



POLITECNICO DI TORINO
Repository ISTITUZIONALE

CitySim Guide : Urban Energy Modelling

Original

CitySim Guide : Urban Energy Modelling / Mutani, Guglielmina; Coccolo, Silvia; Kaempf, Jérôme; Bilardo, Matteo. - (2018), pp. 1-114.

Availability:

This version is available at: 11583/2713921 since: 2018-09-26T11:07:58Z

Publisher:

CreateSpace

Published

DOI:

Terms of use:

openAccess

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

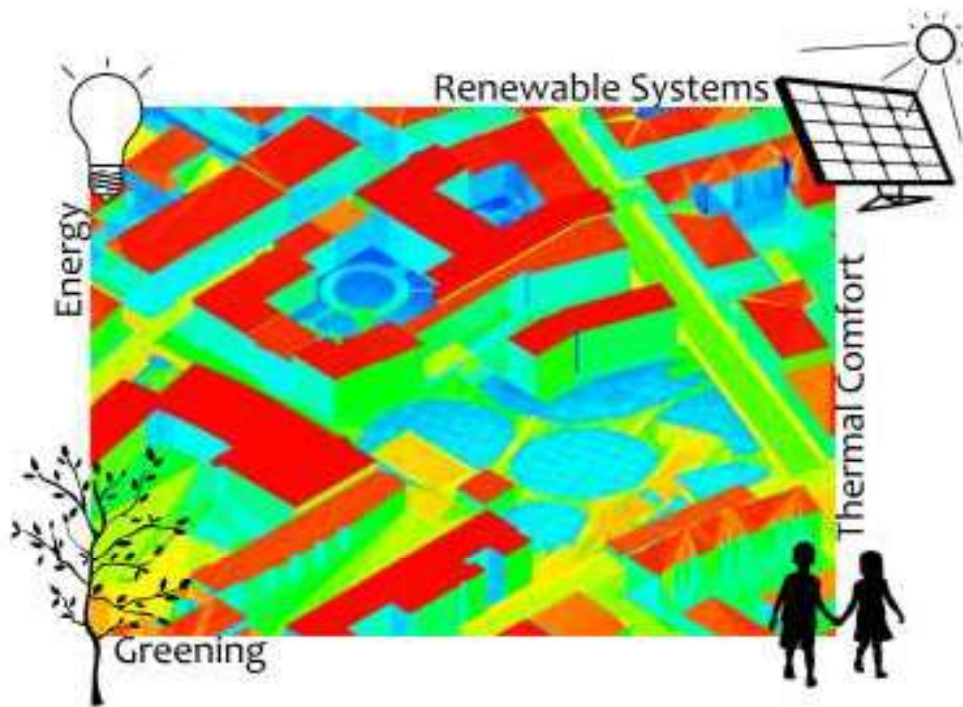
Publisher copyright

(Article begins on next page)

CitySim Guide

Urban energy modelling

G. Mutani, S. Coccolo, J. Kämpf and
M. Bilardo



Acknowledgments

This research has been partially financed by the EPFL Middle East, the Swiss International Scientific School of Dubai (SISD), the VP-RHO of the EPFL and the Swiss Competence Center for Energy Research SCCER FEEB&D of the Swiss Innovation Agency Innosuisse (CTI.2014.0119).

This guide was realized in collaboration between the Department of Energy of Politecnico di Torino, the Solar Energy and Building Physics Laboratory (LESO-PB, EPFL) and kaemco LLC.



**POLITECNICO
DI TORINO**
DENERG
Dipartimento Energia



Cover image adapted from:

Coccolo, S., Kämpf, J., Mauree, D., Scartezzini, J.-L., 2018. Cooling potential of greening in the urban environment, a step further towards practice. *Sustain. Cities Soc.* 38, 543–559.

Contents

Acknowledgments	2
1.0 Introduction.....	6
1.1 CitySim	6
1.1.1 Installation and licence request.....	7
1.1.2 CitySim	11
1.1.3 Input information	14
1.2 Meteonorm© - How to create climate data	14
1.2.1 How to create a .cli file.....	16
1.2.2 How to create a .hor file.....	22
1.3 Building the model	23
1.3.1 Google SketchUp installation	24
1.3.2 Google SketchUp – basic guide	28
1.3.3 Rhinoceros model.....	35
1.4 Additional programs needed.....	36
1.5 CitySim import	37
1.5.1 Import error.....	39
2.0 CitySim simulation	40
2.1 Setting location data	40
2.2 Setting building characteristics	40
2.3 Composites and insulations	41
2.3.1 Realisation of a material/composite in XML	42
2.3.2 Ground properties	48
2.3.3 Setting the grass evapotranspiration.....	52
2.4 Opening properties	52

2.5	Outdoor surfaces properties	53
2.6	Occupants info.....	54
2.7	Simulation	54
3.0	Results.....	57
4.0	The case study of Turin, Italy	59
4.1	Step 1: define the model.....	60
4.2	Step 2: building the 3D model.....	67
4.2.1	Method 1 – AutoCAD + SketchUp	70
4.2.2	Method 2 – SketchUp.....	86
4.3	Step 3: CitySim import.....	88
4.4	Case study simulation.....	90
	References	108
	List of Figures.....	111

References

The following references helped drawing up this document. In addition, they can also be checked as focus work on the CitySim simulation topic.

Carozza M., Mutani G., Coccolo S., Kaempf J. H. 2017. Introducing a hybrid energy-use model at the urban scale: the case study of Turin (Italy). *Conference Proceedings BU Press 3rd BSA-Italy*. pp. 209-216. ISSN: 25316702, ISBN: 978-886046136-0.

Coccolo, S. 2017. *Bioclimatic design of sustainable campuses using advances optimization methods*. EPFL Thesis n. 7756.

Coccolo, S., et al. 2018. Cooling potential of greening in the urban environment, a step further towards practice. *Sustainable Cities and Society* 38, pp. 543-559.

Coccolo, S., et al. 2018. Thermal Comfort Maps to estimate the impact of urban greening on the outdoor human comfort. *Urban Forestry & Urban Greening* 35, pp. 91-105.

Guen, M.L., et al. 2018. Improving the energy sustainability of a Swiss village through building renovation and renewable energy integration. *Energy and Buildings* 158, pp. 906-923.

Kämpf, J.H. 2009. *On the Modelling and Optimisation of Urban Energy Fluxes*. EPFL Thesis n. 4548.

Kämpf, J.H., D. Robinson. 2007. A Simplified Thermal Model to Support Analysis of Urban Resource Flows. *Energy and Buildings* 39, pp. 445-53.

Kämpf, J.H., M. Montavon, J. Bunyesc, R. Bolliger, D. Robinson. 2010. Optimization of buildings' solar irradiation availability. *Solar Energy* 84, pp. 596-603.

Martin, L., L. March. 1972. Urban space and structure.

Mauree, D., et al. 2018. A new framework to evaluate urban design using urban microclimatic modeling in future climatic conditions. *Sustainability* 10 (4), 1134.

Mauree, D., et al. 2017. Multi-scale modelling to evaluate building energy consumption at the neighbourhood scale. *PLoS One*.

Mutani, G., et al. 2018. Building energy consumption modeling at urban scale: three case studies in Europe. *INTELEC® 2018 - International Telecommunications Energy Conference, Torino, Italy 7-11th October*, in press.

Mutani, G., Gamba, A. and Maio, S. 2016. Space heating energy consumption and urban form. The case study of residential buildings in Turin (Italy). *11th Conference on Sustainable of Energy, Water and Environmental Systems, SDEWES2016.0441*, pp. 1-17. ISSN 1847-7178 (digital proceedings).

Mutani, G., Martino, M. and Pastorelli, M. 2017. Hybrid models for the evaluation of energy sustainability in urban areas. *GeoProgress Journal* Vol. 4, Issue 2. (http://www.geoprogress.eu/wp-content/uploads/2018/09/GPJ2017_VOL4_2-02MutaniMartinoPastorelli.pdf).

Mutani, G., Todeschi, V. and Matsuo, K. 2018. The Microclimate in Hiroshima. A Model to Mitigate the Urban Heat Island Effects. *Journal of Weather Changes* Vol. 1, pp. 1-26. (<https://openaccesspub.org/jwc/article/836>).

Perera, A.T.D., et al. 2018. Quantifying the impact of urban climate by extending the boundaries of urban energy system modeling. *Applied Energy*, Vols. 222, pp. 847-860.

Remund, J., Müller, S. and Kunz, S. *Meteonorm - Global Meteorological Database - Version 7*.

Robinson, D. 2011. *Computer modelling for sustainable urban design. Physical principles, methods & applications.* . Earthscan, London and Washington DC : s.n.

Robinson, D., A. Stone. 2005. A Simplified Radiosity Algorithm for General Urban Radiation Exchange. *Building Services Engineering Research Technology* 26, pp. 271–84.

Robinson, D., F. Haldi, J. Kämpf, P. Leroux, D. Perez, A. Rasheed, U. Wilke. 2009. Citysim: comprehensive micro-simulation of resource flows for sustainable urban planning. *Proceedings of the 11th International IBPSA Conference*.

Rode, P., C. Keim, G. Robazza, P. Viejo, J. Schofield. 2014. Cities and energy: urban morphology and residential heat-energy demand. *Environment and Planning B: Planning and Design* 41, pp. 138–162.

Torabi Moghadam, S., et al. A new clustering and visualization method to evaluate urban energy planning scenarios, Cities, under revision.

Upadhyay, G., D. Mauree, J. Kampf, J.L. Scartezzini. 2015. Evapotranspiration Model to Evaluate the Cooling Potential in Urban Areas - a Case Study in Switzerland. *Proceedings of Building Simulation 2015 - 14th International IBPSA Conference*.

Walter, E., J. Kämpf. 2015. A verification of CitySim results using the BESTEST and monitored consumption values. *Proceedings of the 2nd Building Simulation Applications BSA*.

List of Figures

Figure 1 CitySim logo, designed by Laurent Deschamps	7
Figure 2 CitySim download page	8
Figure 3 Files in CitySim folder	9
Figure 4 Licence agreement to be filled.....	10
Figure 5 Licence agreement to be filled	11
Figure 6 District properties input window	15
Figure 7 Global Solar irradiation of Europe. Meteonorm©	15
Figure 8 Climatic elements to be defined by Meteonorm© in the .cli file.....	16
Figure 9 Meteonorm©. Locations.....	17
Figure 10 Meteonorm©. Modifications	18
Figure 11 Meteonorm©. Data	19
Figure 12 Meteonorm©. Format.....	20
Figure 13 Meteonorm©. User defined output format	21
Figure 14 File .cli.....	22
Figure 15 Meteonorm©. Skyline obstructions.....	22
Figure 16 File .hor.....	23
Figure 17 Google SketchUp download window	24
Figure 18 Google SketchUp download window.....	24
Figure 19 Google SketchUp extension setup	26
Figure 20 SketchUp template choice	28
Figure 21 Rectangle tool in SketchUp.....	30
Figure 22 Quote and meter tools in SketchUp.....	32
Figure 23 SketchUp building model.....	34
Figure 24 Building volume correct definition.....	35
Figure 25 Export properties in Rhinoceros	36
Figure 26 CitySim model import	38
Figure 27 CitySim import error.....	39
Figure 28 District properties	40
Figure 29 Building properties.....	41
Figure 30 Composites and insulation properties	42
Figure 31 CitySimDatabase.xml - Notepad++ view.....	43
Figure 32 Lesosai. Construction types.....	45
Figure 33 Lesosai. Creation of the envelope.....	46
Figure 34. xml code in Notepad++.....	47

Figure 35 Ground composite selection.....	50
Figure 36 Adding the evapotranspiration to the grass layer	52
Figure 37 Opening properties	53
Figure 38 Visible surfaces	53
Figure 39 Occupants information.....	54
Figure 40 Occupants information.....	55
Figure 41 Result TH.tsv in Excel window	57
Figure 42 Case of study district.....	60
Figure 43 GEOPORTALE of Turin Municipality	61
Figure 44 GEOPORTALE - zoom on case of study area	62
Figure 45 GEOPORTALE - map view of the case of study area	64
Figure 46 GEOPORTALE - information window	66
Figure 47 GEOPORTALE - technical sheet download.....	68
Figure 48 Technical sheet N.78 Scale 1:2000	69
Figure 49 AutoCAD importing windows	71
Figure 50 PDF underlay in AutoCAD	72
Figure 51 AutoCAD - new layer definition.....	74
Figure 52 Building contour drawing	75
Figure 53 Building locations	77
Figure 54 Analysed area footprint.....	78
Figure 55 Buildings on different layers.....	79
Figure 56 Polyline extrusion example	81
Figure 57 3D model.....	82
Figure 58 SketchUp model import	83
Figure 59 Sketch Up blocks explosion	85
Figure 60 Image import and scale in SketchUp	87
Figure 61 Building model drawing	88
Figure 62 CitySim model import	89
Figure 63 CitySim import error	90
Figure 64 Surfaces resistances	92
Figure 65 Stratigraphy examples from UNI/TR 11552	97
Figure 66 .xml code in Notepad++	100
Figure 67 Composites and insulation drop-down menu, with user defined composite	101
Figure 68 Simulation scene ground.....	102
Figure 69 Ground vertexes	102

Figure 70 CitySim different simulation grounds103