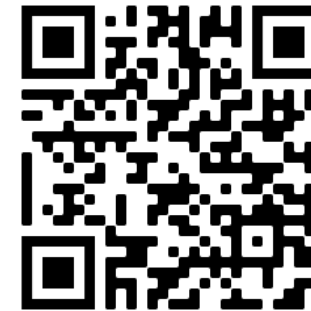
Conclusions

- **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**





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

Thank you for your attention

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A special thanks to Dr. Jean Pierre Campana

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