



Carnegie Mellon University

Building Energy Simulations (Part I)

Dr. Miguel Martin

Learning objectives

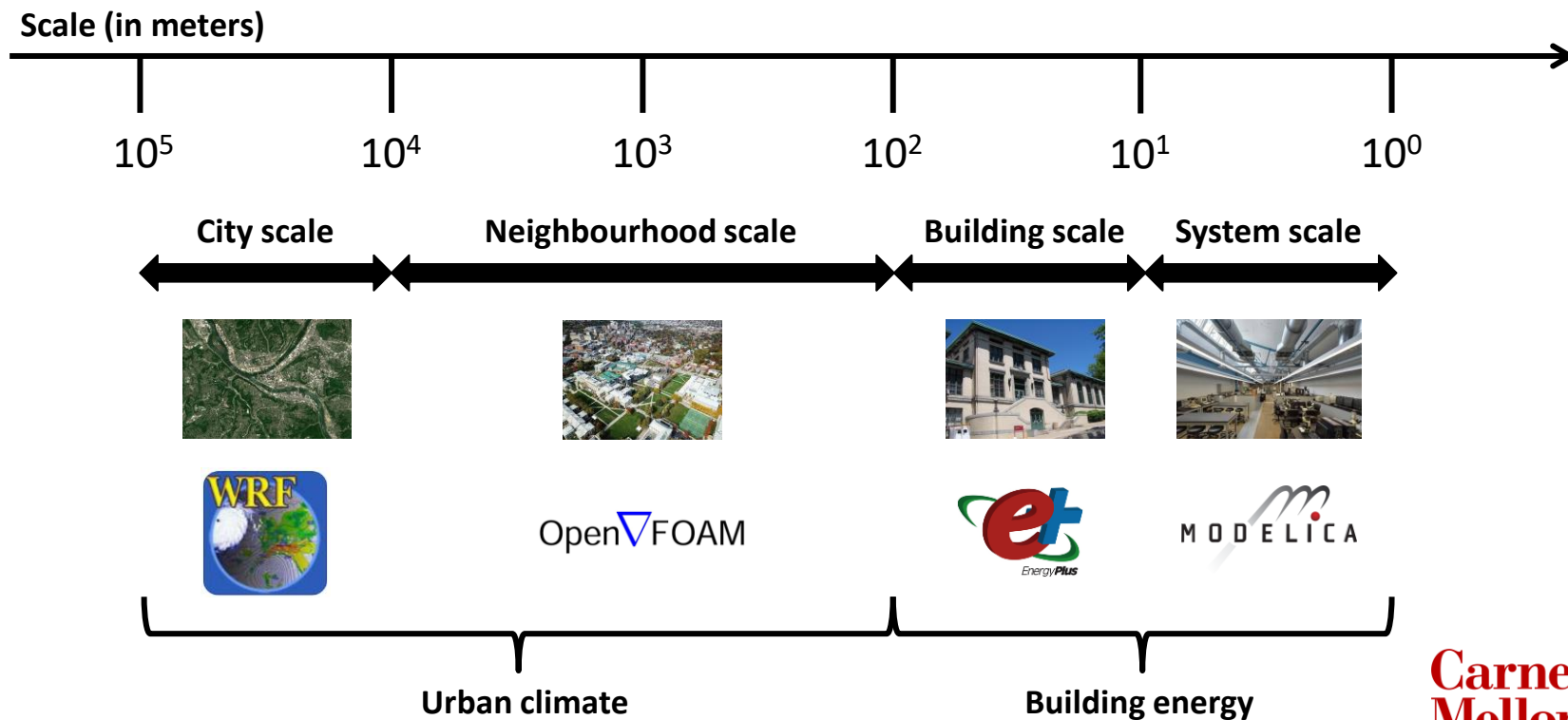
1. Overview of simulation tools in urban climatology and building science
2. Creation of a building energy model

References

Garg, Vishal, Jyotirmay Mathur, and Aviruch Bhatia. "**Building Energy Simulation : A Workbook Using Designbuilder**". Second edition. Boca Raton, FL ; CRC Press, Taylor & Francis Group, (2021).

What are the simulation tools we can use in urban climatology and building science?

Simulation tools

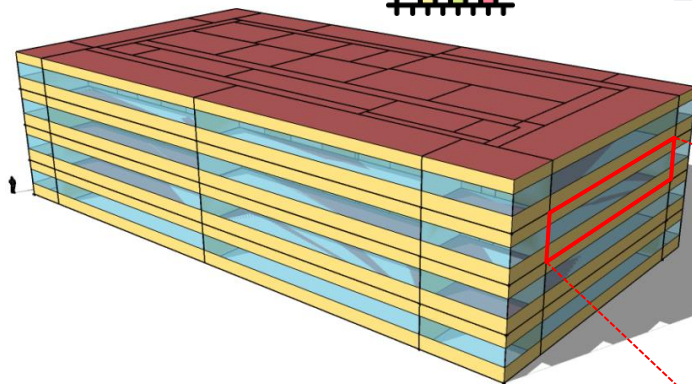
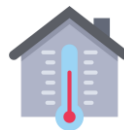


Building energy simulations

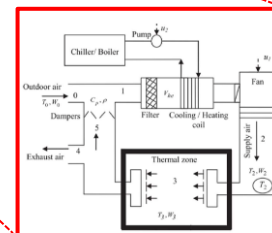
Energy
consumption



Indoor
conditions

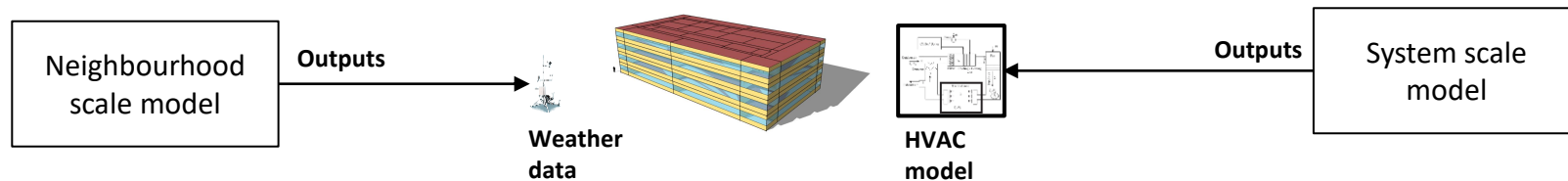


Weather data
(rural)



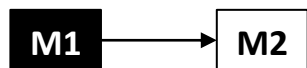
HVAC model
(simplified)

Coupling

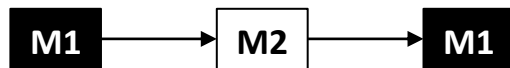


Static coupling

One Step

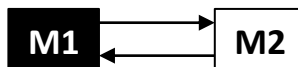


Two Step



Dynamic coupling

One-time-step



Is convergence achieved?

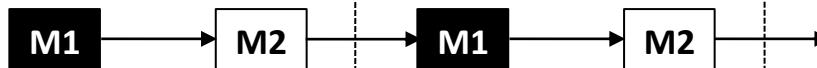
Full dynamic



Is convergence achieved?

Is convergence achieved?

Quasi dynamic



1st time step

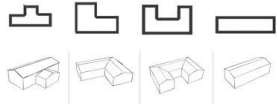
2nd time step

How do we create a building energy model?

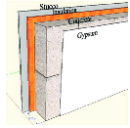
Creation of a building energy model

What is the procedure?

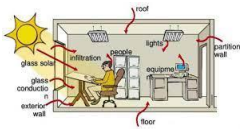
1. Geometry



2. Material composition



3. Internal heat gains



4. HVAC system



Where do I get the information from?

Architectural plan



3D city model



Database



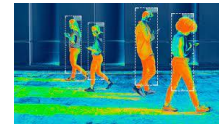
TABULA WebTool



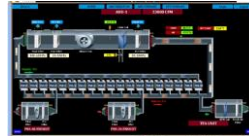
Smart metering



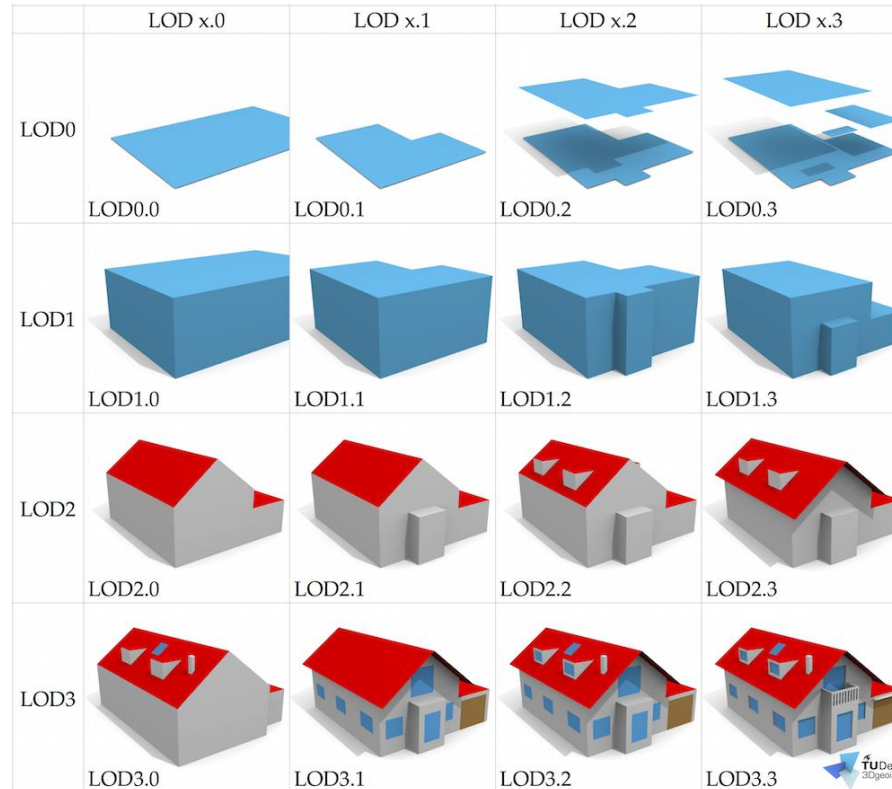
Infrared thermography



Building management system



Geometry in 3D city models



Install OpenStudio Sketchup plugging

OpenStudio SDK Version Compatibility Matrix

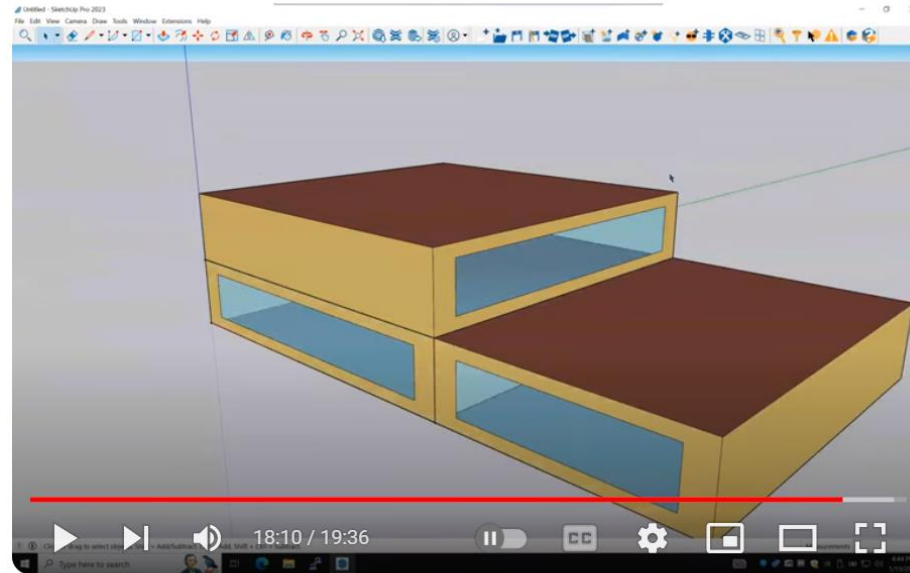
wenykuang edited this page on Nov 22, 2023 · 13 revisions

	E+	Radiance	SketchUp	Ruby	SHA	Released	Gemfile
v3.7.0	23.2.0	5.0.a.12	See	2.7.2	d5269793f1	2023-11-20	Gemfile
v3.6.1	23.1.0	5.0.a.12	See	2.7.2	bb9481519e	2023-05-22	Gemfile
v3.6.0	23.1.0	5.0.a.12	See	2.7.2	860f5de185	2023-05-09	Gemfile
v3.5.1	22.2.0	5.0.a.12	See	2.7.2	22e1db7be5	2022-12-29	Gemfile
v3.5.0	22.2.0	5.0.a.12	See	2.7.2	7b14ce1588	2022-11-10	Gemfile
v3.4.0	22.1.0	5.0.a.12	See	2.7.2	4b8816785	2022-05-05	Gemfile
v3.3.0	9.6.0	5.0.a.12	See	2.7.2	ad235f36e	2021-11-05	Gemfile
v3.2.1	9.5.0	5.0.a.12	See	2.7.2	bd0bc9da6	2021-06-25	Gemfile
v3.2.0	9.5.0	5.0.a.12	See	2.7.2	e110a08b2	2021-05-04	Gemfile
v3.1.0	9.4.0	5.0.a.12	See	2.5.5	e16590621	2020-10-16	Gemfile
v3.0.1	9.3.0	5.0.a.12	See	2.5.5	09b7c8a554	2020-06-26	Gemfile
v3.0.0	9.3.0	5.0.a.12	See	2.5.5	1c96171a4e	2020-04-27	Gemfile
v2.9.1	9.2.0	5.0.a.12	2017	2.2.4	3472e8b799	2019-12-07	Gemfile
v2.9.0	9.2.0	5.0.a.12	2017	2.2.4	801fa459c	2019-10-11	Gemfile
v2.8.1	9.1.0	5.0.a.12	2017	2.2.4	691444f90	2019-06-18	Gemfile
v2.8.0	9.1.0	5.0.a.12	2017	2.2.4	556656350	2019-04-12	Gemfile

Tutorial EnergyPlus - Install OpenStudio Sketchup Plugin in Virtual Andrew

<https://youtu.be/IEWey-yiv-E>

Describe the geometry



Tutorial EnergyPlus Define Building Geometry

<https://youtu.be/vNSAXC96bao>

Define the material composition

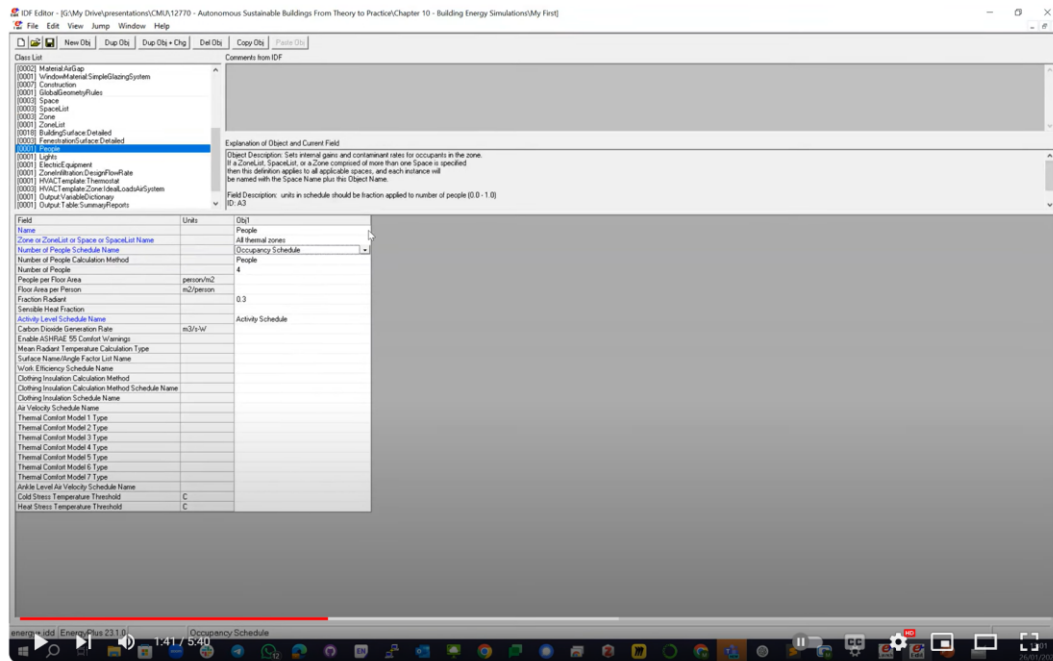
The screenshot shows the 'Material' class definition for 'Material_MatGap' in the IDF Editor. The main workspace displays a table of material properties for various material types. The table has 11 columns representing different material types and 11 rows representing different properties.

Field	Units	Mat1	Mat2	Mat3	Mat4	Mat5	Mat6	Mat7	Mat8	Mat9	Mat10	Mat11
Name		Heat Insulation	Heat Insulation [2]	Heat Insulation	Ins. Insoco	BN Concrete HV	Wall Insulation [42]	1/2" Gypsum	Mat [205] 4 HV/C	1 1/2" Open Lightwe	Flt Acoustic tile	5/8" 13mm gypsum
Surface		MediumSmooth	MediumSmooth	MediumSmooth	Smooth	MediumRough	MediumRough	Smooth	Rough	MediumRough	MediumSmooth	MediumSmooth
Thickness	m	0.0015	0.263	0.0016	0.0252	0.2023	0.14000000E-02	0.0237	0.1016	0.1016	0.0191	0.0191
Conductivity	W/m.K	45.006	0.049	45.006	6.31000000E-01	1.72600000E-02	0.0432	0.16	1.311	0.53	0.06	0.16
Density	kg/m3	7680	205	7680	1800	2.24300000E-02	91	794.9	2240	1260	368	800
Specific Heat	J/kg.K	418.4	8.36000000E-02	418.4	8.37000000E-02	8.37000000E-02	0.37000000E-02	8.36000000E-02	8.46000000E-02	8.46000000E-02	5.90000000E-02	1380
Thermal Absorptance		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Solar Absorptance		0.6	0.7	0.6	0.82	0.65	0.5	0.4	0.85	0.5	0.3	0.4
Visible Absorptance		0.6	0.7	0.6	0.82	0.65	0.5	0.4	0.85	0.5	0.3	0.4

Tutorial EnergyPlus - Install EnergyPlus and Define Material Composition

<https://youtu.be/8AD6-vdiJE>

Define internal heat gains



Tutorial EnergyPlus - Define Internal heat Gains

<https://youtu.be/QmLrMX5XOd8>

Design an ideal HVAC system

DF Editor - [C:\My Drive\presentations\CMU\12770 - Autonomous Sustainable Buildings From Theory to Practice\Chapter 10 - Building Energy Simulation\My First]

Class List

- 00001 Construction
- 00002 SubcomponentRules
- 00003 Space
- 00004 Zone
- 00005 ZoneList
- 00010 BuildingSurfaceDetailed
- 00006 ExteriorSurfaceDetailed
- 00007 Floor
- 00008 Light
- 00009 ElectricEquipment
- 00010 ConcentrationControlSurface
- 00011 HVACThermostat
- 00012 HeatingCoolingControlSurface
- 00013 OutputControlVariable
- 00014 OutputTableSummaryReports
- 00015 OutputTableSummaryReports
- 00016 OutputTableSummaryReports
- 00017 OutputTableStyle
- 00018 OutputVariable

Fields

Field Name	Units	Thermal Zone 1	Thermal Zone 2	Thermal Zone 3
Template Thermostat Name		Thermostat	Thermostat	Thermostat
System Availability Schedule Name		Always On	Always On	Always On
Maximum Heating Supply Air Temperature	C	50	50	50
Minimum Cooling Supply Air Temperature	C	13	13	13
Maximum Heating Supply Air Humidity Ratio	kgWater/kgDry	0.0156	0.0156	0.0156
Minimum Cooling Supply Air Humidity Ratio	kgWater/kgDry	0.0077	0.0077	0.0077
Heating Limit		NoLimit	NoLimit	NoLimit
Maximum Heating Air Flow Rate	m3/s			
Maximum Sensible Heating Capacity	W			
Cooling Limit		NoLimit	NoLimit	NoLimit
Maximum Cooling Air Flow Rate	m3/s			
Maximum Total Cooling Capacity	W			
Heating Availability Schedule Name		Always On	Always On	Always On
Cooling Availability Schedule Name		Always On	Always On	Always On
ControlSensibleControlType		ControlSensible	ControlSensible	ControlSensible
Cooling Sensible Heat Ratio	dimensionless	0.7	0.7	0.7
Dehumidification Control Type		None	None	None
Humidification Control Type	percent	None	None	None
Dehumidification Setpoint	percent	30	30	30
Outdoor Air Method		Flow/Person	Flow/Person	Flow/Person
Outdoor Air Flow Rate per Person	m3/s	0.0044	0.0044	0.0044
Outdoor Air Flow Rate per Zone Floor Area	m3/s/m2			
Outdoor Air Flow Rate per Zone	m3/s			
Design Specification Outdoor Air Object Name		None	None	None
Demand Controlled Ventilation Type		None	None	None
Outdoor Air Economizer Type		NoEconomizer	NoEconomizer	NoEconomizer
Heat Recovery Type		None	None	None
Outdoor Air Economizer Type		None	None	None
Sensible Heat Recovery Effectiveness	dimensionless	0.7	0.7	0.7
Latent Heat Recovery Effectiveness	dimensionless	0.05	0.05	0.05

1:58 / 4:30

Tutorial EnergyPlus - Define Ideal HVAC system

https://youtu.be/vChO8_leqYU