CNRS Summer School
Urban Circular Systems
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SIMUTEC/MUST-B : a multi-sectoral simulation platform dedicated to the ecological transition of urban territories

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Context elements

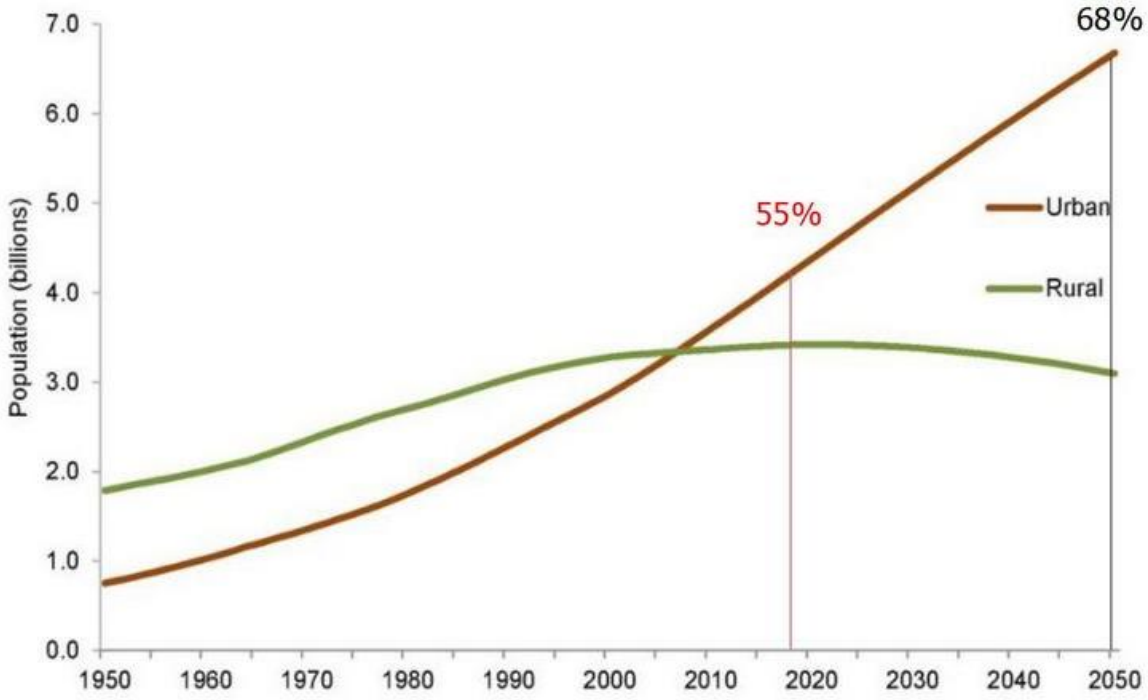
Growth of urban territories

- 1950, 1/3 people lived in cities

- Today, 55% of the world's population, or 4.2 billion people, live in cities.

- In 2050, the current number of townspeople will double, and 7/10 people in the world will live in urban areas.

Figure 1. Urban and rural populations of the world, 1950-2050

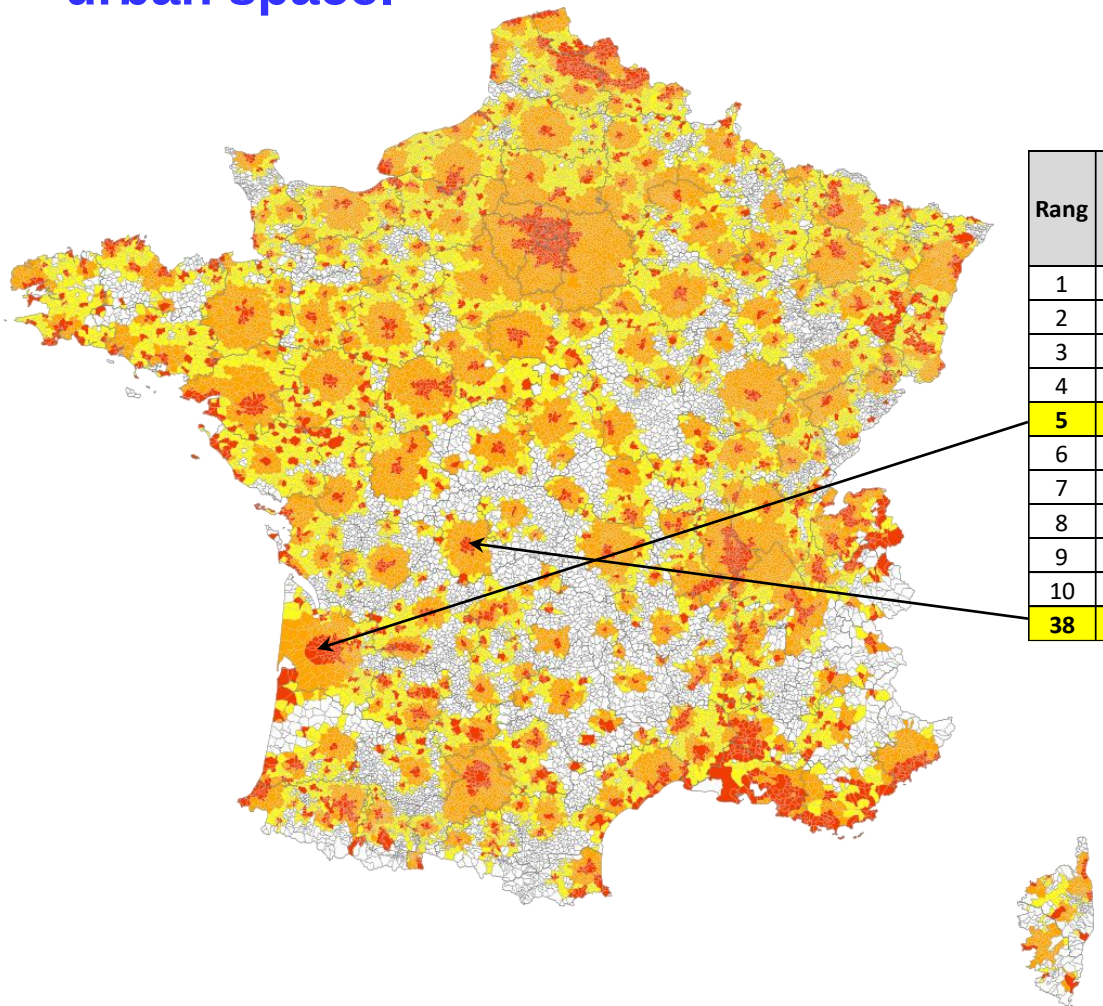


Data source: United Nations, Department of Economic and Social Affairs, Population Division (2018a). *World Urbanization Prospects 2018.*

Context elements

Growth of urban territories

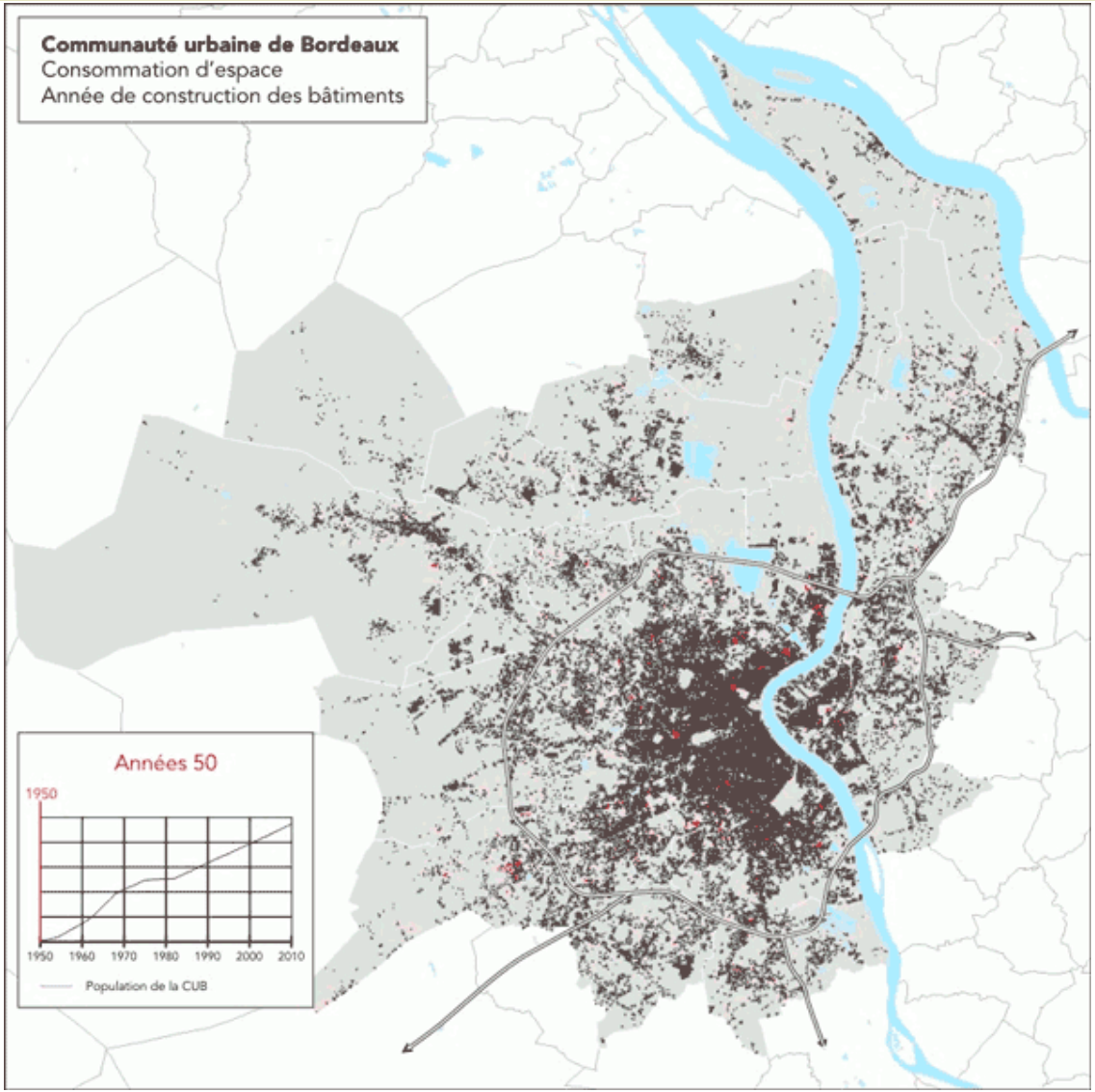
80% of the French metropolitan population lives in a predominantly urban space.



Rang	Aire urbaine	Population de l'aire urbaine (2017)	Population de la commune-centre (2018)
1	Paris	12 628 266	2 175 601
2	Lyon	2 323 221	518 635
3	Marseille - Aix-en-Provence	1 760 653	862 211
4	Toulouse	1 360 829	486 828
5	**Bordeaux**	**1 247 977**	**257 068**
6	Lille (partie française)	1 191 117	233 098
7	Nice	1 006 201	341 032
8	Nantes	972 828	314 138
9	Strasbourg (partie française)	790 087	284 677
10	Rennes	733 320	217 728
38	**Limoges**	**283 556**	**131 479**

Context elements

Growth of urban territories



Source : A'urba

Context elements

Consequences:
Price of real estate

Source : MeilleursAgents

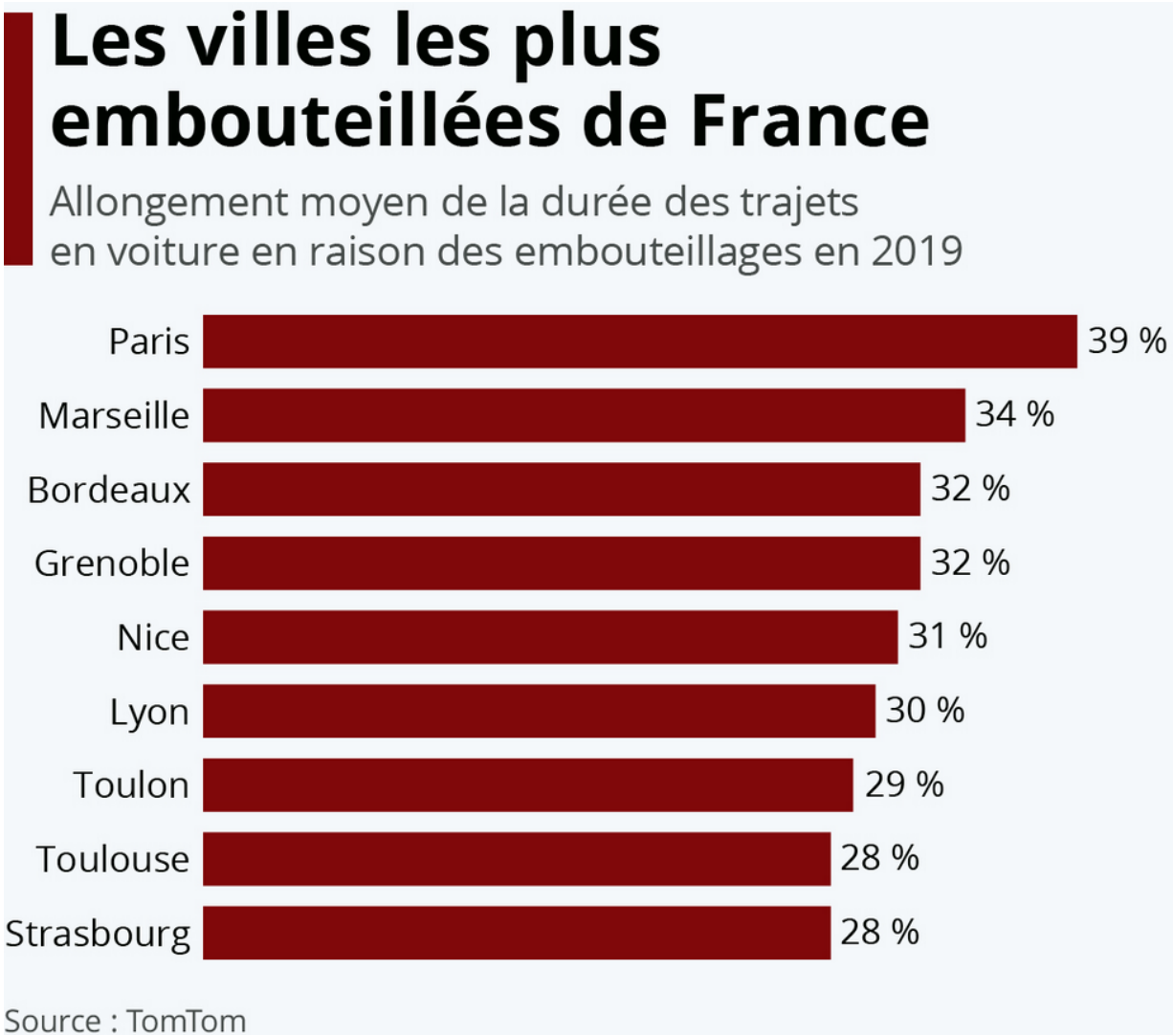
The price of real estate in Bordeaux has more than quintupled since 1998, an average increase of 7.1% per year.

Context elements

Consequences:
Congestion

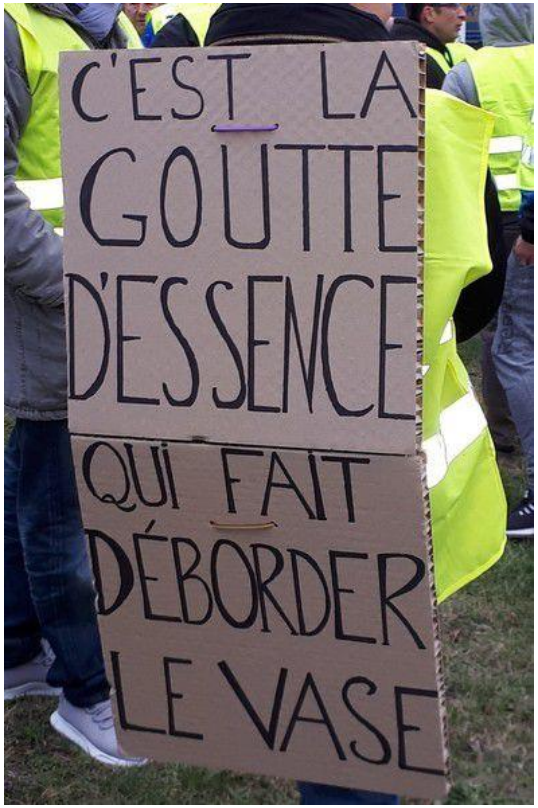
Context elements

Consequences:
Congestion



Eléments de contexte

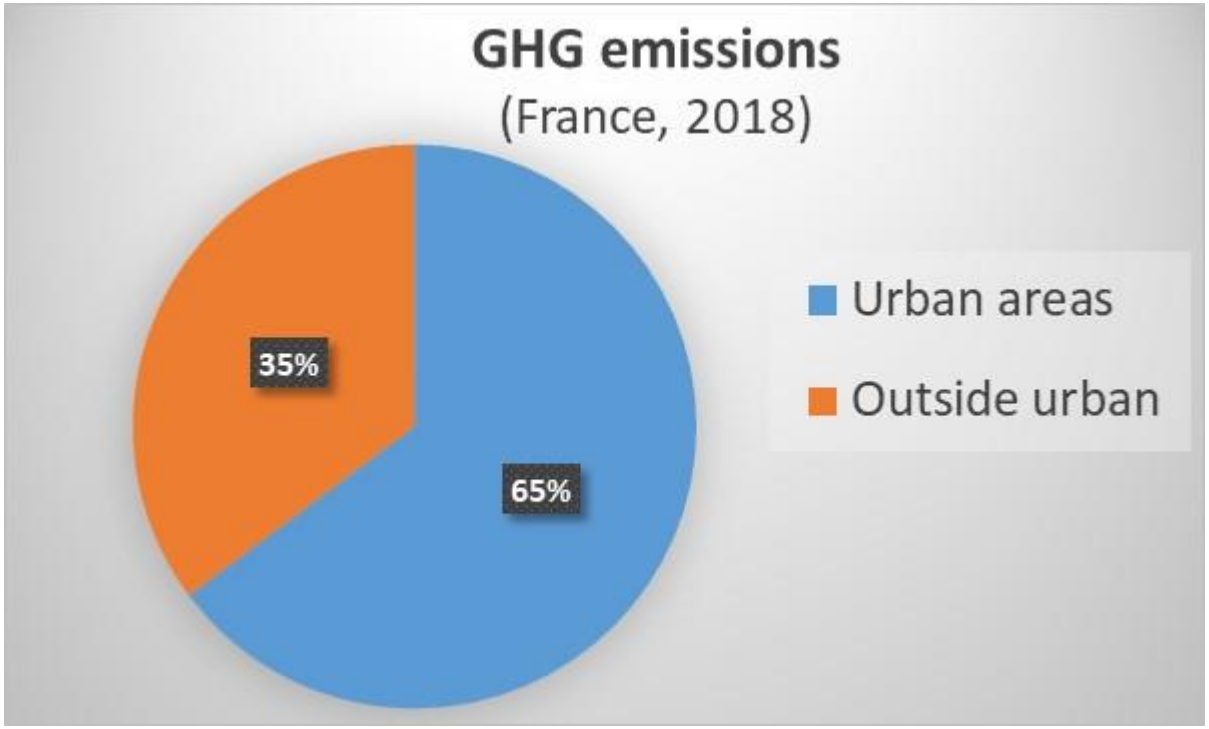
Conséquences
Gilets Jaunes



Context elements

Consequences:
Greenhouse Gases (GHG)

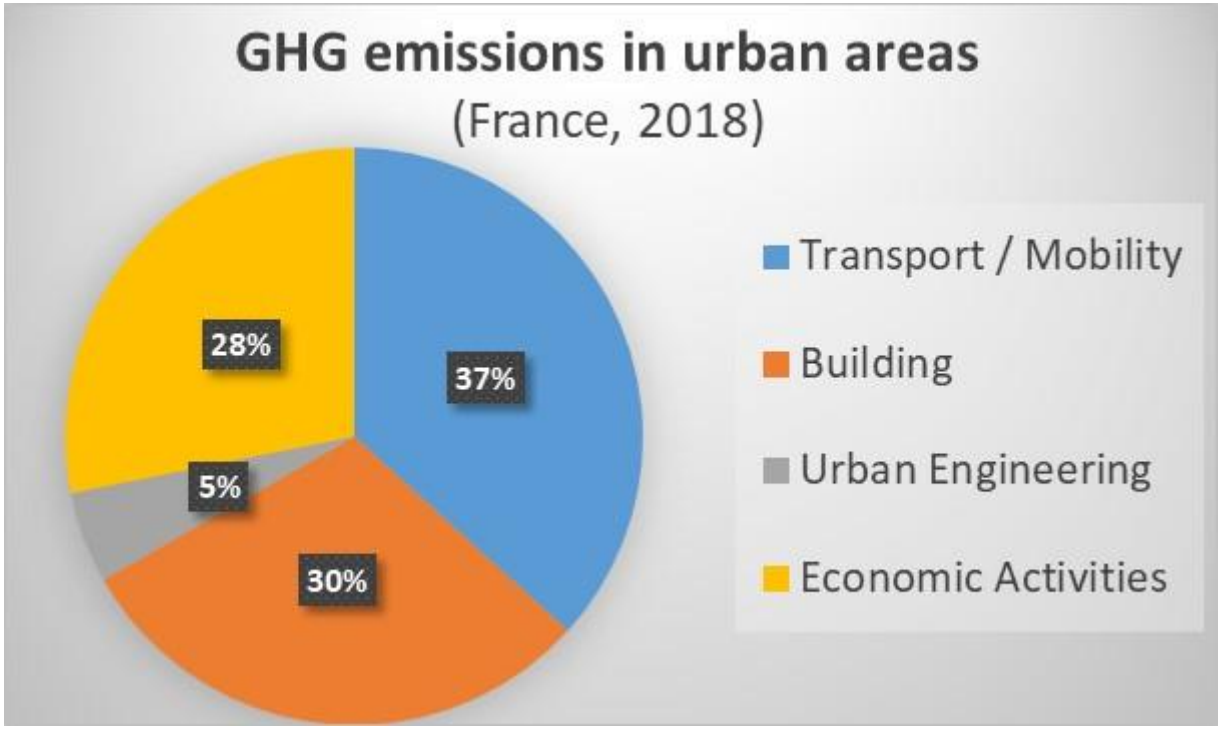
Two-thirds of GHG emissions are produced in the urban environment.



Context elements

Consequences:
Greenhouse Gases (GHG)

The distribution of GHG emissions by sector.



Context elements

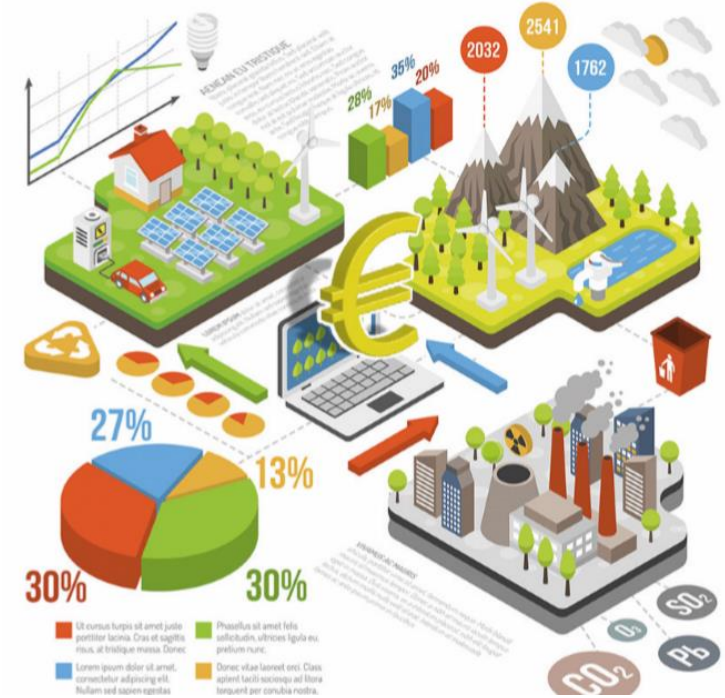
Consequences:
Greenhouse Gases (GHG)

The municipalities (local and regional authorities) control, directly and indirectly, two-thirds of the GHG emissions produced in France.

But these municipalities do not have tools capable of assessing the effects of actions to reduce GHG emissions on their territories.

SIMUTEC Project

… develop the modeling and simulation platform to support decision-making by local officials in the ecological transition of their territories.



SIMUTEC Platform

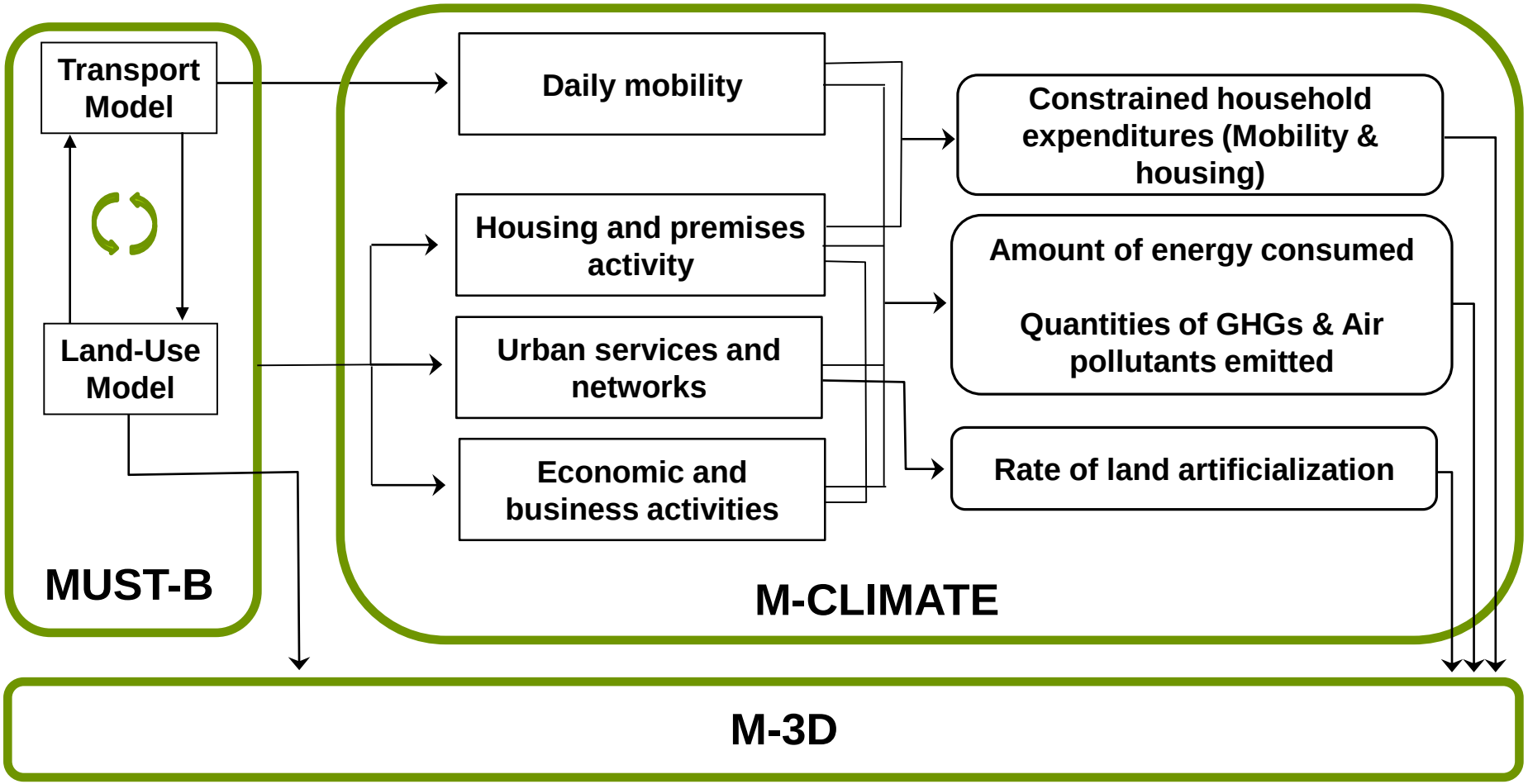
- **MUST-B**: Integrated “Land use - Transport” model that simulates the location choices of households and jobs
- **M-Climate** : Module to calculate, at territorial level, energy consumption and emissions (GHGs and air pollutants)
- **M-3D** : Module to visualize in 3D the urbanization of the territory and the effects of simulated urban policies

M-Climate modules

For a scenario simulated at a given horizon, an inventory of the energy consumed and emissions (CO2, atmospheric pollutants) must be made across the sectors characterising the functioning of the city, i.e.:

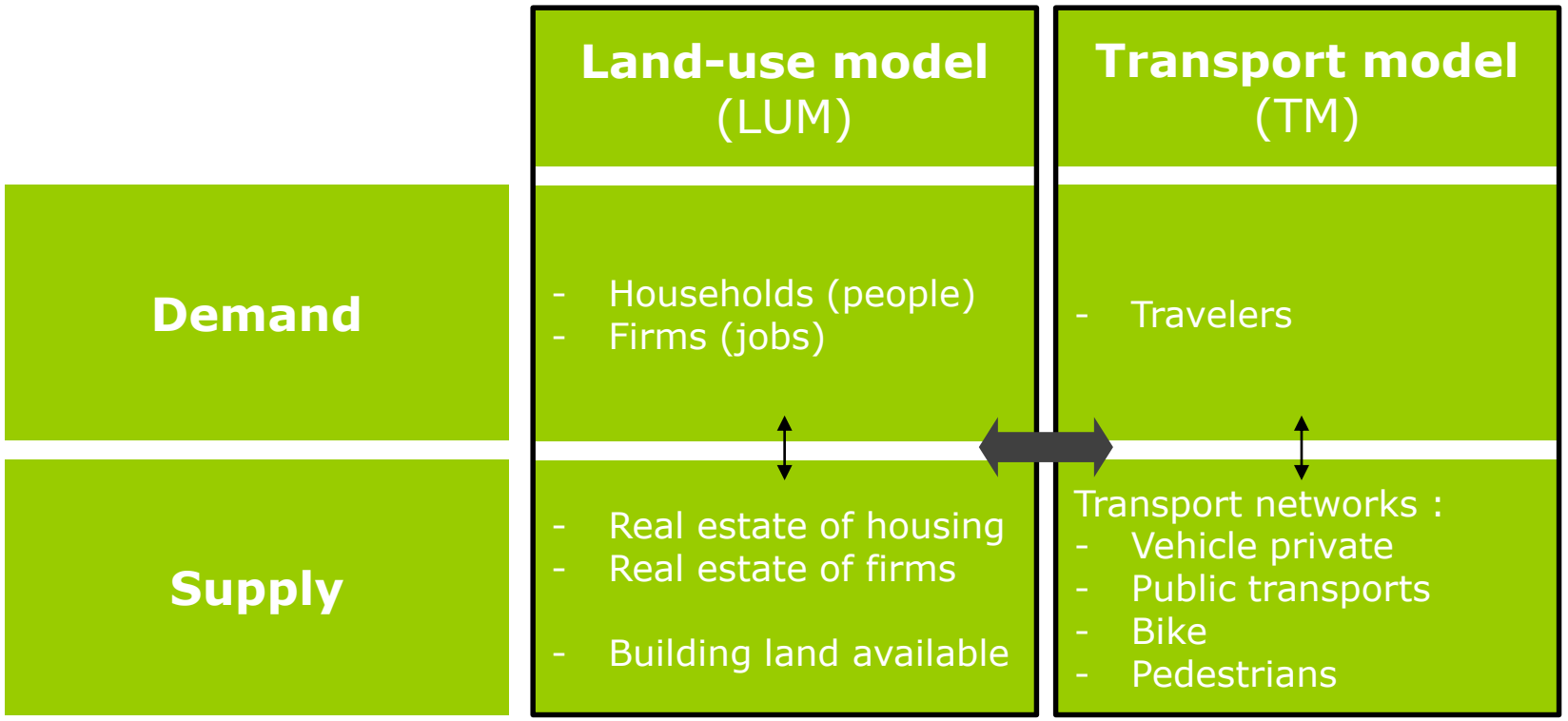
- **Daily mobility**: which involves considering the daily journeys made by people for trip purpose (home-to-work, shopping, leisure, etc.).
- **Housing and premises activity:** For this sector we will take into account residential buildings, public buildings (schools, town halls, ...) and premises for economic activities (offices, factories, warehouses, ...).
- **Urban services and networks:** urban networks (public lighting, sanitation, drinking water, etc.) and services (waste collection, etc.) are considered.
- **Economic and business activities:** for this sector we will take into account economic and commercial activities (shops, transport and delivery of goods in town, etc.).

SIMUTEC Platform



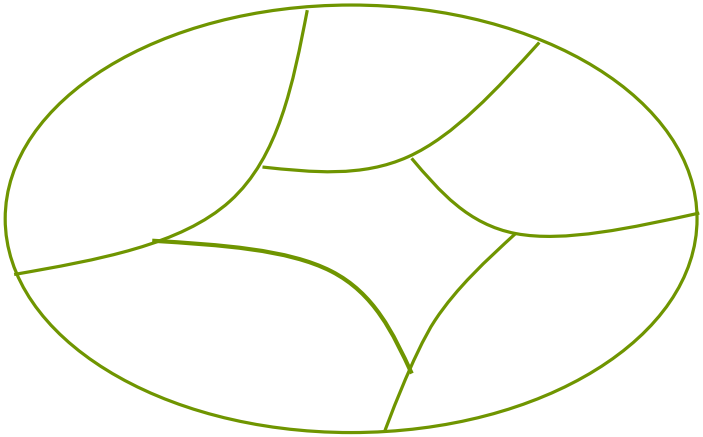
MUST-B Model

Systemic interaction Land-Use / Transport

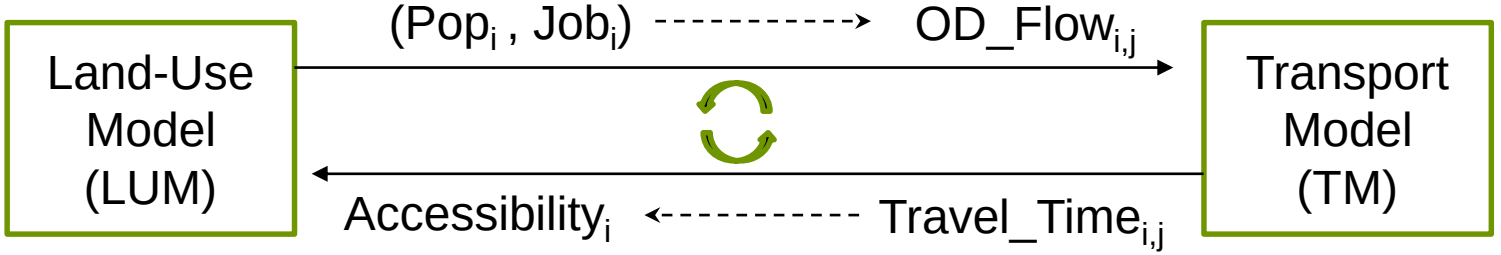


MUST-B model

Systemic Interaction Land-use / Transport

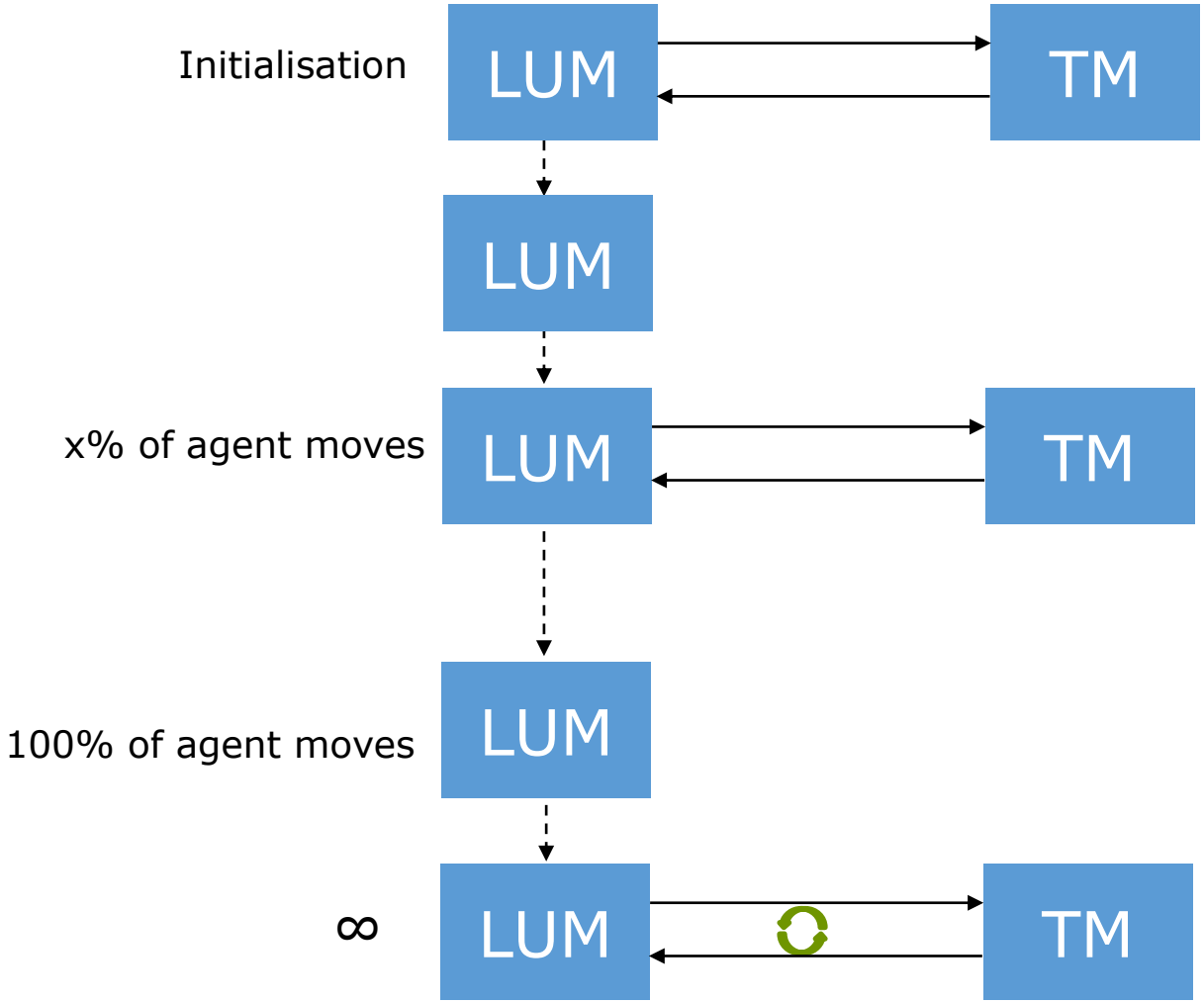


Division of urban territory into n zones



MUST-B model

Systemic Interaction Land-use / Transport



MUST-B model

Land-use

- MUST-B is a model for locating households and jobs at the agglomeration scale.
  - It uses a **systemic agents-based approach** that takes into account the individual behavior of urban actors: households, firms, developers, planners, public policies.
  - It simulates the land and real estate markets based on an **auction mechanism**.
  - The location choice mechanism is based on **maximizing the utility** that an agent (household/firm) acquires by locating in a property at a given location.

MUST-B model

Modeling Principles: Supply / Demand

- Demand is described by two types of agents:
  - The population defined in terms of households (size x socio-professional category)
  - Employment defined in terms of firms (size x type of activity)

- Supply is characterized by:
  - Current housing stock: private housing, social housing, type of housing (number of rooms : 1, 2, 3, 4, 5 and +)
  - Current activity premises park: 8 sizes of firms (3, 7, 15, 35, 75, 150, 350 & 750)
  - The **constructible potential** (capacity reserve): unbuilt land, that can be built on in accordance with urban planning rules

Theoretical choices of modeling

Utility function (household)

- The utility function of the ***household h*** residing in zone z can be expressed as follows:

$$U_{h,z} = \alpha_{1_h} AC_z + \alpha_{2_h} NO_z + \alpha_{3_h} DS_h - EB_z * DS_h - P_z^h * DS_h$$

  - AC: accessibility to jobs for zone z
  - NO: notoriety of the zone z (reflects the image and amenity of an area that can be described by various parameters such as green spaces, atmosphere, style, specificity and diversity of the shops that are present)
  - DS : desired surface area of the dwelling
  - EB : energy bill per m² of the dwelling according to the zone considered
  - P : price per m² of housing in the zone considered
  - α_i : *parameters to be estimated according to the household's socio-economic class*

Theoretical choices of modeling

Utility function (firms)

- The utility function of the ***firm f*** located in zone z can be expressed as follows:

$$U_{f,z} = \left(\lambda_{1_f} AC_z + \lambda_{2_f} NO_z + \lambda_{3_f} RF_z - TT_z * DS_f - P_z^f * DS_f\right) * S_f$$

  - AC : accessibility to the workforce for zone z
  - NO : notoriety of the zone z (reflects the image and specificity of an area)
  - DS : desired surface of the premises
  - RF : ratio of firms in the same activity of the firm concerned to all firms present in the zone z (reflects the agglomerations effects)
  - TT : taxes in the zone z
  - P : price per m² of local activities for zone z
  - S_f : size of the firm
  - λ_i *parameters to be estimated according to the activity of the firm*

Theoretical choices of modeling

Characteristics of the auction mechanism

- At iteration *n* of the simulation, the bid that agent *a* will make to move into zone *j* depends on the price of housing in his home zone *i*, and on the difference in utilities between zones *i* and *j*.

  This bid is expressed as follows:

$$\pi_{j,n}^{a} = P_{i,n} + \varepsilon\left(U_{j,n}^{a} - U_{i,n}^{a}\right)$$

Where:

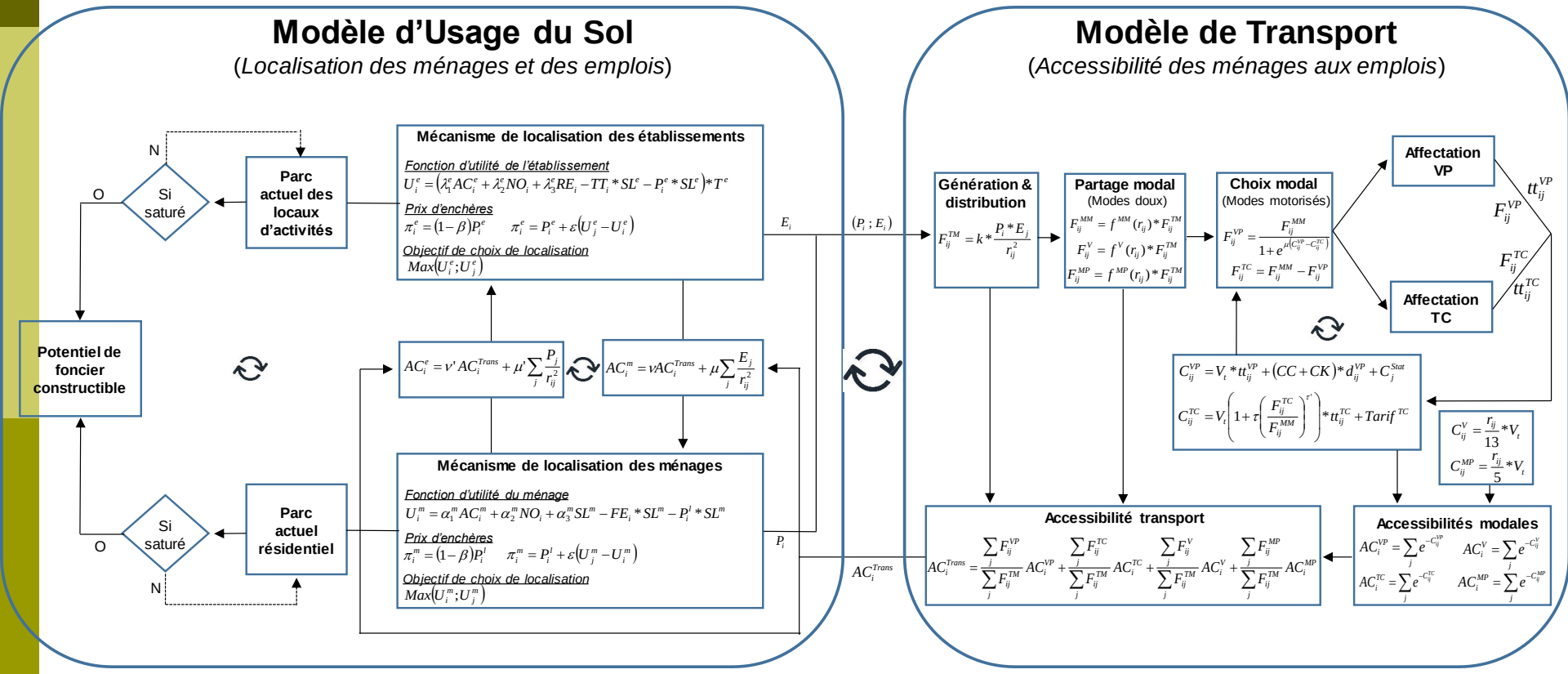
- P_i: Real estate price of the zone *i*
- U_j^a: Utility value associated with new location in zone *j* for the agent *a*
- ε: Amplitude of the auction, determines the utility gain transformed into a price added to the initial price in their origin zone.

- Wassumed that the agent can renounce moving if they obtain a reduction on the price of real estate in their origin zone i. The bid that the agent makes in order to remain in their origin zone is expressed as:

$$\pi_{i,n}^{a} = (1-\beta)P_{i,n}$$

Modèle MUST-B

Interaction systémique Usage du sol / Transport



Choix théoriques de modélisation

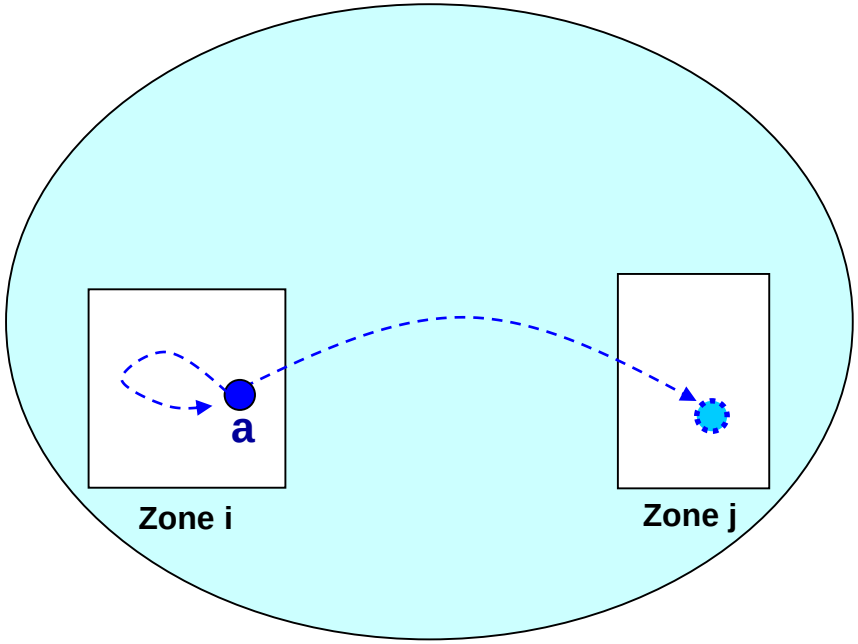
Mécanisme de choix de localisation

- The location choice mechanism of households and establishments is based on **maximizing the utility** of the agent (household/firm) by a location in a given good at a given location.

Theoretical choices of modeling

Mechanism of choice location (auction)

$$\pi_{n+1}^{i,a} = (1-\beta)P_n^i$$



$$\pi_{n+1}^{j,a} = P_n^i + \varepsilon\left(U_n^{j,a} - U_n^{i,a}\right)$$

Agglomeration composed of n zones

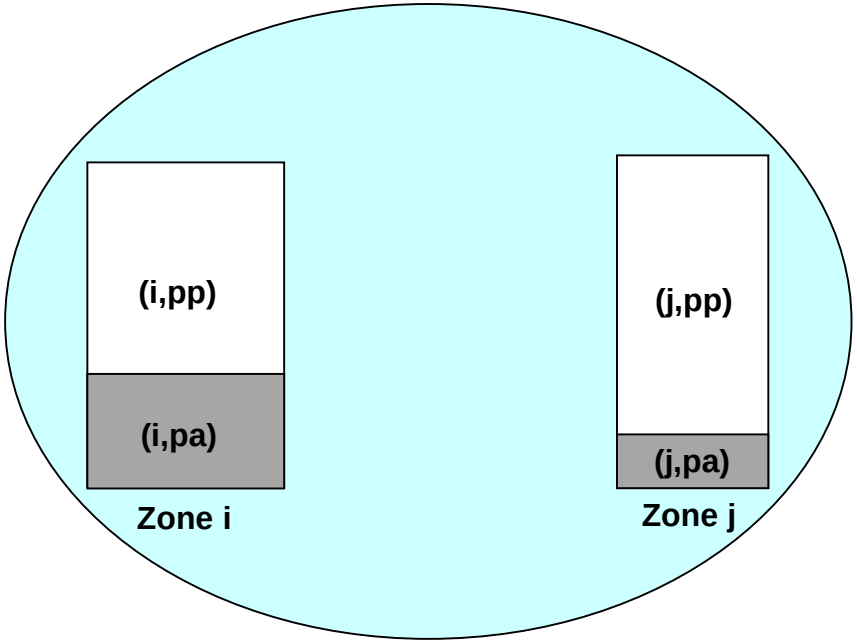
If $U(\pi_{n+1}^{j,a}) > U(\pi_{n+1}^{i,a})$ **so the agent *a* moves to *j* and the price of zone *j* becomes the price of the bid that the agent has just made** $\pi_{n+1}^{j,a}$

If $U(\pi_{n+1}^{j,a}) \leq U(\pi_{n+1}^{i,a})$ **so the agent *a* waives the move and the price of zone *i* becomes the discounted price** $\pi_{n+1}^{i,a}$

Theoretical choices of modeling

Mechanism of choice location (auction)

Cases where social housing is considered



Agglomeration composed of n zones and 2 types of housing stock (private, social)

Private housing stock (pp)

Social housing stock (pa)

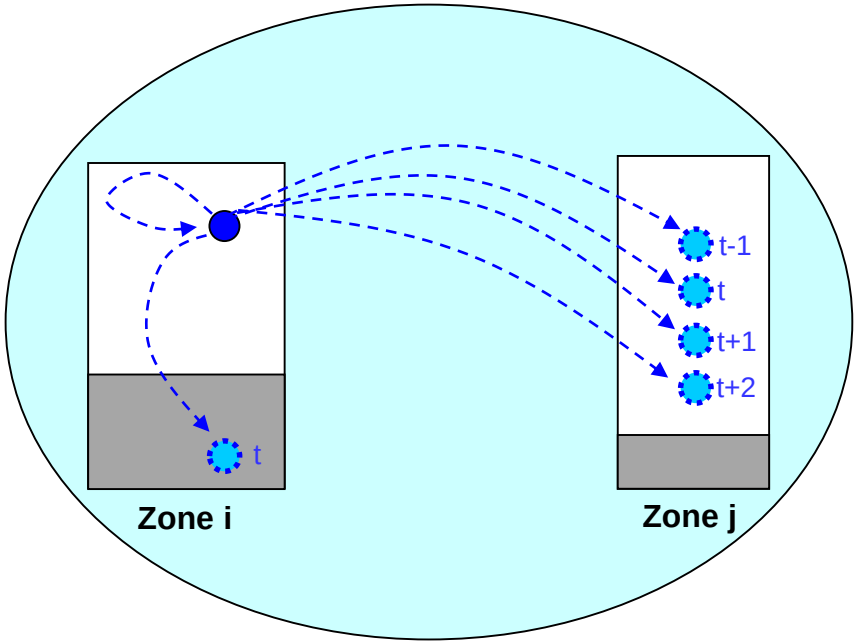
Theoretical choices of modeling

Mechanism of choice location (auction)

Consider a random draw of a household *m* of size *t* located in the private housing stock *pp* in zone *i* to be relocated eventually in zone *j* or in the social housing stock pa in zone *i*

$$\pi_{n+1,pp}^{i,m} = (1-\beta)P_{n,pp}^{i}$$

$$P_{n+1,pa}^{i,m} = \varphi P_{n,pp}^{i}$$



$$\pi_{n+1,pp}^{j,m}(t-1) = P_{n,pp}^{i} + \varepsilon\left[U_n^{j,m}(SL_{t-1}) - U_n^{i,m}\right]$$

$$\pi_{n+1,pp}^{j,m}(t) = P_{n,pp}^{i} + \varepsilon\left[U_n^{j,m}(SL_{t}) - U_n^{i,m}\right]$$

$$\pi_{n+1,pp}^{j,m}(t+1) = P_{n,pp}^{i} + \varepsilon\left[U_n^{j,m}(SL_{t+1}) - U_n^{i,m}\right]$$

$$\pi_{n+1,pp}^{j,m}(t+2) = P_{n,pp}^{i} + \varepsilon\left[U_n^{j,m}(SL_{t+2}) - U_n^{i,m}\right]$$

The household m has the following possibilities:

- ❑ Stay where he is (i,pp): 1 possibility
- ❑ Go to (i,pa): 1 possibility
- ❑ Go to (j,pp): Between 2 and 4 possibilities

The utilities are calculated with the auction prices and ranked in descending order.

If the housing of the 1st choice is available then we relocate the household in this housing, otherwise we move on to the following choices

If the possibility of staying in his initial housing (with a discount of β) is the one that gives the lowest utility, then the developer is brought in to build him a housing of a size that corresponds to the housing of the 1st choice.

If the developer does not respond favorably to this request (no building land available or no financial profitability) then we go to the mechanism of eviction of a household which has the lowest utility of the housing stock corresponds to the housing of the 1st choice.

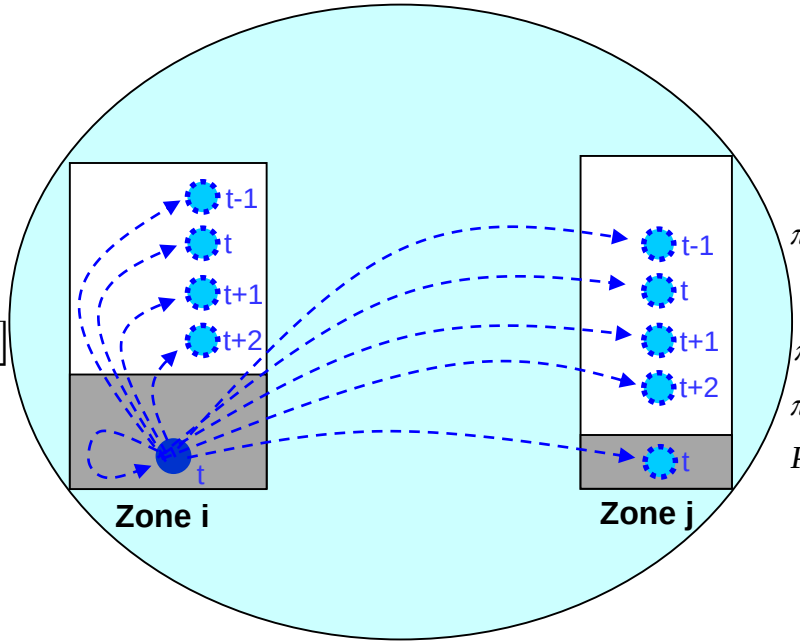
Theoretical choices of modeling

Mechanism of choice location (auction)

Consider a random draw of a household *m* of size *t* located in the social housing stock *pa* in zone *i* to be relocated eventually in zone *j* or in the private housing stock *pp* in zone *i*

$$\pi^{i,m}_{n+1,pp}(t-1) = P^{i}_{n,pa} + \varepsilon\left[U^{i,m}_{n,pp}(SL_{t-1}) - U^{i,m}_{n,pa}\right]$$
$$\pi^{i,m}_{n+1,pp}(t) = P^{i}_{n,pa} + \varepsilon\left[U^{i,m}_{n,pp}(SL_{t}) - U^{i,m}_{n,pa}\right]$$
$$\pi^{i,m}_{n+1,pp}(t+1) = P^{i}_{n,pa} + \varepsilon\left[U^{i,m}_{n,pp}(SL_{t+1}) - U^{i,m}_{n,pa}\right]$$
$$\pi^{i,m}_{n+1,pp}(t+2) = P^{i}_{n,pa} + \varepsilon\left[U^{i,m}_{n,pp}(SL_{t+2}) - U^{i,m}_{n,pa}\right]$$

$$P^{i,m}_{n+1,pa} = P^{i}_{n,pa}$$



$$\pi^{j,m}_{n+1,pp}(t-1) = P^{i}_{n,pp} + \varepsilon\left[U^{j,m}_{n}(SL_{t-1}) - U^{i,m}_{n}\right]$$
$$\pi^{j,m}_{n+1,pp}(t) = P^{i}_{n,pp} + \varepsilon\left[U^{j,m}_{n}(SL_{t}) - U^{i,m}_{n}\right]$$
$$\pi^{j,m}_{n+1,pp}(t+1) = P^{i}_{n,pp} + \varepsilon\left[U^{j,m}_{n}(SL_{t+1}) - U^{i,m}_{n}\right]$$
$$\pi^{j,m}_{n+1,pp}(t+2) = P^{i}_{n,pp} + \varepsilon\left[U^{j,m}_{n}(SL_{t+2}) - U^{i,m}_{n}\right]$$

$$P^{j,m}_{n+1,pa} = P^{j}_{n,pa}$$

The household m has the following possibilities:

- ❑ Stay where he is (i,pa): 1 possibility
- ❑ Go to (i,pp): Between 2 and 4 possibilities
- ❑ Go to (j,pp) : Between 2 and 4 possibilities
- ❑ Go to (j,pa) : 1 possibility

The utilities are calculated with the auction prices and ranked in descending order.

If the housing of the 1st choice is available then we relocate the household in this housing, otherwise we move on to the following choices

If the maximum utility he gets is in his original home then he stays in his home.

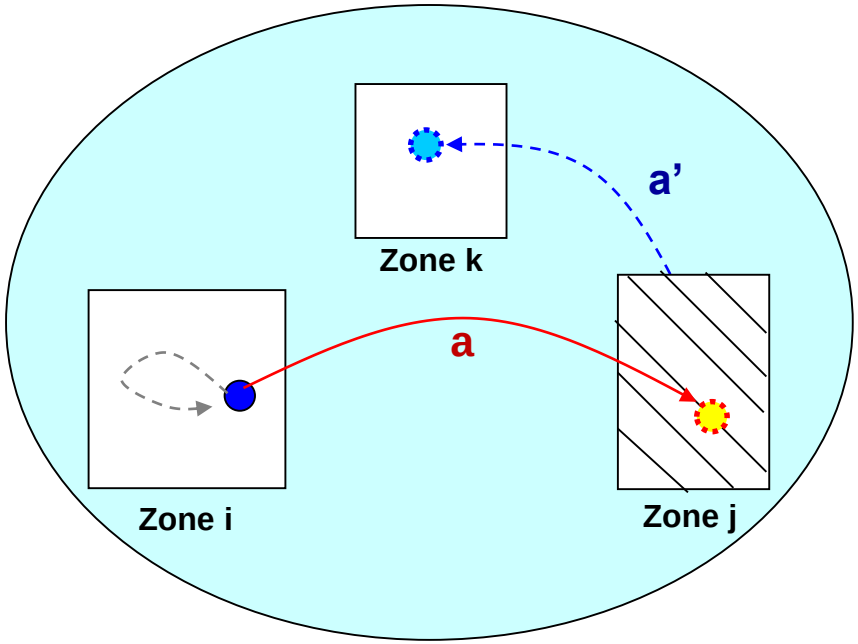
Theoretical choices of modeling

Mechanism of choice location (auction)

Eviction Mechanism

Case where the randomly selected agent has the maximum utility of relocating to zone j but this zone is already saturated

$$\pi_{n+1}^{i,a} = (1-\beta)P_n^i$$



$$\pi_{n+1}^{j,a} = P_n^i + \varepsilon\left(U_n^{j,a} - U_n^{i,a}\right)$$

Agent *a* is relocated to *j* in place of household *a'* (same size as a) which has the lowest utility in zone *j* and which will in turn be relocated to zone *k* drawn at random.

Theoretical choices of modeling

Mechanism of choice location (auction)

Decisional investment mechanism of developer

We pose :

- π : Price of the auction made by the agent at iteration *n*
- C_L : Cost of land
- *p* : Weight of the cost of land in the price of real estate ($p = C_L/\pi$)
- C_C : Cost of construction
- *M* : Developer's margin
- C_P : Cost of production (land cost + construction cost + margin)

$$C_P = C_L + C_C + M \Rightarrow C_P = p\pi + C_C + xC_P \Rightarrow C_P = \frac{p\pi + C_C}{1-x}$$

The developer's profitability condition is expressed as follows: $\pi > C_P$

We deduce the condition of profitability for the developer who is expressed as follows:

$$\pi > \frac{C_C}{1-x-p}$$

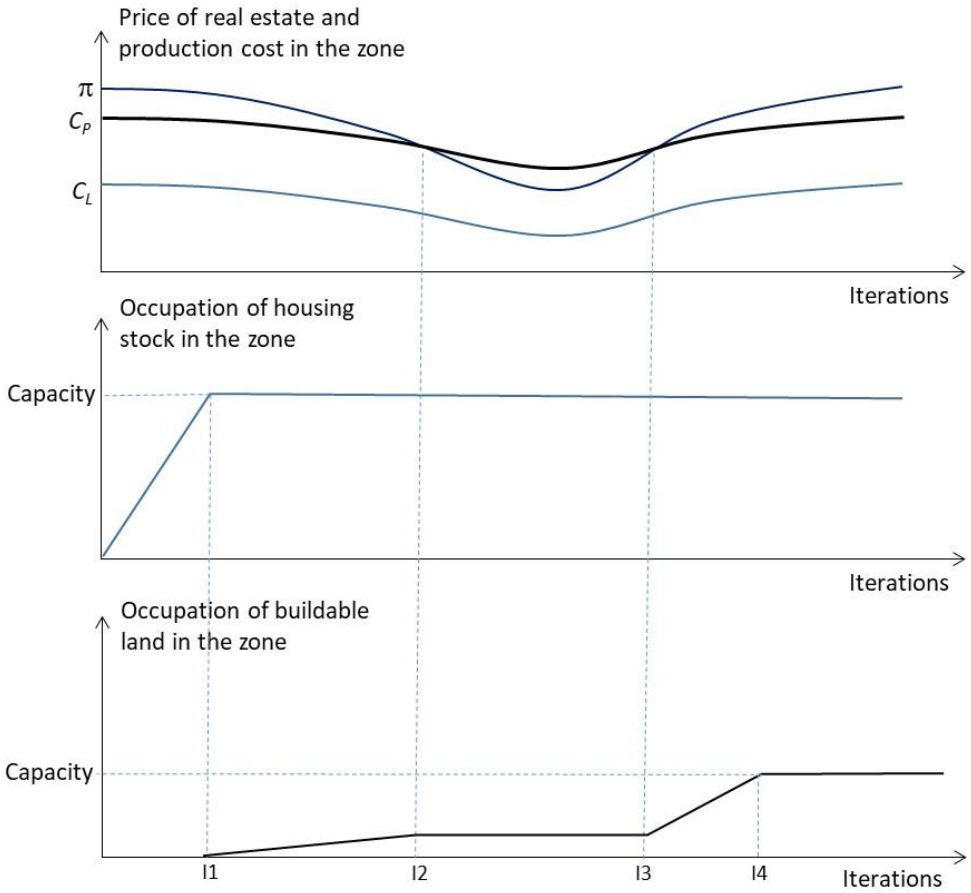
Theoretical choices of modeling

Mechanism of choice location (auction)

Decisional investment mechanism of developer

We can identify 4 configurations for one considered zone:

- Between the beginning of the simulation and iteration I1, the agents are located in housing stock of a zone.
- Between iteration I1 and iteration I2, the agents are located in the buildable land because, on the one hand, the housing stock is saturated and, on the other hand, the price of the auction made by the agent is higher than production cost (profitability condition).
- Between iteration I2 and iteration I3, the zone is still considered saturated, but the buildable land is not mobilized because the developer's condition of profitability is not fulfilled.
- Between iteration I3 and iteration I4, the agents are located in the buildable land as the profitability condition is fulfilled once again.
- From iteration I4, the zone is considered definitively saturated (the capacities of the zone and buildable land being full).



Theoretical choices of modeling

Mechanism of choice location (auction)

Process of spatial occupation of the buildable land

We pose :

- *IS: Inhabitable surface area sought by the agent (real estate demand)*
- *BF: Building footprint*
- *GS: Ground surface area of the land used*
- *NF_{max}: Maximal number of floors allowed in the zone*
- *k_1: Increase coefficient of the surface occupied taking into account the exterior walls of the building*
- *k_2: Increase coefficient taking into account the networks (road, water, sanitation, public lighting, etc.) and urban planning easements (view, right of way, etc.)*

Theoretical choices of modeling

Mechanism of choice location (auction)

Process of spatial occupation of the buildable land

The building footprint satisfying real estate demand IS is expressed as:

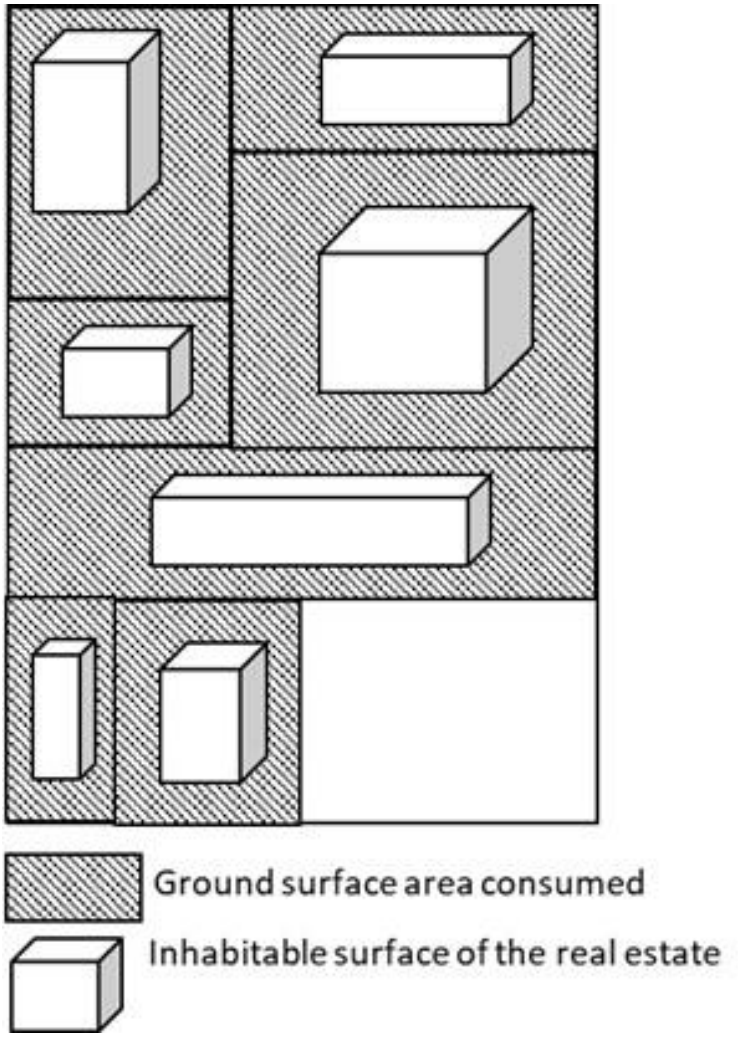
$$BF = k_1 * \frac{IS}{NF_{\max}}$$

The ground surface area of land consumed by this real estate demand is equal to:

$$GS = k_2 * BF$$

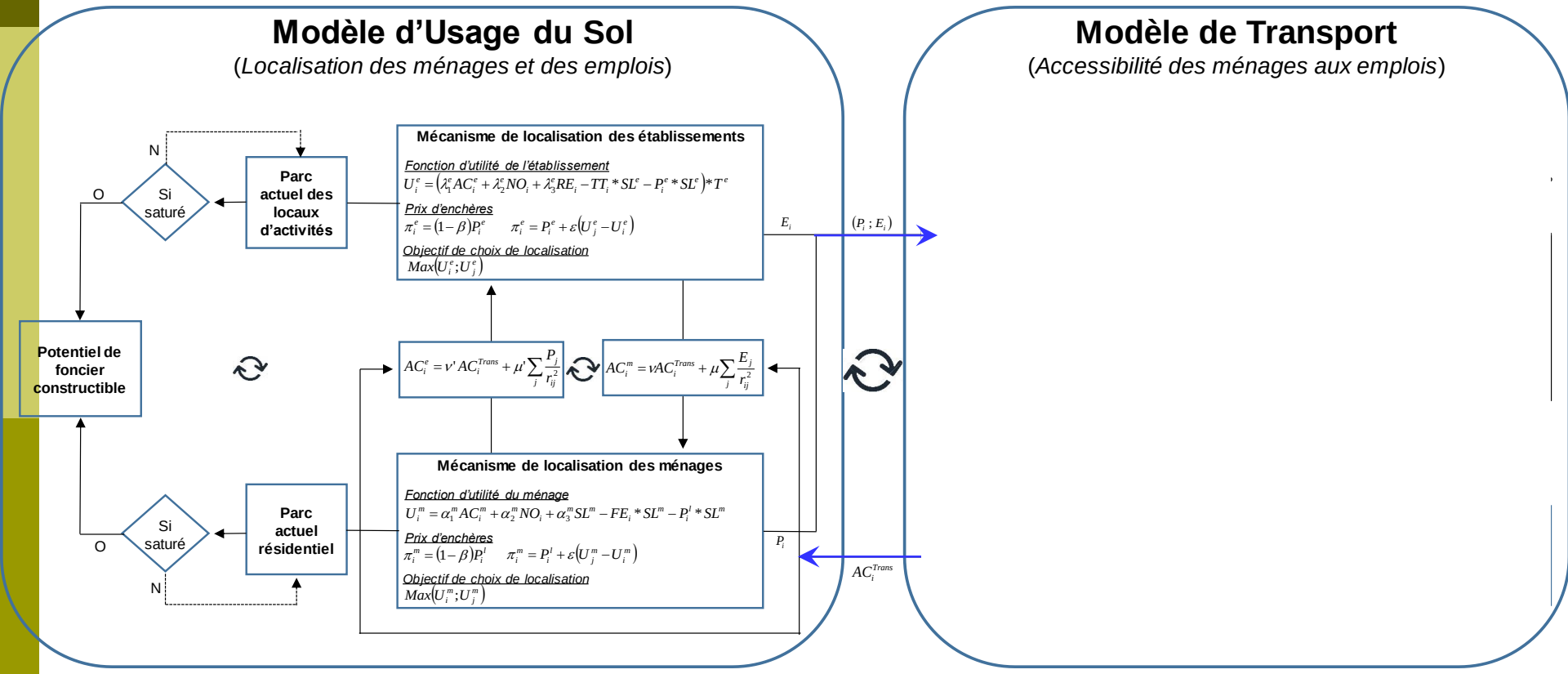
We finally obtain:

$$GS = \frac{k_1 * k_2}{NF_{\max}} * IS$$



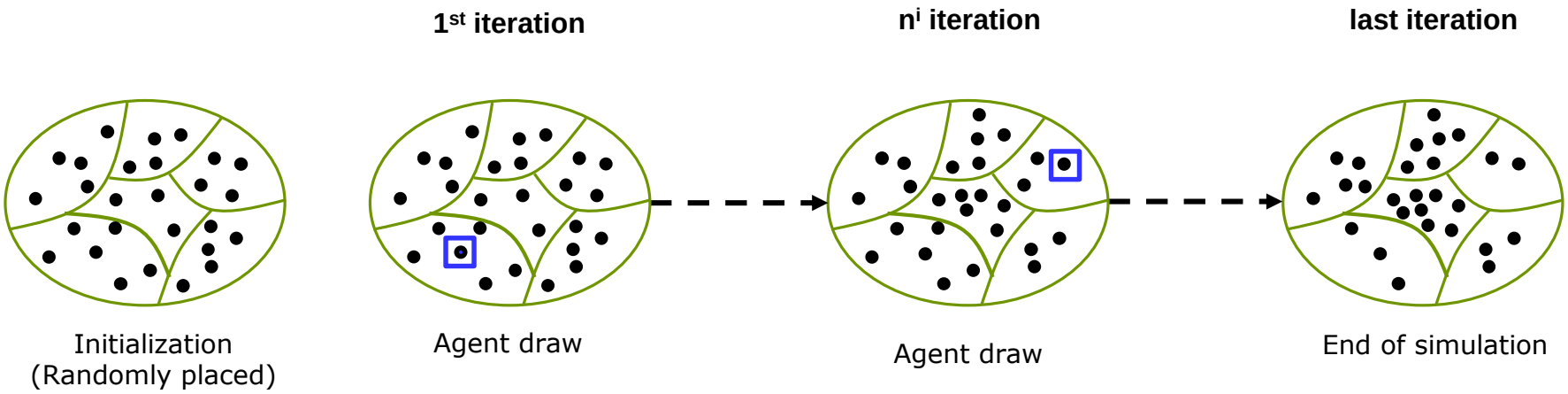
Modèle MUST-B

Interaction systémique Usage du sol / Transport



Theoretical choices of modeling

Mechanism of choice location



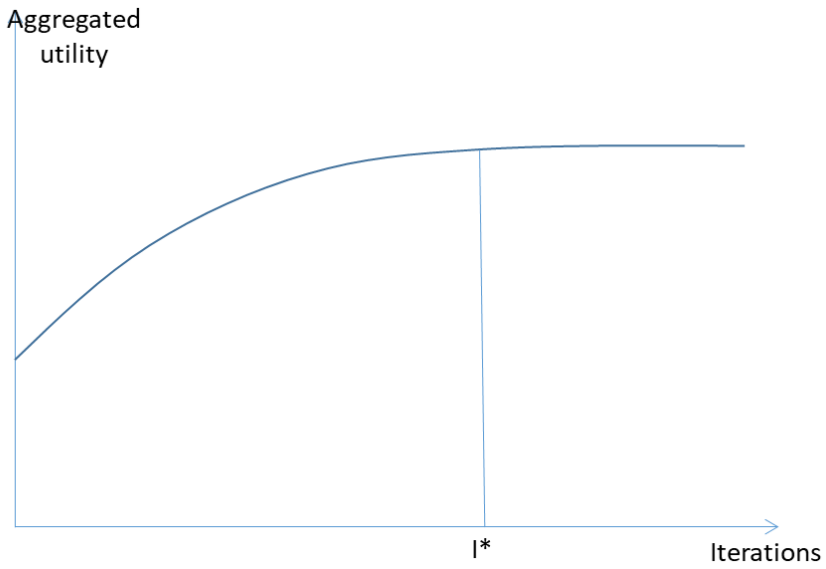
Theoretical choices of modeling

The notion of equilibrium in MUST-B

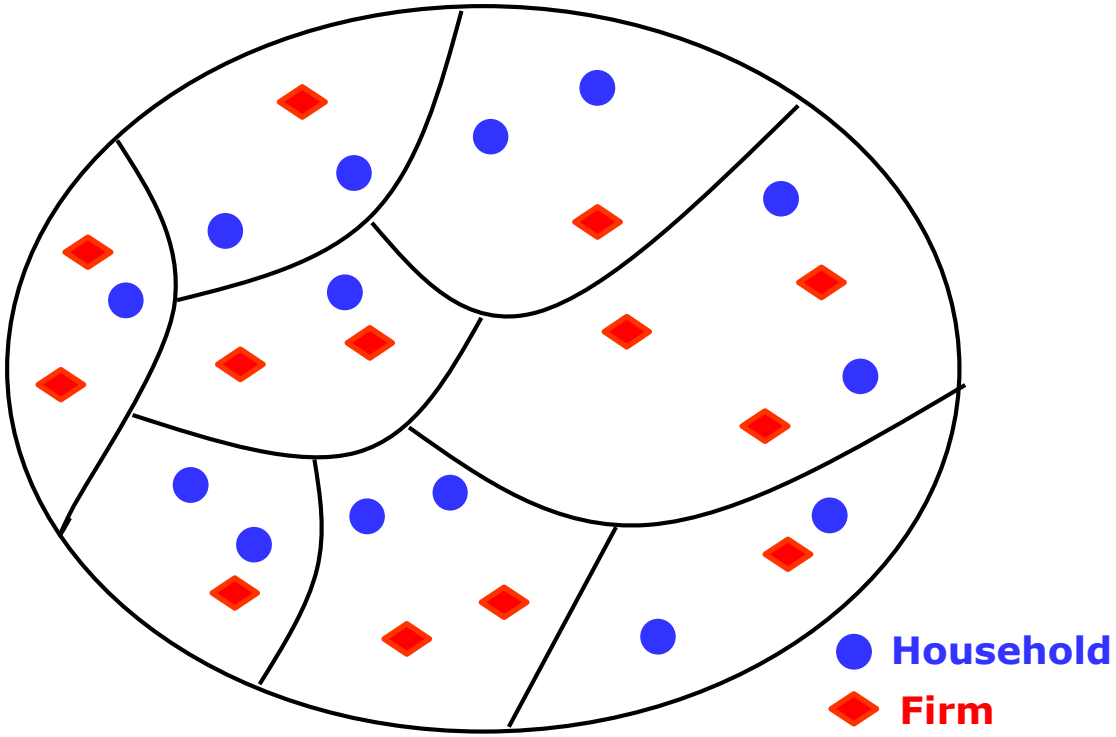
The equilibrium is derived from the simulated dynamics of household and firms location choices. Equilibrium is considered to be achieved when agents no longer improve the utility they can derive from a new location.

It can therefore be considered that, after a certain number of iterations I*, the aggregate utility of households will no longer increase, and that no household can increase its utility without at least decreasing that of another.

Like the Pareto optimum, nothing says that all households are satisfied with their location. The same goes for firms.

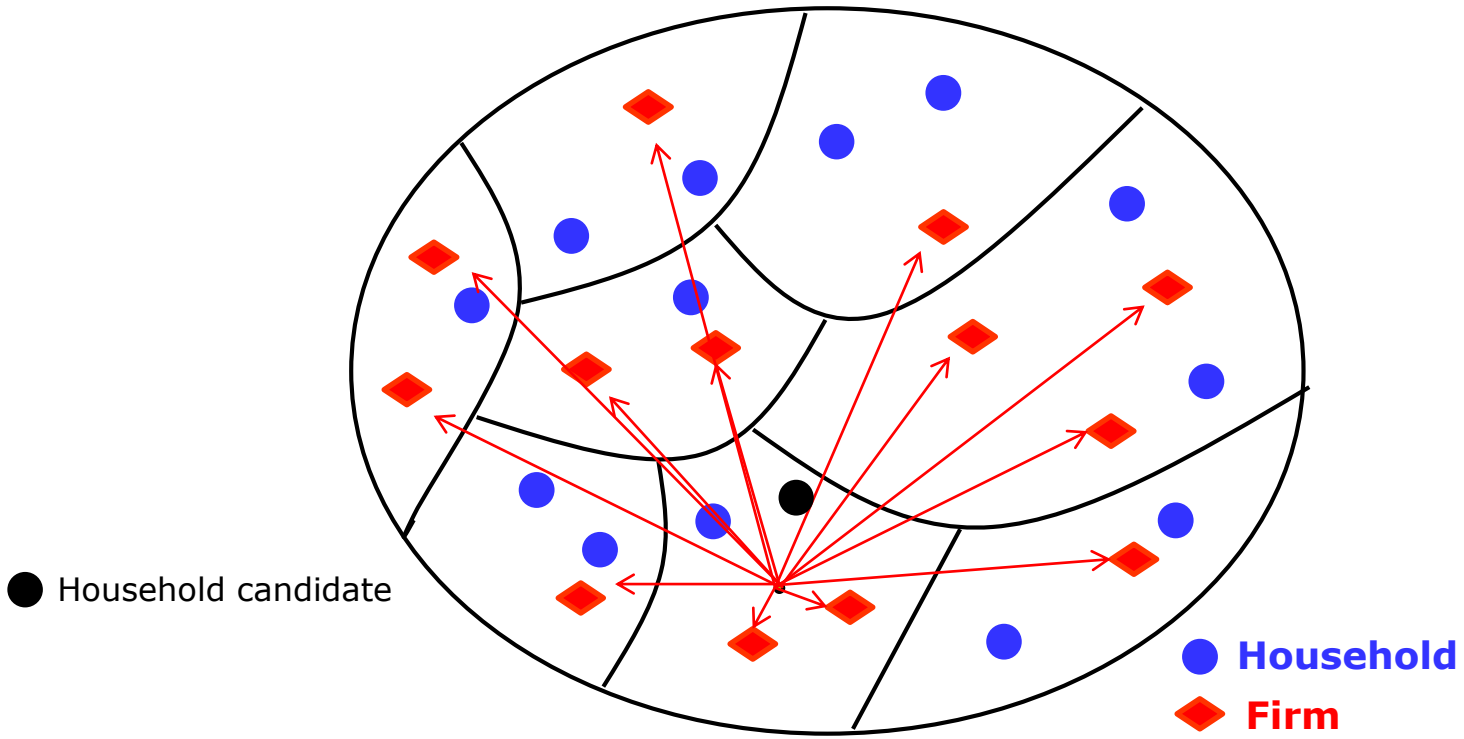


What is Accessibility ?



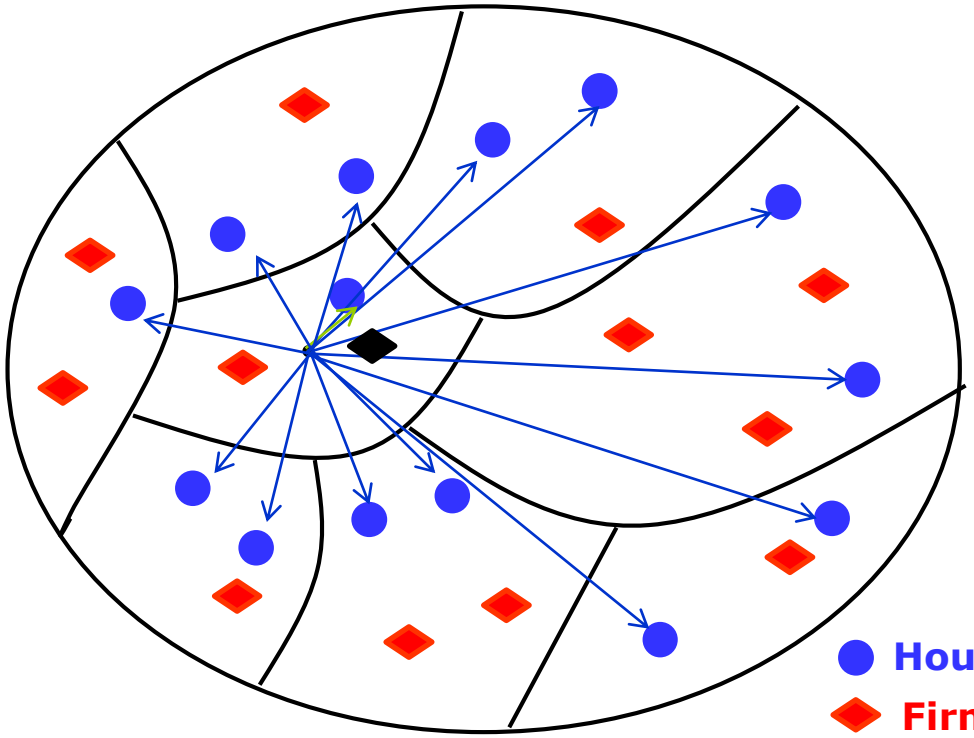
What is Accessibility ?

Accessibility for a Household: Accessibility to employment of every other zones



What is Accessibility ?

Accessibility for a Firm: Accessibility to labor of every other zones



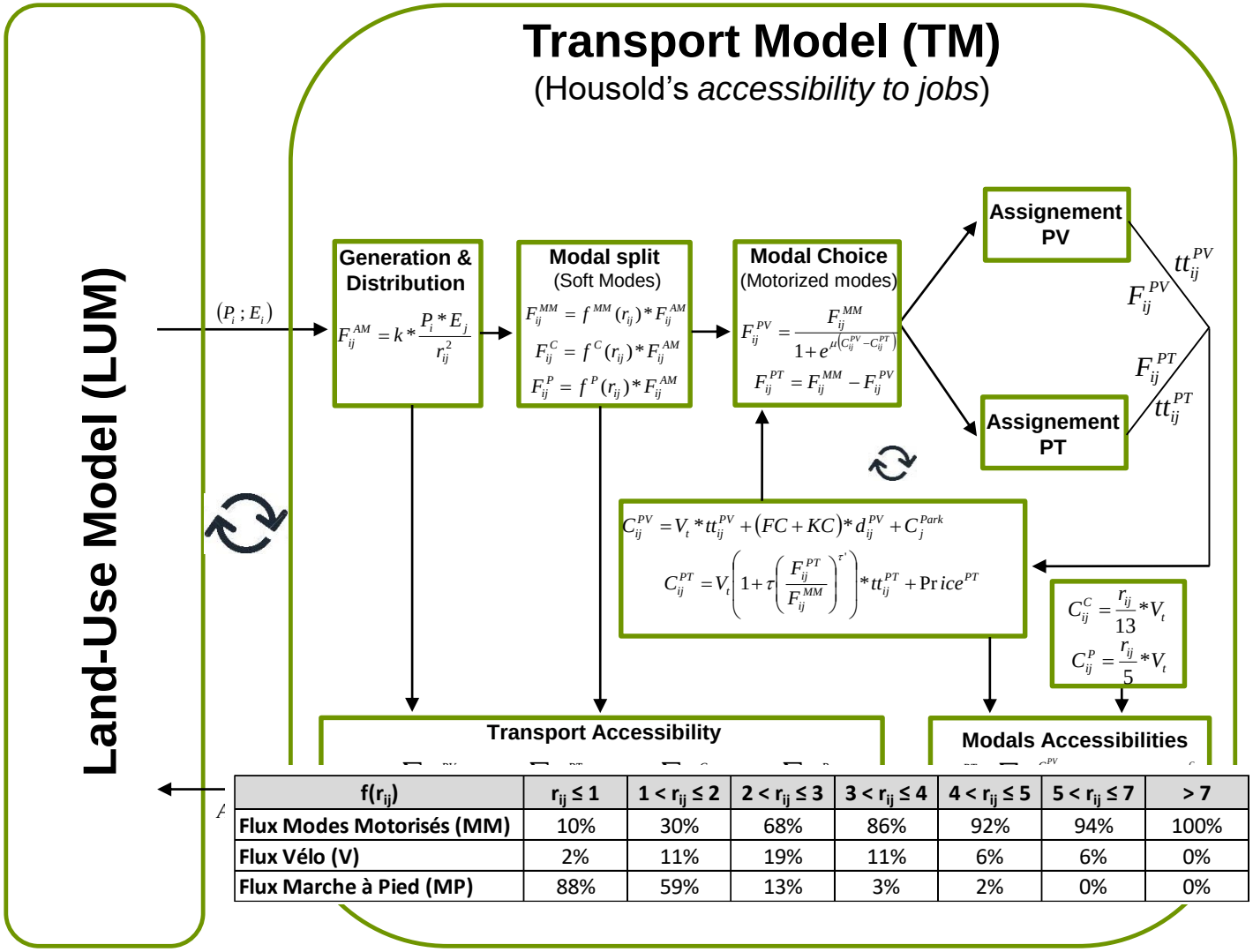
Firm candidate

Household

Firm

Modèle MUST-B

Interaction systémique Usage du sol / Transport



f(r_{ij})	$r_{ij} \leq 1$	$1 < r_{ij} \leq 2$	$2 < r_{ij} \leq 3$	$3 < r_{ij} \leq 4$	$4 < r_{ij} \leq 5$	$5 < r_{ij} \leq 7$	> 7
Flux Modes Motorisés (MM)	10%	30%	68%	86%	92%	94%	100%
Flux Vélo (V)	2%	11%	19%	11%	6%	6%	0%
Flux Marche à Pied (MP)	88%	59%	13%	3%	2%	0%	0%

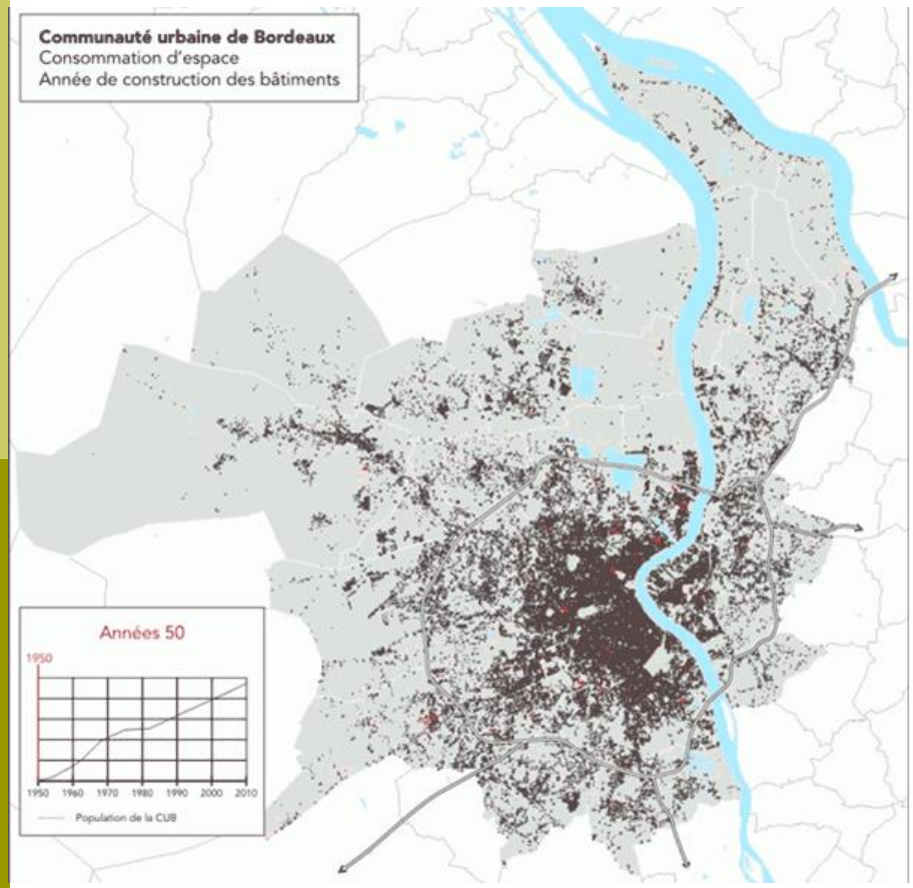
SIMUTEC Platform

Land use

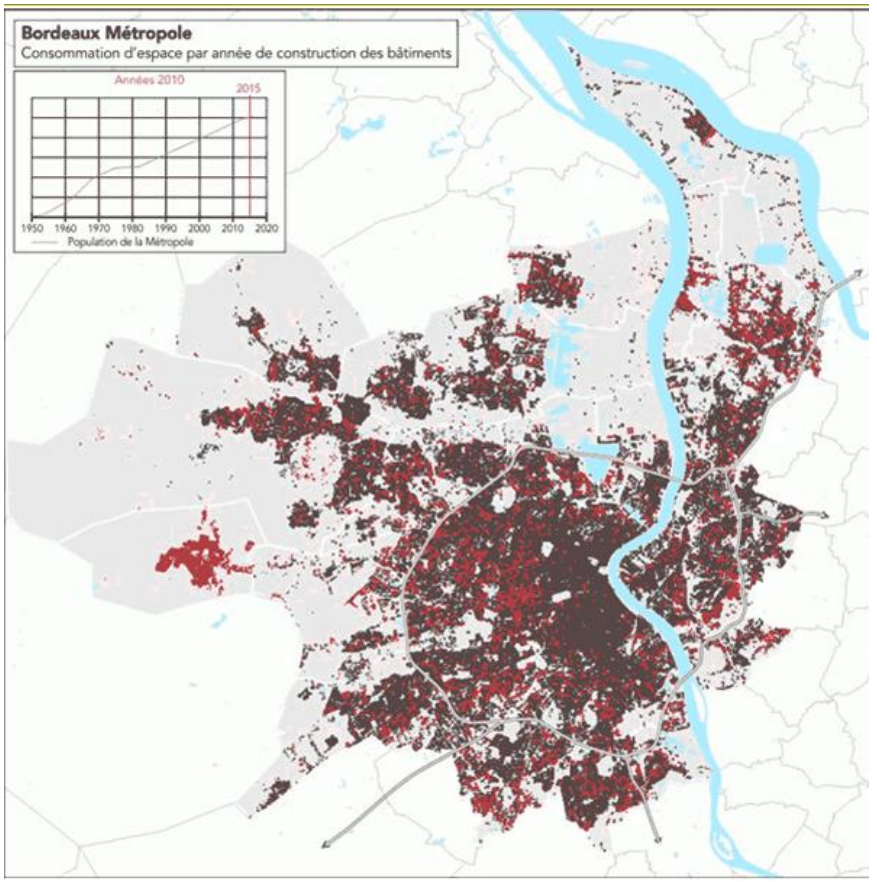
Artificialization

SIMUTEC Platform

Bordeaux area between 1950 and 2015



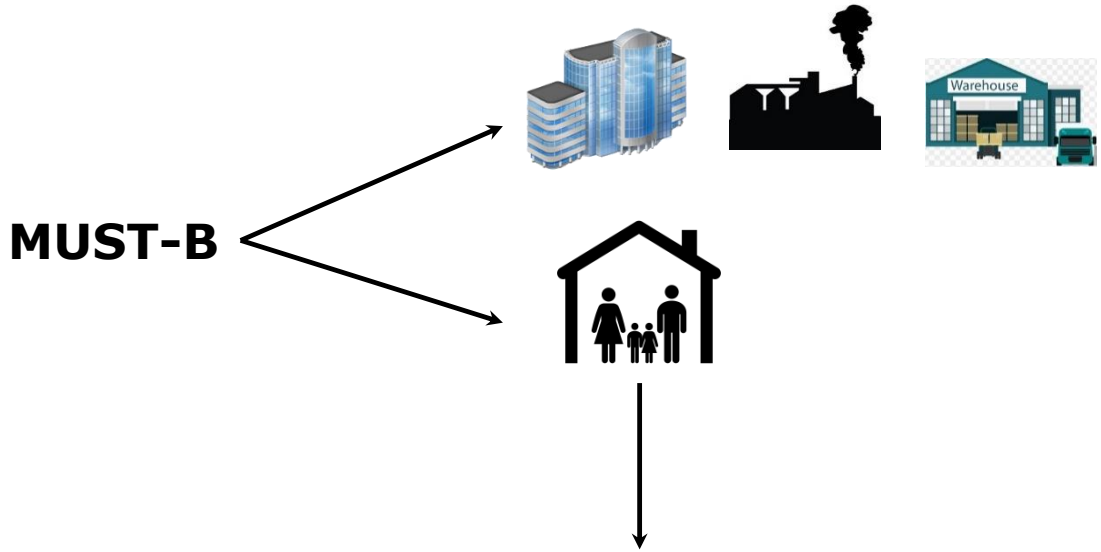
1950

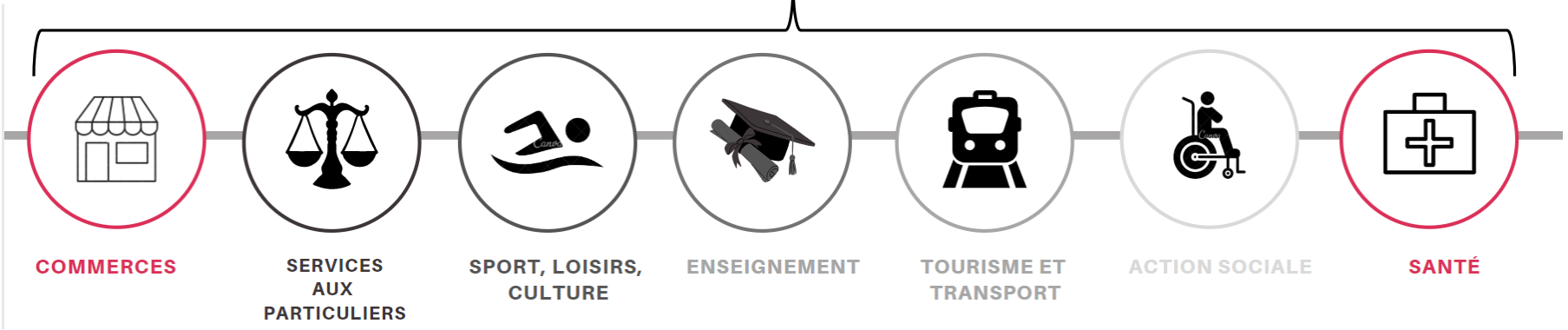


2015

Land use

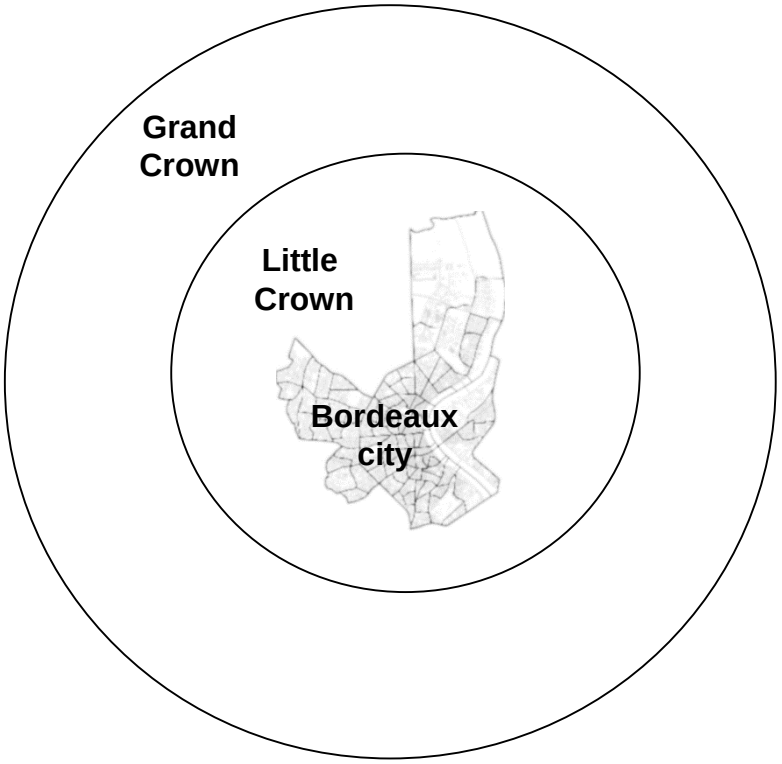
Generation of equipment



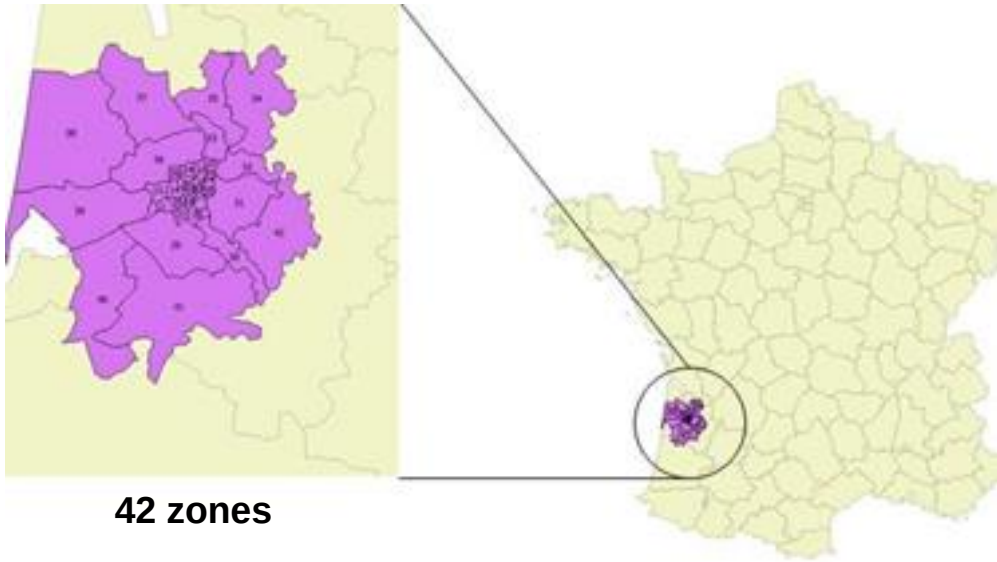


APPLICATION: Urban Area of Bordeaux (UAB)

Data collection and processing



3 macro-zones



42 zones

APPLICATION: Urban Area of Bordeaux (UAB)

Data collection and processing

The Urban Area of Bordeaux:

523,310 households (1,158,431 inhabitants)

- 2 income levels (low, high)
- 5 size levels (1, 2, 3, 4, 5 & +)

34,676 firms (467,211 jobs)

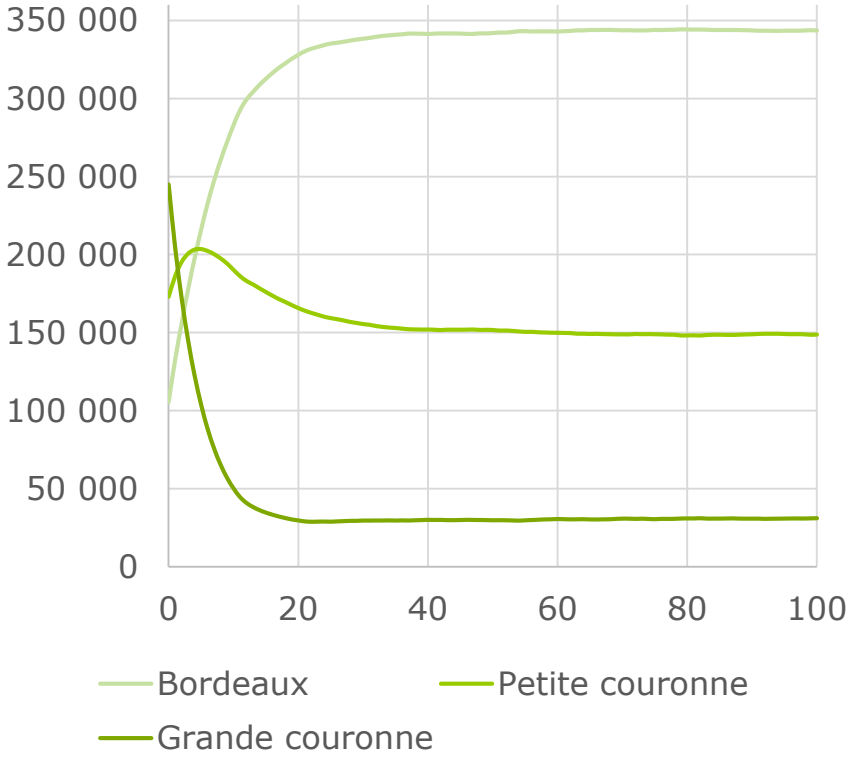
- 4 types of activities (Offices, Services, Factories, Warehouse/Agriculture)
- 8 size levels (3, 7, 15, 35, 75, 150, 350 & 750)

APPLICATION: Urban Area of Bordeaux (UAB)

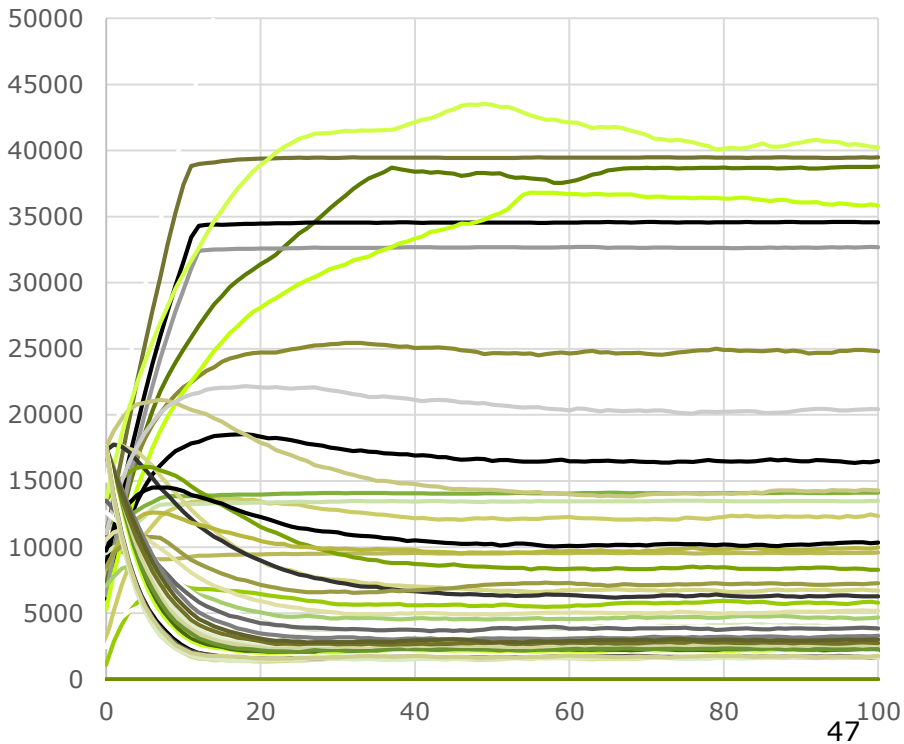
Some results

Population

Number of households per macro-zone



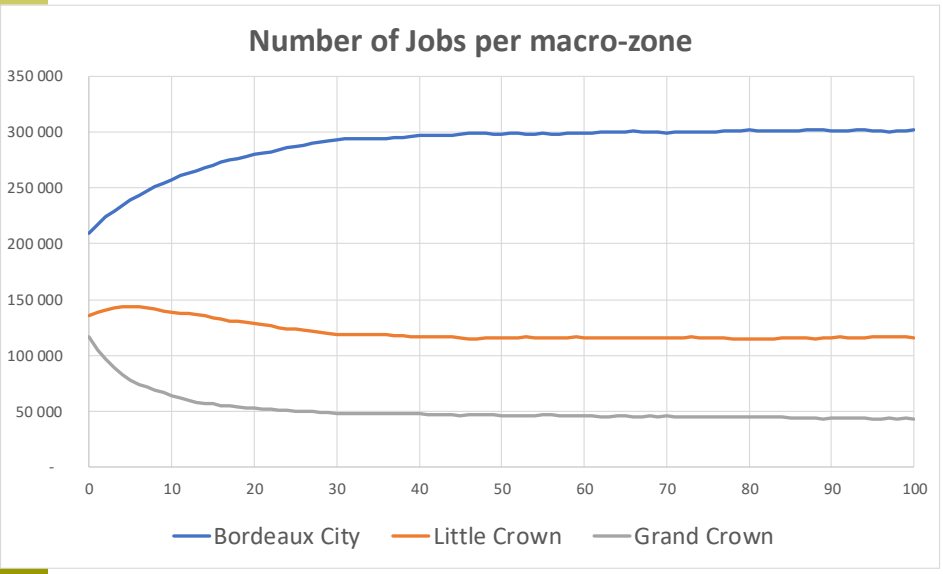
Number of households per zone

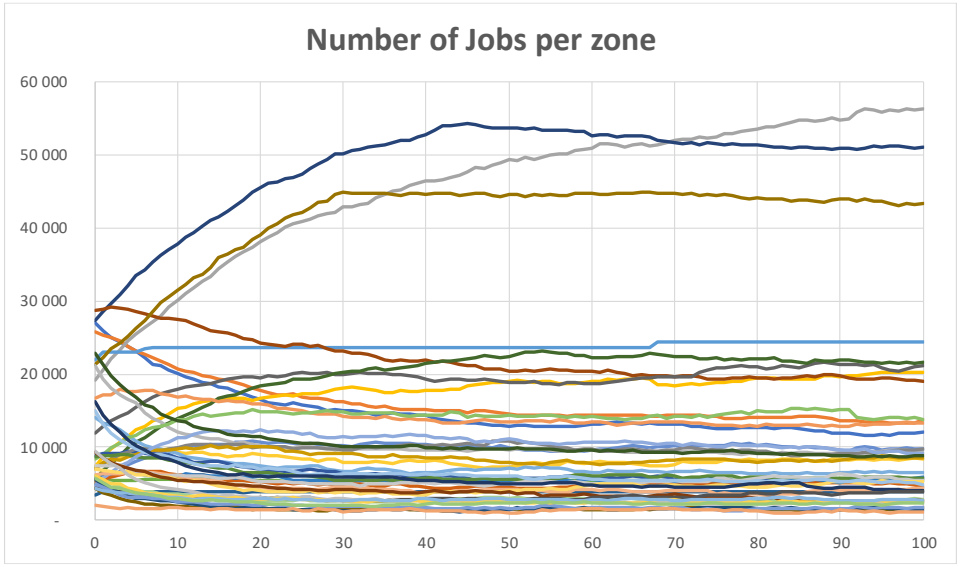


APPLICATION: Urban Area of Bordeaux (UAB)

Some results

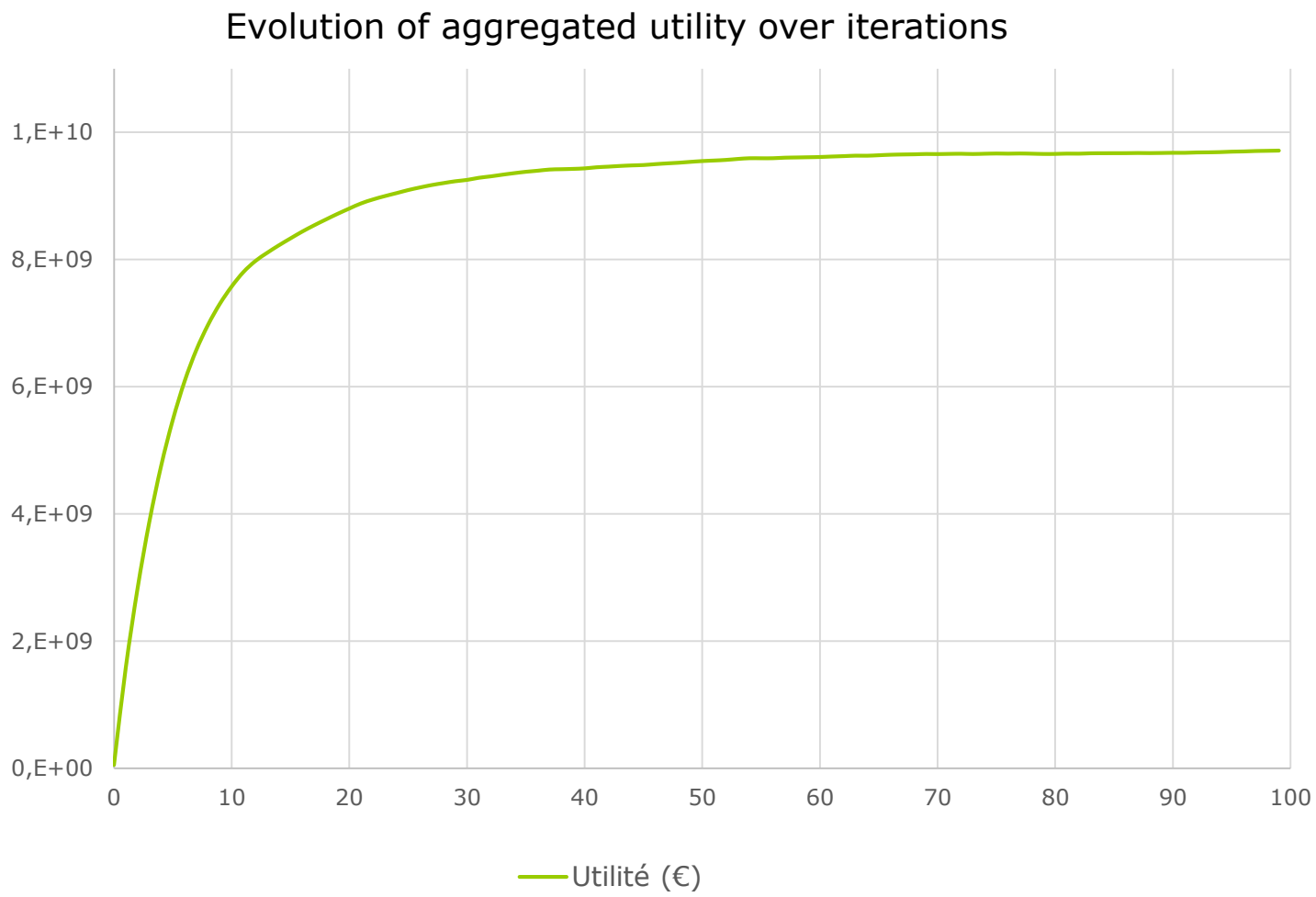
Jobs





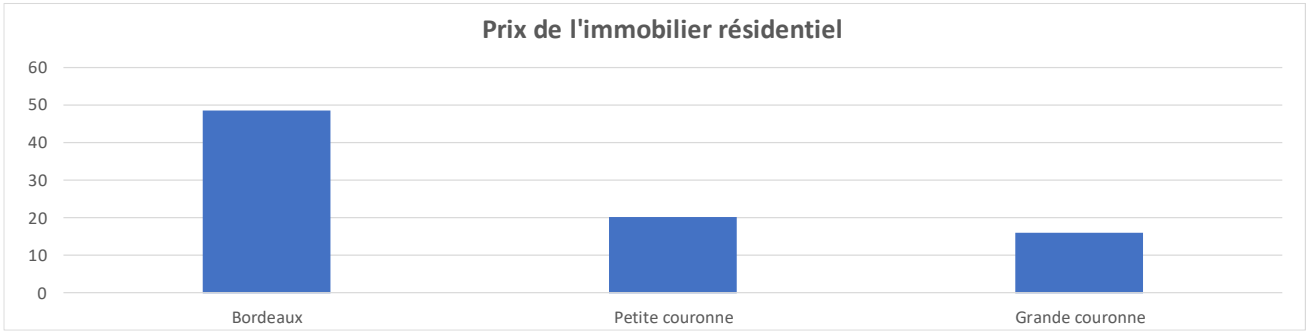
APPLICATION: Urban Area of Bordeaux (UAB)

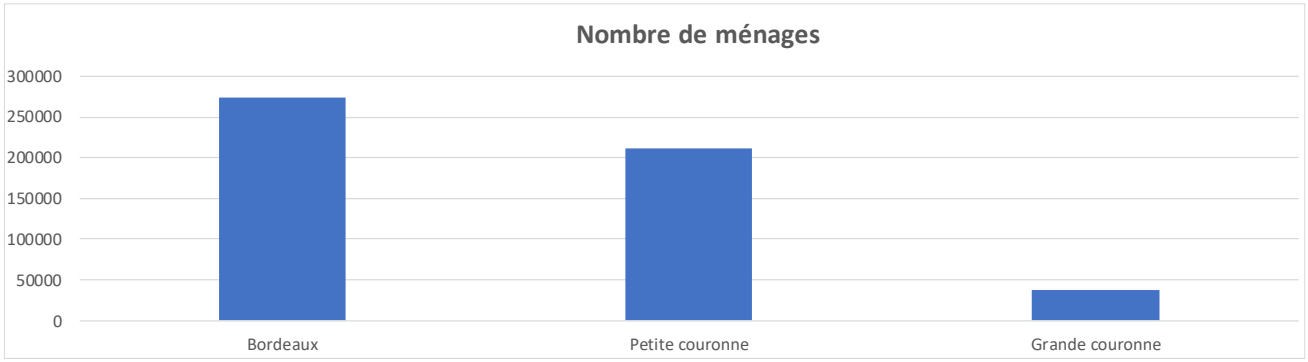
Some results

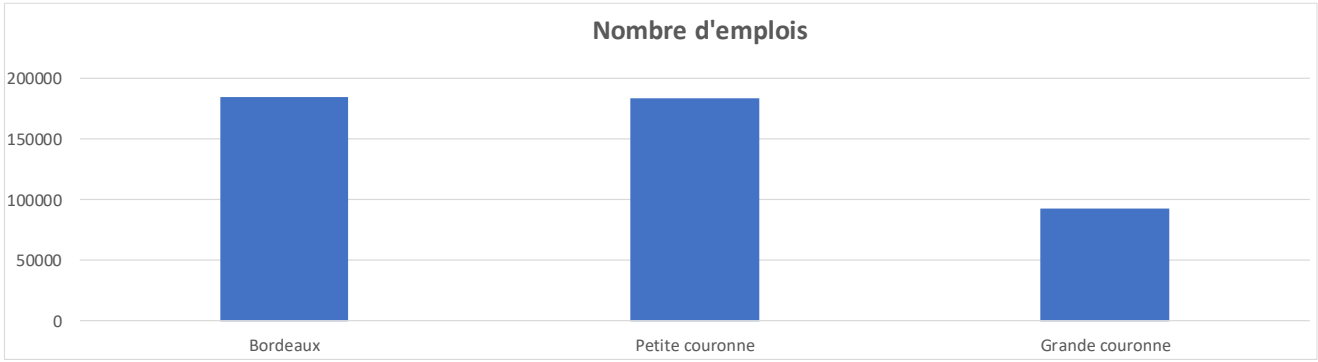


APPLICATION: Urban Area of Bordeaux (UAB)

Some results







APPLICATION: Urban Area of Bordeaux (UAB)

Some results

Simulation and evaluation of the **energy price increase** scenario which intervenes at 2 levels:

- In transport (generalized cost of travel by private vehicle)
- In housing (housing energy bill in the household utility)

Reference Situation

Mobility Home-to-Work:

- 64% by PV
- 36% by PT

Housing:

- 90.5 m²/household is the average area of the occupied housing
- 30% are new homes (built by the developer)

Scenario

Mobility Home-to-Work:

- 52% by PV
- 48% bu PT

Housing:

- 76,2 m²/household is the average area of the occupied housing
- 8% are new homes (built by the developer)

SIMUTEC Platform

M-CLIMATE

APPLICATION: Urban Area of Bordeaux (UAB)

Some results

Reference Situation	Energy consumption (TWh/year)	CO2 Emission (Mtons/year)	Emissions of atmospheric pollutants (Tons/year)				
			NOx	CO	HC	SOx	PM
Daily mobility							
Domicile-Travail							
Autres motifs							
Housing/premises activity							
Résidentiel							
Activités							
Urban services and networks							
Eclairage public							
Assainissement							
Eau potable							
Déchets ménagers							
Economic and business activites							
Commerces							
Restauration & Hôtellerie							
Etablissements spotifs & Loisirs							
Fret urbain							

APPLICATION: Urban Area of Bordeaux (UAB)

Some results

Reference Situation	Energy consumption (TWh/year)	CO2 Emission (Mtons/year)	Emissions of atmospheric pollutants (Tons/year)				
			NOx	CO	HC	SOx	PM
Daily mobility	**2,6**	**0,69**	**1 175**	**4 177**	**424**		**175**
Domicile-Travail	*1,108*	*0,293*	*500*	*1777*	*180*		*74*
Autres motifs	*1,496*	*0,395*	*675*	*2399*	*243*		*101*
Housing/premises activity	**11,8**	**1,80**					
Résidentiel	*8,040*	*1,274*					
Activités	**3,768**	0,526					
Urban services and networks	**0,4**	**0,05**	**393**			**1,386**	**9,479**
Eclairage public	*0,079*	*0,001*					
Assainissement	*0,045*	*0,007*					
Eau potable	*0,089*	*0,005*					
Déchets ménagers	*0,156*	*0,042*	*393*			*1,386*	*9,479*
Economic and business activites	**2,1**	**0,24**	**197**			**0,693**	**4,740**
Commerces	*1,664*	*0,180*					
Restauration & Hôtellerie	*0,106*	*0,011*					
Etablissements spotifs & Loisirs	*0,208*	*0,023*					
Fret urbain	*0,078*	*0,021*	*197*			*0,693*	*4,740*
Urban area total	**16,8**	**2,8**	**1765**	**4177**	**424**	**2,080**	**189**

APPLICATION: Urban Area of Bordeaux (UAB)

Some results

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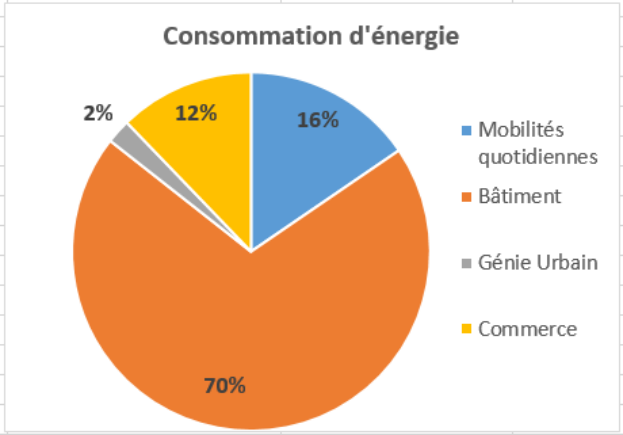
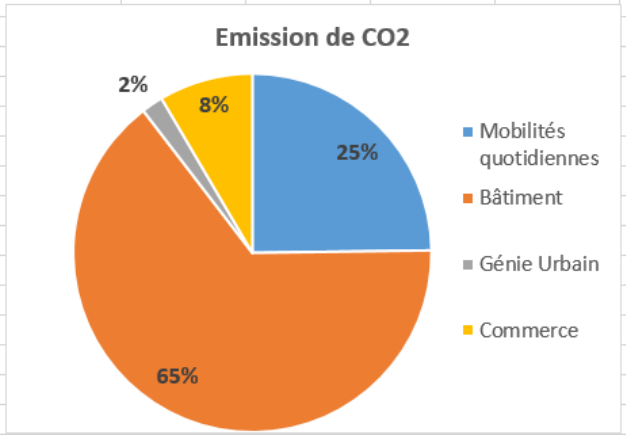
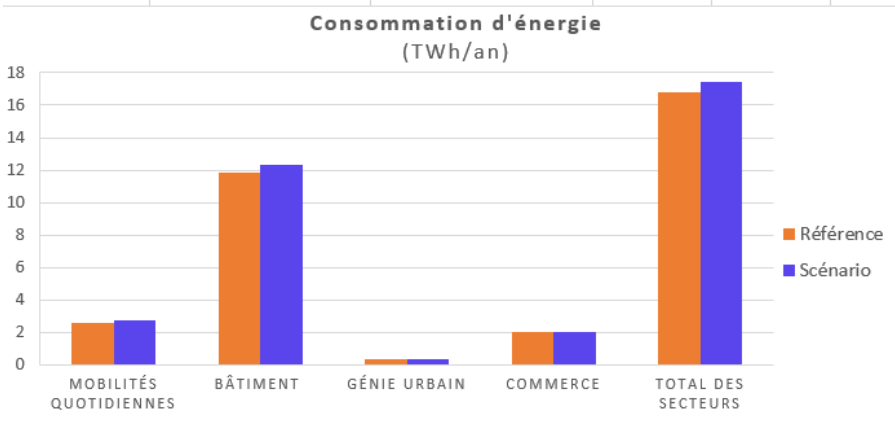


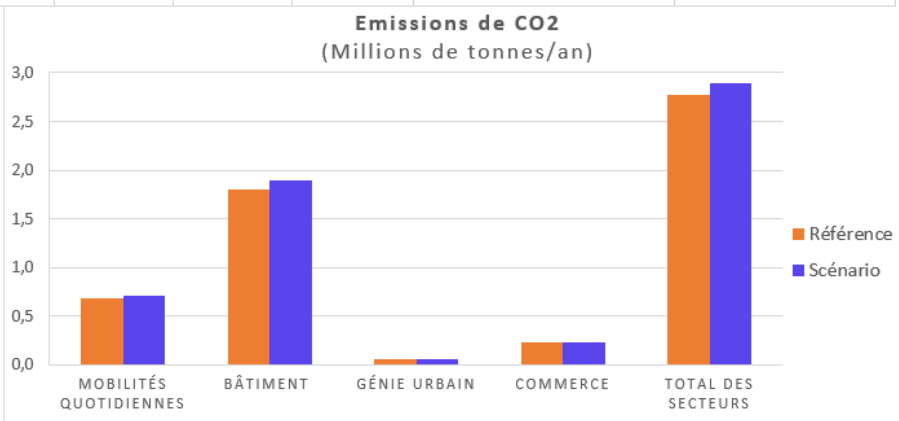


APPLICATION: Urban Area of Bordeaux (UAB)

Some results

Reference Situation	Energy consumption (TWh/year)	CO2 Emission (Mtons/year)	Emissions of atmospheric pollutants (Tons/year)				
			NOx	CO	HC	SOx	PM
Daily mobility	**3,9%**	**3,3%**	**2,9%**	**2,4%**	**2,3%**		**2,3%**
Domicile-Travail	*3,9%*	*3,3%*	*2,9%*	*2,4%*	*2,3%*		*2,3%*
Autres motifs	*3,9%*	*3,3%*	*2,9%*	*2,4%*	*2,3%*		*2,3%*
Housing/premises activity	**4,4%**	**5,3%**					
Résidentiel	*6,2%*	*7,3%*					
Activités	0,5%	0,3%					
Urban services and networks	**0,0%**	**0,0%**	**0,0%**			**0,0%**	**0,0%**
Eclairage public	*0,0%*	*0,0%*					
Assainissement	*0,0%*	*0,0%*					
Eau potable	*0,0%*	*0,0%*					
Déchets ménagers	*0,0%*	*0,0%*					
Economic and business activites	**0,0%**	**0,0%**	**0,0%**			**0,0%**	**0,0%**
Commerces	*0,0%*	*0,0%*					
Restauration & Hôtellerie	*0,0%*	*0,0%*					
Etablissements spotifs & Loisirs	*0,0%*	*0,0%*					
Fret urbain	*0,0%*	*0,0%*					
Urban area total	**3,7%**	**4,2%**	**1,9%**	**2,4%**	**2,3%**	**0,0%**	**2,2%**





MUST-B

2D/3D Visualization

Congestion:

MUST-B

2D/3D Visualization

Housing | Warehouses | Parcs | Offices | Factories

MUST-B

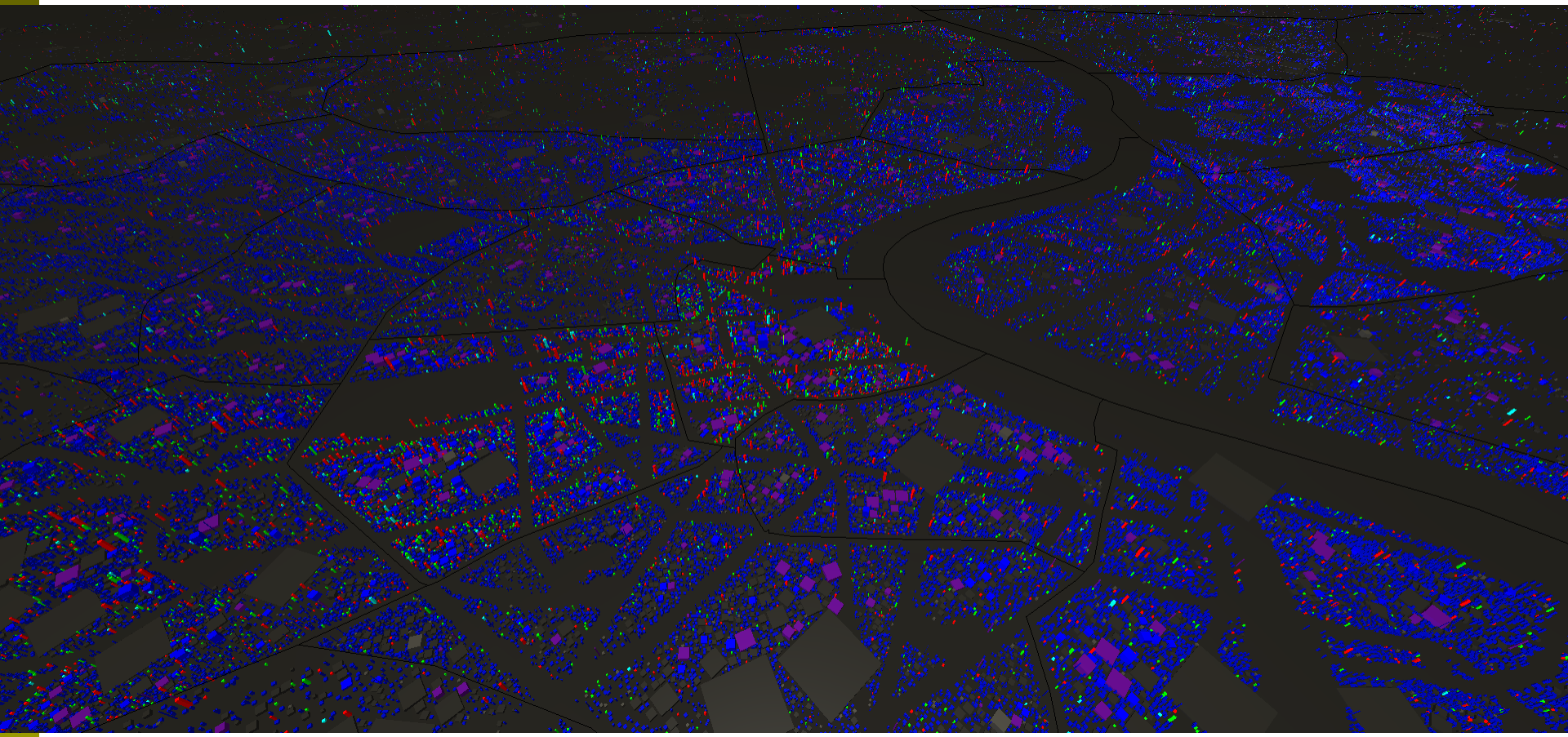
2D/3D Visualization

MUST-B

2D/3D Visualization

MUST-B

2D/3D Visualization



MUST-B

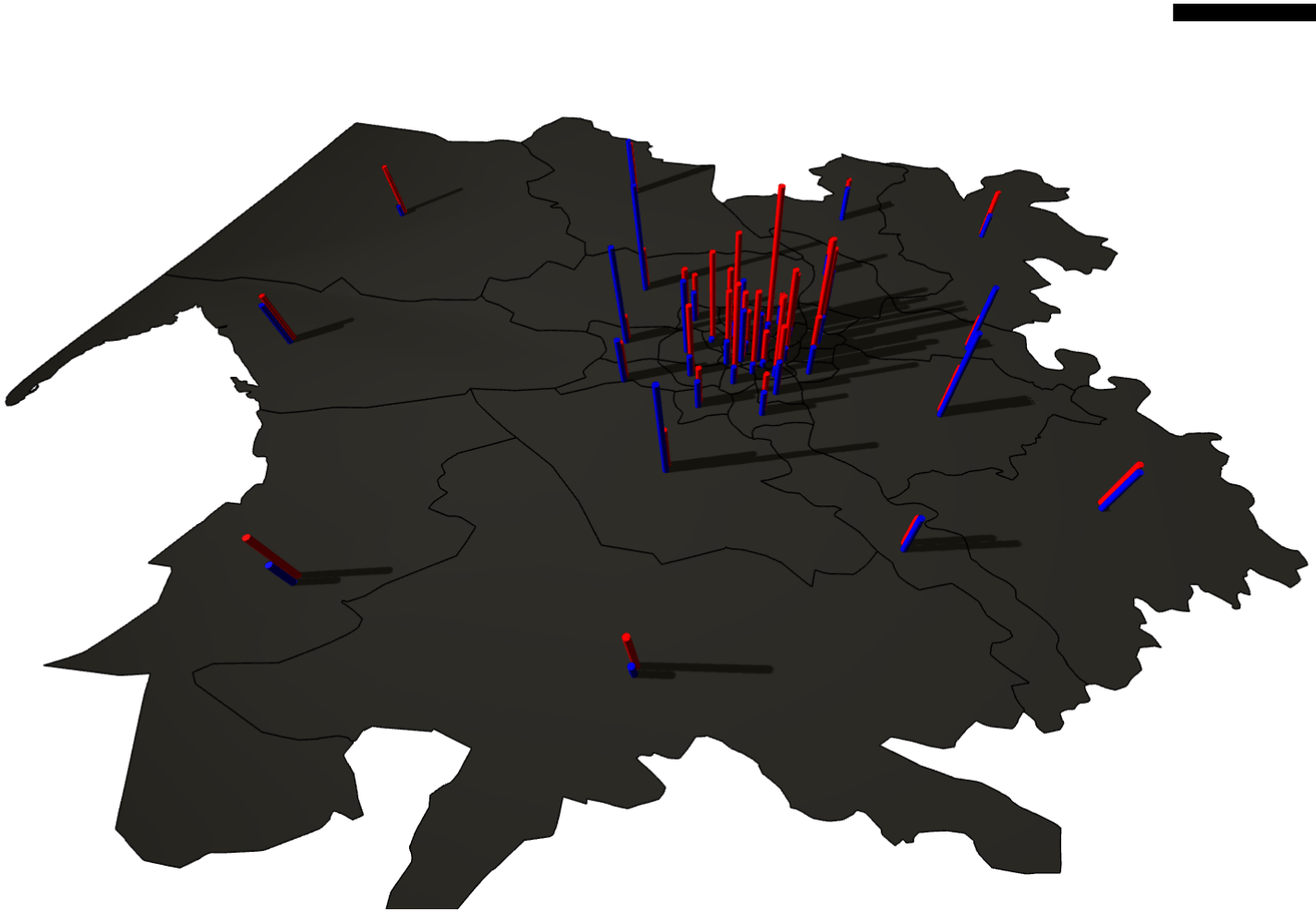
2D/3D Visualization

MUST-B

2D/3D Visualization

MUST-B

2D/3D Visualization



Prospective scenarios that can be modeled and simulated by the platform

- Mobility sector:
  - Transport pricing (urban toll, parking, public transport subsidy/free, etc.)
  - Creation of new structuring transport infrastructures (metro lines, tramway, BHNS)
  - Technological and organizational innovations (car sharing, etc.)

- Residential sector and business premises:
  - Energy renovation of the existing residential stock
  - Increase in the residential supply (densification)
  - Construction of subsidized and social housing
  - Housing price cap
  - Building regulations
  - Creation of activity zones

- Others :
  - Higher energy prices
  - Population increase
  - Creation of a green frame
  - Taxes and fees