MOOSAS Ver 0.6.0 Users Manuals

Moosas Development Team

Tsinghua University

December 9, 2023

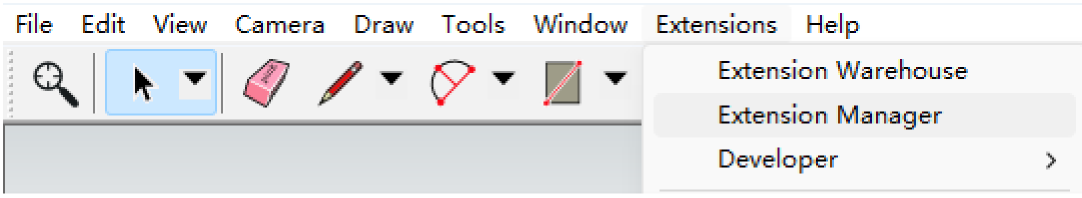
CONTENT

1. Installation 3
2. Features in MOOSAS 4
3. What is the "Analytical Model"? 13
5. Energy Analysis...16
6. Ventilation Analysis 20
7. Daylight Simulation 23
8. Q&A 26
9. Reference...28

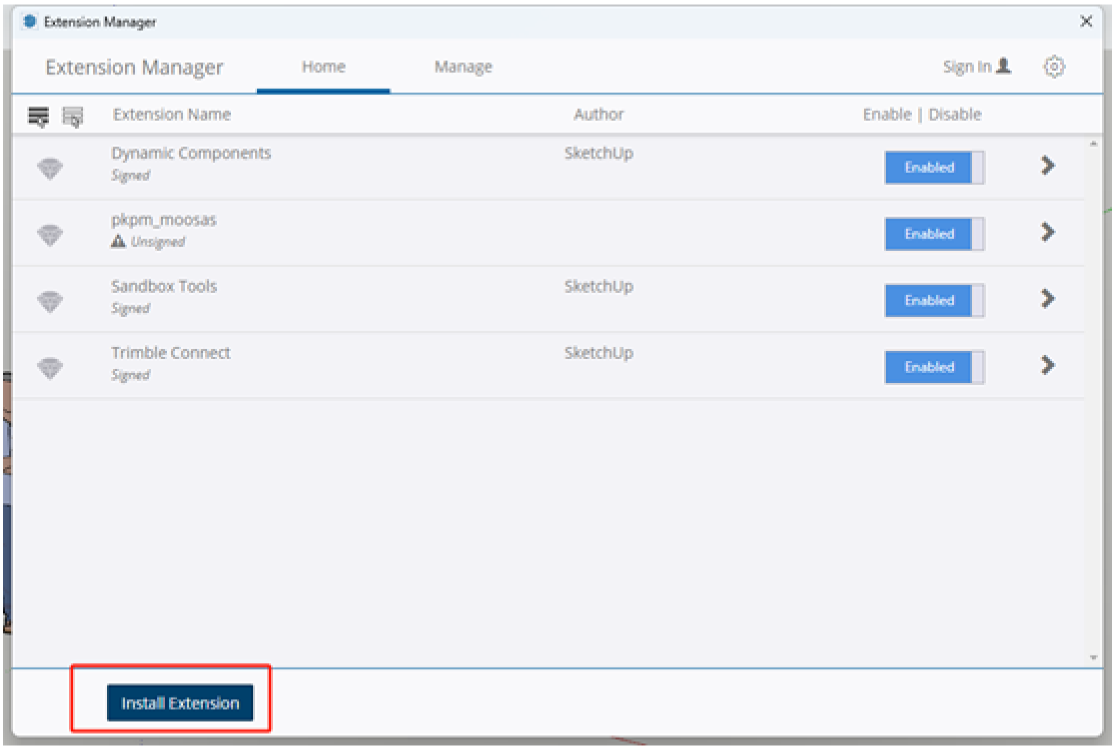
1. Installation

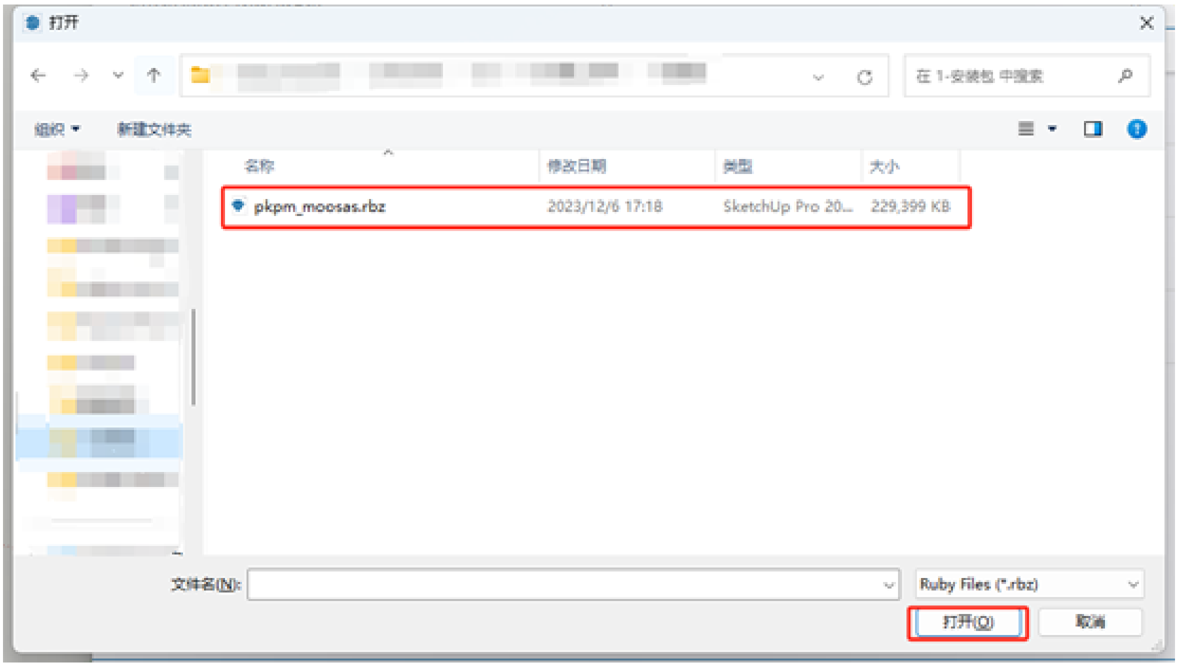
1.1. Download pkpm-moosas.rbz to anywhere. Prepare the latest version of SketchUp Software (later than SketchUp 2019): https://www.sketchup.com/

1.2. Open the SketchUp, open Extensions => Extension Manager in the toolbar.



1.3. Click "Install Extension" and find the pkpm-moosas.rbz.



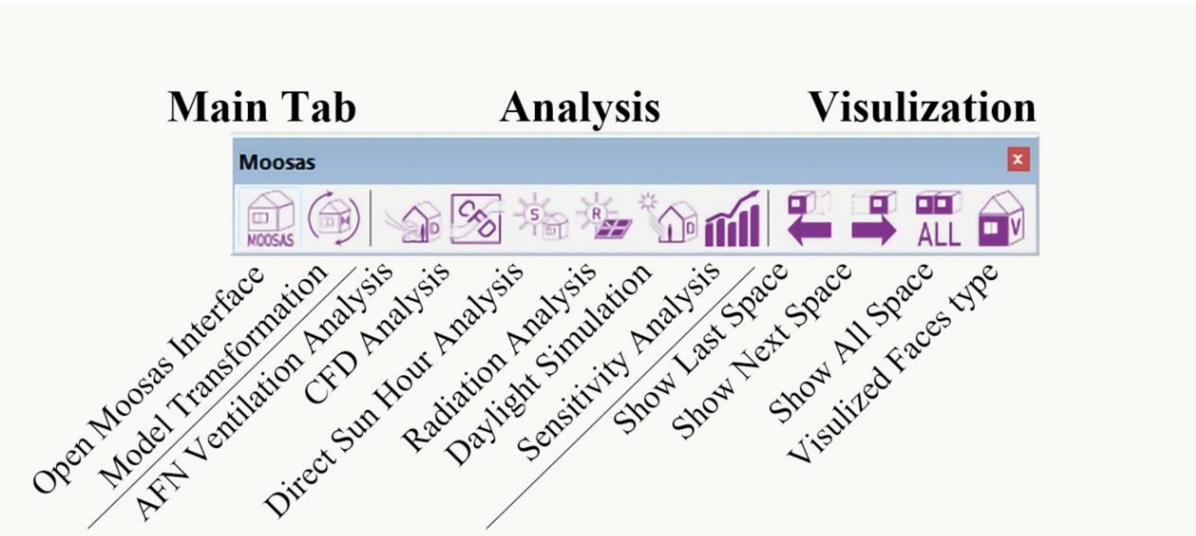


1.4. If users want to try the CFD simulation, please also install blueCFD 2017-2. We should provide the installation package, or users can download from: [Downloads · blueCFD-Core Project]

1.4.1. Please do not change the default settings of file location during the installation. The program call blueCFD ONLY FROM: C:\Program Files\blueCFD-Core-2017

1.5. Please notice that now the MOOSAS is a test version. It will be available until Dec-31, 2024. Don't worried, it will be Open Access after the test!

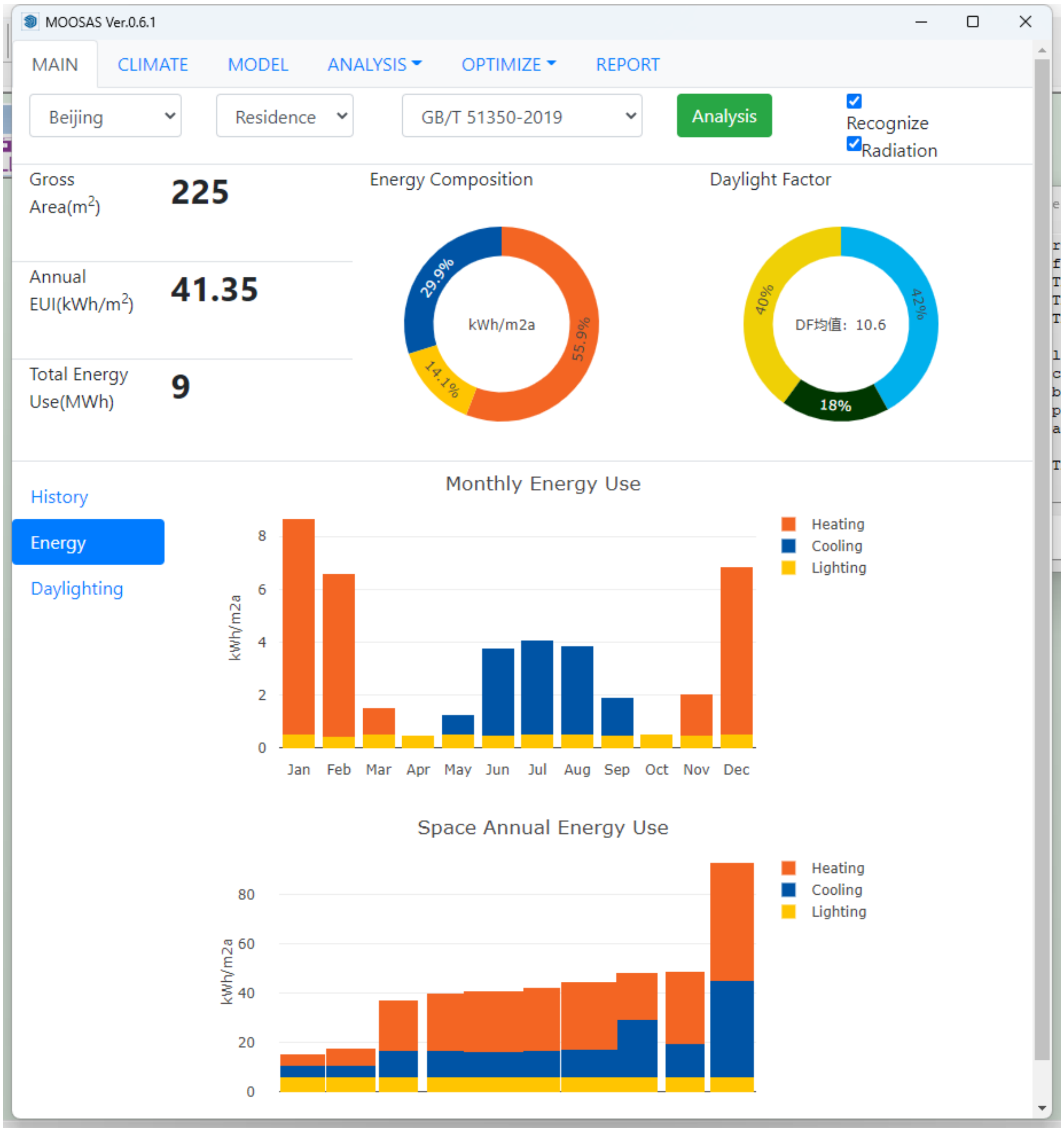
2. Features in MOOSAS



2.1. MOOSAS is a FAST AND EASY-TO-USE performance analysis tools for the sketch design stage. All kinds of analysis are based on the same analytical model (Section 3).

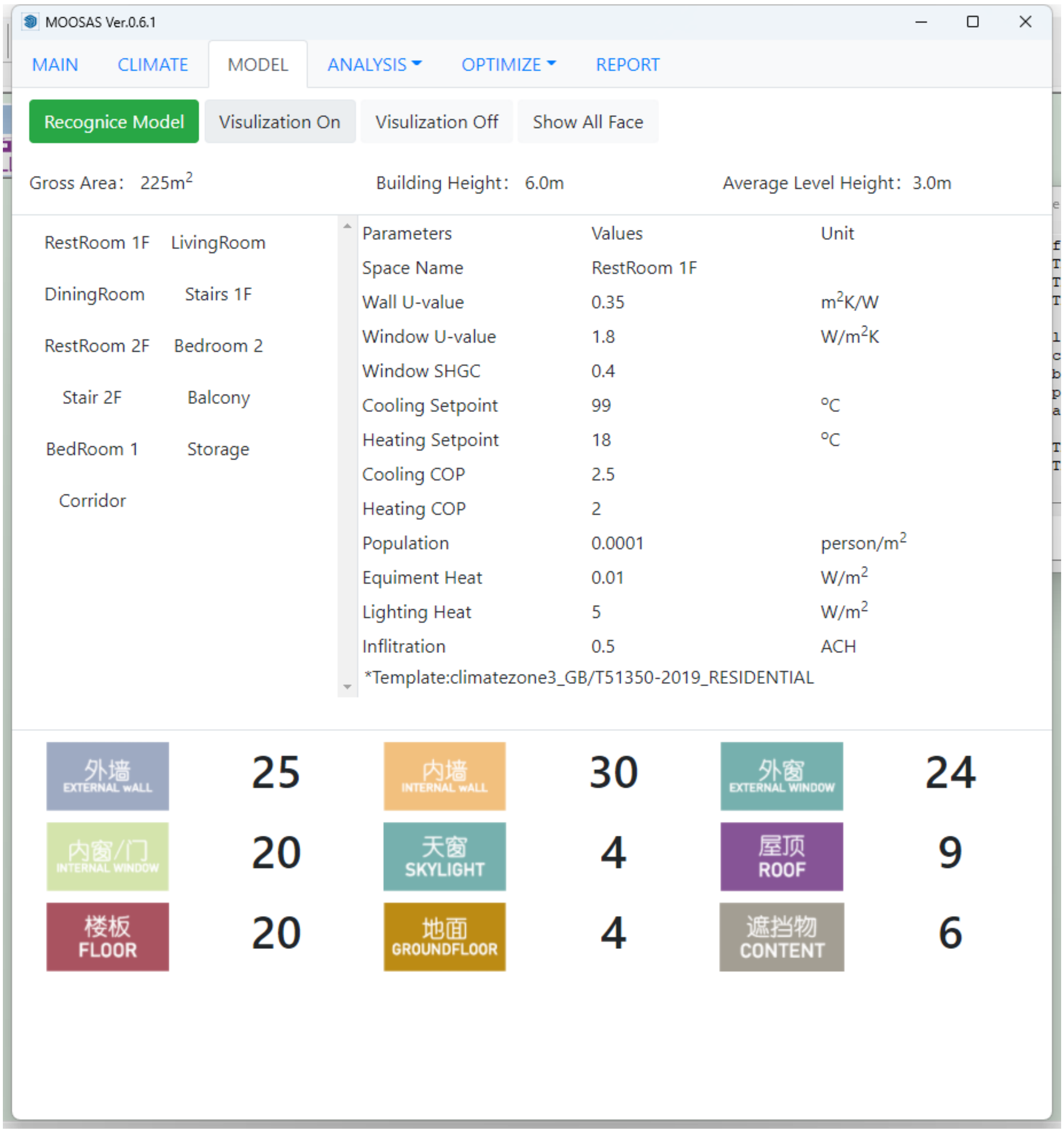
2.2. **MOOSAS Interface**: users can change settings in the interface:

2.2.1. In the MAIN tab, users can change the climate and building type. The energy analysis can be run in this tab. (Section 5)



2.2.2. In the CLIMATE tab, users can find some general analysis on the climate data.

2.2.3. In the MODEL tab, users can visualize any spaces or change their thermal parameters.

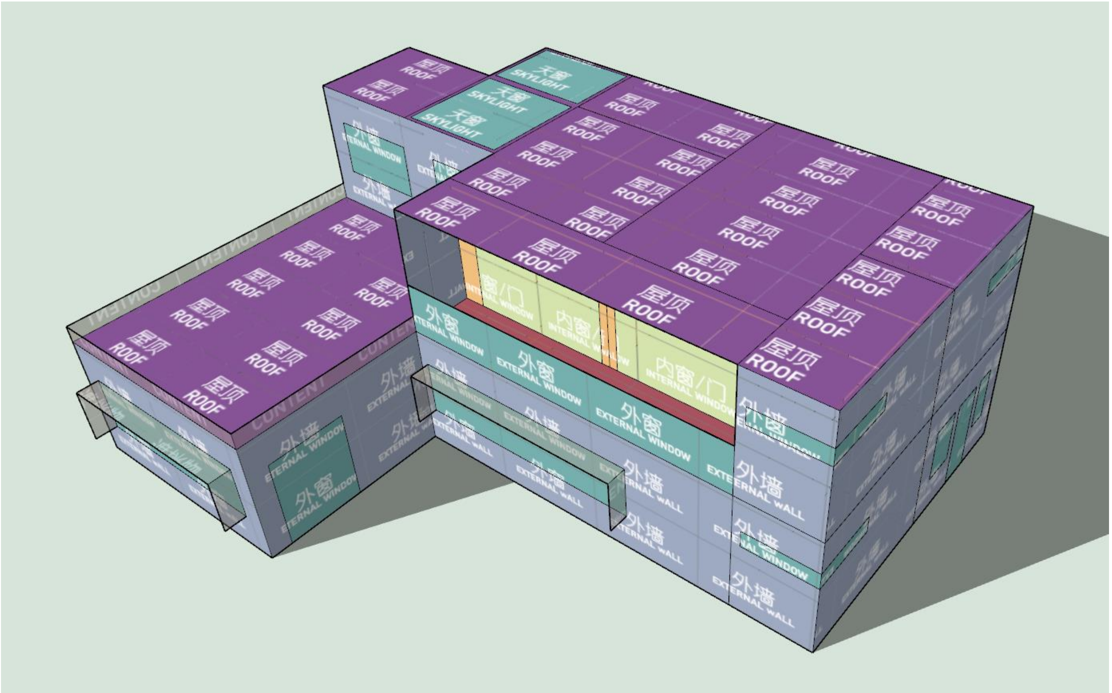


2.2.4. The ANALYSIS tab provides the hyperlinks to the analysis.

2.2.5. In the OPTIMIZE tab, users can run the parameters analysis on energy and daylighting. (Section 8)

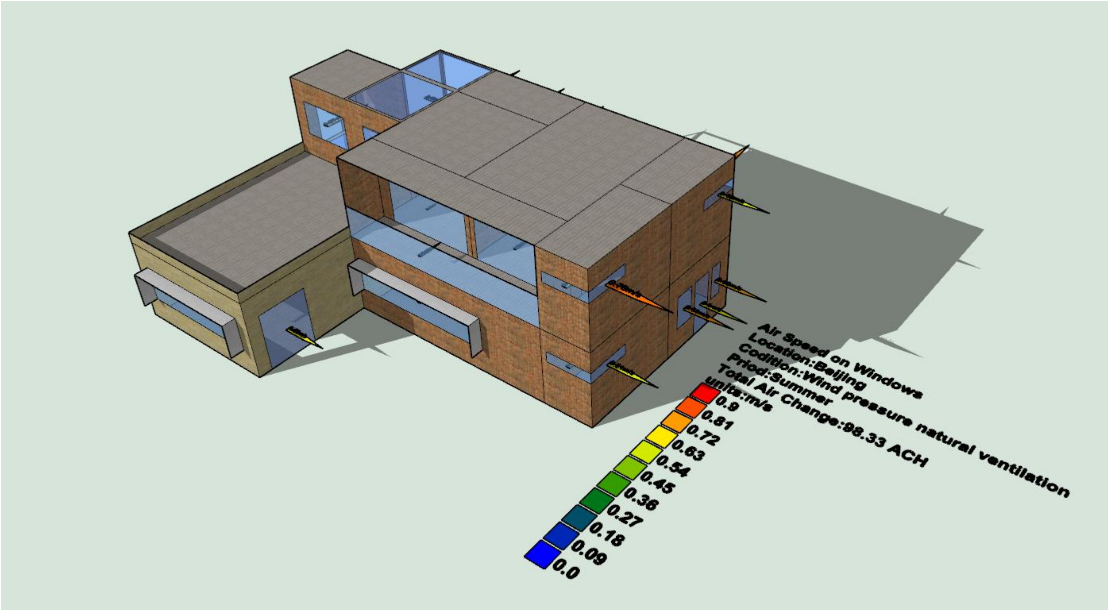
2.2.6. In the REPORT tab, users can get a report formatted in Word or PDF.(***THIS FUNCTION IS UNDER DEVELOPED***)

2.3. **Model Transformation:** this function can transform the model in SketchUp into an integrated analytical model. It should be finish before any analysis; though we also integrated the transformation in any analysis function. (Xiao et al. 2023)(Section 4)

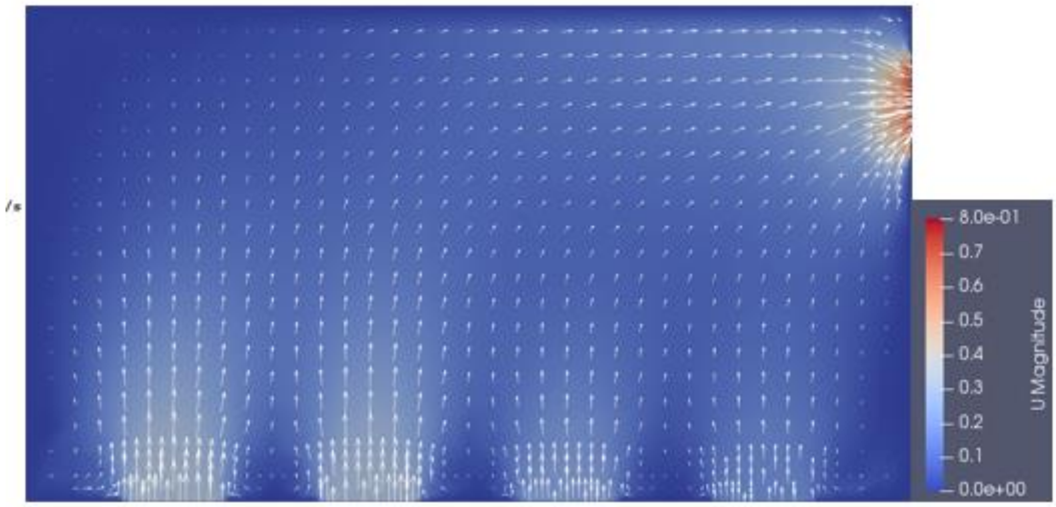


2.4. **Energy Analysis**: this function can be found in the MOOSAS Interface. It is a fast energy analysis based on **simplified engineering model** (Lin et al. 2021) which can be processed within 0.01 s/room. (Section 5)

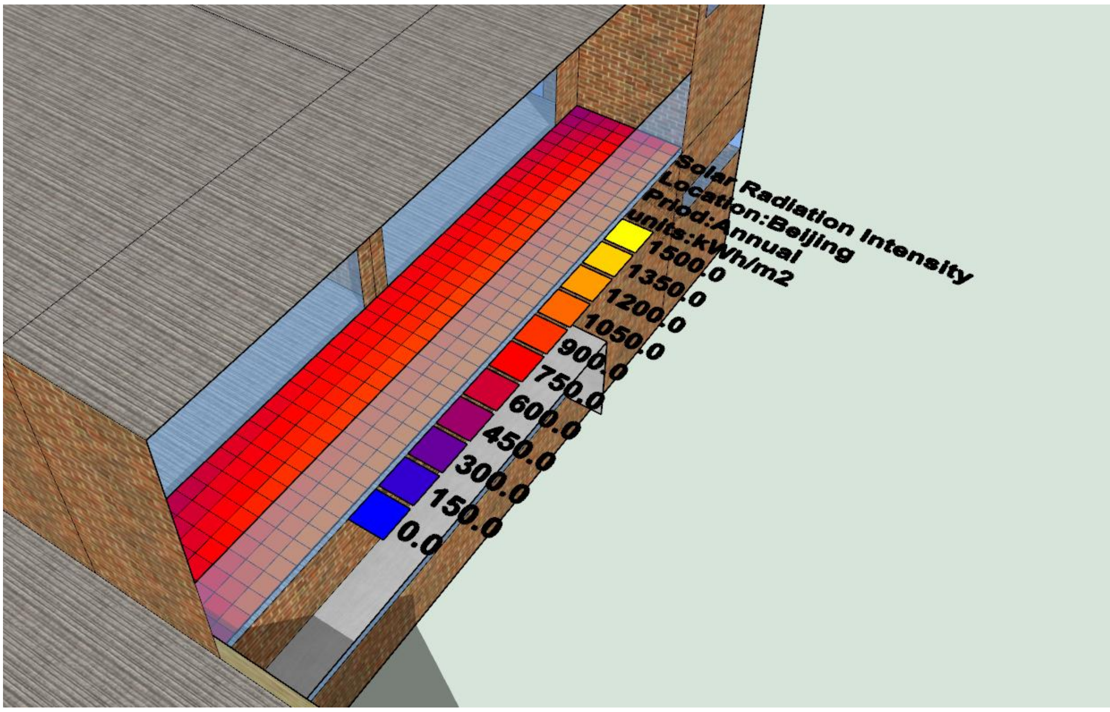
2.5. **AFN Ventilation Analysis**: this function can get the boundary ventilation condition (wind speed and direction of each window) of all the spaces. (Section 6)



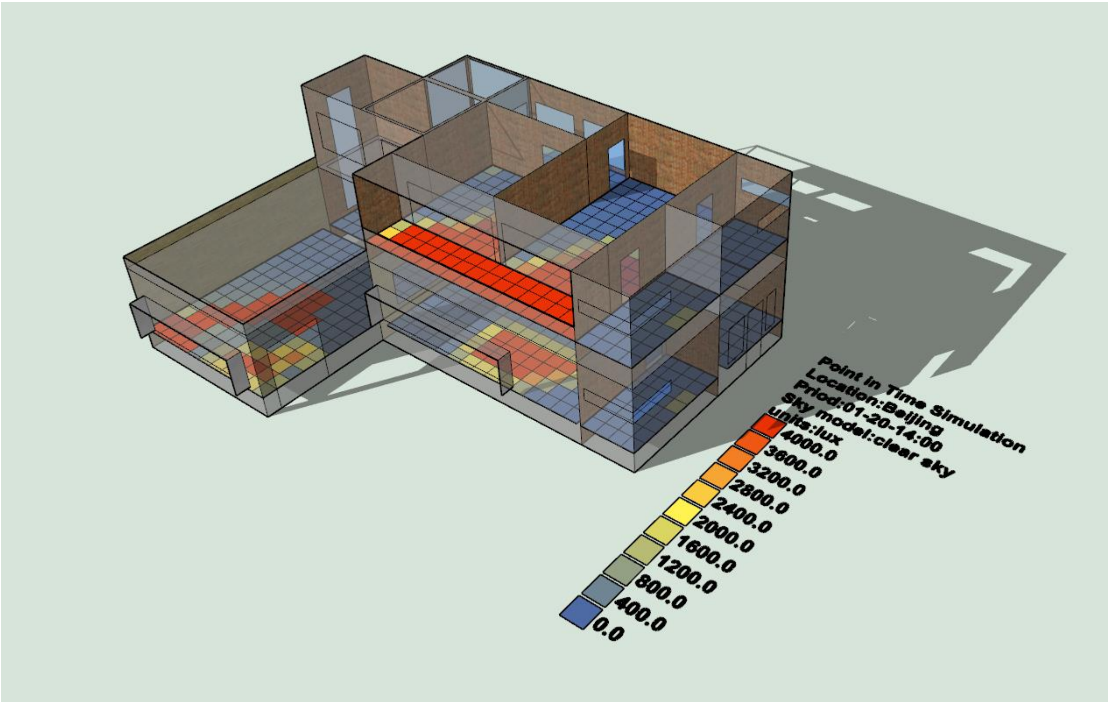
2.6. **CFD Ventilation Simulation**: this function is an accelerated CFD simulation based on CONTAM-OPENFOAM integration. (Tan and Glicksman 2005) (Section 6)



2.7. **Direct Sun Hour Analysis and Radiation Analysis**: This function can calculate the period when the reference grid can receive direct sunlight. It is a face-based analysis and the gridding process will be automatically run following usersr settings.



2.8. **Daylight Simulation**: this function can run a point-in-time daylight simulation based on RADIANCE for the recognized spaces. (Section 7)



2.9. **A simple workflow in MOOSAS** is: geometry transformation => climate and type settings => thermal parameters settings (optional) => radiance material settings (optional) => run analysis. (Section 5)

2.9.1. Before users play the analysis on usersr project, please model, or reorganize it following the Geometry Instruction (Section 4)

2.9.2. Please choose a climate and building type in the MAIN tab MOOSAS Interface. Users can also import *.epw file in this page.

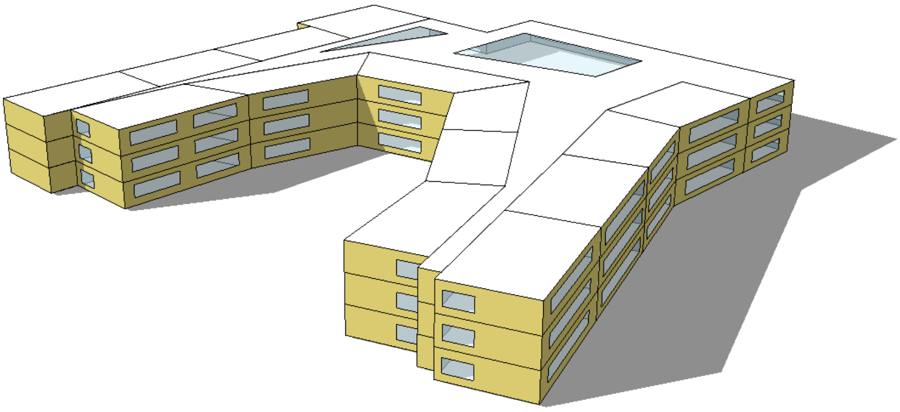
2.9.3. Users can change the thermal properties of spaces in MODEL tab if users want a more accurate energy analysis. It is an optional step since we have embedded a series of templated in the database. They will be automatically applied once users choose a climate and a building type. (Section 5)

2.9.4. All default materials in SketchUp will be auto transform into a rad material in daylight simulation according to their names. In this way, users can easily evaluate the performance and beauty together. So just try any materials in the library! (Section 7)

3. What is the "Analytical Model"?

3.1. It presents as a prototype model that only contains the building elements related to performance analysis like: walls, floors, ceilings, windows, skylights, and shadings. The elements should be as simple as possible.

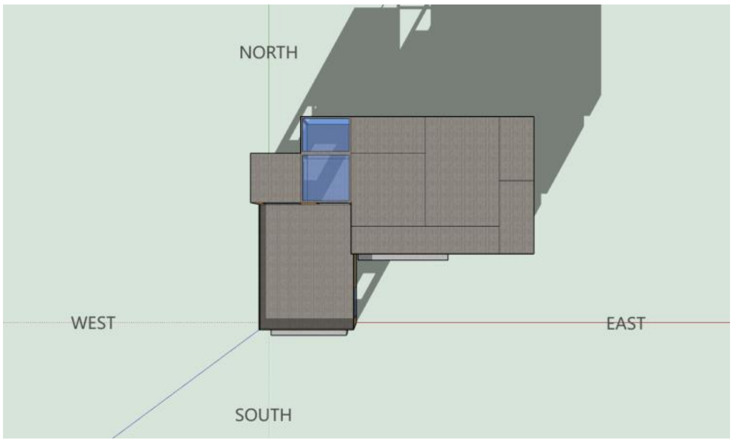
3.2. MOOSAS develop an integrated analytical model for all kinds of performance analysis. The model transformation has a high flexibility to the input, so just try usersr sketch model directly!



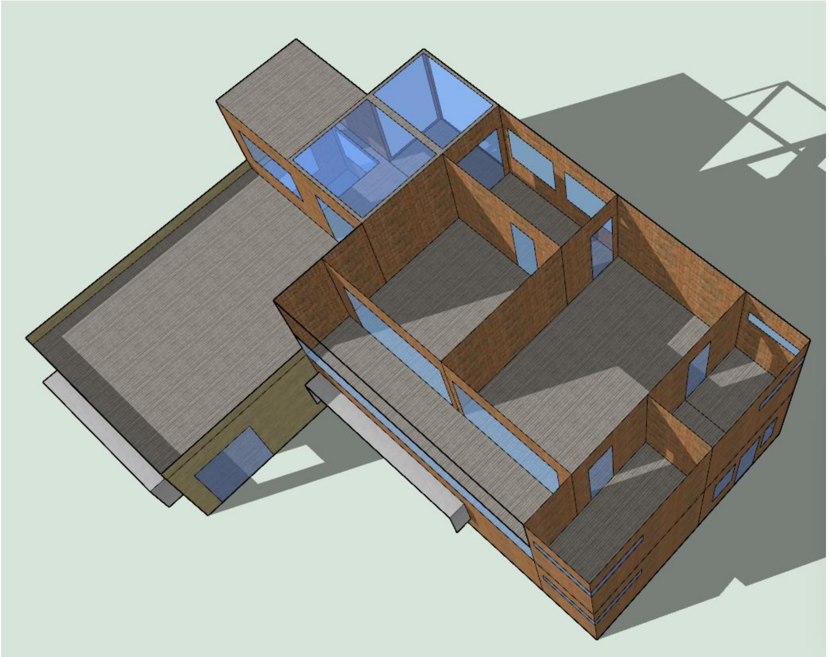
A sample of analytical model in MOOSAS

4. Geometries Instruction

4.1. The positive red axis (X axis) is the EAST direction, and the positive green axis (Y axis) is the NORTH direction.



4.2. **Please use a single surface to present an element.** If the wall is modeled with thickness, the space topology information will be lost in ventilation analysis. However, if users don't care about the ventilation, users can still model walls with thickness for more precise daylight simulation!



4.3. Please ensure the walls can be connected into closed boundaries and such walls should be higher than 0.9 meters. Otherwise, the space will be regraded as exterior and will not be included into energy and daylight analysis.

4.3.1. For the semi-open space, users can use transparent faces with opacity < 0.1 to represent the Air Boundaries.

4.4. We suggest **exploding users groups and self-intersect** the model before transformation. (Select all faces, right click=>Intersect Faces=>With Selection)

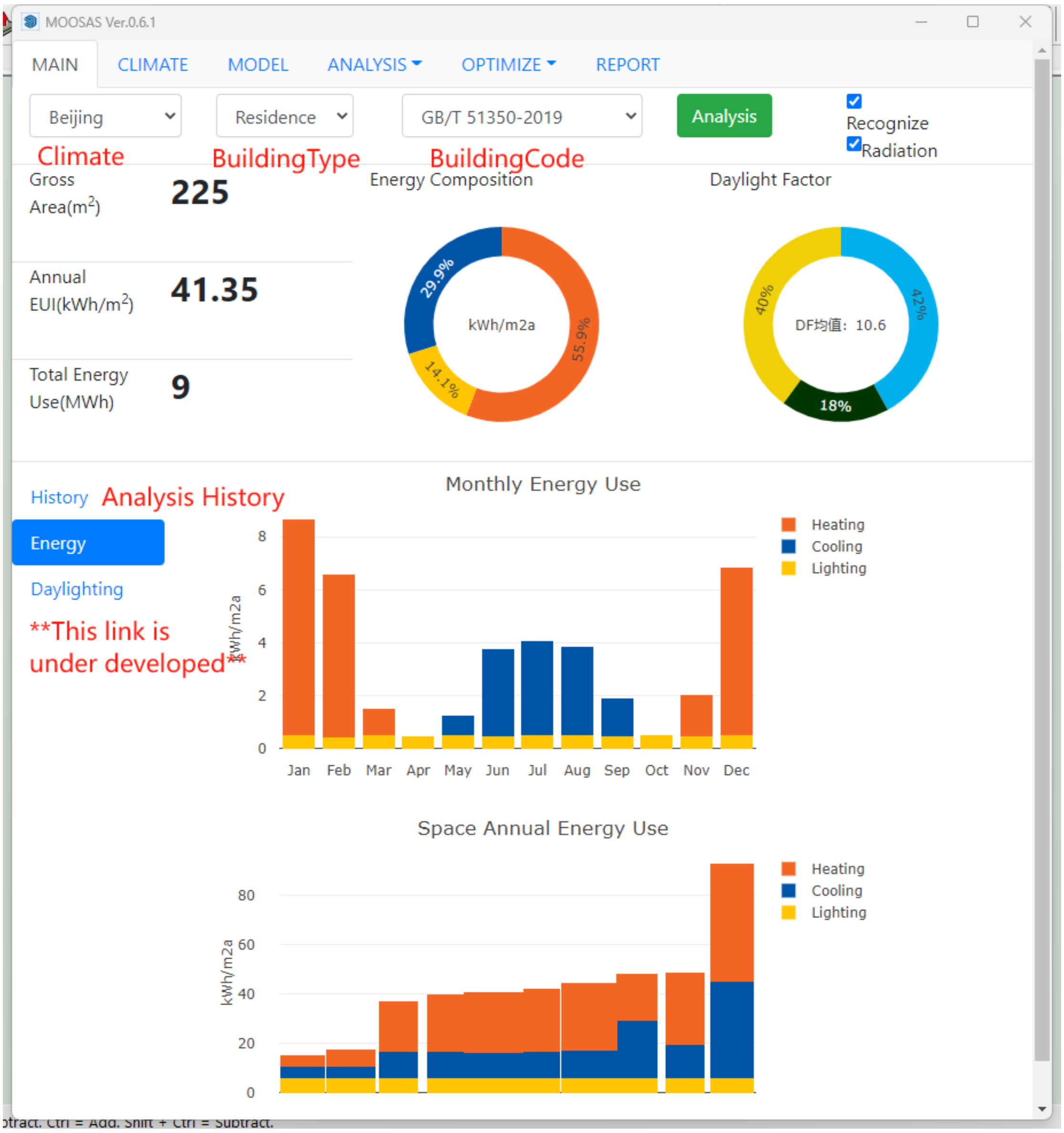
4.4.1. The model transformation also allows users to organize their models in groups. Any first-depth groups will be transformed individually; however, the second-depth groups (groups in a group) will be exploded in transformation.

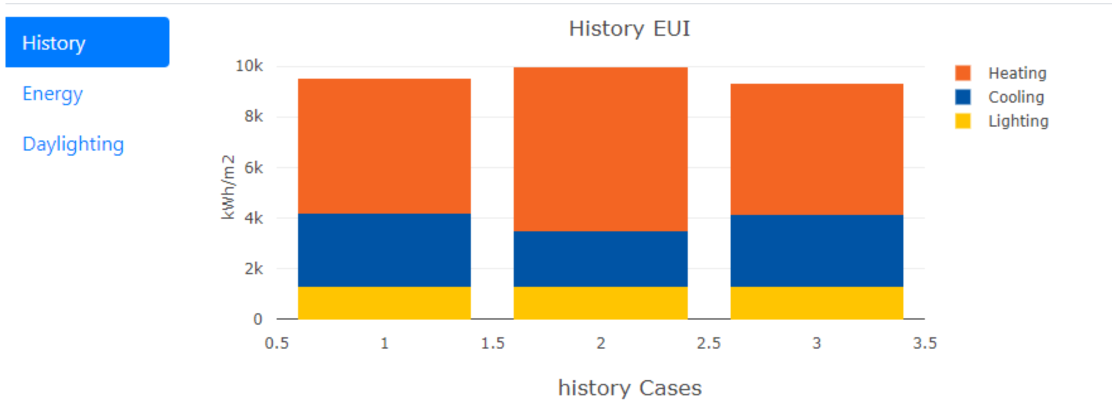
4.5. Users can use the visualization to check whether the model is recognized correctly.

5. Energy Analysis

5.1. Building type, climate data, and thermal parameters will be included in the energy analysis. Changes on parameters can be done in the MOOSAS Interface.

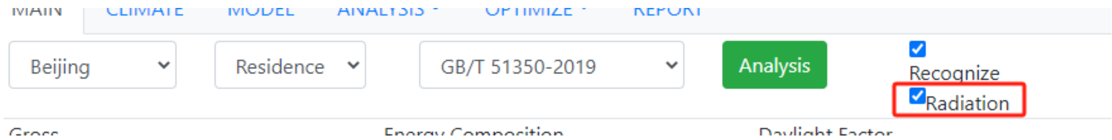
5.2. Users can change climate and building type here in the MAIN tab. If users have analyzed any models before (in this *.skp file), the analysis history will show the comparison between these cases.



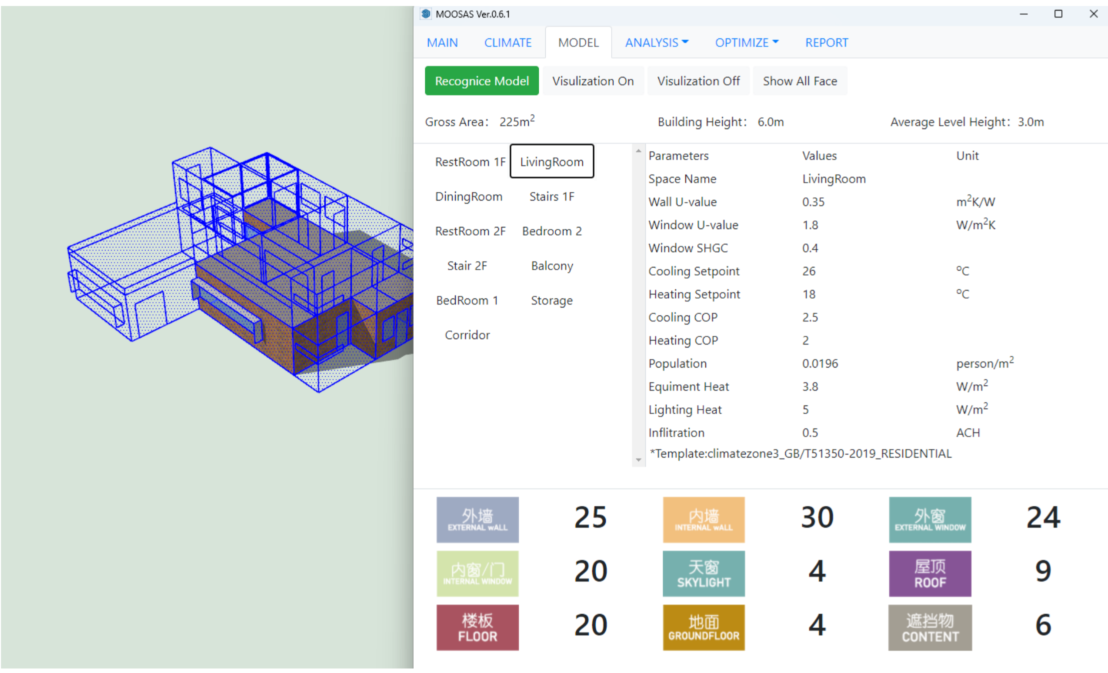


编号	名称	面积				
#1	wise_2023-11-24_	225	9509.27	2858.64	5334.03	1316.60
#2	wise_2023-11-24_	225	9930.85	2150.75	6463.51	1316.60
#3	wise_2023-12-05_	225	9322.15	2791.01	5214.54	1316.60

5.3. Users can choose whether to apply a fast calculation on radiation heat gain. (Wen et al. 2022) It can get an approximated values within 1% duration. Otherwise, the same method for the grid-based radiation analysis (Section 2.6) will be applied.

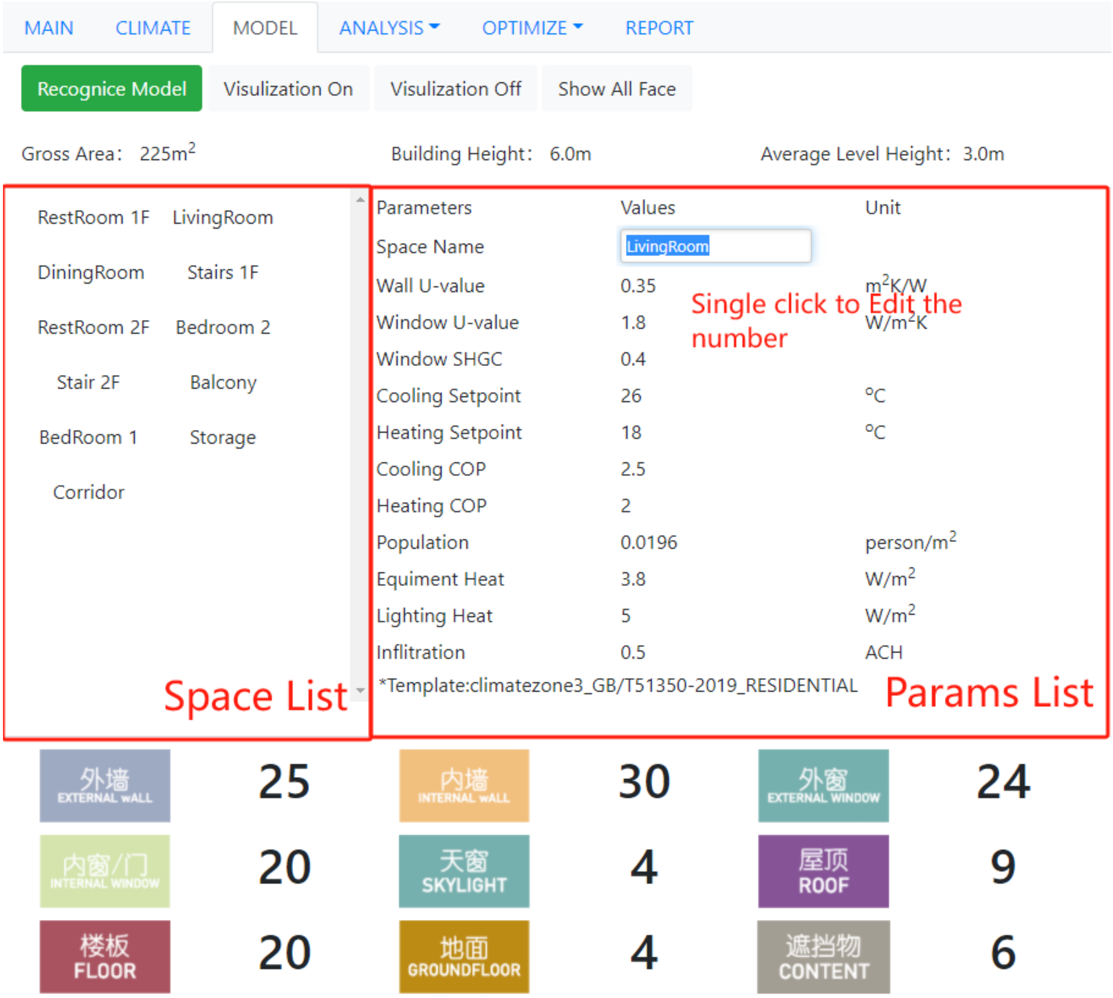


5.4. Users can change the thermal parameters of spaces in the MODEL tab after model transformation. It can also be run in the MODEL tab by “Recognize Model”.



5.4.1. Space thermal parameters will be auto allocated after changing the climate and building type following the template. **Usually, they don't need to be changed.** Users can find the values on the MODEL tab.

5.4.2. Choose any space on the left. Users can change the name of the space or any other parameters in the parameters list by **a single click on the value numbers.**



5.4.3. The settings will be saved in MOOSAS following the *.skp file name and the building geometry's location in the model. **If users change the file name or move the whole building to anywhere, the thermal parameters will be reset.**

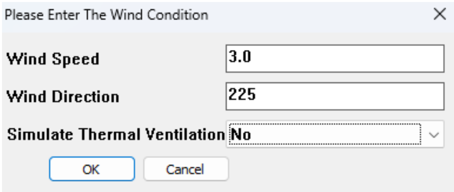
MOOSAS allows users to custom the building template. You can find the *.csv file in: C:\Users\[UserName]\AppData\Roaming\SketchUp\SketchUp 2022\SketchUp\Plugins\pkpm_moosas\db\building_template.csv

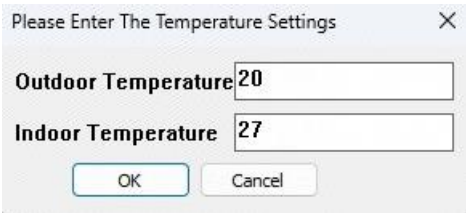
*There are only 7 templates until Dec 25, 2023. (cold climate, building code GB/T51350-2019 in China, 7 types of building) In the future, the "*template" text can also be edited to match those in the database.

6. Ventilation Analysis

6.1. This module contains 2 functions: the Airflow Network (AFN) analysis and the CFD simulation. They are in the same workflow that the program calculates the boundary conditions of each space by AFN analysis, then use the flow or pressure conditions of all windows to simulate the air flow pattern of the room. This method has been validated (Tan and Glicksman 2005) and it is implemented by Contamx and OpenFoam in MOOSAS.

6.2. The AFN analysis can simulate thermal ventilation and wind pressure ventilation simultaneously or individually. Users need to define the wind conditions include wind speed/ direction (in degree) for pressure ventilation and outdoor/ indoor air temperature.





6.2.1. The thermal ventilation analysis based on the conservation of flow volume and heat balance like the following balance for zone b:

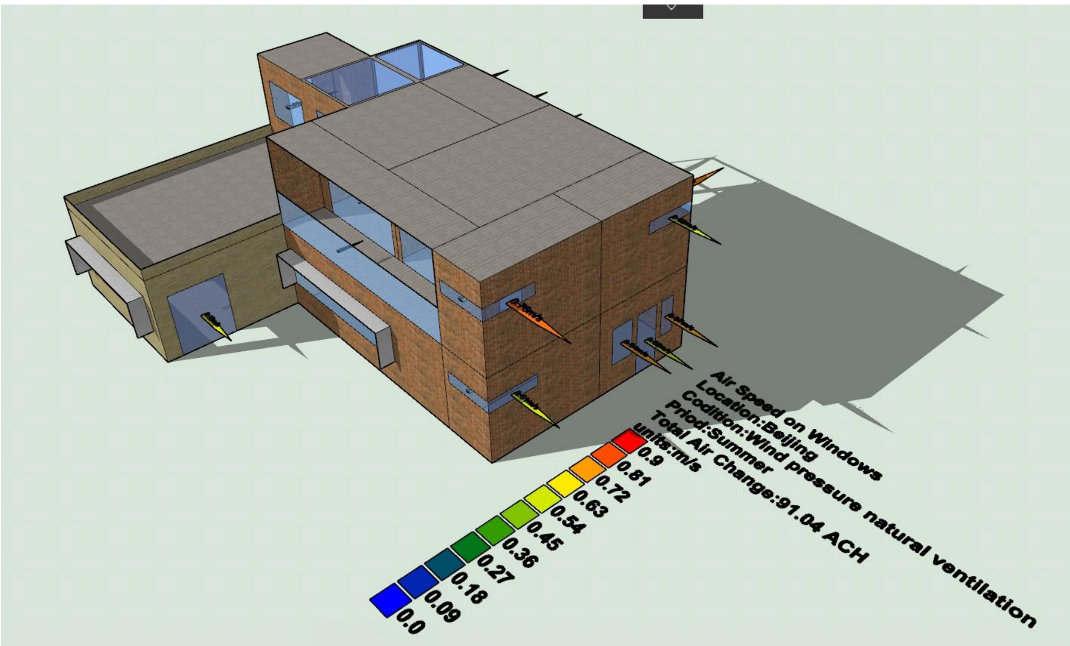
$$\sum_{i}^{n} G_{to,i} * t_b + G_{to,out} * t_b = \sum_{i}^{n} G_{from,i} * t_i + G_{from,out} * t_{out}$$

In this case, the thermal ventilation analysis needs to be iterative calculated until converged. However, it is very hard to be converged since there are always cyclic solutions for zones' temperature. We set 10 times for iteration based on our practices.

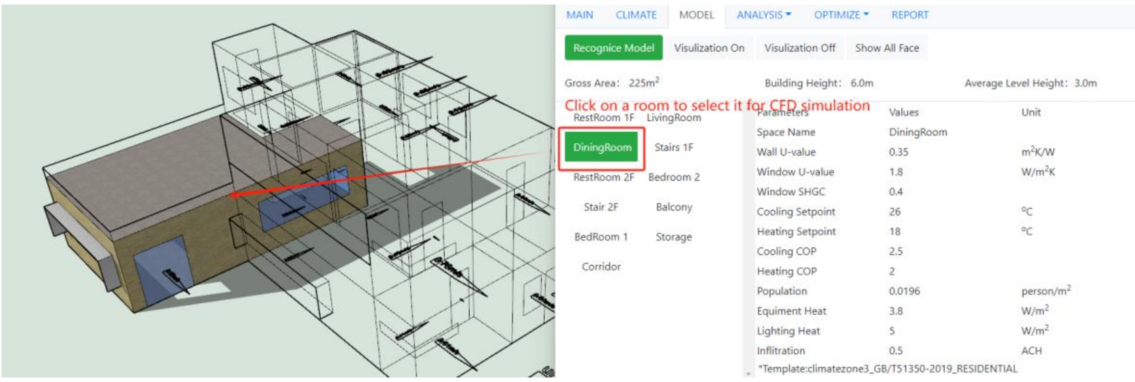
6.2.2. **THIS PART IS UNDER DEVELOPED** After the thermal ventilation analysis, a file named "result.csv" will be open, which records the converge process of temperature and air change coefficient. In next version, more readable visualization of the result will be present based on html.

ACH	DiningRoo	RestRoom	Stairs 1F	LivingRoom				
vol	142.73	22.8	22.28	218.7				
0	5337.553	994.5442	5539.61	8899.889	-17012.5			
1	5348.857	995.1317	5553.676	8913.472	-17041.1			
2	5345.741	995.8282	5548.493	8913.612	-17041.5			
3	5351.264	995.5296	5545.041	8913.582	-17041			
4	5344.878	994.8228	5548.56	8913.602	-17041.4			
5	5351.17	994.3546	5552.077	8913.071	-17040.5			
6	5351.371	994.7832	5549.969	8913.352	-17041			
7	5345.64	994.3646	5546.195	8913.201	-17040.7			
8	5346.41	994.8328	5546.006	8913.181	-17040.3			
9	5349.499	994.3845	5550.091	8913.211	-17040.6			
10	5350.889	995.6588	5545.518	8913.352	-17041.1			
Temperatu	DiningRoo	RestRoom	Stairs 1F	LivingRoom				
0	26.02671	26.37963	25.83874	25.66071	20			
1	26.00037	26.38858	25.81438	25.66146	20			
2	26.02147	26.38298	25.86822	25.65633	20			
3	25.99681	26.39702	25.82425	25.67634	20			
4	26.05909	26.43243	25.84707	25.69663	20			
5	26.0359	26.38694	25.85579	25.66047	20			
6	26.02316	26.43062	25.86796	25.70025	20			
7	26.05462	26.40906	25.88266	25.69203	20			
8	26.03038	26.42388	25.86303	25.6869	20			
9	26.03972	26.39833	25.84376	25.66225	20			
10	26.01392	26.42375	25.84276	25.68611	20			
ACH	Balcony	RestRoom	BedRoom	Bedroom 2	Stair 2F	Storage	Corridor	
vol	36.45	22.8	48.6	72.9	44.84	19.95	24.3	
0	7457.167	1238.482	0	0	18882.21	2290.676	8056.75	-27151.9
1	7458.269	1237.888	0	0	18922.38	2290.943	8060.604	-27192.9
2	7457.868	1238.406	0	0	18922.68	2291.559	8054.077	-27192.8
3	7458.068	1238.203	0	0	18922.68	2291.294	8054.378	-27193
4	7457.968	1238.609	0	0	18921.58	2289.896	8058.149	-27191.8
5	7458.369	1239.336	0	0	18921.88	2291.892	8066.508	-27192.7
6	7458.269	1237.883	0	0	18921.78	2294.117	8067.598	-27192.5
7	7458.168	1238.262	0	0	18922.38	2289.775	8062.842	-27192.8
8	7458.269	1239.876	0	0	18922.18	2292.455	8063.042	-27192.8
9	7458.068	1239.03	0	0	18922.68	2289.582	8057.28	-27193

6.3. After the AFN analysis, a visualized result about the wind speed and wind direction will be drawn on each window. Users can find the air change coefficient of the whole building in Air Change per Hour (ACH). Notice that this will be an ideal result that the program considers all your windows are fully open.



6.4. The CFD simulations can **only run on single room per time** and **only run after AFN analysis**. Users can use the MODEL tab in MOOSAS Interface or the visualization tools to choose one room, then click the CFD simulation button. (**THIS WILL BE IMPROVE IN LATER VERSION TO RUN MORE ROOMS SIMULTANEOUSLY**)



6.4.1. The visualization of CFD result should be automatically open after the simulation. The program uses Paraview to visualize. It is a stable visualization tool for OPENFOAM. Instructions can be found in: [ParaView for Computational Fluid Dynamics]

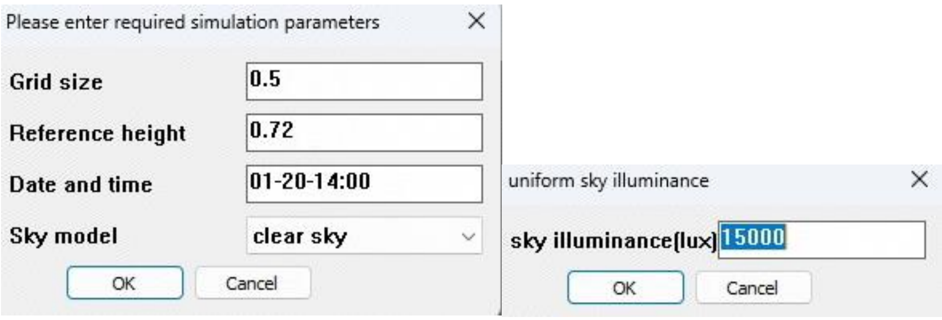
7. Daylight Simulation

7.1. MOOSAS provides point-in-time daylight simulation by RADIANCE. Users don't need to install RADIANCE since the engine has been embedded into MOOSAS. Currently we have banned the cloud services for daylight simulation in order to test the local simulation module. The cloud services will be available after testing.

7.1.1. **THIS FUNCTION IS UNDER DEVELOPED** Our team are working on the connection to Daysim for annual daylight simulation in MOOSAS. In the future, a new page on the MOOSAS Interface's tab ANALYSIS=>Daylight simulation will be added for result visualization on daylighting.

7.2. The program will first ask users whether to simulate all spaces in the building. If not, only the space selected by MODEL interface or visualization tools will be analyzed.

7.3. Gridding settings, simulation datetime and sky model are required for input in daylight simulation. Users need to enter the sky illuminance if the uniform sky is selected.



7.4. Scene Materials in SketchUp will be recognized according to their names.Users can add custom materials to the library in:

C:\Users\[UserName]\AppData\Roaming\SketchUp\SketchUp 2023\SketchUp\Plugins\pkpm_moosas\db\rad_material_lib.csv

Generally, the opaque materials can use "plastic" as the rad_type and set 0 to spec and rough; transparent materials can use "glass" and the RGB will be the opacity instead of reflectance.

Main Hint	Second hint	Main Hint	Second hint	Main Hint	Second hint	Main Hint	Second hint
plaster	-	tile	blue	stone	terrazzo	glazing	fencing
print	-	tile	black	stone	red	default	wall
print	white	tile	ceramic	stone	black	default	roof
print	moter	cladding	-	stone	dark_grey	default	floor
print	yellow	cladding	yellow	stone	vein_grey	default	window
print	brown	cladding	light	stone	light_grey		
brick	-	cladding	dark	concrete	-		
brick	grey	cladding	siding	concrete	asplalt		
brick	red	metal	-	glazing	-		
tile	-	metal	ground	glazing	safety		
tile	white	aluminium	-	glazing	translucent		
tile	yellow	aluminium	white	glazing	gold		
tile	pink	aluminium	mirror	glazing	grey		
tile	blue	aluminium	gold	glazing	blue		
tile	black	stone	-	glazing	green		
tile	ceramic	stone	marble	glazing	corrugated		

A sample of rad material

Category(Main hint)	subname(Second hint)	rad_type	R	G	B	spec	rough
print	white	plastic	0.75	0.75	0.75	0	0

7.5. Material may not be considered in a more common scene in sketch design stage. In this case, default material will be set according to the elements' type classified during model transformation:

Wall: vertical, opaque surfaces.

Window/ Door: vertical, transparent surfaces based on their location and size.

Ground Floor: the lowest horizontal surfaces.

Floor: horizontal opaque surfaces. (front material)

Ceiling: horizontal opaque surfaces. (back material)

Air boundary: surfaces with the opacity lower than 0.1.

Shading: Other surfaces located within one meter to a window.

Other Content: Other surfaces.

8. Q&A

Q1. Why some of the rooms are **TOTALLY** recognized as the Content?

A1. Most of these failures are due to the unclosed loop of walls. Any interval bigger than 0.01 m will be remain and may cause such mistake. We suggest you double checking your model before transforming.

Besides, if the size of the room is invalid (usually too thin/ small/ height < 1.5 m) the room will be ignored.

Lastly, the space will be ignored if it cannot find a floor and a ceiling. This can be solved by self-intersection (Section 4.4)

Q2. Why only **PARTLY** of the wall is recognized?

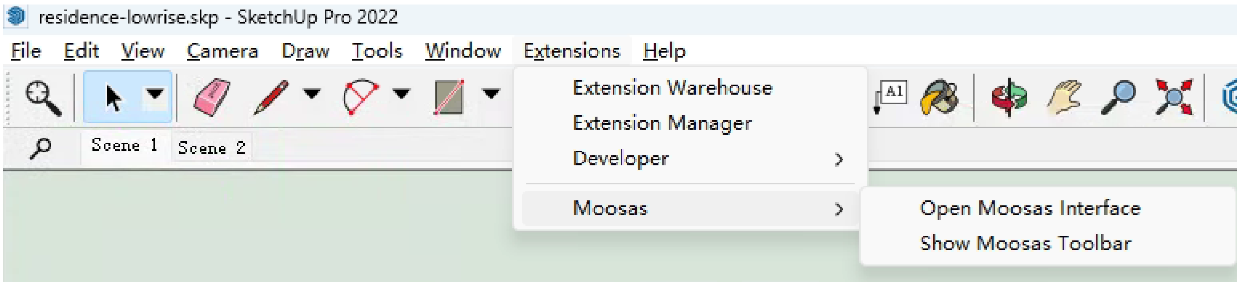
A2. Don't worry, everything goes green in analysis! There is a bug in SketchUp visualization. We will try to fix it in later version. Or if you really care about this, you can simplify the surface and try to use ONE surface to represent ONE wall.

Q3. Where is my space thermal information? They are lost in the second transformation.

A3. The thermal information is recorded according to **the file name of *.skp file** and **location of the space in the model.** If you move the model or rename the file, all settings would be reset until you cancel the changes. On the other hand, **you can easily reset all settings by moving the building for a distance**, **or rename your file.**

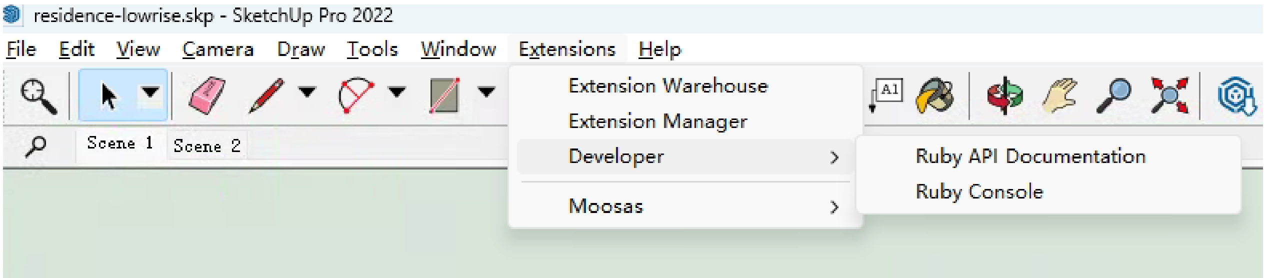
Q4. Where is the toolbar of MOOSAS?

A4. It shows that MOOSAS hasn't installed if you cannot find such a tab in SketchUp. Mostly because of the SketchUp Version.



Q5. My error hasn't recorded in Q&A.

A5. Please open the Ruby Console, retry your actions, take a screenshot of the ruby console, and send your error to junx026@gmail.com. We will try to fix the bug as soon as possible and update the pkpm-moosas.rbz in the same download link. Thank you for your help to improve the Software!



9. Reference

General introduction about MOOSAS

Lin, Borong, Hongzhong Chen, Qiong Yu, Xiaoru Zhou, Shuai Lv, Qiushi He, and Ziwei Li. 2021. "MOOSAS – A Systematic Solution for Multiple Objective Building Performance Optimization in the Early Design Stage." Building and Environment 200 (August): 107929. https://doi.org/10.1016/j.buildenv.2021.107929.

*Method Prototype:

Li, Ziwei et al. "Development Of A Fast Simulation-aided-design Method For Office Building In Early Design Stage." (2014).

AFN+CFD Ventilation Analysis Method

Shiji Yang. (2024). Research on Methods and Tool of Building Energy Consumption and Ventilation Performance Analysis for Early Design Stage, M.D. Thesis, Tsinghua University (In Chinese).

*Method Prototype:

Tan, Gang, and Leon R. Glicksman. 2005. "Application of Integrating Multi-Zone Model with CFD Simulation to Natural Ventilation Prediction." Energy and Buildings 37 (10): 1049–57. https://doi.org/10.1016/j.enbuild.2004.12.009.

Model Transformation

Xiao, Jun, Hao Zhou, Shiji Yang, Deyin Zhang, and Borong Lin. 2023. "A CAD-BEM Geometry Transformation Method for Face-Based Primary Geometric Input Based on Closed Contour Recognition." Building Simulation, December. https://doi.org/10.1007/s12273-023-1081-6.

*Method Prototype:

Chen H, Li Z, Wang X, et al. (2018). A graph- and feature-based building space recognition algorithm for performance simulation in the early design stage. Building Simulation, 11: 281–292.

Energy Analysis

Li, Ziwei, Hongzhong Chen, Borong Lin, and Yingxin Zhu. 2018. "Fast Bidirectional Building

Performance Optimization at the Early Design Stage." Building Simulation 11 (4): 647–61. https://doi.org/10.1007/s12273-018-0432-1.

*Fast Radiation Calculation on Energy Analysis

Wen, Jianxiu, Shiji Yang, Yongxin Xie, Juan Yu, and Borong Lin. 2022. "A Fast Calculation Tool for Assessing the Shading Effect of Surrounding Buildings on Window Transmitted Solar Radiation Energy." Sustainable Cities and Society 81 (June): 103834. https://doi.org/10.1016/j.scs.2022.103834.

*Method Prototype:

Chunhai, Xia. 2008. Research on energy conservation design methodology oriented to building's conceptual design stage, Ph.D. Thesis, Tsinghua University (In Chinese).

Preference-base NSGA optimization (not included in test version)**

Lin, B., Chen, H., Liu, Y., He, Q., & Li, Z. (2021). A preference-based multi-objective building performance optimization method for early design stage. Building Simulation, 14(3), 477–494. https://doi.org/10.1007/s12273-020-0673-7

POE interview

Wang, Chunxiao, Shuai Lu, Hongzhong Chen, Ziwei Li, and Borong Lin. 2021. "Effectiveness of One-Click Feedback of Building Energy Efficiency in Supporting Early-Stage Architecture Design: An Experimental Study." Building and Environment 196 (June): 107780. https://doi.org/10.1016/j.buildenv.2021.107780.