Urban Futures Conference
Emerging interdisciplinary challenges for understanding, planning and creating the cities of tomorrow

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Land-use modeling and urban prospective energy

Seghir ZERGUINI (seghir.zerguini@enpc.fr)
Jean LATERRASSE (jean.laterrasse@enpc.fr)
LVMT (Université Paris-Est)

Champs-sur-Marne, January 17, 2013

Plan of the presentation

- Context and works realized in the ASPECT Project
  - Project partners
  - Team of modelisation
  - Objectives & issues
  - Constraints
  - Approach
- Development of Land-Use Model PROSPEG
  - Global model
  - Utility function of households
  - Mechanism of spatial assignment of the households
- Application on the urban area of Mulhouse
  - Socio-economic characteristics
  - Calibration of the model PROSPEG
  - Prospective scenario

ASPECT 2050 Project

A Systemic approach for designing Territorial Climate and Energy Action Plan (PCET): Forecasting for 2050

ASPECT 2050 Project

Project partners

Engineering companies

BURGEAP

ICE

egis mobilité

Isée les chiffres font sens

TRACÉS URBAINS

Research laboratories

CSTB le futur en construction

EIFER

LVMT Laboratoire Ville Mobilité Transport

ASPECT 2050 Project

The team that has contributed to the development of the model

LVMT :
- **Jean Laterrasse**
- **Olivier Morellet**
- **Florent Le Néchet**
- **Seghir Zerguini**

EIFER :
- **Monika Heider**
- **Markus Peter**

BURGEAP :
- **Simon Aulagnier**
- **Raphael Nahon**

Objectives & Issues

Objectives of the ASPECT Project :

- ❑ **Design a method to assist local authorities in developing and implementing Climate/Energy Plans. This method is based on an approach where the city is considered as a complex and interacting system.**

- ❑ **Analyze the main interactions between urban form, mobility and energy management that influence GHG emissions.**

Constraints

- Absence of a LUTI model in the business which allows to meet the requirements of the ASPECT project
- Difficulties to adapt existing LUTI models which are at the R & D stage
- Time constraints of the ASPECT project

ASPECT 2050 Project

Approach

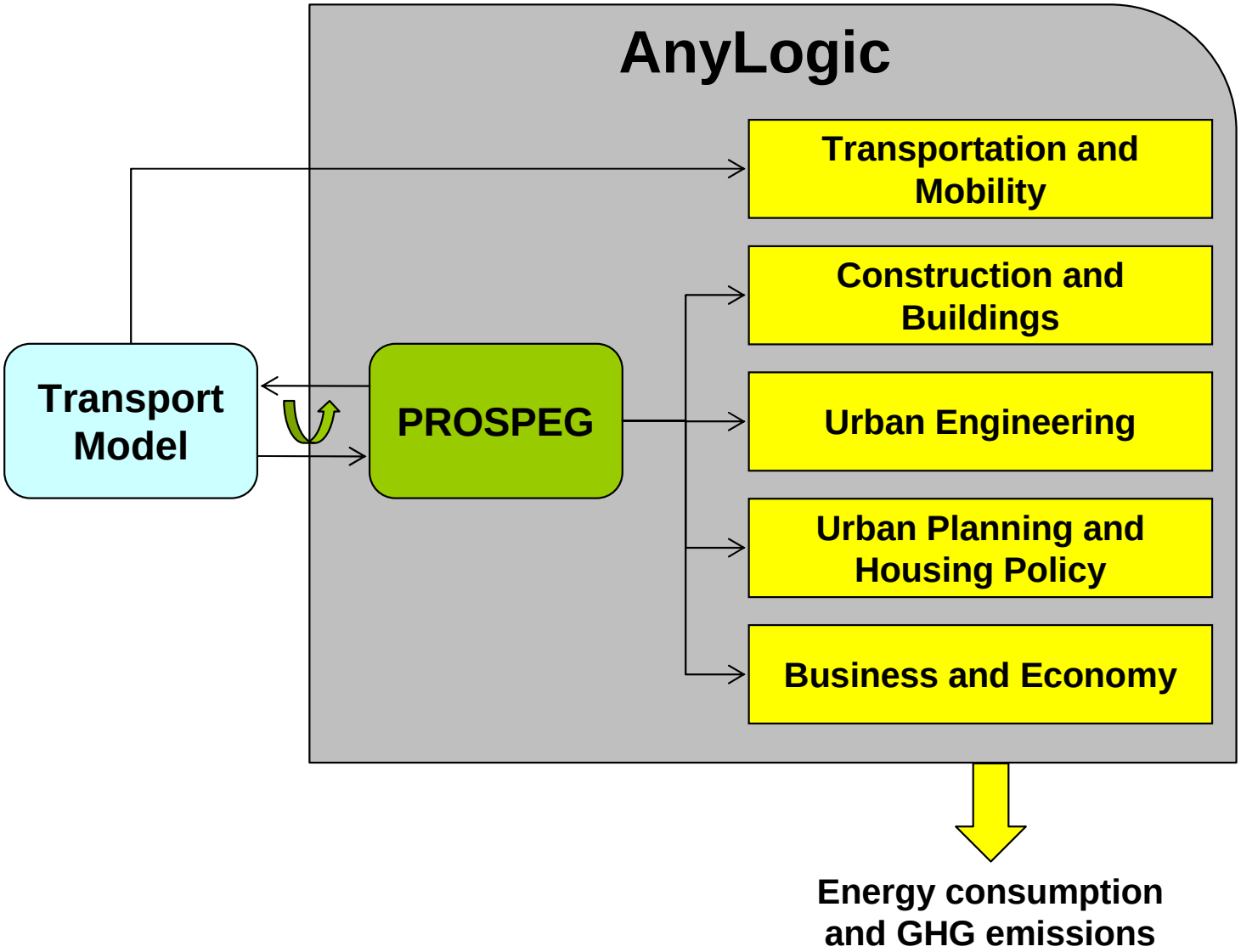
- Develop on a multi-agent platform (AnyLogic) a simplified Land-Use tool (equilibrium model) but which takes into account the particularities of the ASPECT project

- This tool will allow for a given horizon to forecast the land use for each zone and to deduce the energy consumption and GHG emissions for sectors : Transportation and Mobility, Construction and Buildings, Urban Engineering, Urban Planning and Housing Policy, and Business and Economy.

Development of Land-Use Model PROSPEG

Development of Land-Use Model (PROSPEG)

Global Model



Development of Land-Use Model (PROSPEG)

Utility function

$$U = \alpha_1 AC + \alpha_2 NO + \alpha_3 SL - EA - FE - P_x SL$$

With:

- **Accessibility (AC) of the zone considered towards the other zones**
- **Notoriety of the zone considered. This component of the utility integrates all the advantages which are not in the other components as the accessibility for example. It translates for example the quality aspects of the housing (standing, ...) and the immediate environment (green spaces, presence of architectural monuments,…)**
- **Desired surface of housing (SL)**
- **Household equipment car of the zone considered**
- **Energy bill (FE) of the zone considered (energy related to housing such as heating, hot water, electricity specific ...)**
- **Real estate price (Px) in m²**
- **α_i: parameters to be calibrated according to the classes of household income**

Development of Land-Use Model (PROSPEG)

The mechanism of spatial assignment of the households

Multi-agent model of equilibrium

- **Each household will locate randomly seeking to maximize his utility**
- **Zones have a limited capacity in term of housing supply**

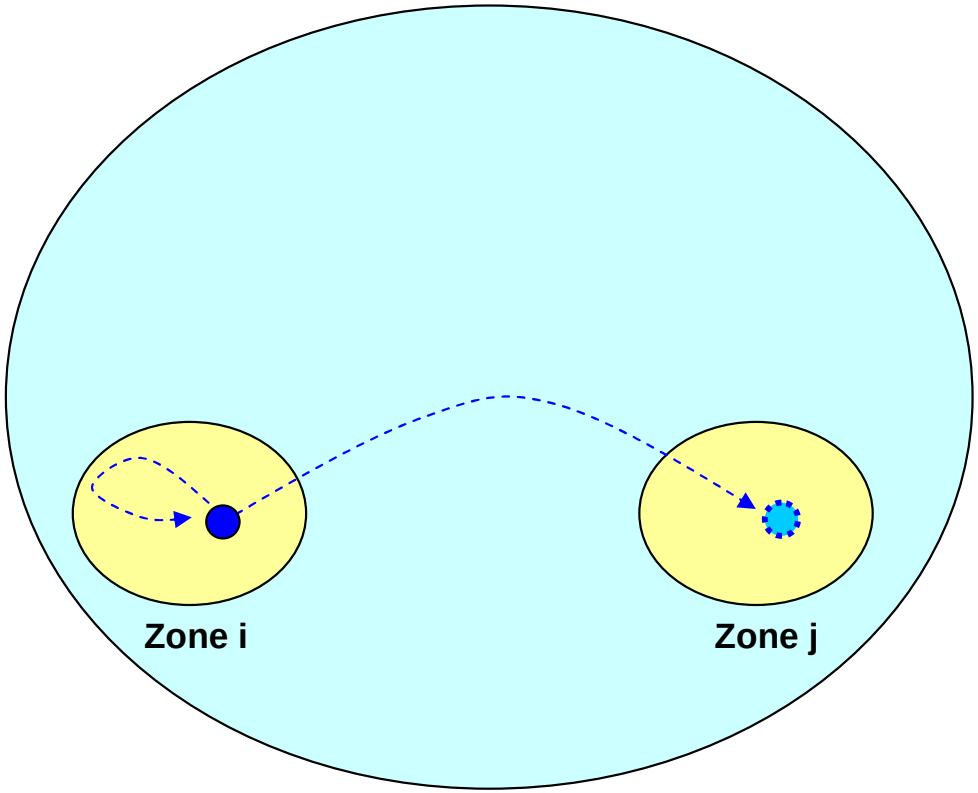
Sixteen categories of households are modeled by combining:

- **Household size (1, 2, 3 and 4 persons per household)**
- **SocioProfessional Group of household**
  - **SPG+ Occupied**
  - **SPG+ unoccupied**
  - **SPG- Occupied**
  - **SPG- unoccupied**

Development of Land-Use Model (PROSPEG)

The mechanism of spatial assignment of the households

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



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

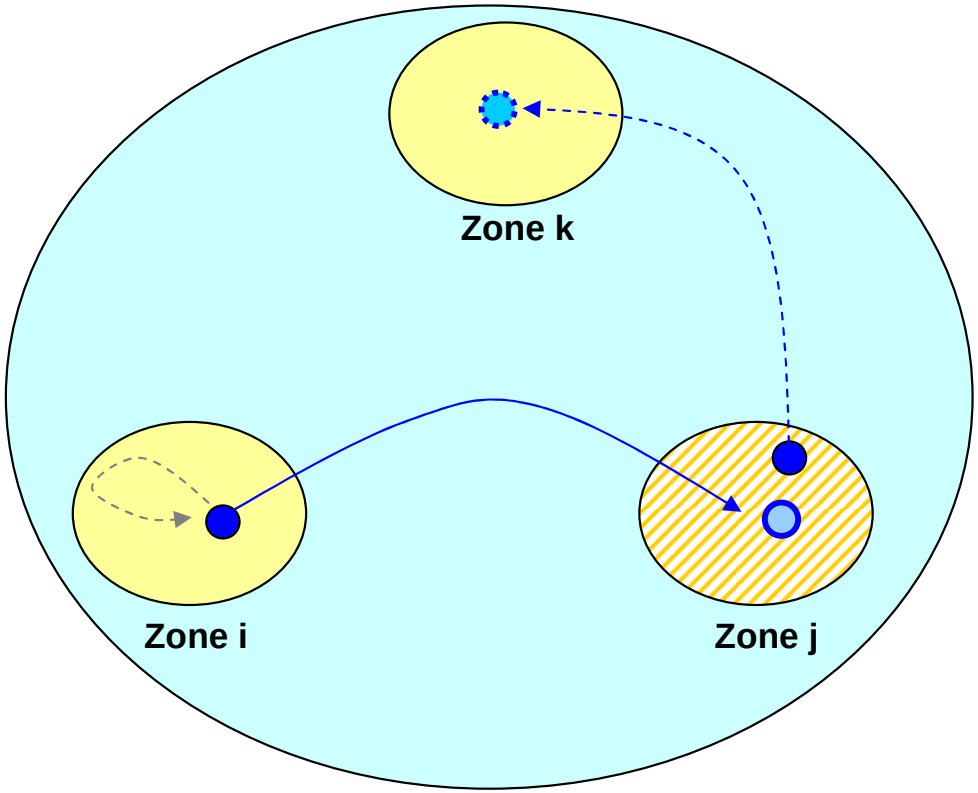
If $U(\pi_{n+1}^j) \le U(\pi_{n+1}^i)$ **Then the household m gives up the moving and the price of the zone i becomes the price with discount** π_{n+1}^i

If $U(\pi_{n+1}^j) > U(\pi_{n+1}^i)$ **Then the household moved to zone j and the price of the zone j becomes the price of the bid comes to household** π_{n+1}^j

Development of Land-Use Model (PROSPEG)

The mechanism of spatial assignment of the households

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



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

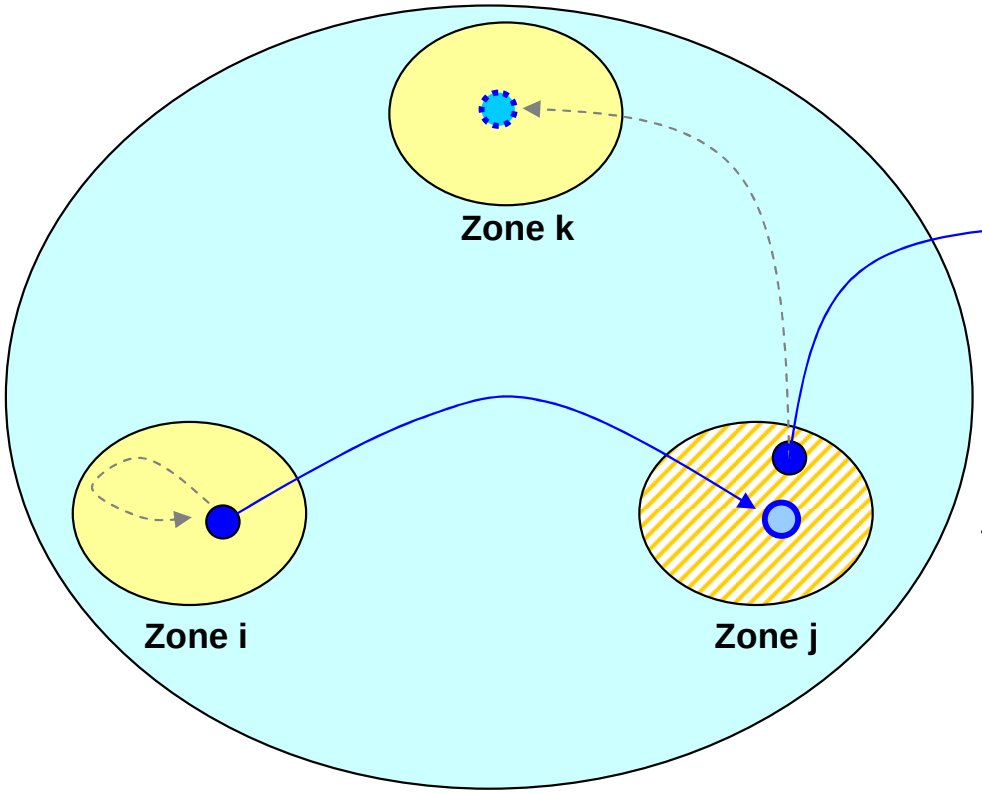
If the zone j of destination is already saturate then:

- **We move all the same the household m of the zone i towards the zone j**
- **And we take a household m' which has the <u>lowest utility</u> in the zone j and we simulate its relocation in the zone k selected randomly.**

Development of Land-Use Model (PROSPEG)

The mechanism of spatial assignment of the households

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



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

If the utility of the household m' is lower or equals in the zone k that the zone j: $U_{n+1}^{j,m'} > U_{n+1}^{k,m'}$

So we put the household m‘ in the "Hotel".

Application on the urban area of Mulhouse

Application on the urban area of Mulhouse

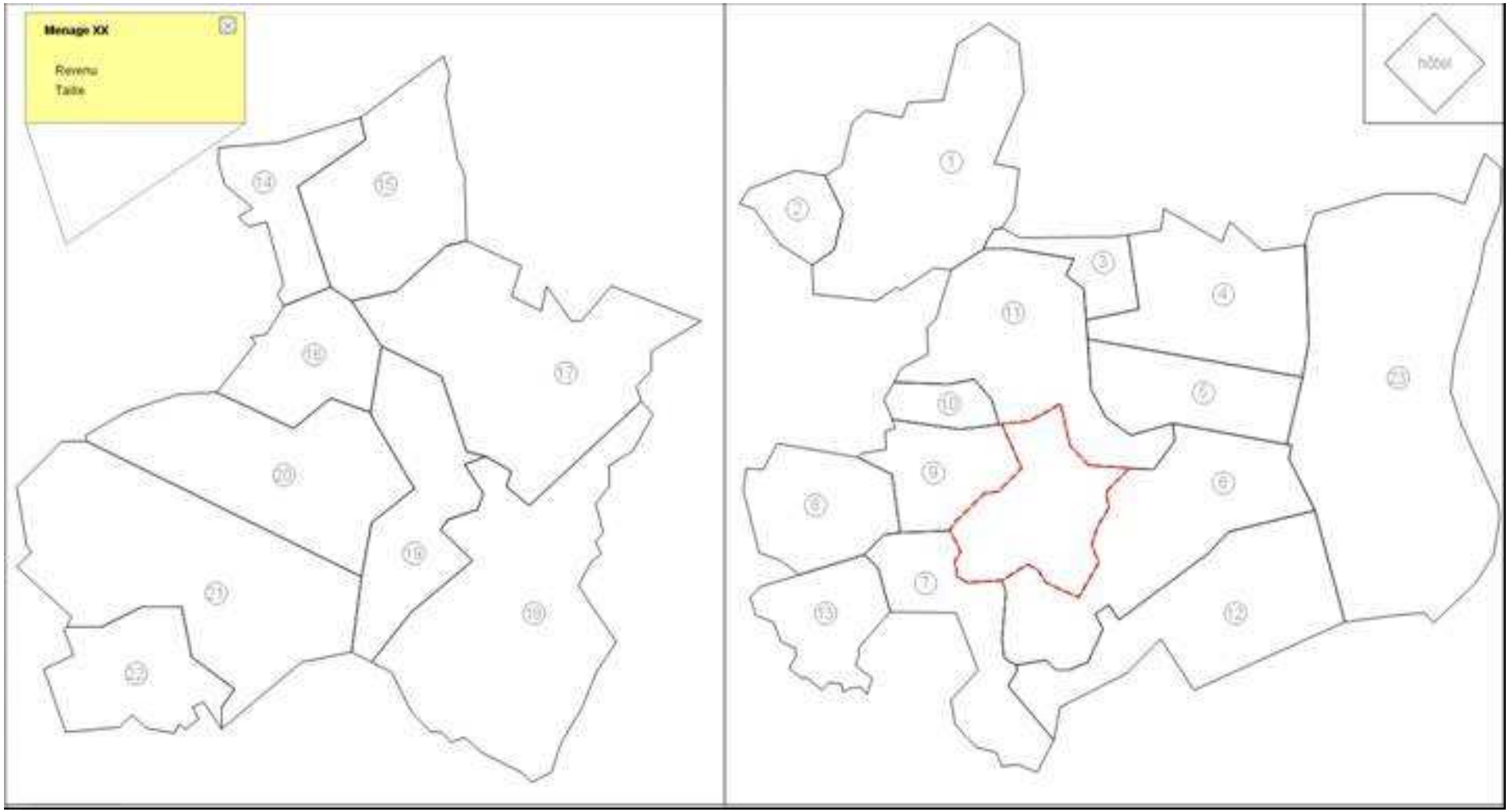
Socio-economic characteristics

Geographical situation

Application on the urban area of Mulhouse

Socio-economic characteristics

Zonage



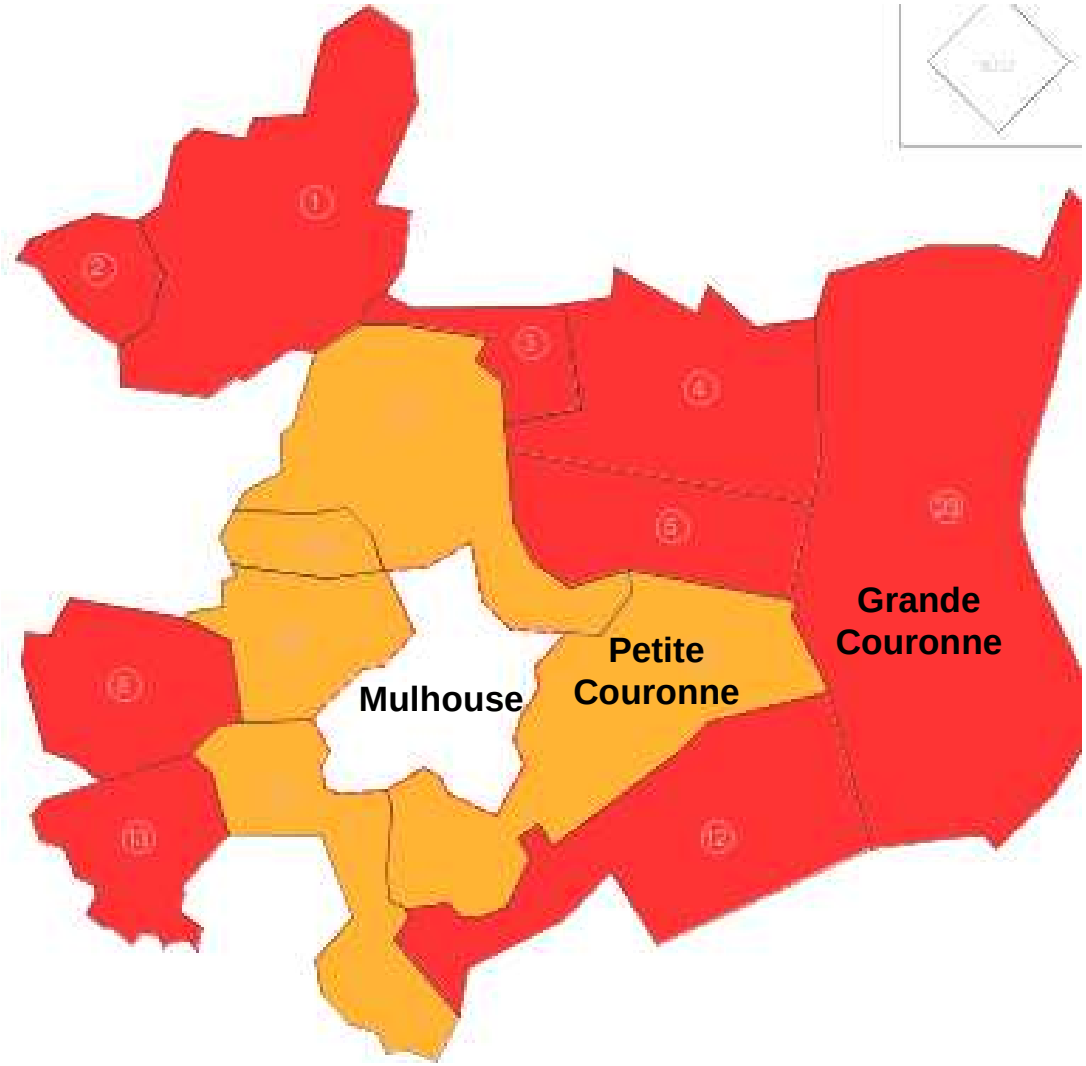
Mulhouse

Urban area

Application on the urban area of Mulhouse

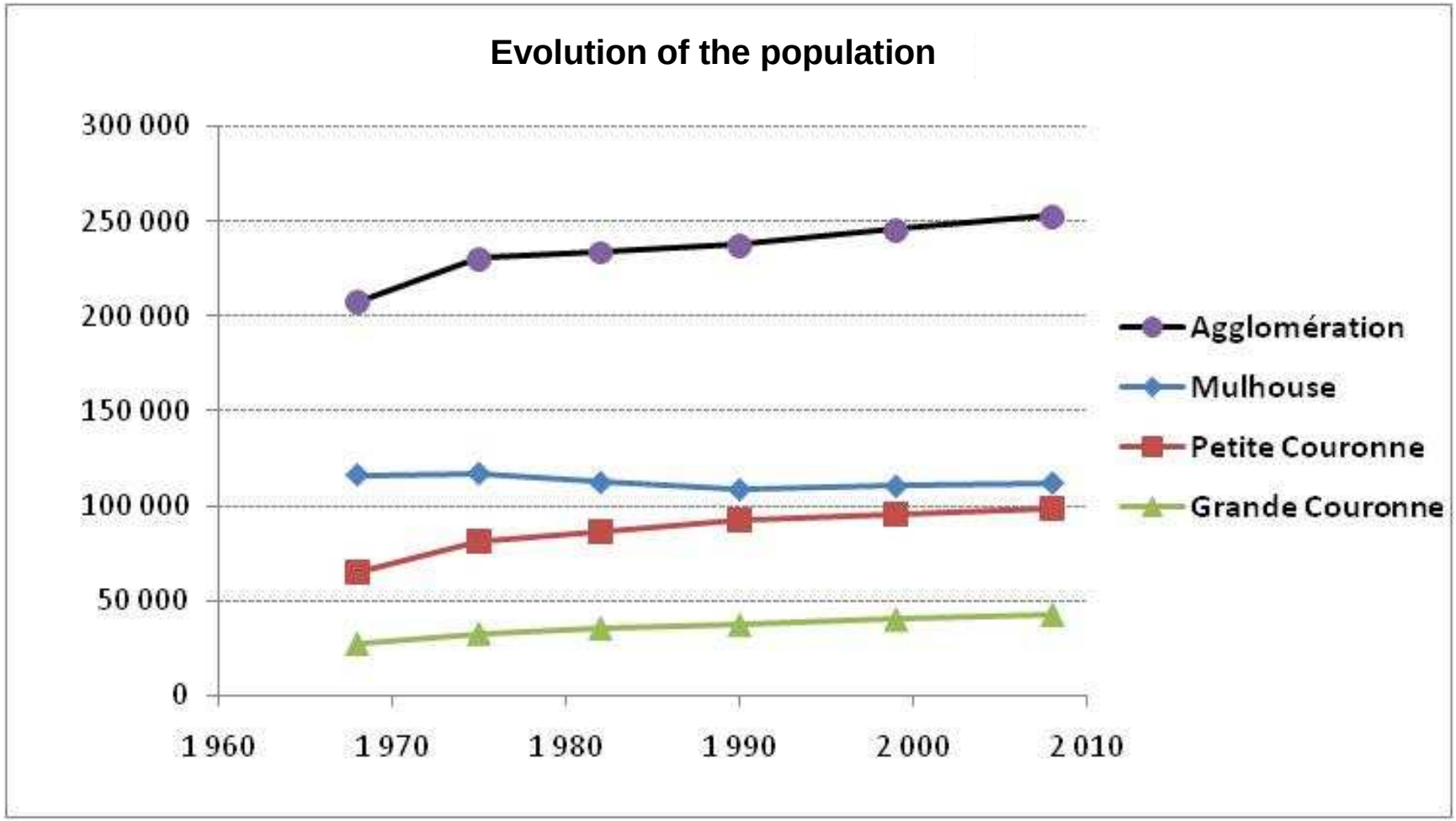
Socio-economic characteristics

Definition of a macro-zoning



Application on the urban area of Mulhouse

Socio-economic characteristics



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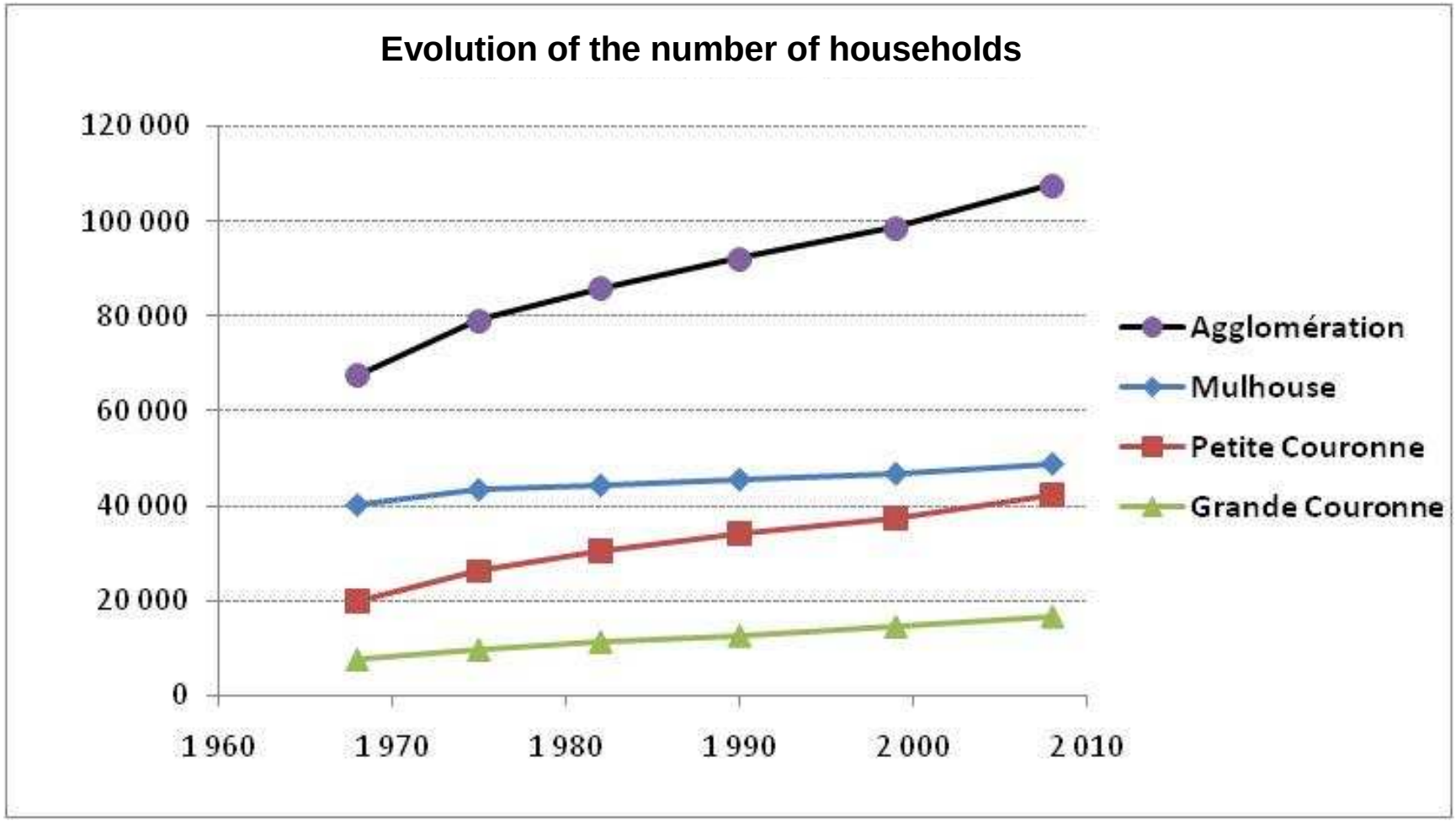
Socio-economic characteristics



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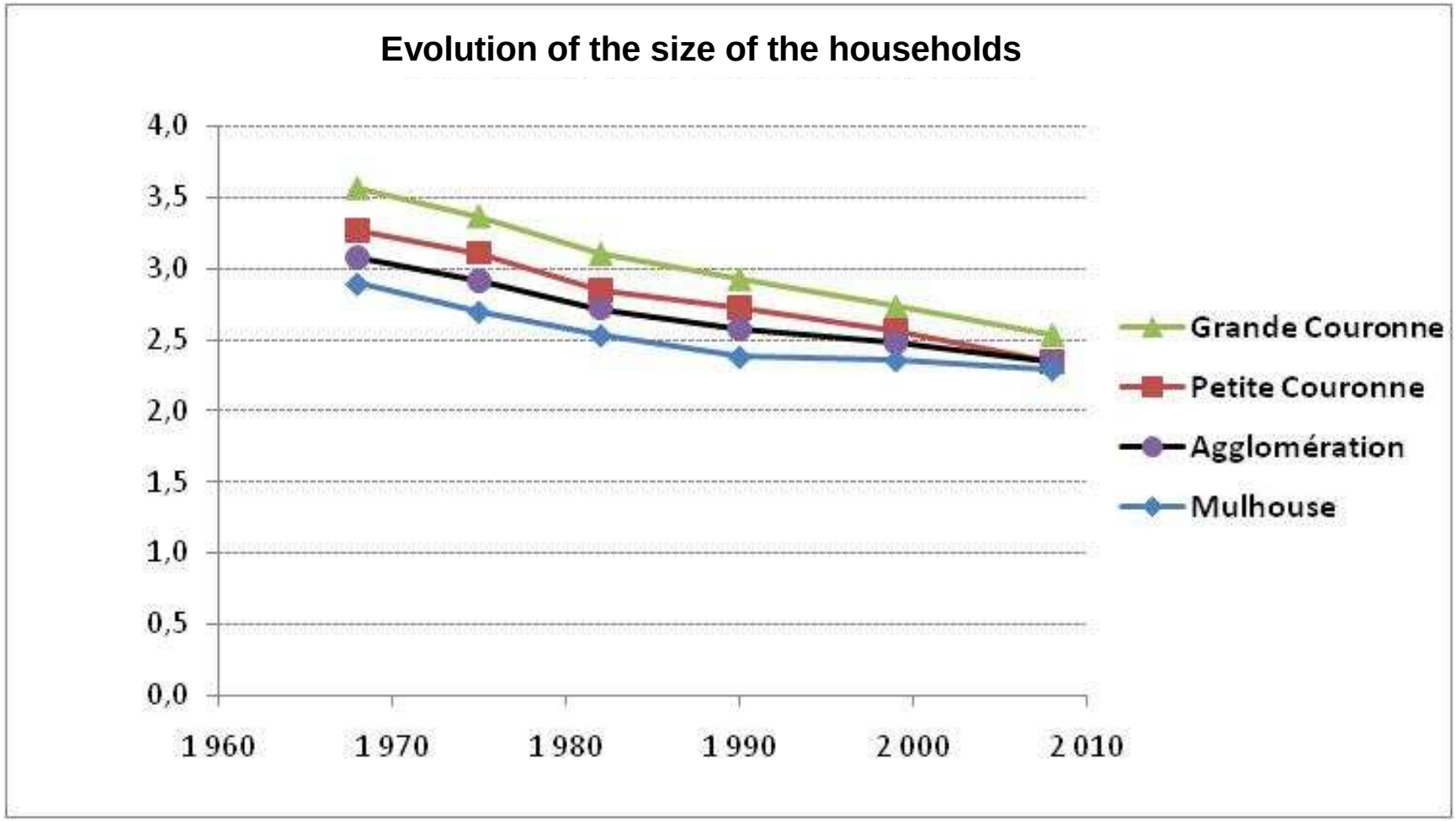
Socio-economic characteristics



Application on the urban area of Mulhouse

Socio-economic characteristics

Data by zones

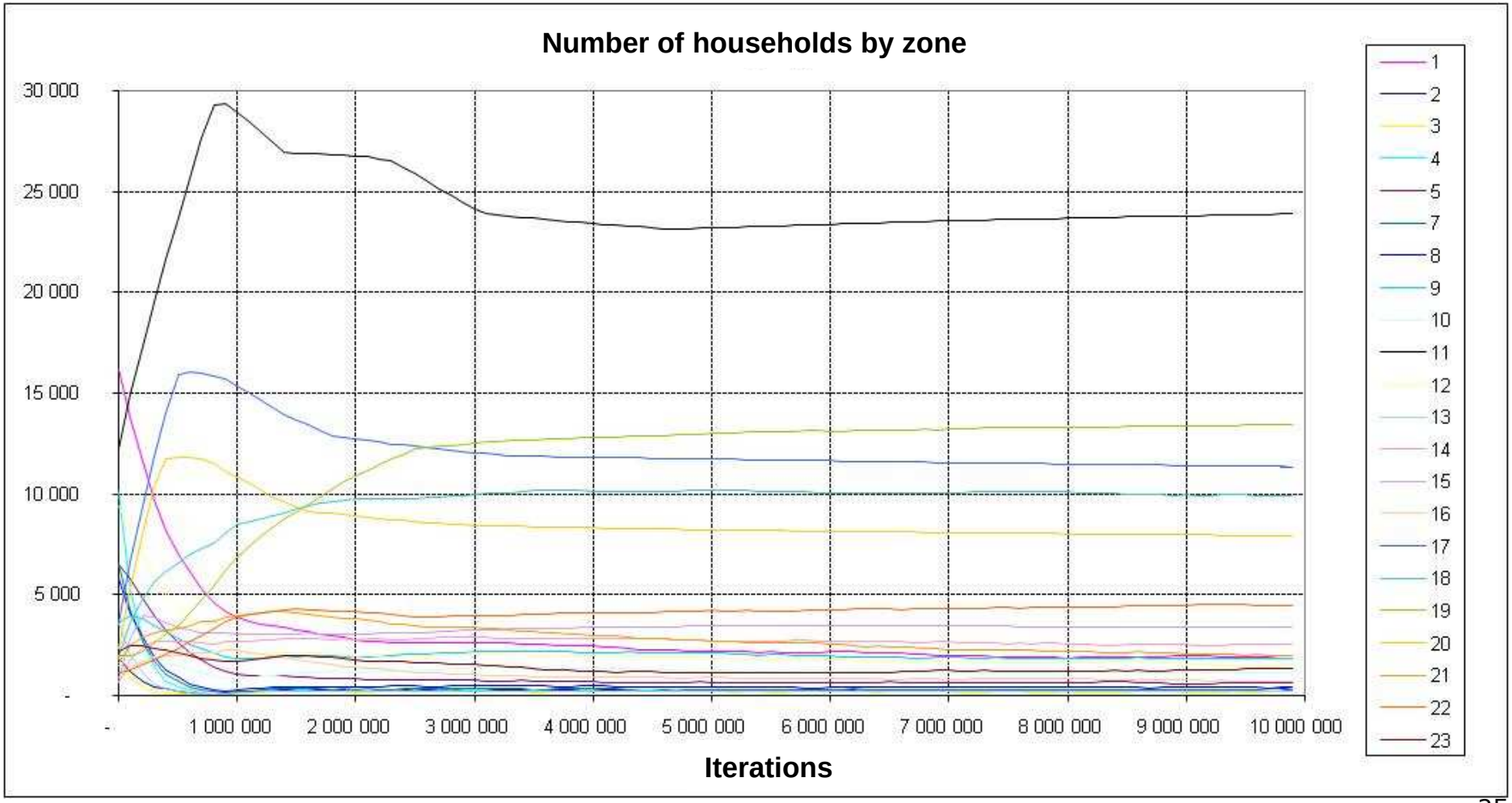
Zone	Surface construite (m²)	Prix €/m² meilleursagents.com (2011)	Prix annuel €/m² (15 ans)	AC	NO	FE (€/m²)
1	480 296	1 994	133	0,44	51,79	17,31
2	49 716	1 705	114	0,54	40,00	13,63
3	98 560	1 607	107	0,37	44,00	16,50
4	156 823	1 629	109	0,33	44,00	16,38
5	217 149	1 894	126	0,30	44,00	15,07
6	1 300 471	1 786	119	0,36	46,39	15,25
7	317 623	1 656	110	0,46	43,02	15,09
8	78 167	2 314	154	0,46	52,00	14,26
9	563 589	1 959	131	0,42	50,88	14,59
10	140 251	1 914	128	0,40	49,71	17,22
11	1 492 581	1 774	118	0,29	52,00	15,88
12	477 440	1 725	115	0,35	50,00	15,38
13	95 931	1 607	107	0,40	50,00	14,43
14	145 184	1 459	97	0,50	37,89	16,49
15	208 534	1 459	97	0,44	37,89	16,37
16	159 466	1 459	97	0,50	37,89	15,19
17	879 834	1 459	97	0,48	37,89	15,44
18	464 359	1 459	97	0,44	37,89	13,20
19	478 566	1 459	97	0,45	37,89	18,17
20	561 261	1 459	97	0,48	37,89	17,18
21	387 252	1 459	97	0,51	37,89	15,57
22	268 662	1 459	97	0,48	37,89	13,60
23	280 093	1 807	120	0,44	46,93	16,04

Application on the urban area of Mulhouse

Iterative functioning of the model

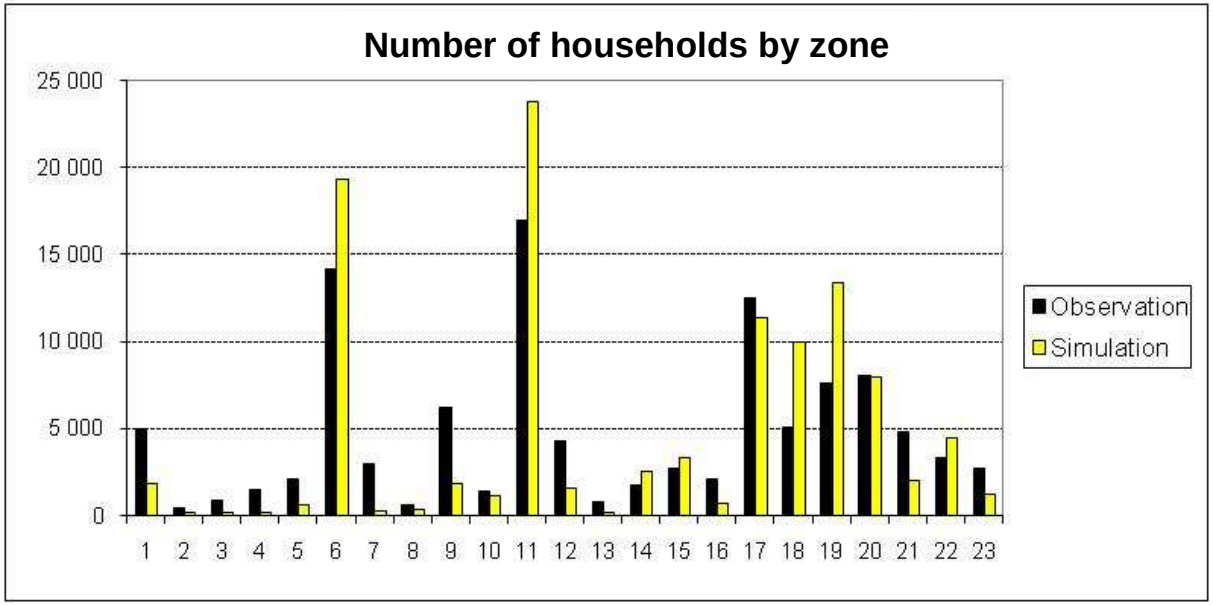
Application on the urban area of Mulhouse

Iterative functioning of the model



Application on the urban area of Mulhouse

Calibration of the model PROSPEG



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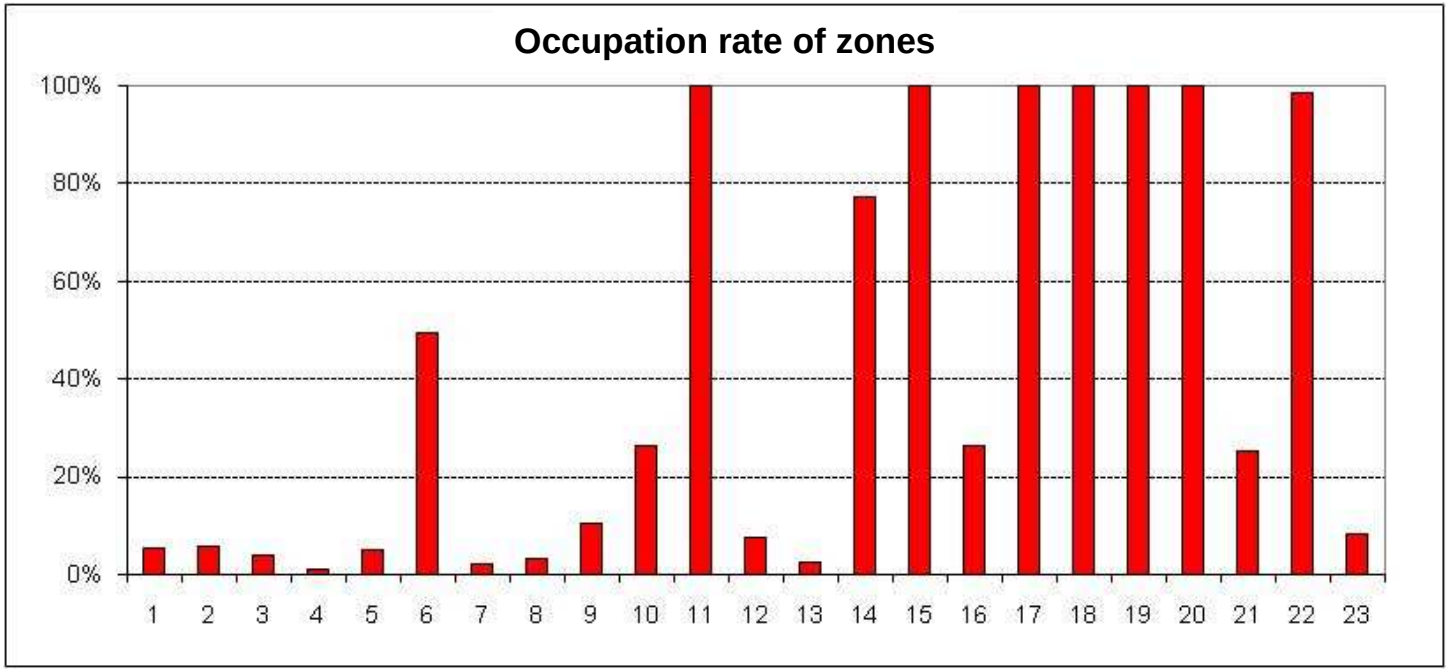

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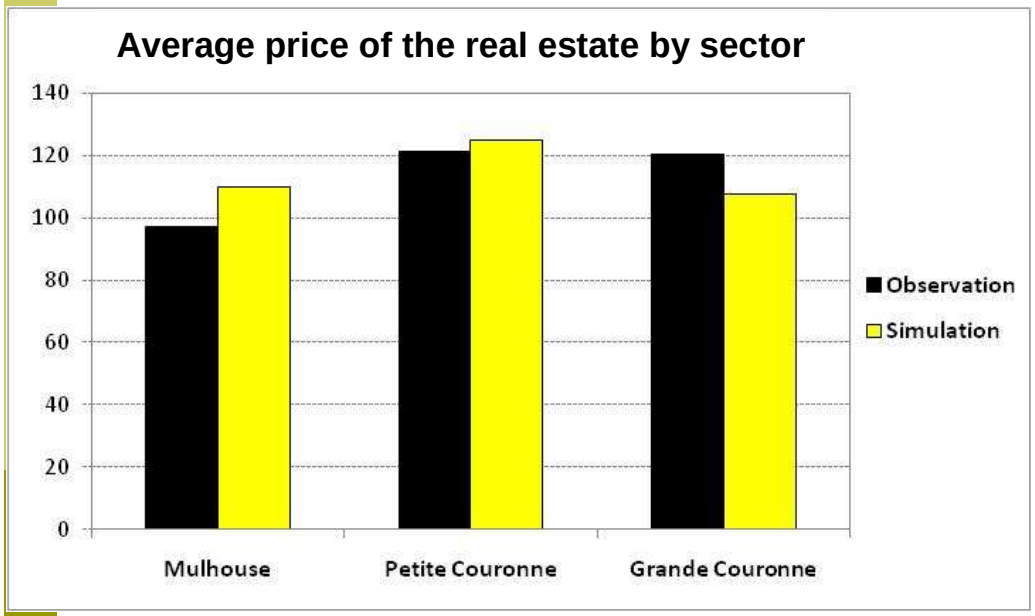

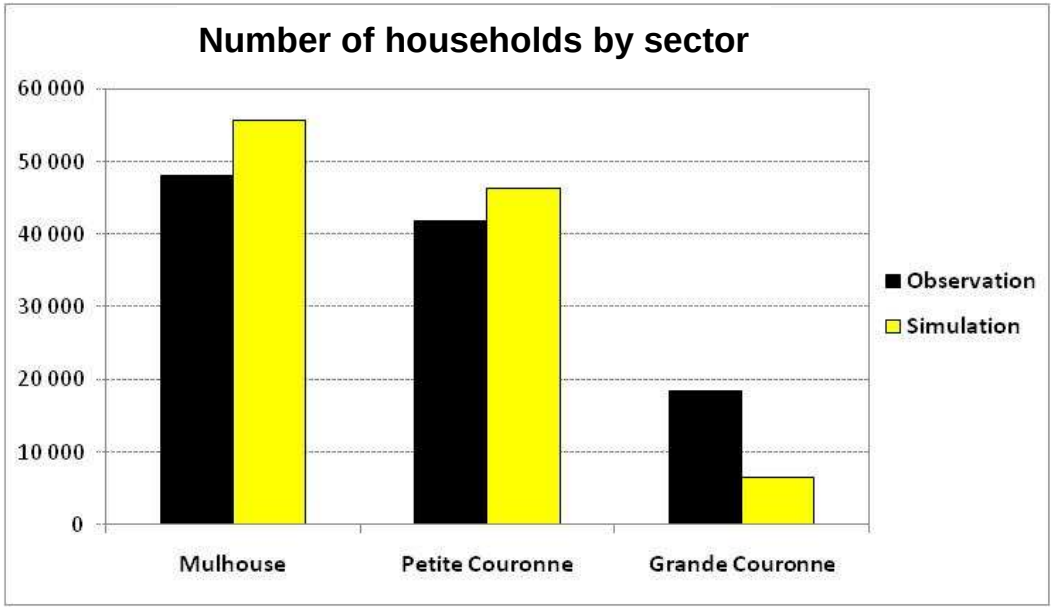

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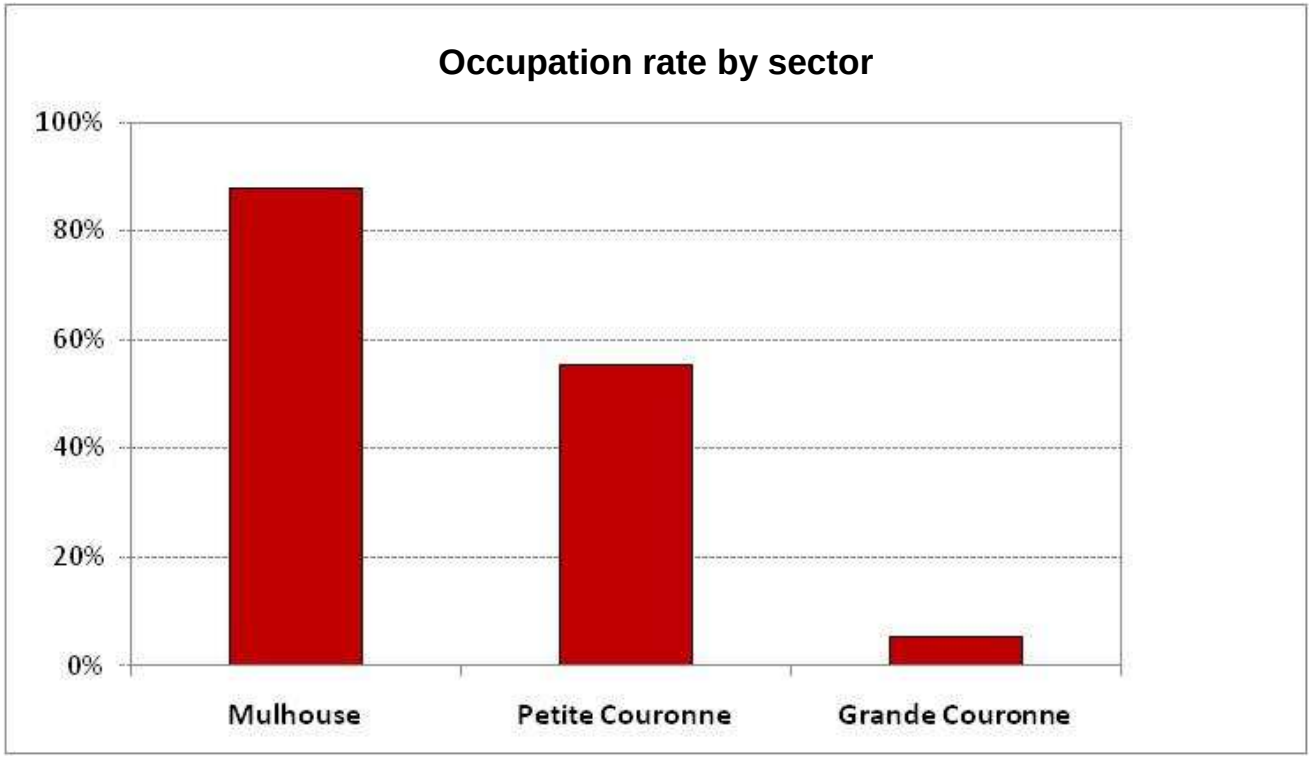
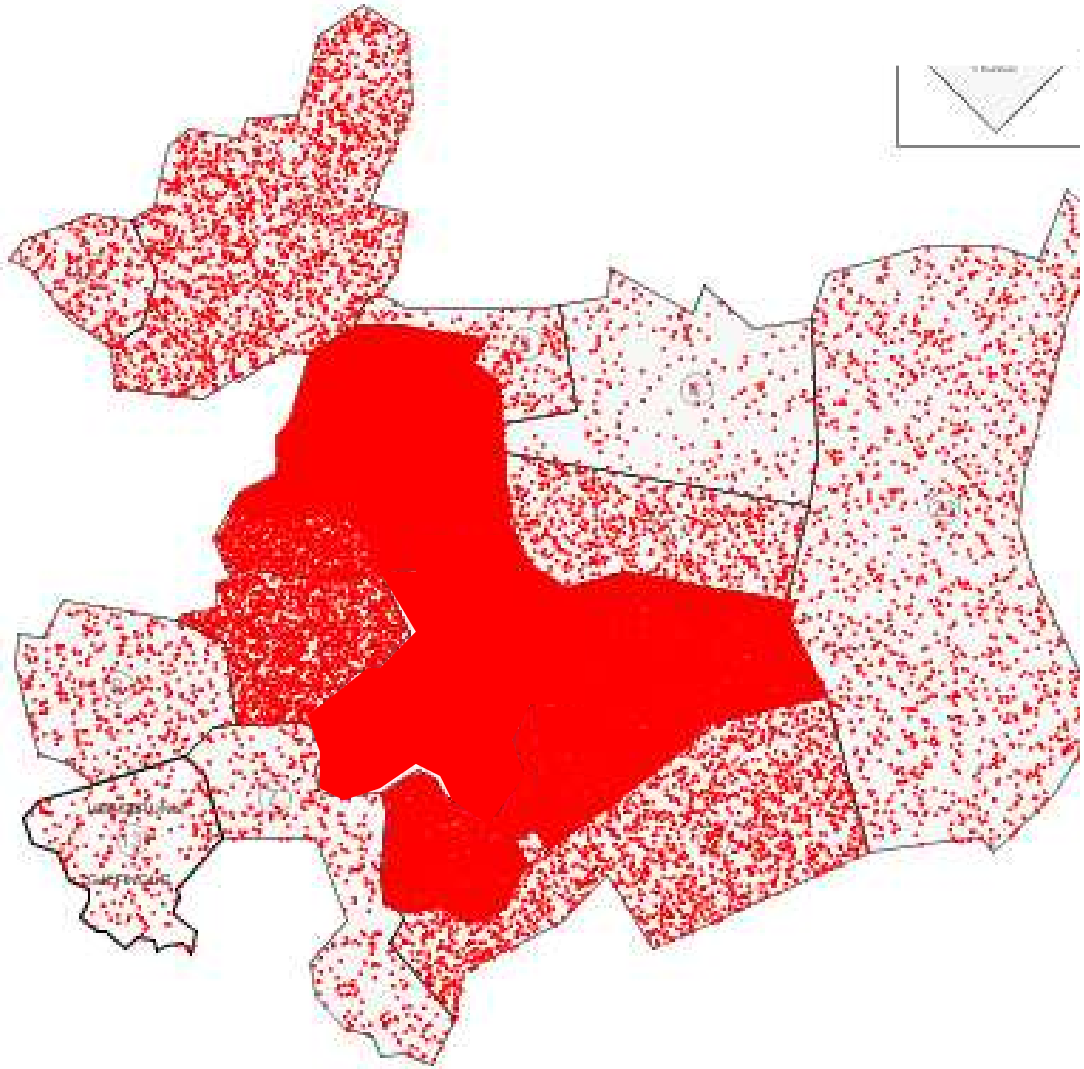


Application on the urban area of Mulhouse

Calibration of the model PROSPEG

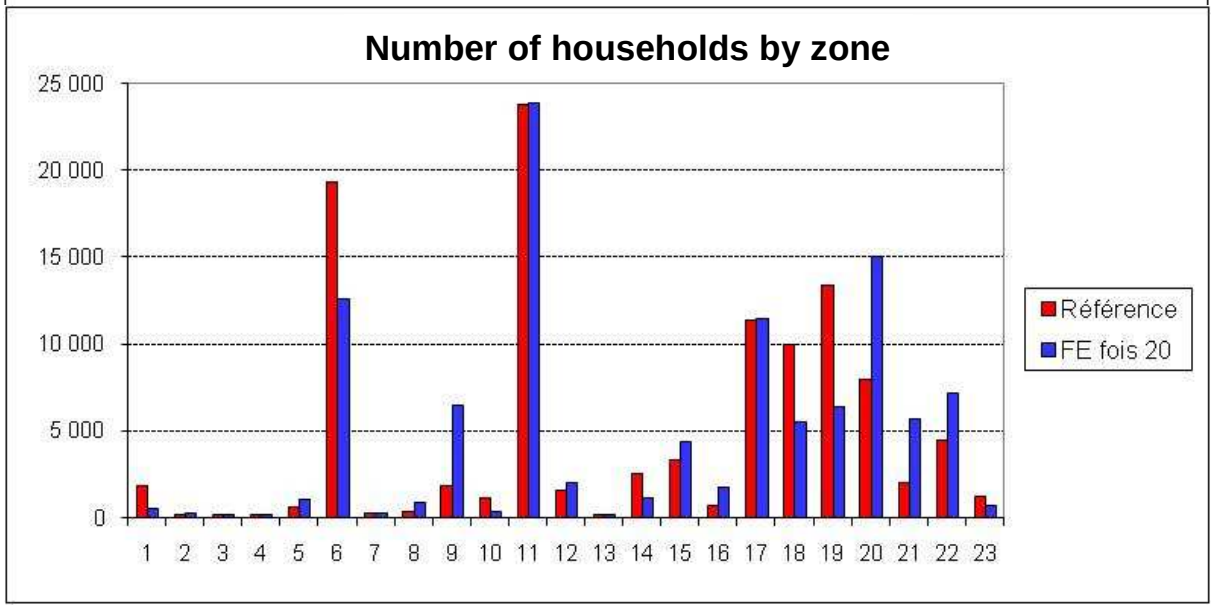
Location of households in the urban area of Mulhouse



Application on the urban area of Mulhouse

Assessing the effect of the increase of the energy bill

Energy bill of the housing multiplied by 20



Application on the urban area of Mulhouse

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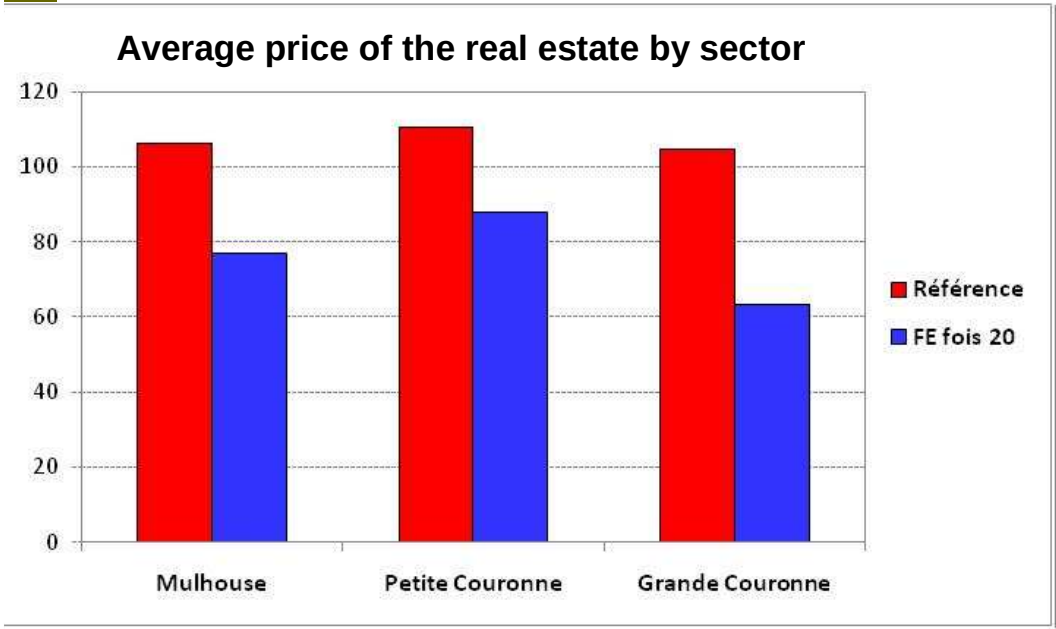

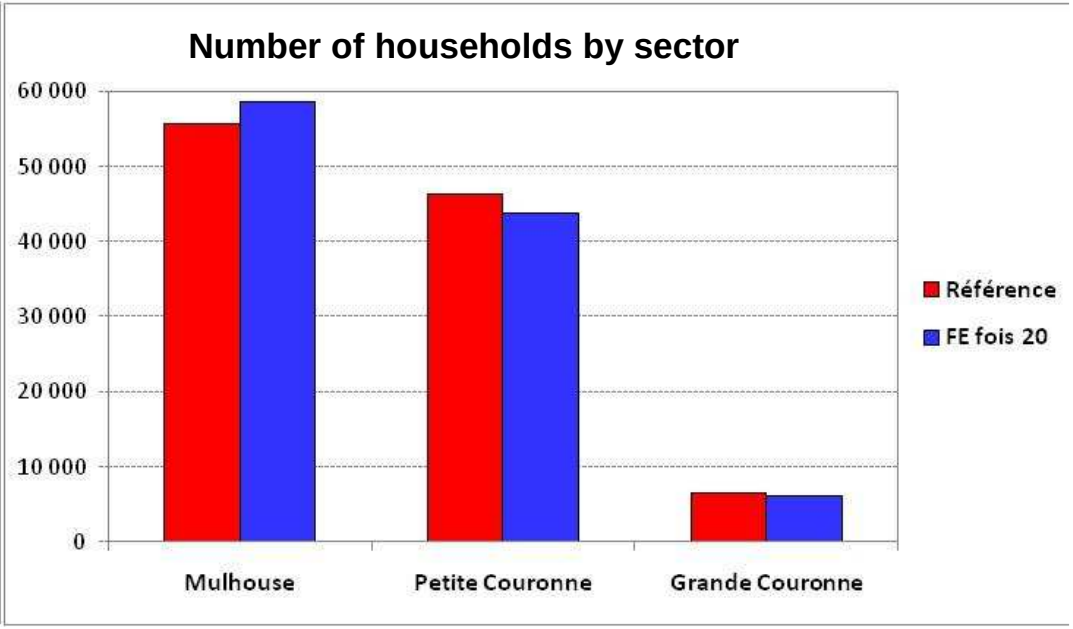

Thank you !

Seghir ZERGUINI (*seghir.zerguini@enpc.fr*)

Université Paris-Est

LVMT
(Ecole des Ponts ParisTech, IFSTTAR, Université de Marne-la-Valée)