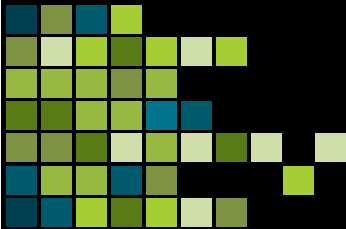


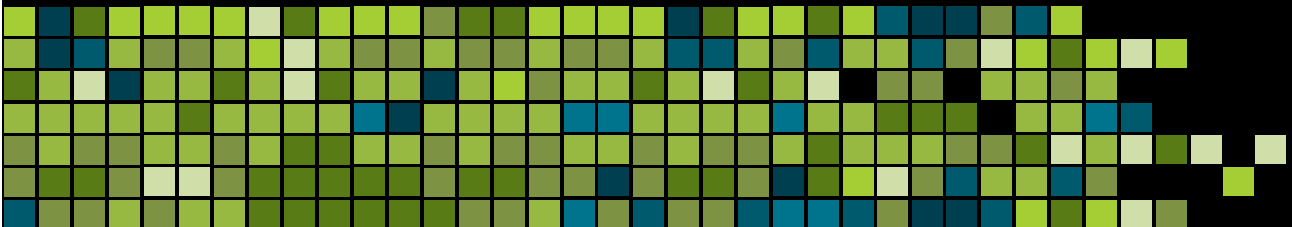
GENIUS, a tool to generate multi-scalar databases for urban energy studies



IFU, 4th of July 2014

Biao WANG - Marion BONHOMME

1. Context



1. Context

1.1. City, energy, climate

1. Context

2. Development of GENIUS

3. Results and Conclusions

3

- Cities are the world's largest energy consumers (transportation, buildings, industries, etc.).
- Buildings (housing and activity)
= **44** % of French energy consumptions
[France, 2011, Commissariat Général du Développement Durable, 2012]
- Urban population growth
= **75** % to **84** %
between 2007 and 2030 in developed countries
[United Nation forecast, 2006]

1. Context

1.1. City, energy, climate

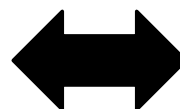
1. Context

2. Development of GENIUS

3. Results and Conclusions

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Consumed
energy in the city



Urban density
and morphology

Many research programs have assessed sustainable neighborhoods and most agreed on the need for urban density: a compact urban form is more efficient in terms of heating and transportation consumption:

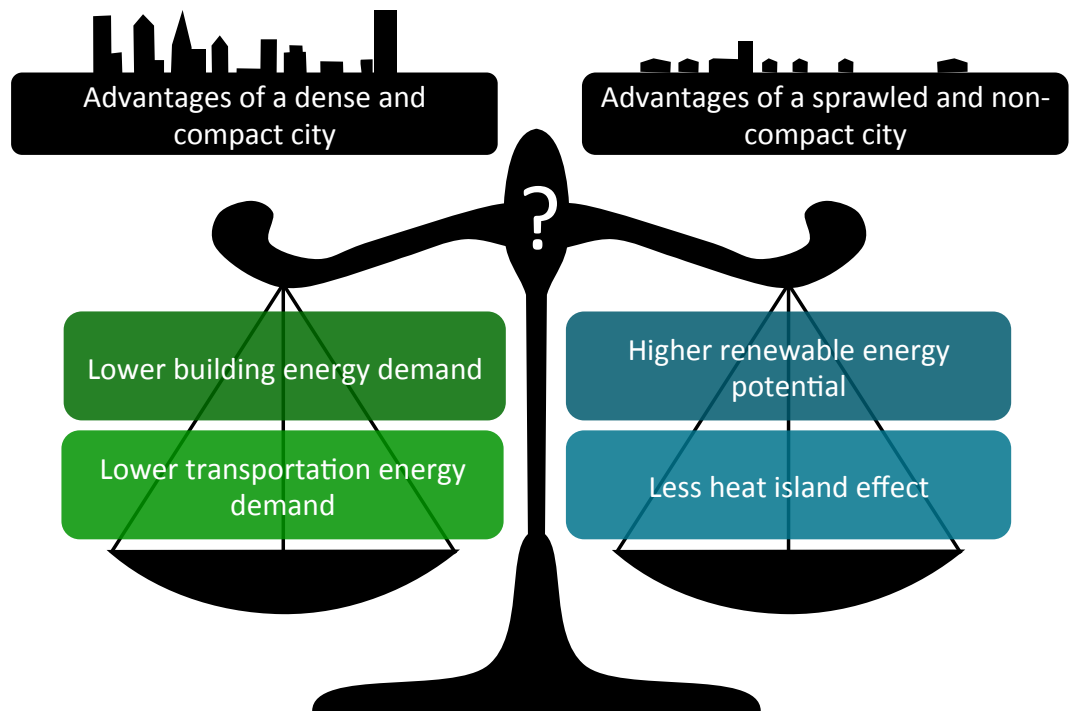
- Adolphe, 2001, 2003
- Chen, Jia, & Lau, 2008
- Hui, 2001
- Newman & Kenworthy, 1989)
- Ratti, Baker, & Steemers, 2005
- Rogers, 2000
- Steemers, Baker, Crowther, Nikolopoulou, & Clocquet, 1996
- Thomas & Cousins, 1996
- Traisnel, 2001 ...



1. Context

1.2. Urban energy and density

The urban energy paradox



1. Context

1.3. Limits of current research

The need for multidisciplinary

The study of urban energy must be multidisciplinary.

Limitations of existing studies related to databases:

- Spatial scales are very different
- The necessary data are highly variable
- Little connection between these scales
- Very different time scales



City

Neighbourhood

Urban block

Building

Room

1. Context

1.4. Objectives

1. Context

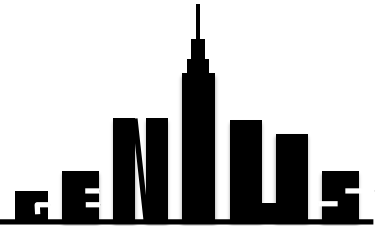
2. Development of GENIUS

3. Results and Conclusions

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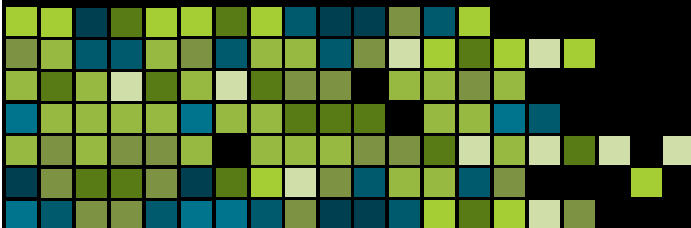
- Development of a tool to create multidisciplinary, multiscale and evolutive databases,

GENerator of Interactive Urban bocks



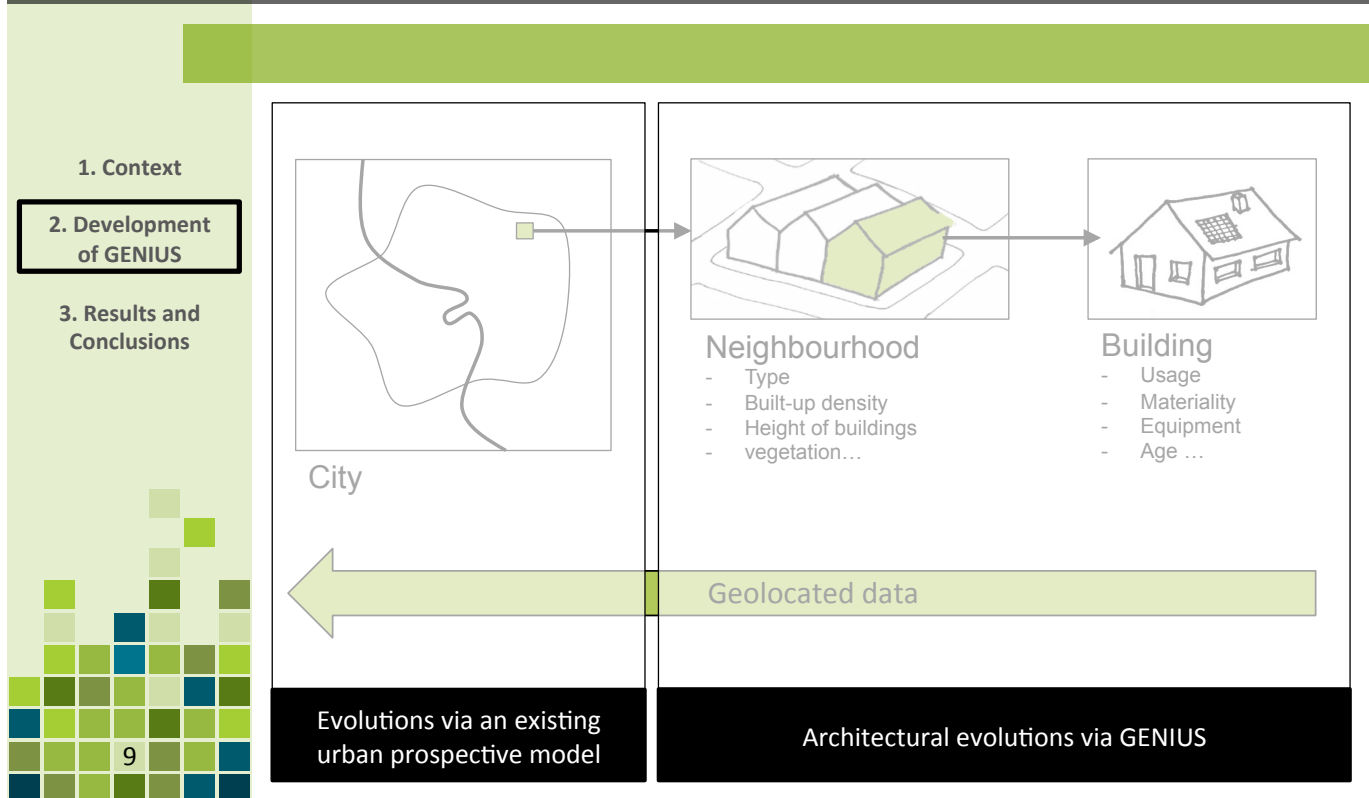
- Recommendations to policy makers and urban planners based on multidisciplinary research projects

2. Development of GENIUS



2. Development of GENIUS

2.1. Objectives

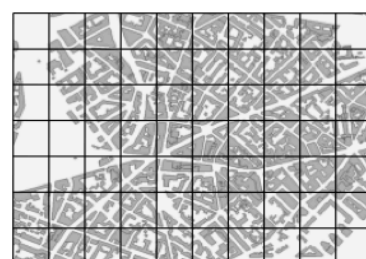


2. Development of GENIUS

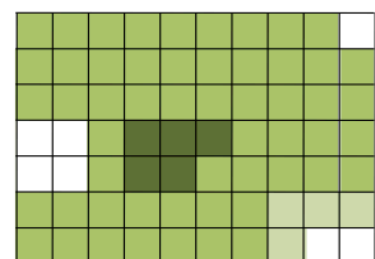
2.2. Synchronic GENIUS

General principle

First step : Generation of an archetypal map



Urban database
available at national
scale



Each cell is characterized by :

- 51 morphological parameters
- A type of neighbourhood determined by a statistical analysis (PCA)

2. Development of GENIUS

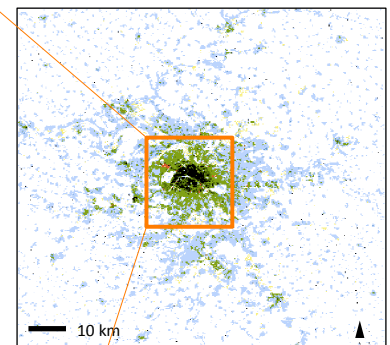
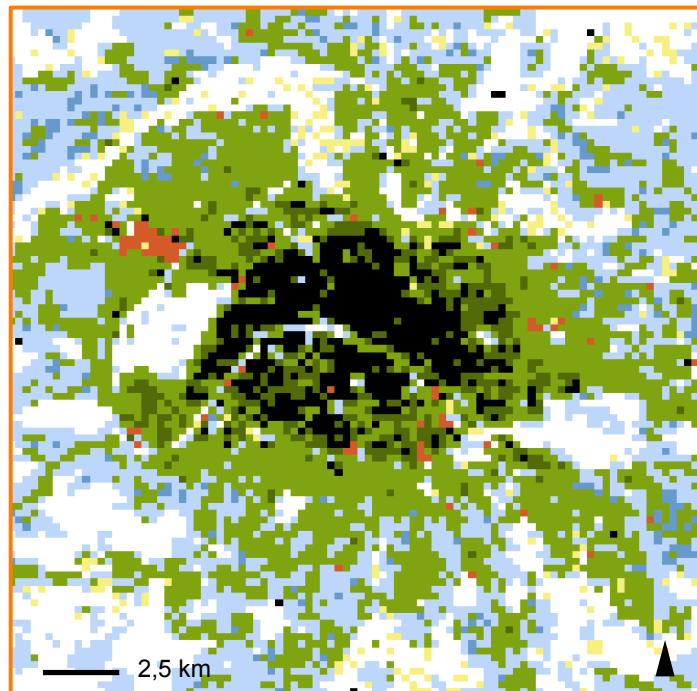
2.2. Synchronic GENIUS

Results for Paris

1. Context

2. Development of GENIUS

3. Results and Conclusions



Types of neighbourhood:

Continuous pavilion	Blue
Discontinuous pavilion	Light Blue
Continuous block	Dark Green
Discontinuous block	Light Green
High-rise tower	Red
Ancient center	Black
Industrial building	Yellow

2. Development of GENIUS

2.3. Diachronic GENIUS

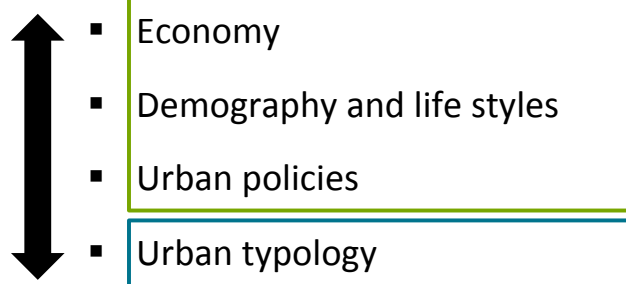
General principal

1. Context

2. Development of GENIUS

3. Results and Conclusions

Mechanisms driving urban expansion:



Mechanisms included in dynamic urban expansion models

Mechanisms that are not included in any existing model

2. Development of GENIUS

2.3. Diachronic GENIUS

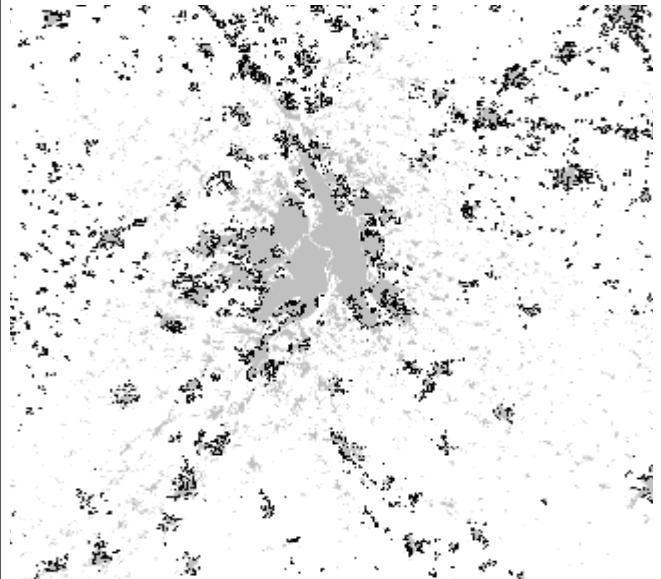
Coupling with an existing urban expansion model

1. Context

2. Development
of GENIUS

3. Results and
Conclusions

SLEDUM model



Example of the possible expansion of the city of Toulouse between 2010 (grey) et 2100 (black)

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2. Development of GENIUS

2.3. Diachronic GENIUS

Rules for the typological evolution

1. Context

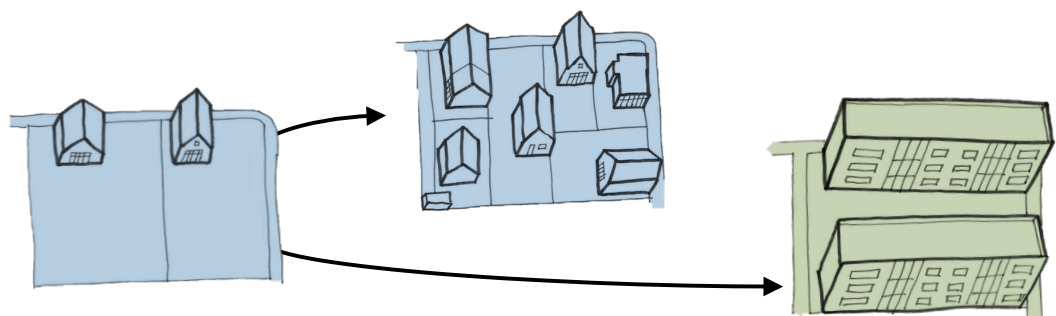
2. Development
of GENIUS

3. Results and
Conclusions

The city keeps track of its history. Thus, it is very likely that the future shape of a neighbourhood depends on its past form.

Rules from the observation of past trends:

- If the built-up density does not exceed a certain level: neighbourhood type remains the same
- Beyond, and if the neighbourhood is over 50 years old, the type of neighbourhood change: it is destroyed to be rebuild denser

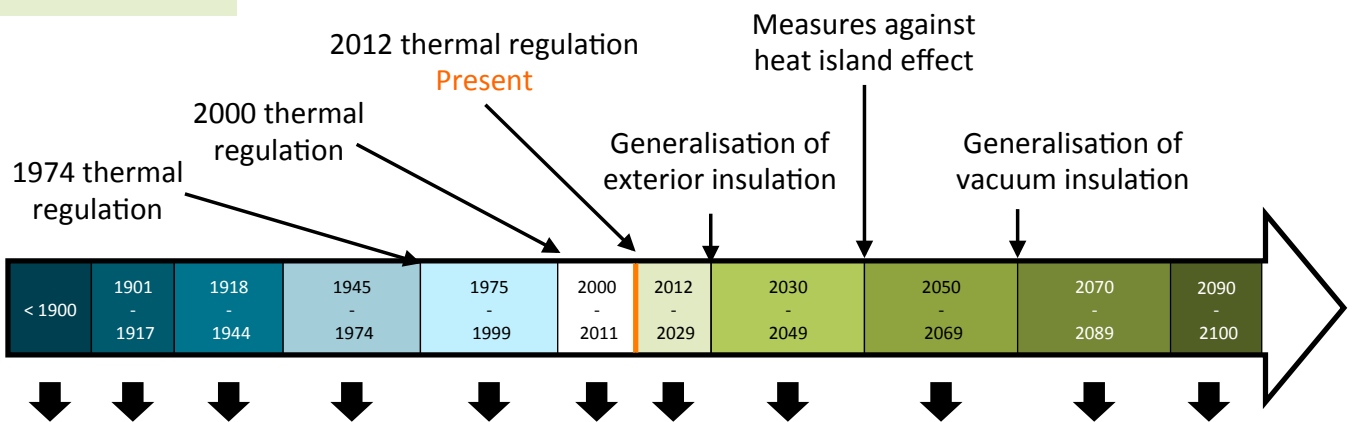


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2. Development of GENIUS

2.3. Diachronic GENIUS

Rules for the technical evolution



Allocation of technical characteristics in terms of:

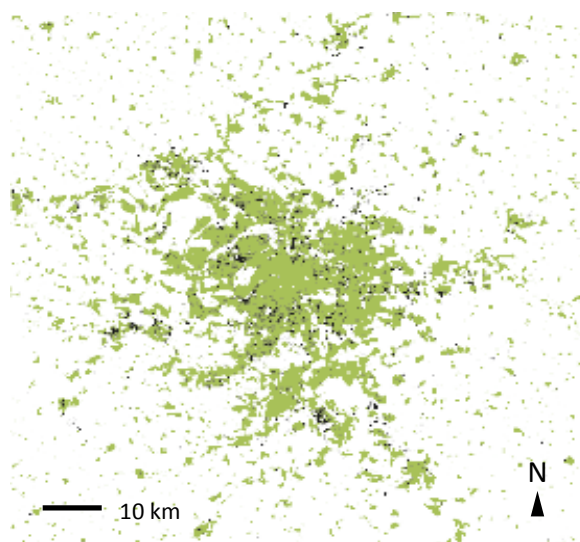
- the construction period,
- the type of neighbourhood,
- usage.

2. Development of GENIUS

2.3. Diachronic GENIUS

Validation

Validation on past evolutions between 1962 and 2008 :



93 % of the neighborhoods build by GENIUS between 1962 and 2008 correspond to the actual Paris

- Correctly build area
- Wrongly build area

1. Context

2. Development of GENIUS

3. Results and Conclusions

3. Results and conclusions



3. Results and conclusions

3.1. Example of results

Continuous pavilion	
Discontinuous pavilion	
Continuous block	
Discontinuous block	
High-rise tower	
Ancient center	
Industrial building	

Maps obtained under 3 different scenarios for the city of Toulouse in 2100 :

Dynamic city:

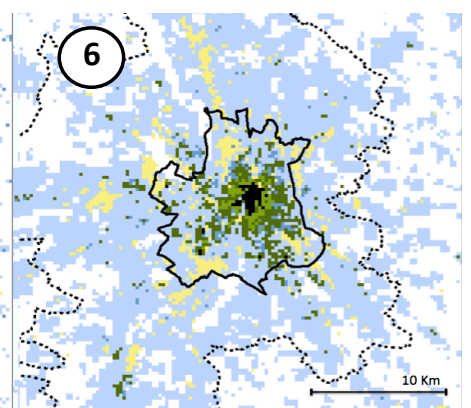
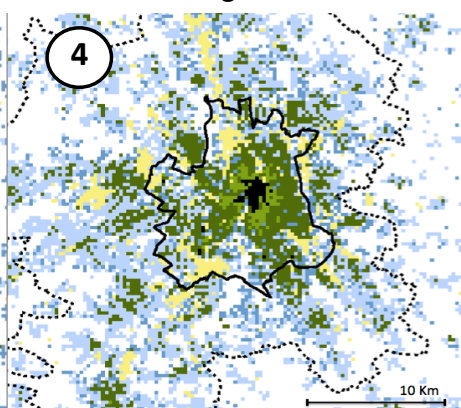
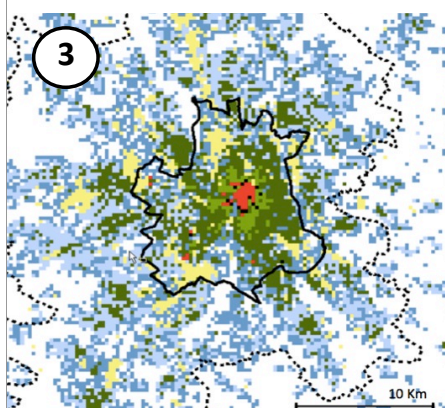
- Expansion controlled by a green belt urban
- Vertical architecture favored

Green City:

- Multipolar urban expansion
- Favored compact design intensive green











Passive city:

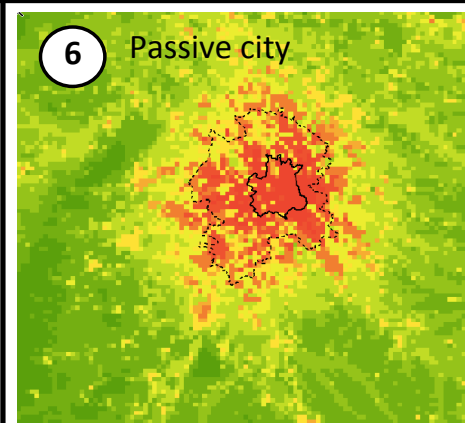
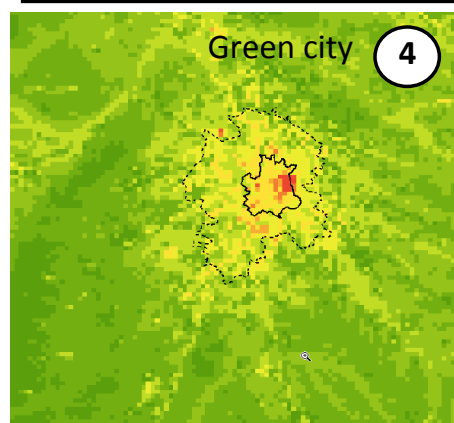
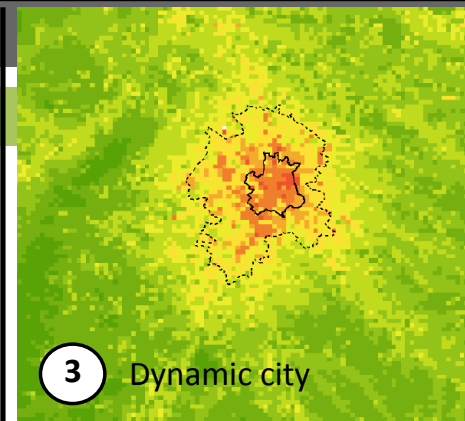
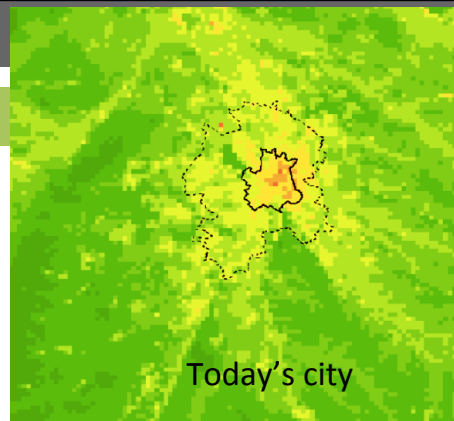
- No control of urban expansion
- No control of architectural form



3. Results and conclusions

Urban heat island (°C)









< -0,5	
-0,5 à 0	
0 à 0,25	
0,25 à 0,75	
0,75 à 1,25	
1,25 à 1,75	
1,75 à 2	
2 à 2,5	
2,5 à 3	
> 3	



3. Results and conclusions

3.1. Example of results

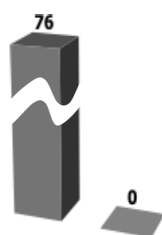
Heating and cooling consumptions

	Consommation de chauffage climat actuel
	Consommation de climatisation climat actuel
	Consommation de chauffage climat futur + 2°C
	Consommation de chauffage climat futur + 4°C
	Consommation de chauffage climat futur + 6°C
	Consommation de climatisation climat futur + 2°C
	Consommation de climatisation climat futur + 4°C
	Consommation de climatisation climat futur + 6°C

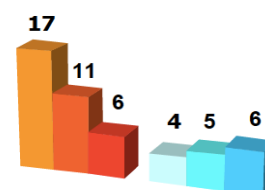
1. Context

2. Development of GENIUS

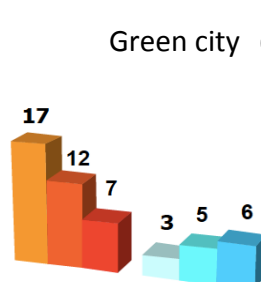
3. Results and Conclusions



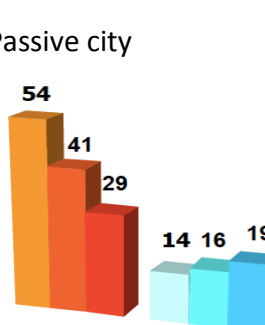
Today's city



3 Dynamic city

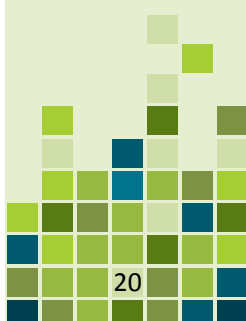


Green city 4



6 Passive city

(Consumptions in kWh/m²/year)



3. Results and conclusions

3.2. Conclusions

1. Context

2. Development
of GENIUS

3. Results and
Conclusions

- A methodology.
- A functional tool.
- First scientific results.
- Many opportunities for application and improvement!

GENerator of Interactive Urban bockS

