Dynamic simulations with ALMABEST: ALMABuild e ALMAHVAC – CARNOT

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Alma Mater Studiorum – University of Bologna

Contents

ALMABEST

- ALMABEST: dynamic modeling of buildings → ALMABuild
- ALMABEST: dynamic modeling of HVAC systems → ALMAHVAC
- ALMABEST: an application case study

ALMABEST (Building Energy Simulation Toolbox)

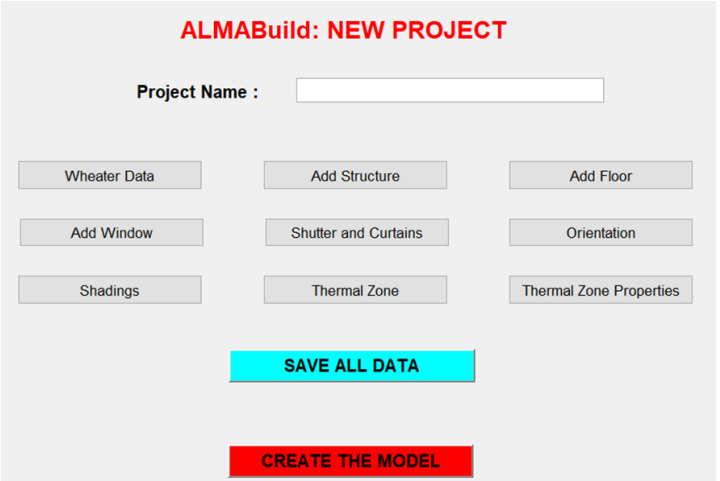
Tool operating in the Simulink environment for the simulation of coupled **building-HVAC systems** under dynamic operating conditions

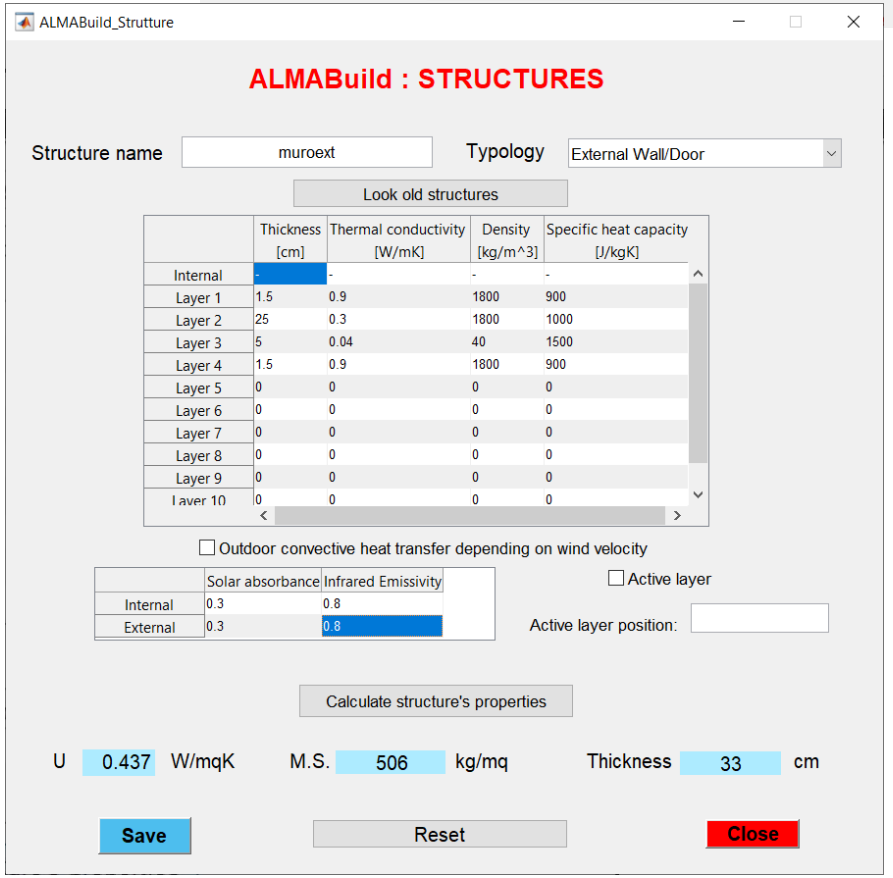
Bu tion

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

ALMABEST (Building Energy Simulation Toolbox)

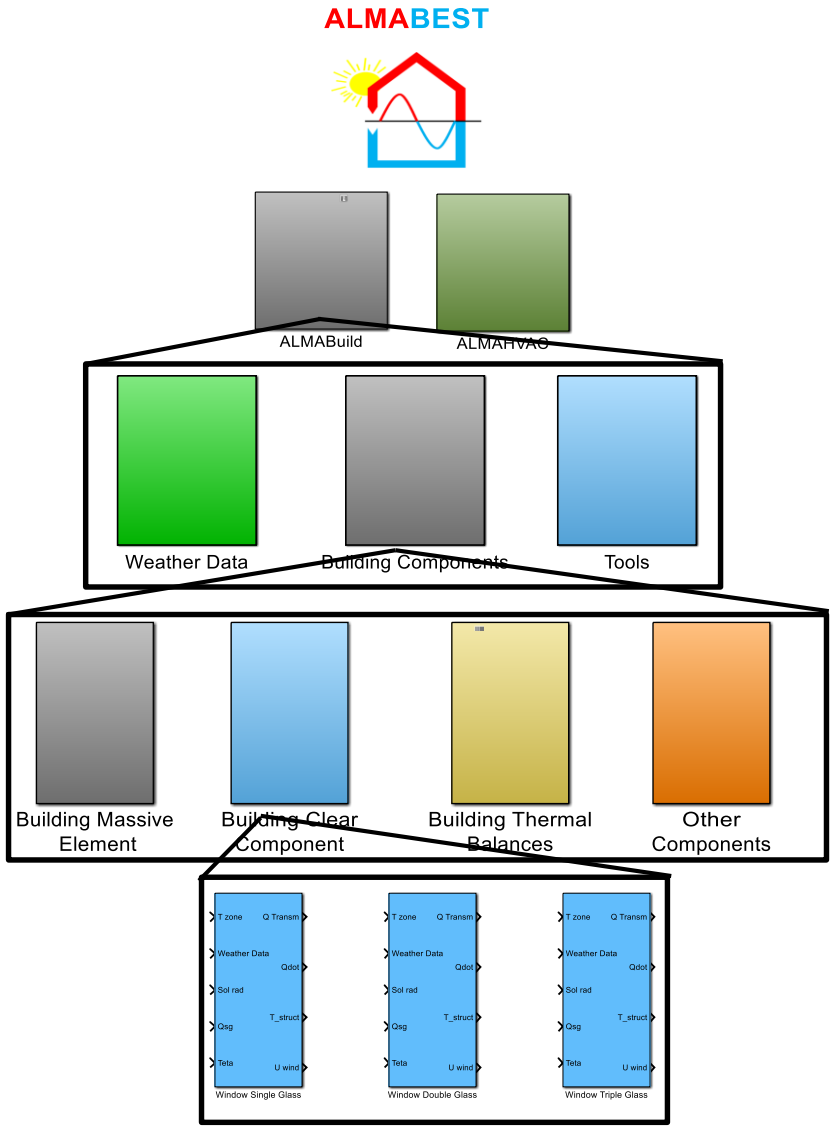
Automated building **implementation** in Simulink through Graphical User Interfaces (**GUIs**)





- **Fast** process
- **Limitation** of users' **errors**
- **No experience** required in Simulink or building modelling
- **No** necessity of **co-simulation**
- Building model **validated**
- **Variable time-step** suitable for HVAC system (seconds)
- **Compatibility** with **CARNOT**
- **Selection** of **the level of detail** in simulation and resolution of **optimization problems**

ALMABuild



Library

Blockset

Subsystem

Elementary blocks

Hierarchical levels

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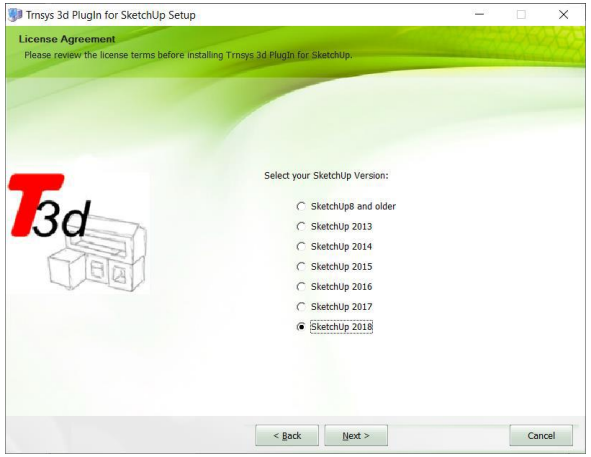
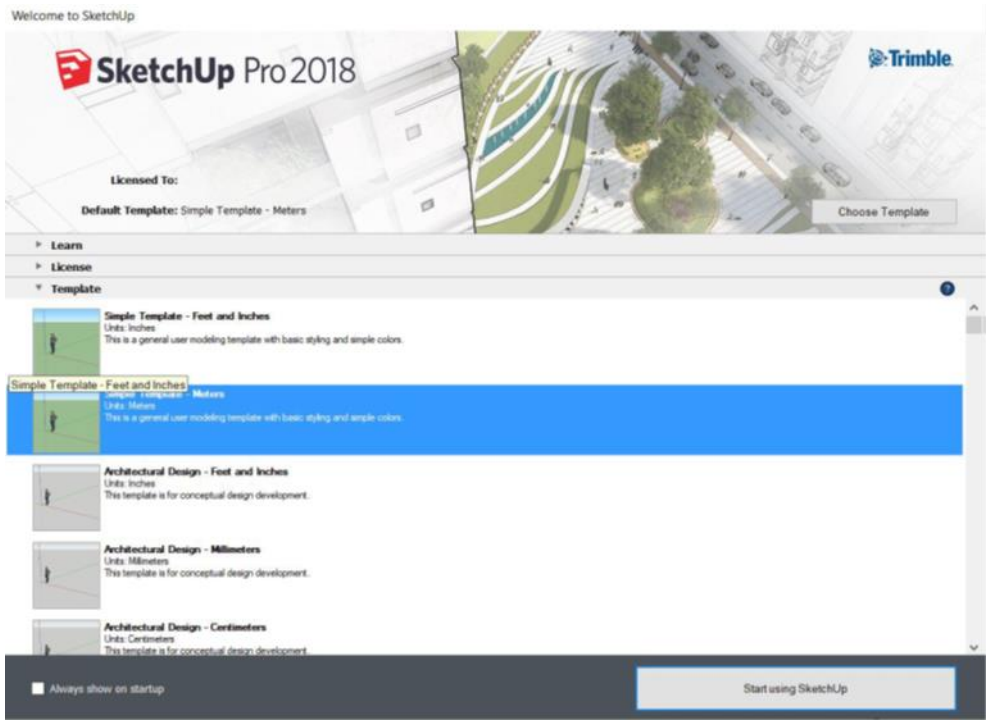
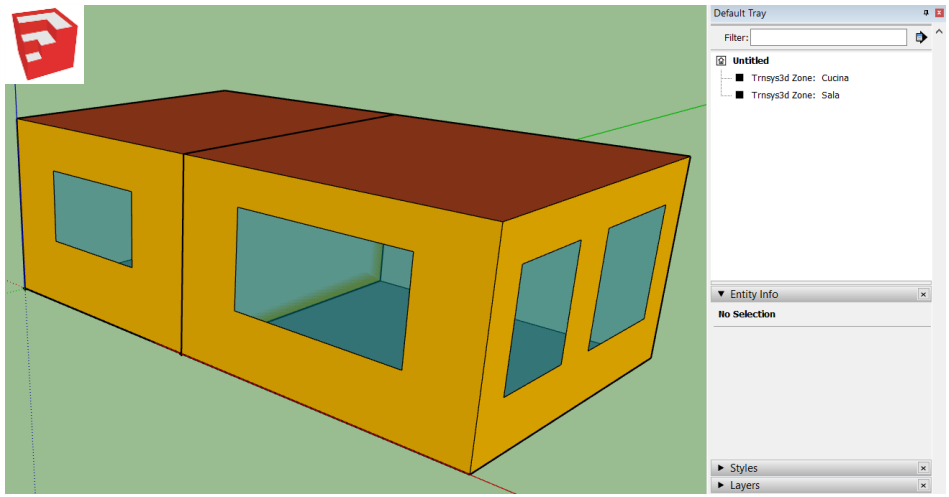
ALMABuild: 3D modeling of buildings

3D modeling of the building through **Google SketchUp** and plugIn **TRNSYS 3D** (free)

Modeling of Multizone building and **automated geometry export** from Google SketchUp to ALMABuild







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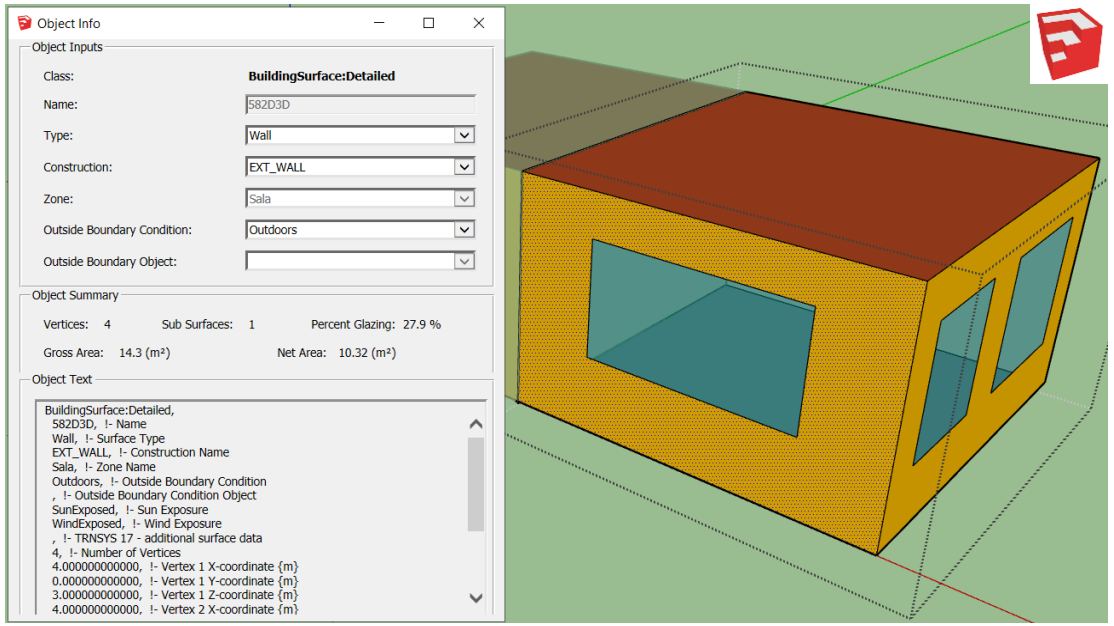
ALMABuild: 3D modeling of buildings



User draws 3D geometry of buildings, selecting the typology of each envelope element: **Floor/Wall/Ceiling/Roof**

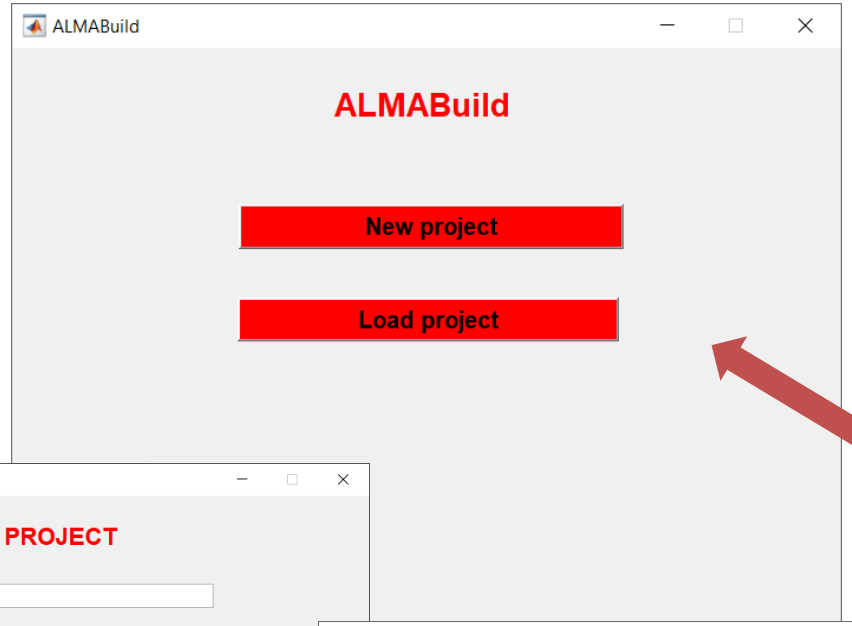
esempio.idf

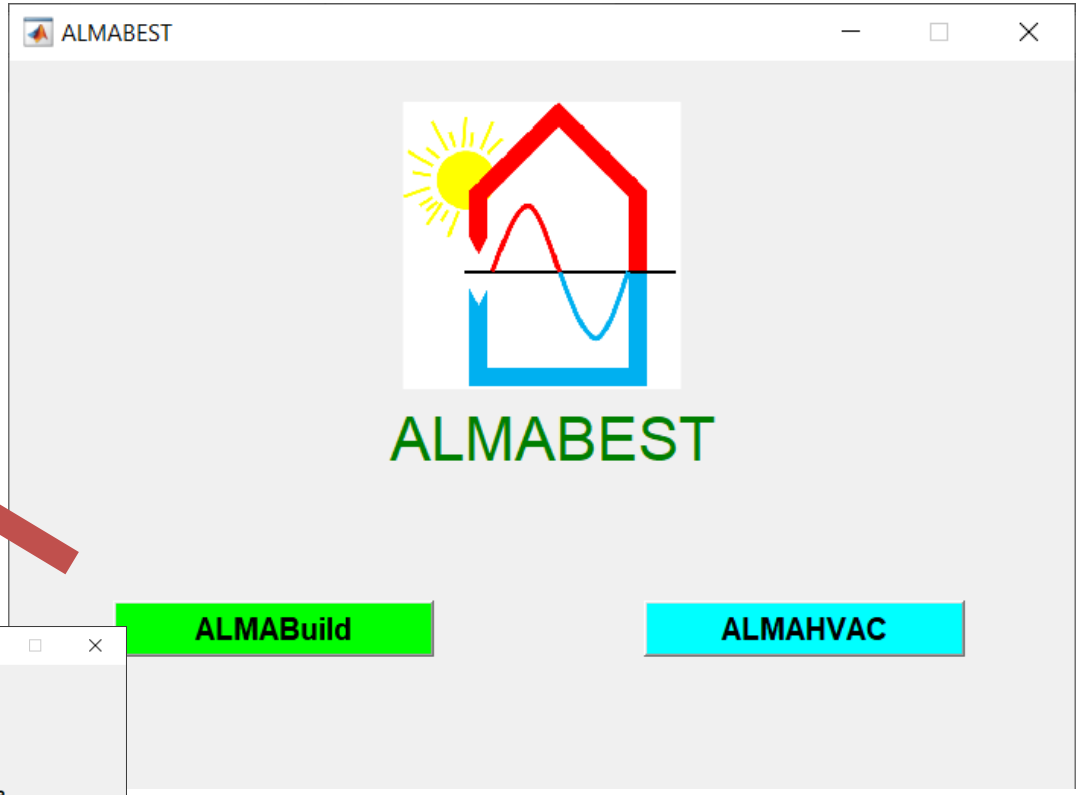
```
403   Zone,
404     Cucina,  !- Name
405     0.0,  !- Direction of Relative North {deg}
406     0.0,  !- X Origin {m}
407     0.0,  !- Y Origin {m}
408     0.0,  !- Z Origin {m}
409     ,  !- ZONE_TYPE
410     1;  !- Multiplier
411
412   BuildingSurface:Detailed,
413     CEA875,  !- Name
414     Floor,  !- Surface Type
415     GROUND_FLOOR,  !- Construction Name
416     Cucina,  !- Zone Name
417     Ground,  !- Outside Boundary Condition
418     BOUNDARY=INPUT 1*TGROUND,  !- Outside Boundary Condition Object
419     NoSun,  !- Sun Exposure
420     NoWind,  !- Wind Exposure
421     ,  !- TRNSYS 17 - additional surface data
422     4,  !- Number of Vertices
423     5.000000000000,  !- Vertex 1 X-coordinate {m}
424     4.000000000000,  !- Vertex 1 Y-coordinate {m}
425     0.000000000000,  !- Vertex 1 Z-coordinate {m}
426     5.000000000000,  !- Vertex 2 X-coordinate {m}
427     0.000000000000,  !- Vertex 2 Y-coordinate {m}
428     0.000000000000,  !- Vertex 2 Z-coordinate {m}
429     0.000000000000,  !- Vertex 3 X-coordinate {m}
430     0.000000000000,  !- Vertex 3 Y-coordinate {m}
431     0.000000000000,  !- Vertex 3 Z-coordinate {m}
432     0.000000000000,  !- Vertex 4 X-coordinate {m}
433     4.000000000000,  !- Vertex 4 Y-coordinate {m}
434     0.000000000000;  !- Vertex 4 Z-coordinate {m}
```

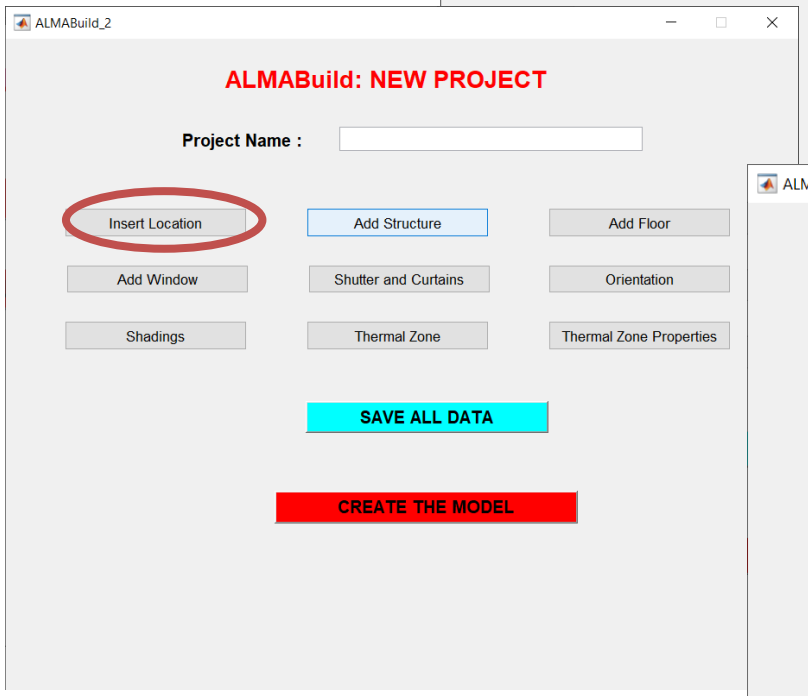
A **.idf** file **(Input Data File)** with **name**, **typology** and **geometrical data** of each envelope component is built through TRNSYS3D

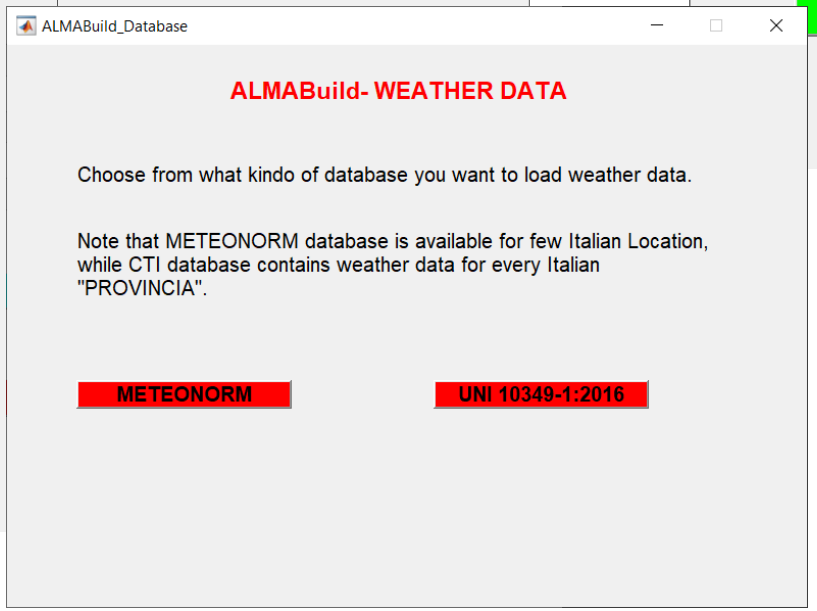
Input data for ALMABuild

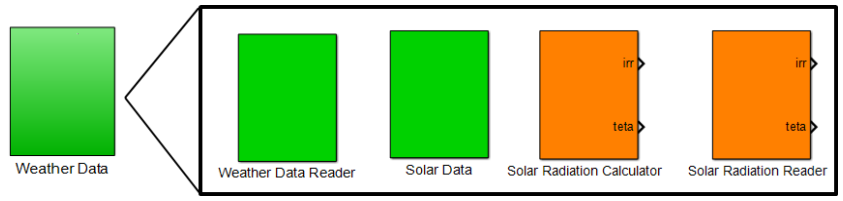
ALMABuild: Graphical User Interfaces (GUIs)



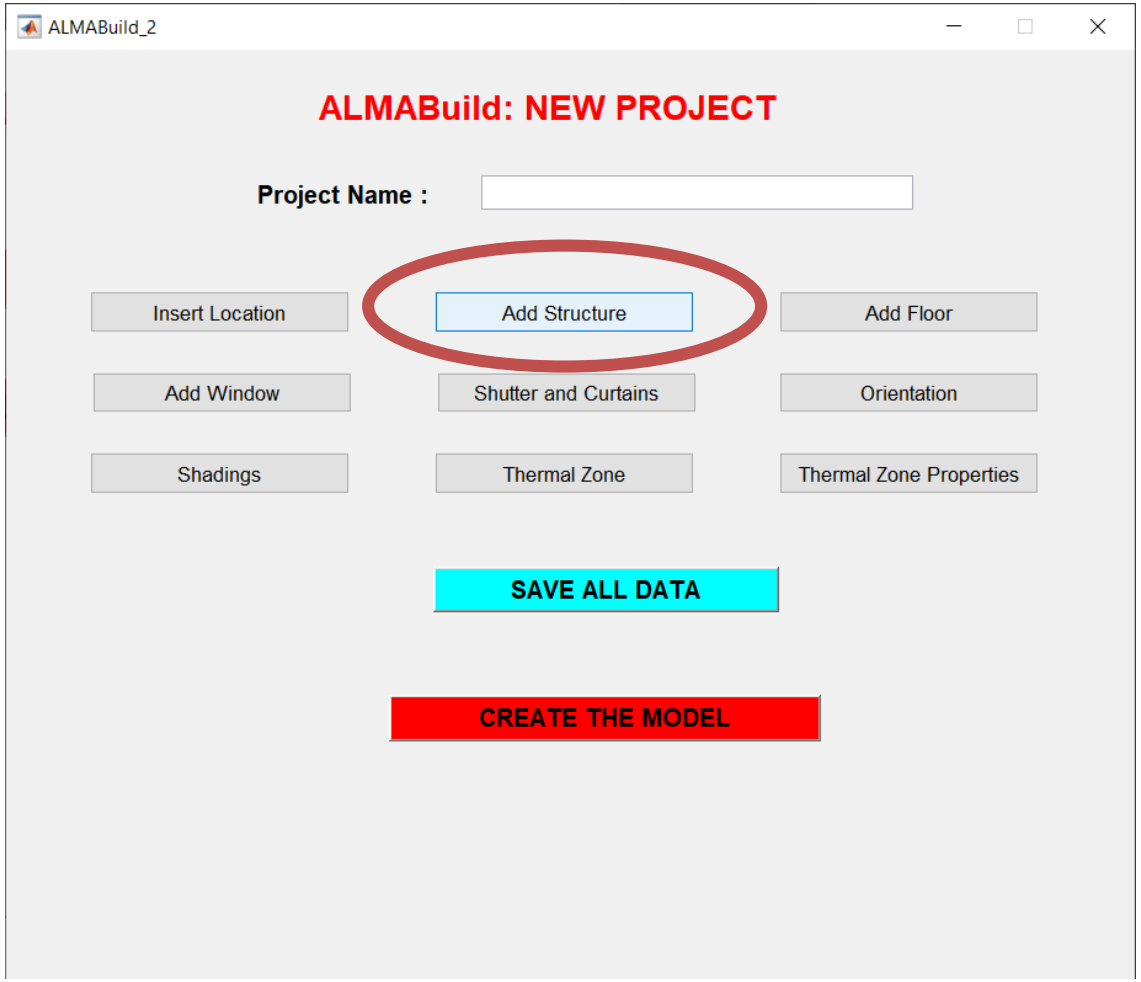


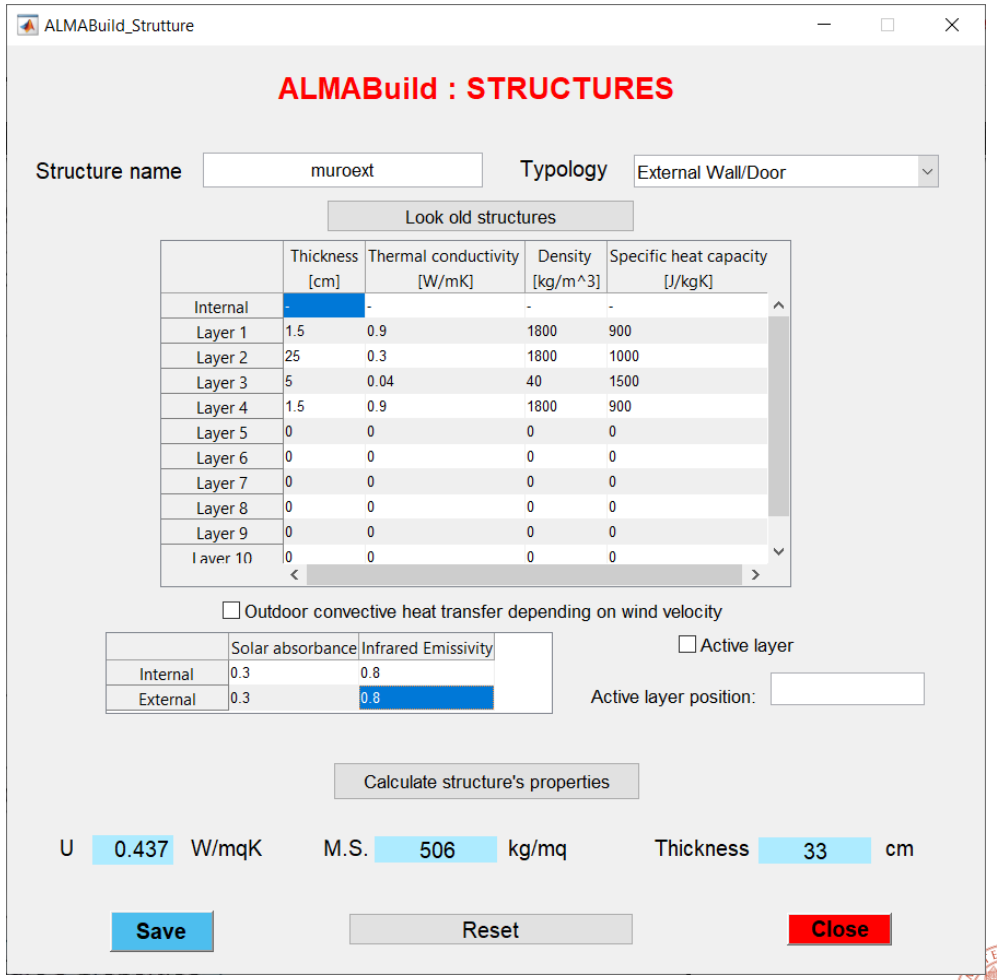






ALMABuild: Graphical User Interfaces (GUIs)





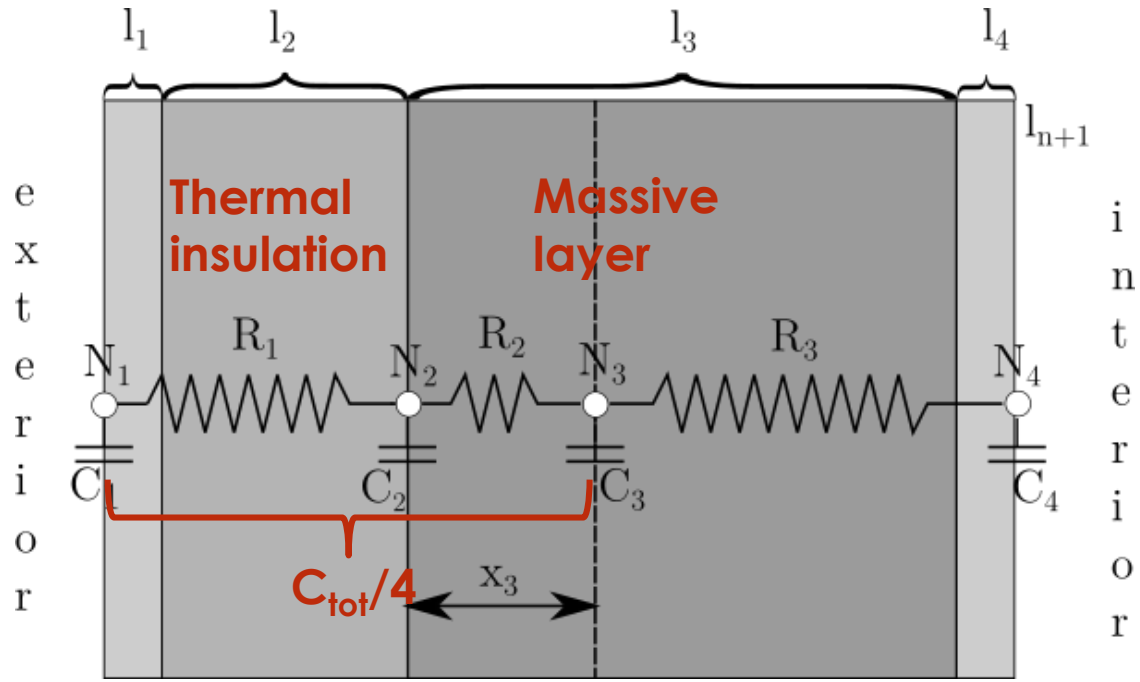
RC model for envelope components

RC models
(thermal resistance + thermal capacity)

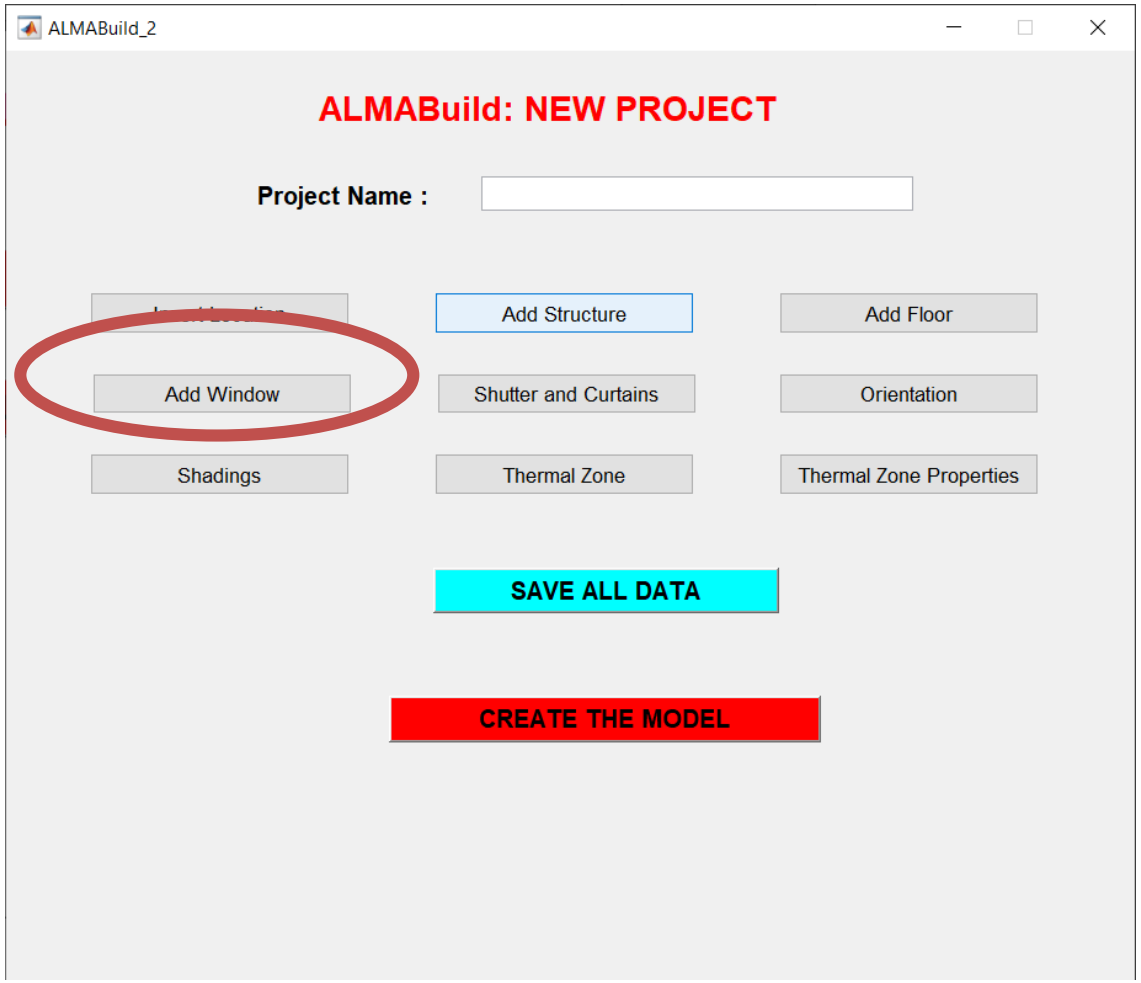
Lumped Parameters Whole Room (LPWR)

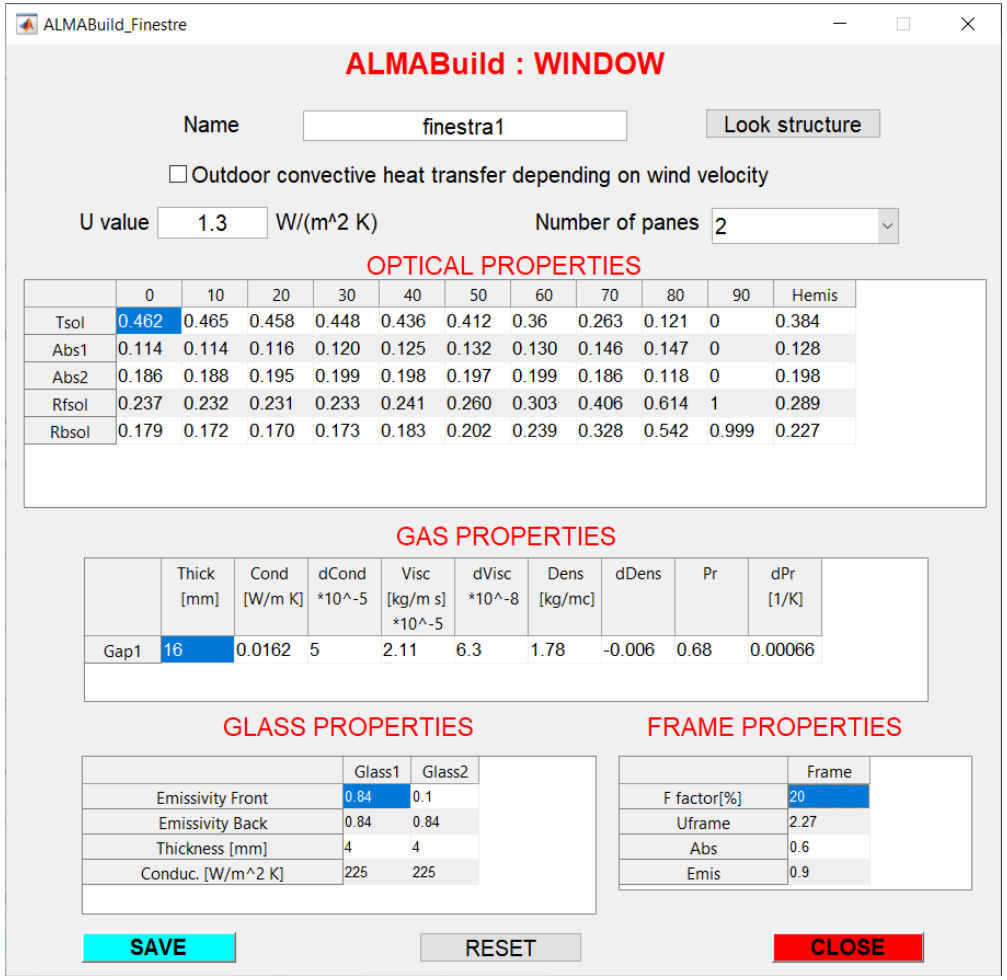
Lumped Parameters Construction Element (LPCE) → 1 RC model for each envelope component

Opaque elements: model 3R4C



RC model for envelope components

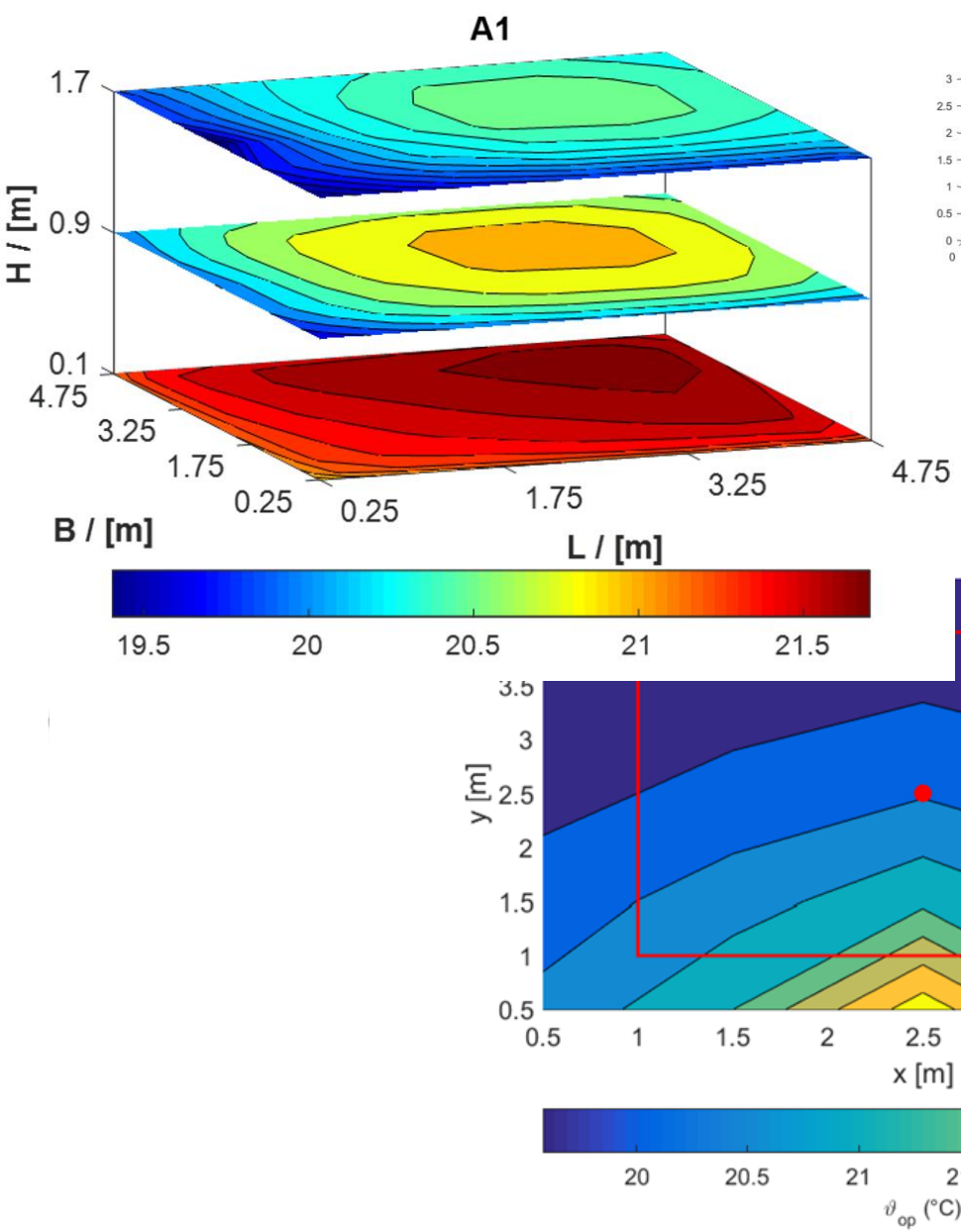


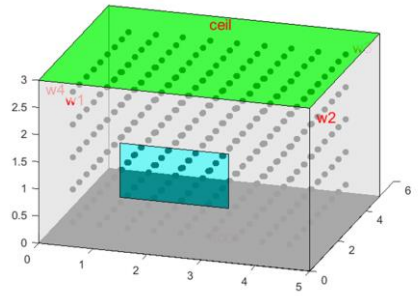


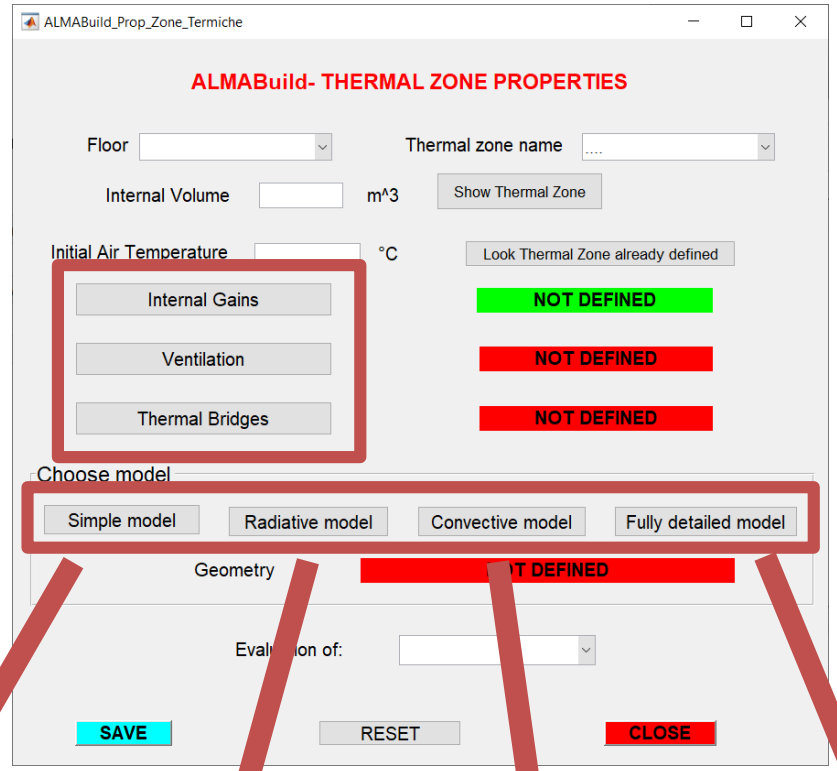
Frame: 1R2C

Glass (single/double) + gas: 1R2C

ALMABuild: Graphical User Interfaces (GUIs)





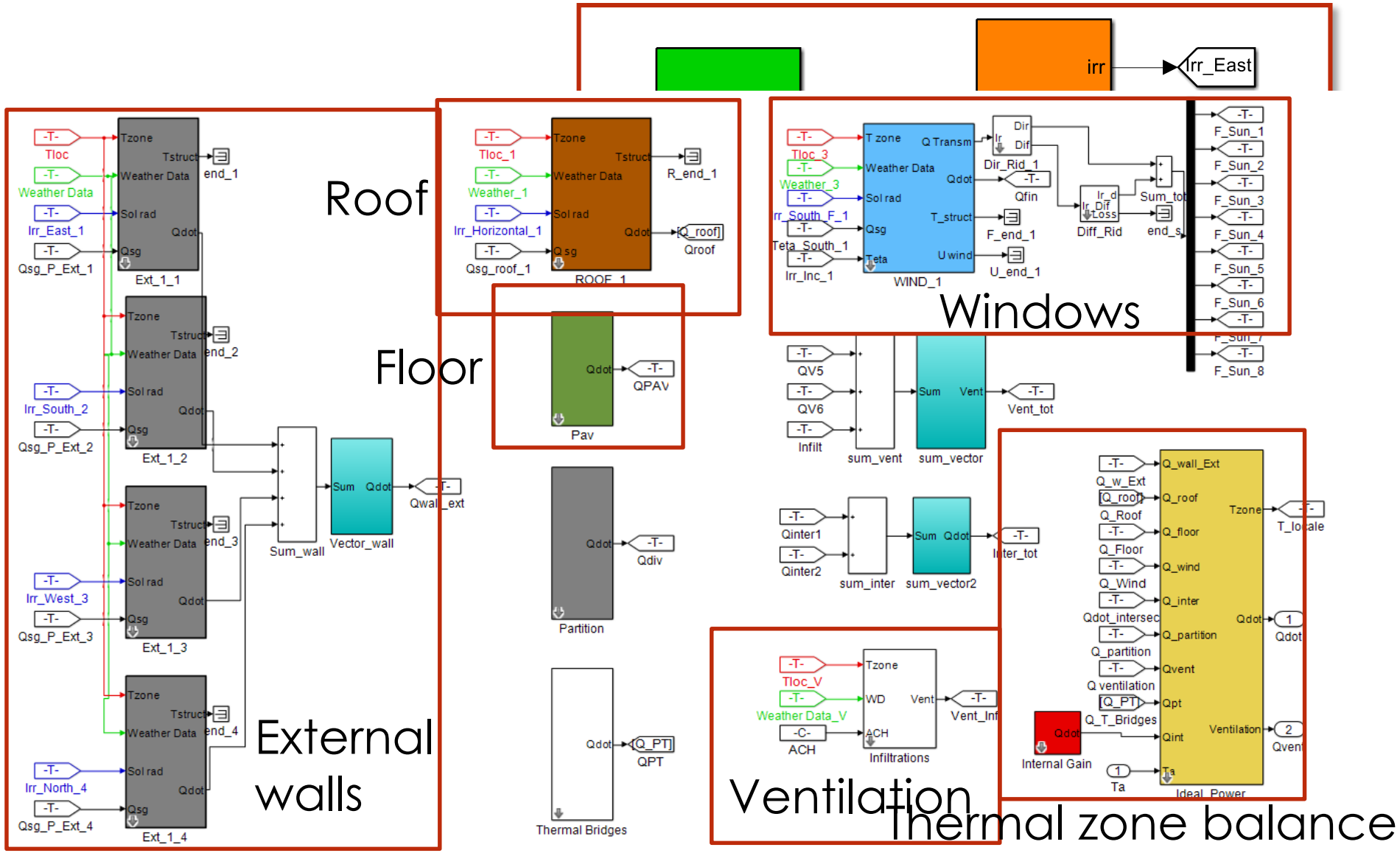


1 T_{air} + 3D T_{rad}

3D T_{air} + 1 T_{rad}

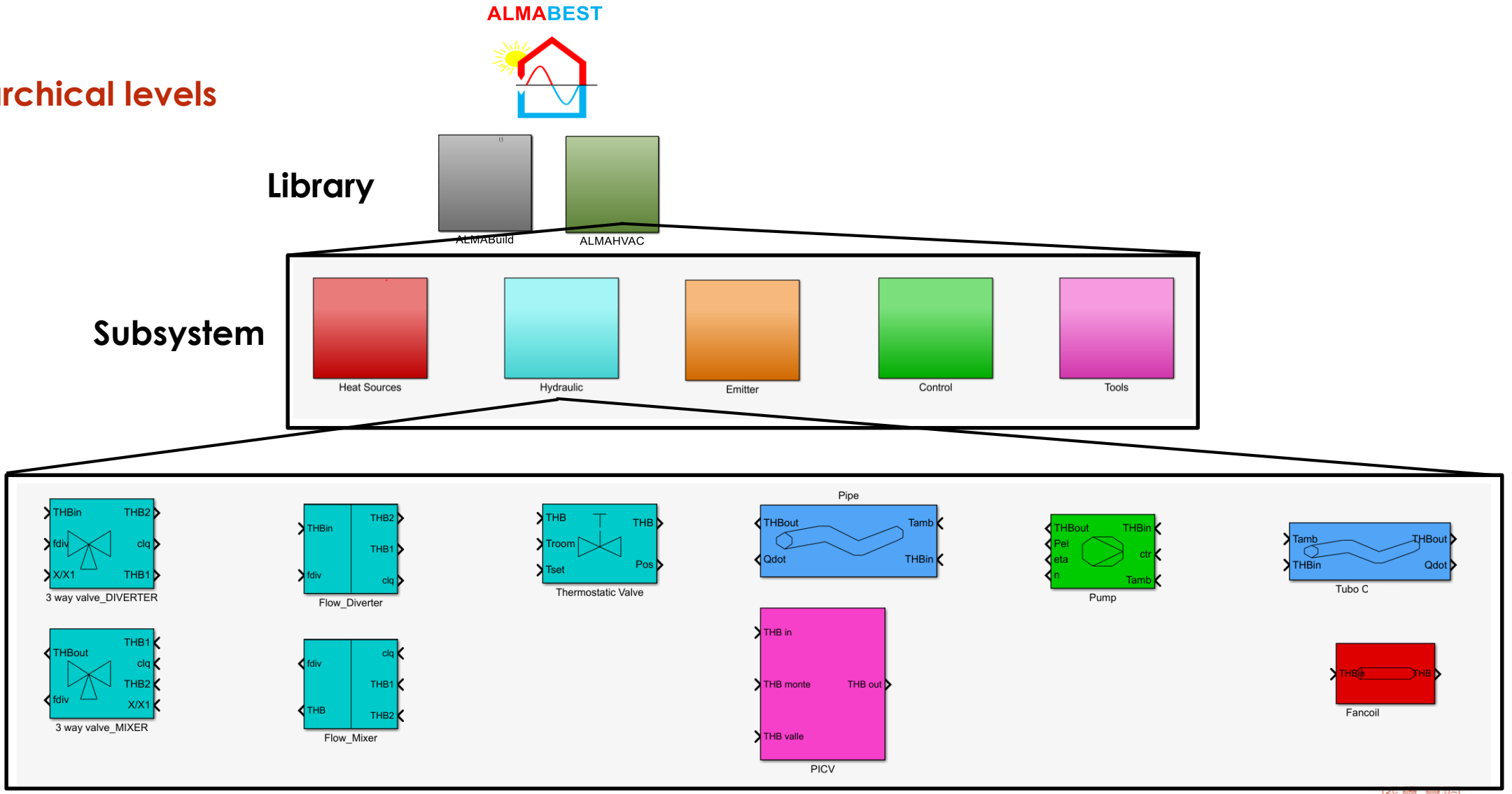
3D T_{air} + 3D T_{rad}

Simulink model: automatic implementation



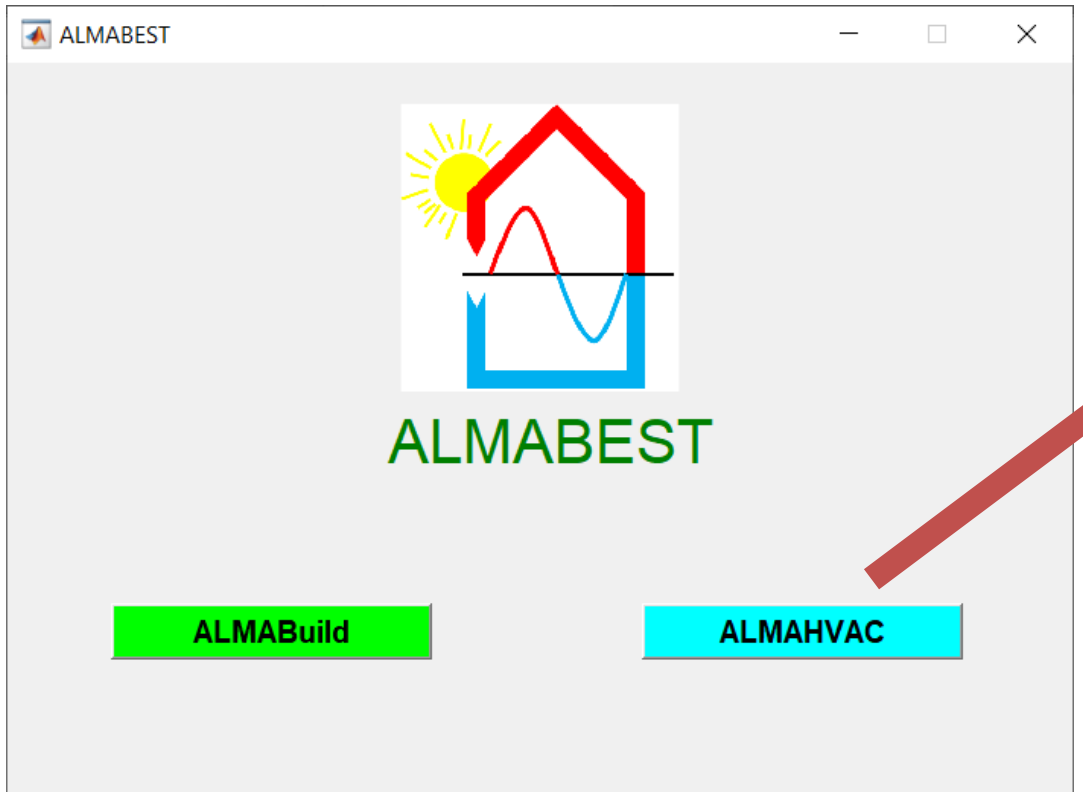
ALMAHVAC

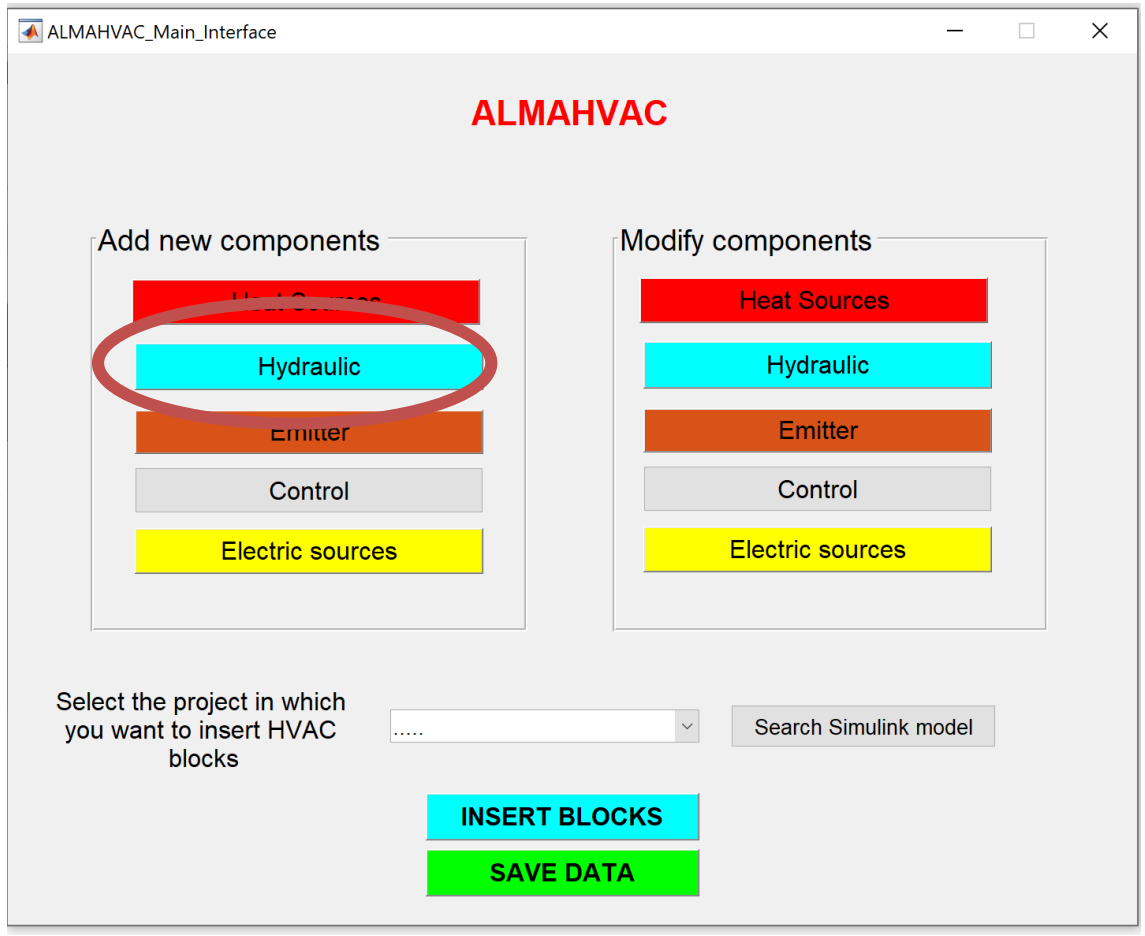
Hierarchical levels



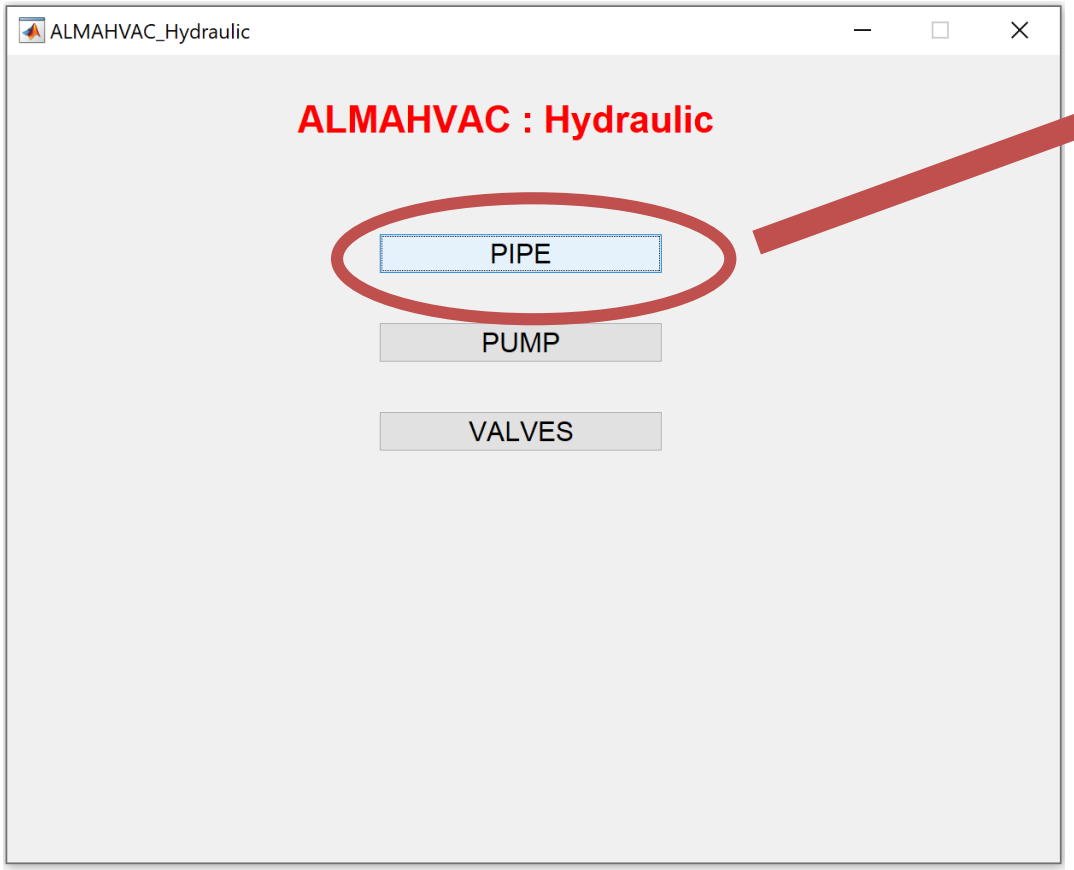
Elementary blocks

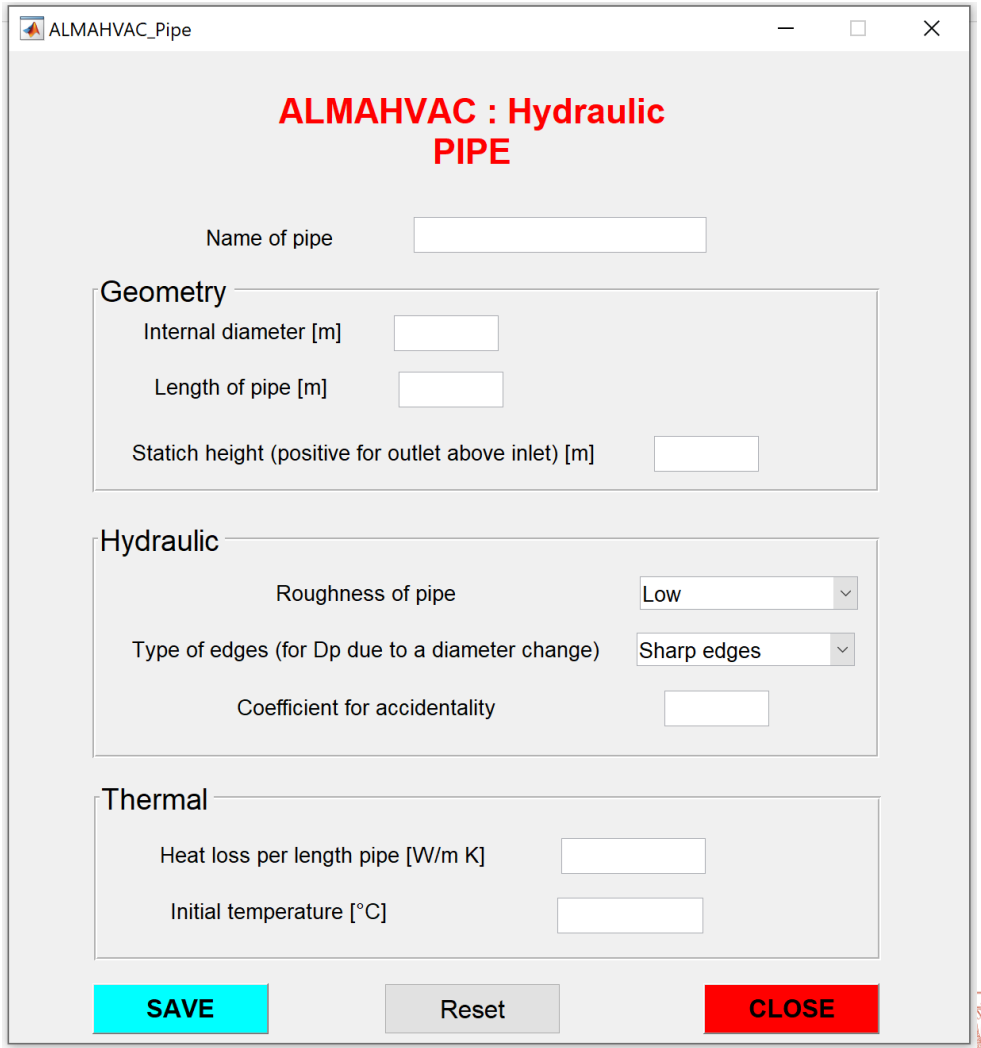
ALMAHVAC: Graphical User Interfaces (GUIs)



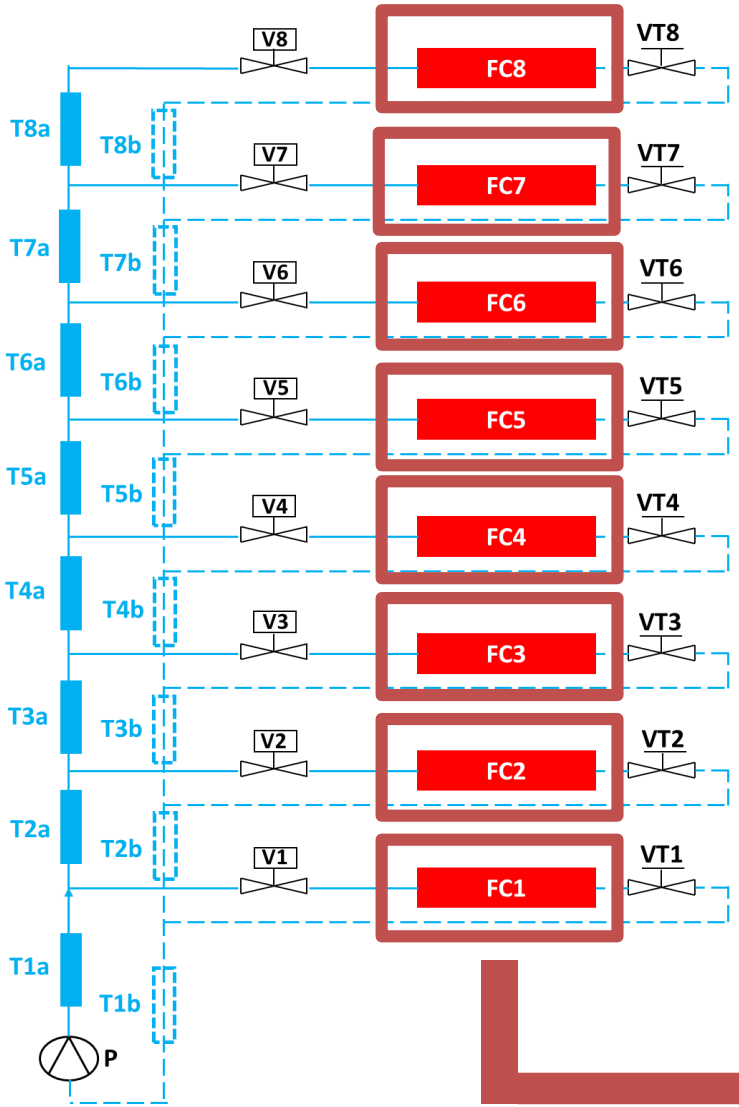


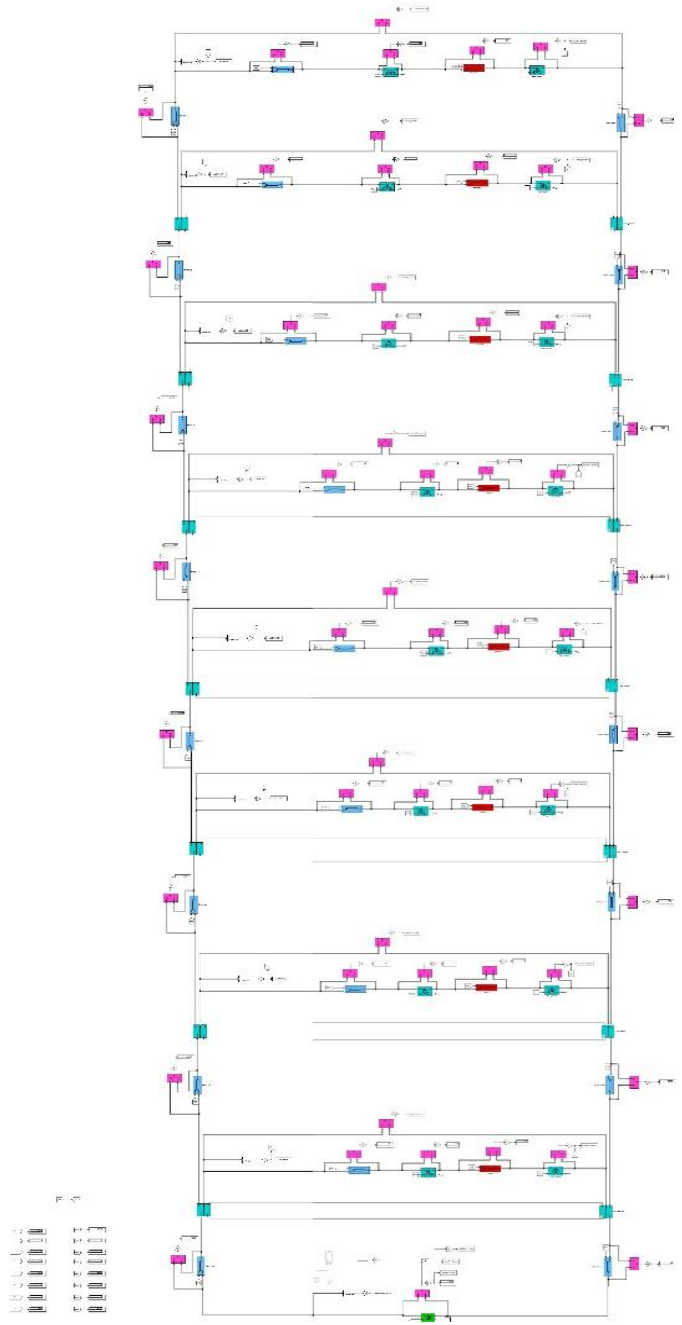
ALMAHVAC: Graphical User Interfaces (GUIs)





Simulink model: automatic implementation





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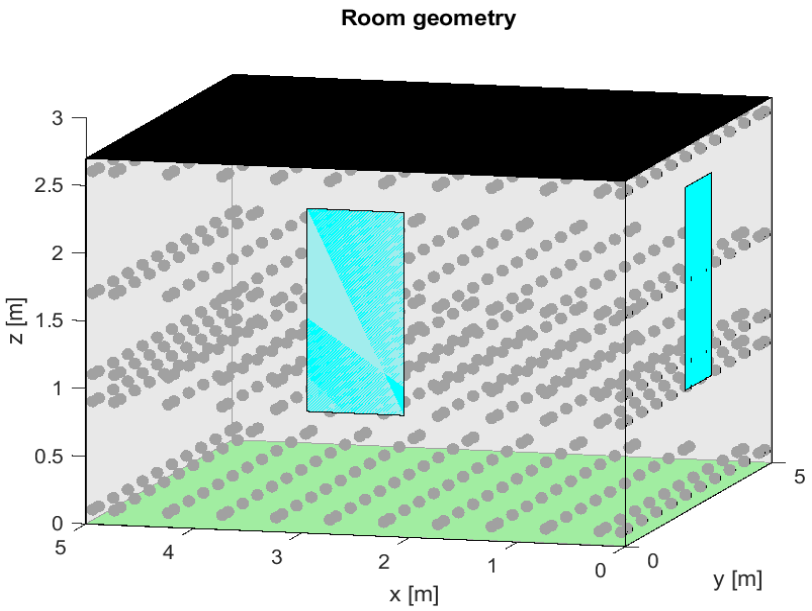
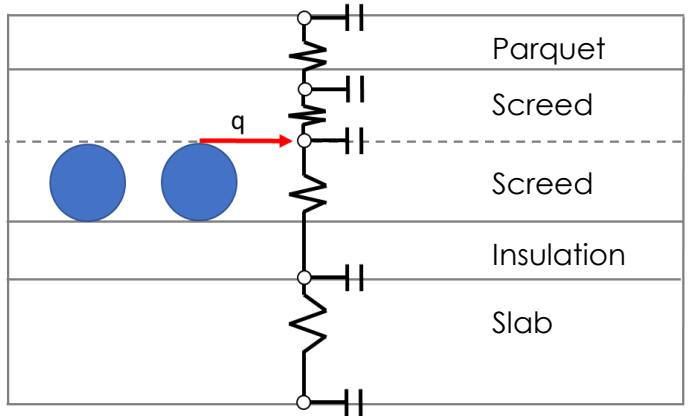
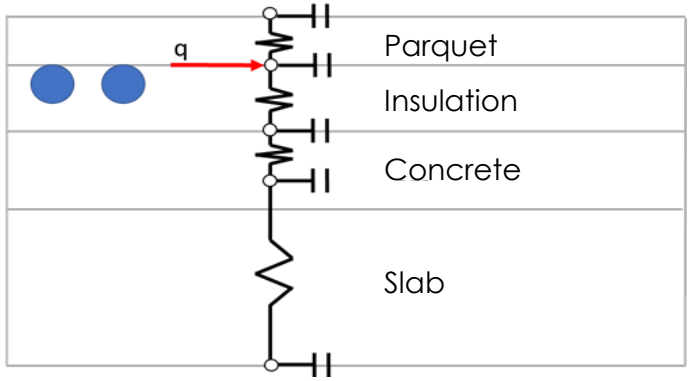
ALMABuild: an application case study on radiant floor heating



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



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



Type A: insulation = 0.1 cm

Type B: insulation = 3.2 cm

Low-inertia radiant floor heating

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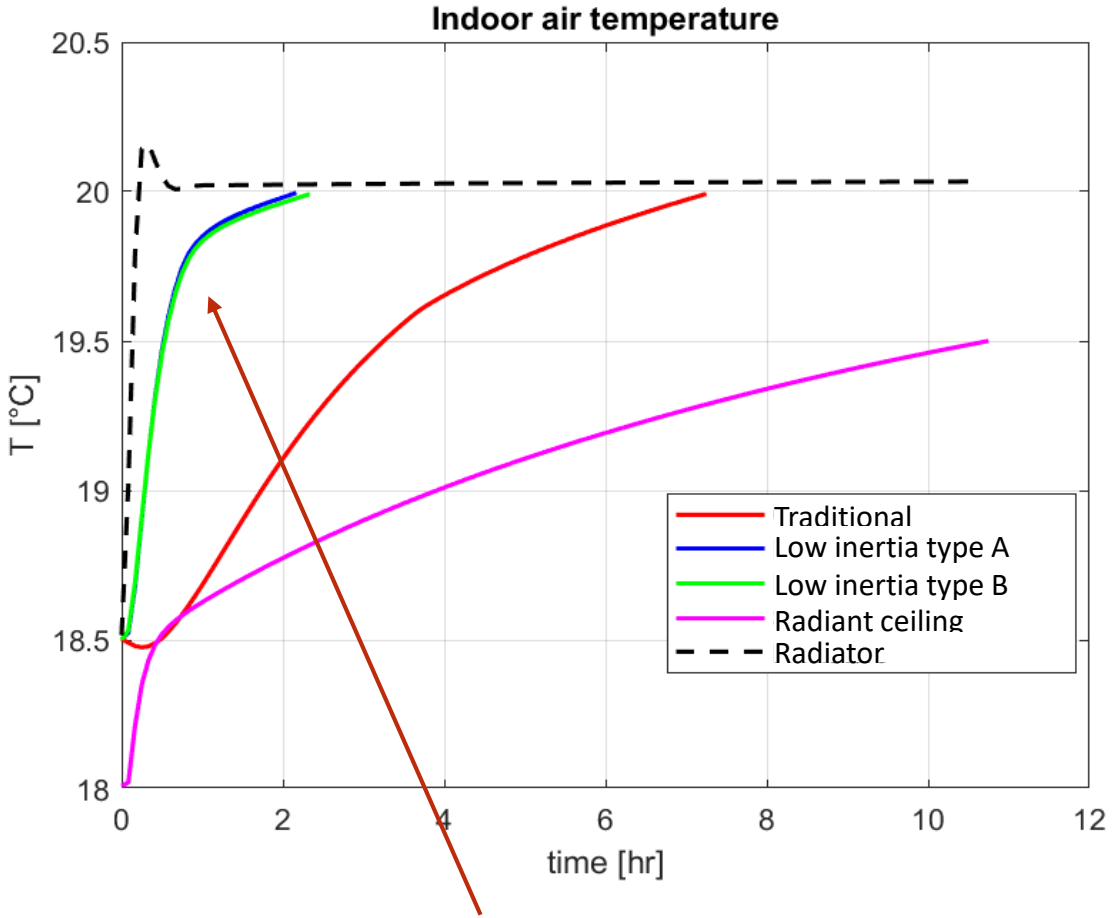
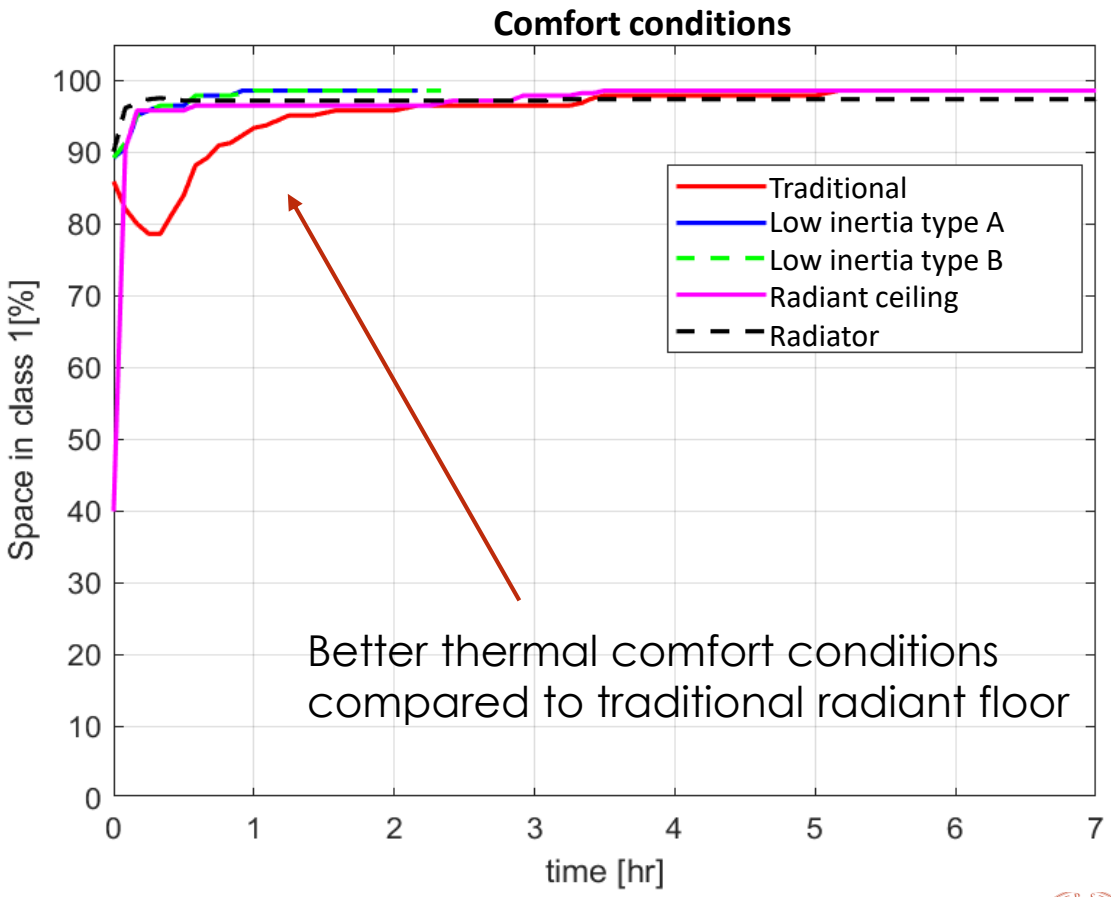
ALMABuild: an application case study on radiant floor heating

Start-up transient (ambient design temperature, no solar gains)

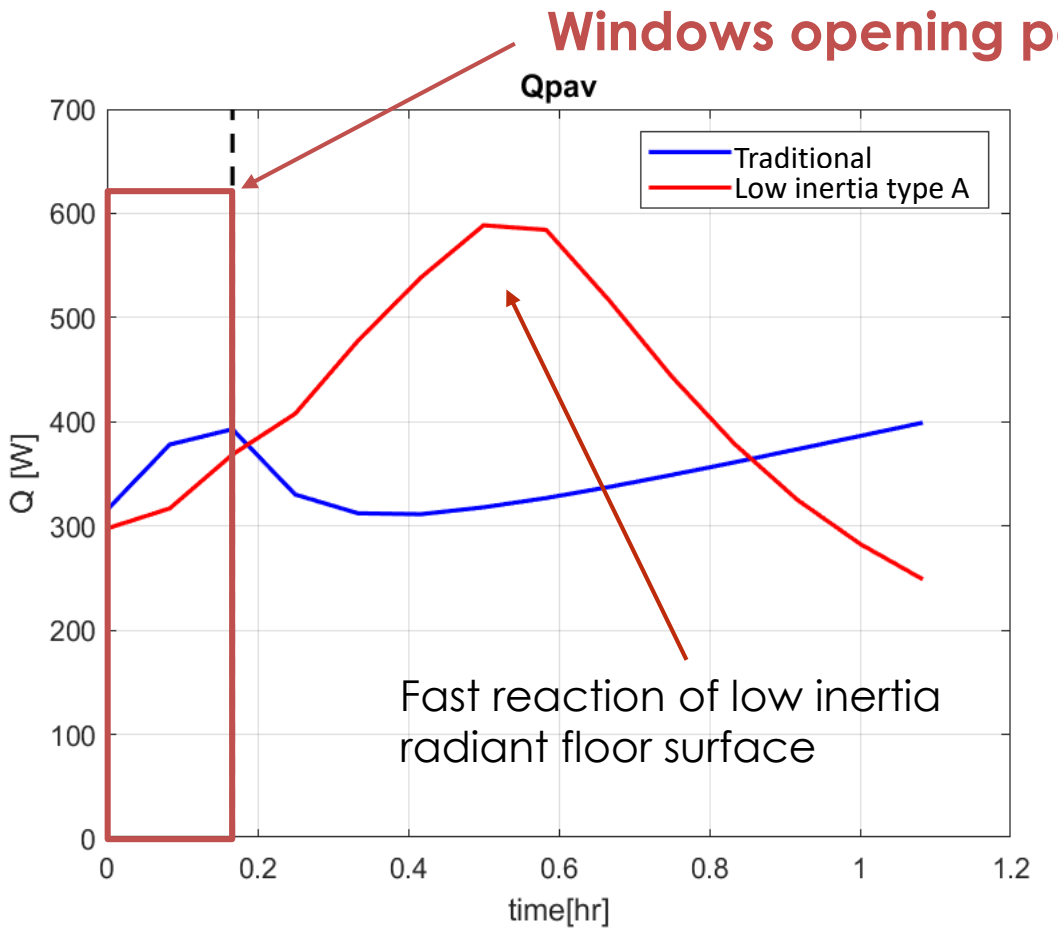


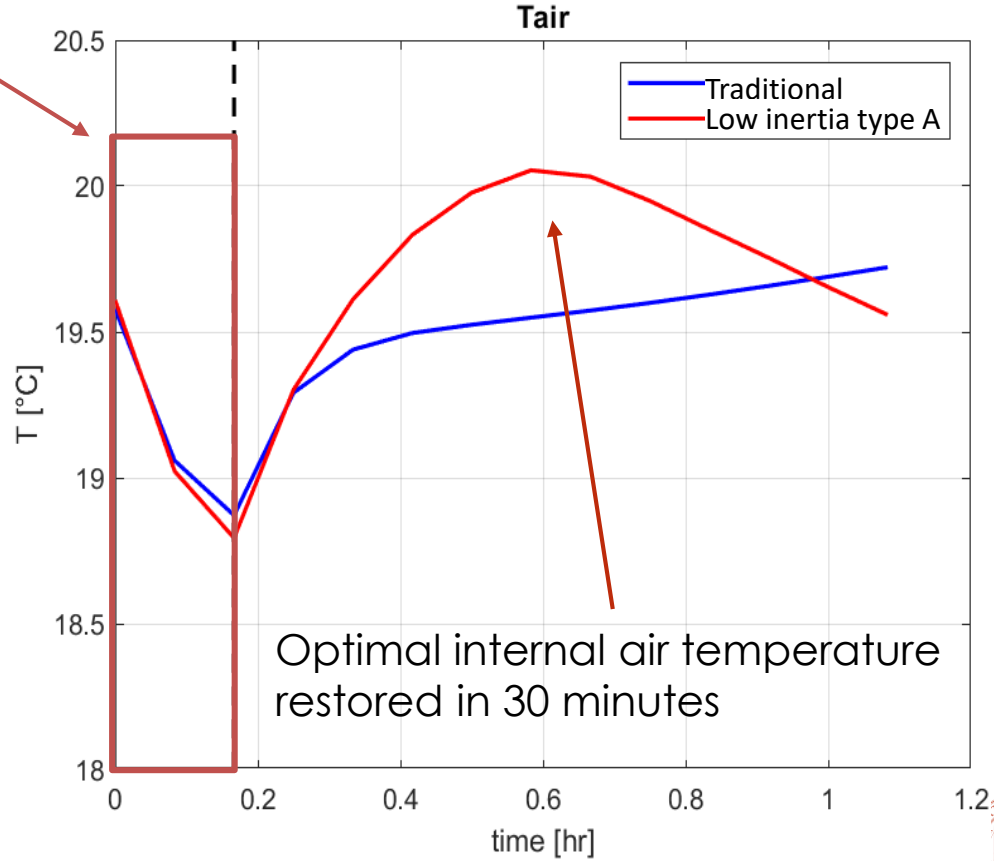
Very fast response low-inertia radiant floor surfaces



ALMABuild: an application case study on radiant floor heating

Transient with increase thermal load (**windows opening**, air change rate from 0.3 to 1 vol/hr)





ALMABuild: an application case study on radiant floor heating

Seasonal results with **intermittent operating mode** (space heating active between 7-23)

System	Percentage of heating season with optimal comfort conditions	Percentage of heating season with low temperature	Room energy demand compared to traditional system
Traditional radiant floor	37.4%	5.7%	0%
Low-inertia radiant floor – Type A	62.4%	2.9%	-6.2%
Low-inertia radiant floor – Type B	62.2%	2.9%	-9.7%

Better comfort conditions along the season and decrease of room energy demand

Conclusions

- Tool **ALMABEST** (ALMABuild + ALMAHVAC):
    - ALMABuild: **detailed 3D modeling** (Google SkechUp) and **automatic import**
    - ALMABuild: **automatic implementation** of the building model with GUIs
    - ALMAHVAC: **compatibility with CARNOT**
    - ALMAHVAC: **automatic implementation** of the HVAC system with GUIs

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Thanks for your attention!

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