Research activities in the LEMA team

Prof. Sigrid REITER
LEMA (Local Environment Management and Analysis),
University of Liège, Belgium

Research areas

The research field of LEMA is the urban environment :

- **sustainability criteria,**
- **environmental aspects (energy, pollution, vegetation),**
- **sensitive aspects (indoor comfort, outdoor comfort)**
- **socio-cultural aspects (architectural heritage, tourism).**

Three main research areas related to smart cities:

- **Modeling buildings : indoor environments and energy consumption of buildings**
- **Modeling neighborhoods and public spaces**
- **Modeling the building stock and urban networks (the city and regional scale)**

A/ Modeling buildings

- **Simulations of thermal comfort and airflows :**

with dynamic thermal and CFD tools and their coupling : natural ventilation, forced convection, radiation effects, influence of the thermal inertia of materials, air quality, …

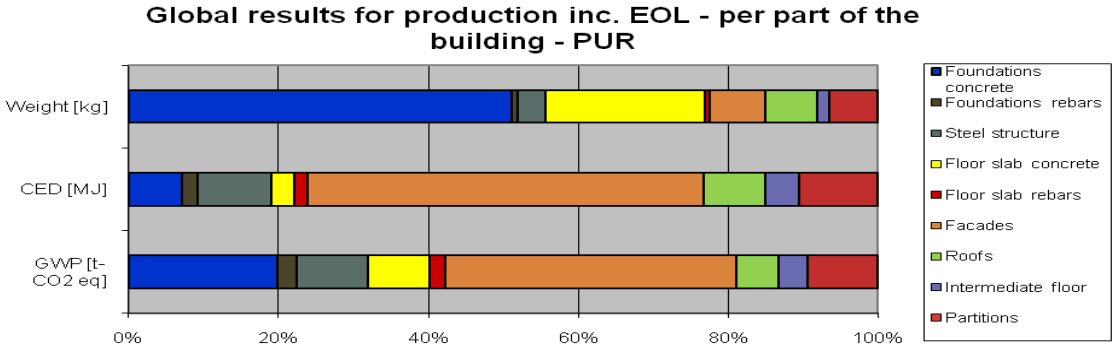
- **Simulation of energy consumption of buildings**

- **Daylighting simulations**

- **Life cycle assessment of buildings**

A/ The building scale

Sustainable Steel Buildings (2009-2012)



Funding source : ArcelorMittal
Coordinator of the project:
LEMA (Sigrid Reiter)

- **aims to identify key indicators of sustainable performance of steel buildings**
- **dynamic thermal simulations and LCA simulations of steel buildings**
- **developing a design tool for steel buildings**
- **participation in the project SB_Steel : Sustainable Building in Steel (2010-2013), financed by the RFCS (Research Fund for Coal and Steel), subcontractor of ArcelorMittal.**

Partners of the SB-Steel project: ArcelorMittal, ULg, VTT, ACCIONA, LABEIN, PUT, FCTUC, UM, AUTH, ECCS

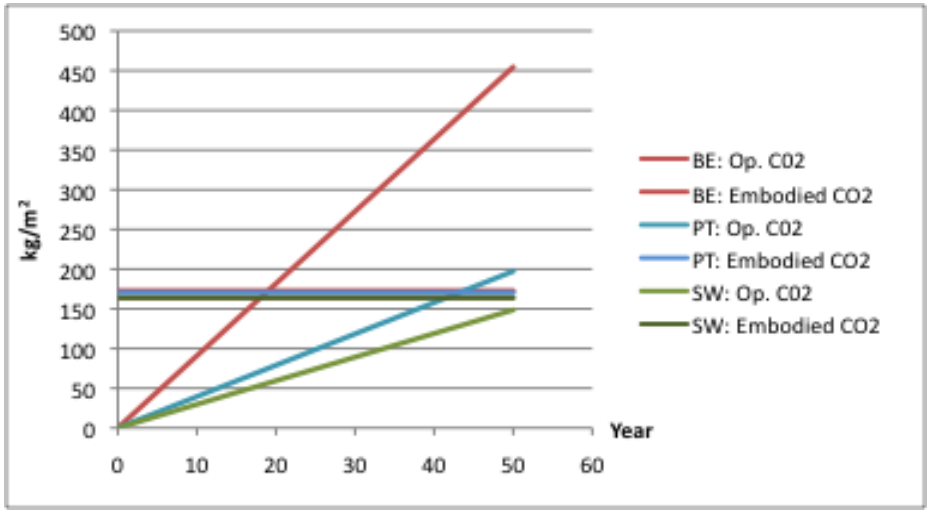
A/ The building scale

Publications

Rossi, B, Marique, A.-F, Glaumann, M, & Reiter, S. 2012. Life-cycle assessment of residential buildings in three different European locations, basic tool. *Building & Environment, 51*, 395-401.

Rossi B., Marique A-F., Reiter S., 2012. Life-cycle assessment of residential buildings in three different European locations, case study. Building and Environment.

Ligia Aquino, Sigrid Reiter, Barbara Rossi, 2011. *Comparative study of the life cycle profile of residential masonry and steel framed buildings in Belgium*, Conf. Cost C25, Innsbruck.



Operational and Embodied carbon in Belgium, Portugal and Sweden.

Reiter S., 2010, Life Cycle Assessment of Buildings – a review, ArcelorMittal International Network in Steel Construction, Sustainability Workshop and Third Plenary Meeting, Bruxelles.

Reiter S., 2009. Steel construction and sustainability, ArcelorMittal International Network in Steel Construction, Second Plenary Meeting, Liège.

A/ The building scale

SIMBA (2009-2013) - "*Simulation Multi-physique du Bâtiment*"
Multiphysics simulation of buildings

Funding sources : the Walloon region of Belgium and ERDF (European Regional Development Fund).

- integrating simulation tools developed by the aeronautic sector (CFD tools) into building physics.
- comparing CFD simulations with wind tunnel tests and field measurements.
- energy and comfort optimization of building physics phenomena, such as natural ventilation, forced convection and radiation.

Coordinator of the project: CENAERO - Centre of Excellence in Aeronautical Research (Cécile Goffaux)

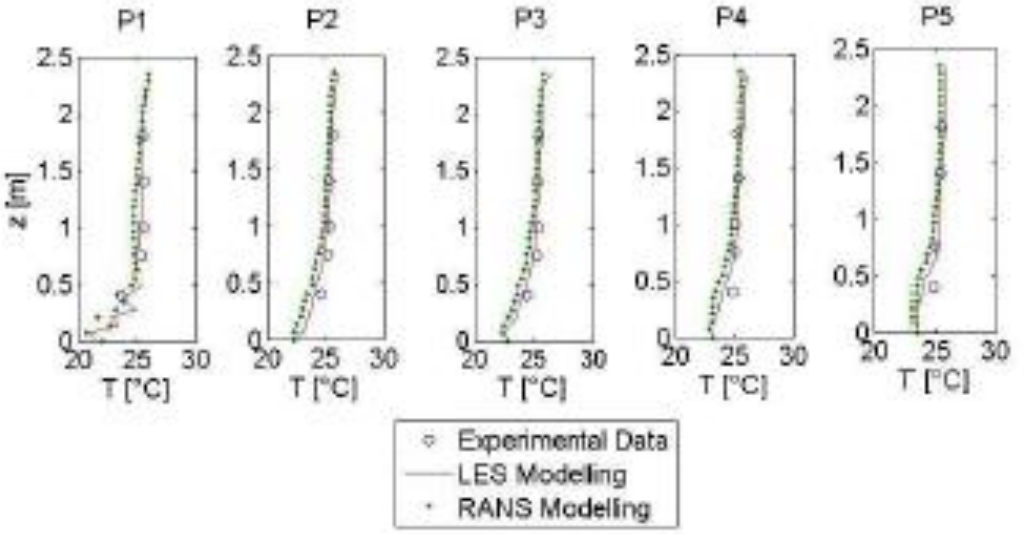
Coordinator for ULg: LEMA (Sigrid Reiter)

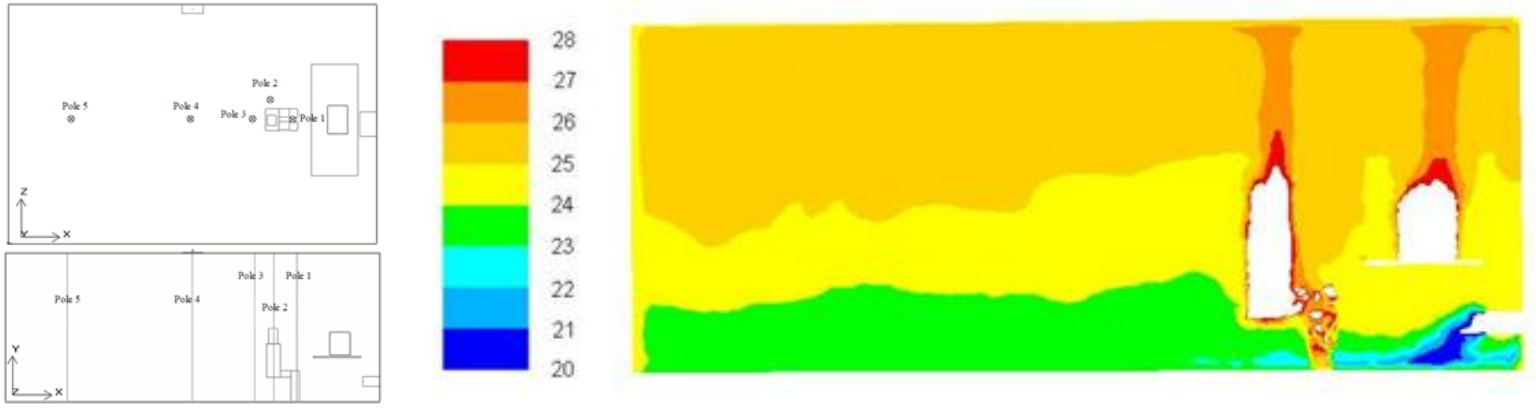
Partners: CSTC (Benoît Parmentier),
UCL-Architecture et climat (André De Herde),
ULg-Aéro (Grigorios Dimitriadis).

A/ The building scale

Results

- **PhD Thesis in progress, promotor : Sigrid Reiter (LEMA)**

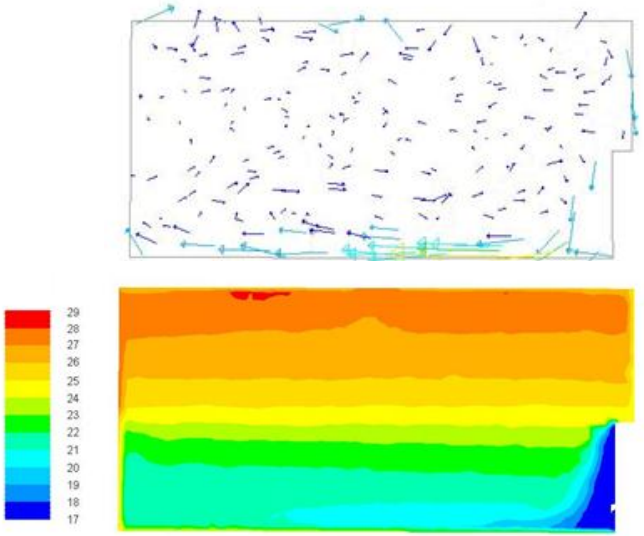




Coupling CFD and Multizone tools for complex thermo-aeraulic simulations

A/ The building scale

Publications :



Barbason, M, & Reiter, S. (2011). A validation process for CFD use in building physics – study of contaminant dispersion. Proceedings of the 5th international conference on advanced computational methods in engineering (ACOMEN 2011).

Deltour J., Van Moeseke G., Barbason M., Reiter S., 2011. A method to compare computational fluid dynamics (CFD) and multizonal dynamics simulations in building physics. Proceedings of CISBAT 2011, Lausanne (Switzerland).

Mathieu Barbason, Sigrid Reiter, Validation of the Large Eddy Simulation model in building physics, Proc. Of the 8th Conf. on System Simulation in Buildings, Liège, 2010.

Barbason M., van Moeseke G., Reiter S., 2010. A validation process for CFD use in building physics, Int. Conf. IAQVEC 2010, USA.

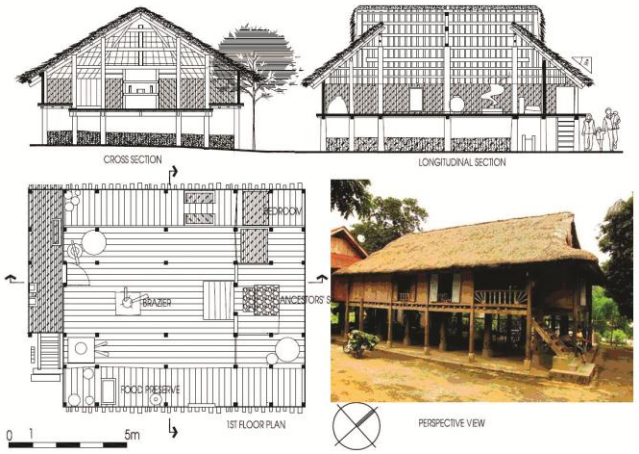
Barbason M., Reiter S., 2010. About the choice of a turbulence model in building physics simulations, Int. Conf. IAQVEC 2010, USA.

A/ The building scale

Strategies for sustainable architectural design adapted to tropical climatic conditions in Vietnam (2010-2013)

Funding source :
doctoral fellowship from Vietnam

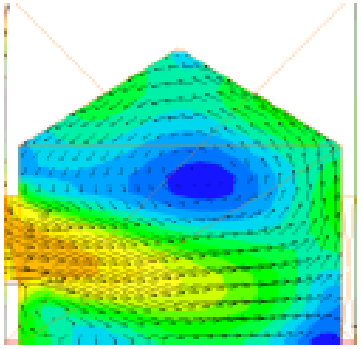
- **aims to develop sustainable strategies for Vietnamese buildings**
- **analysis of local vernacular architecture:**
  in situ measurements
  + dynamic thermal simulations
  + CFD simulations
  + optimization studies
- **optimization of buildings natural cooling and ventilation in a tropical climate**

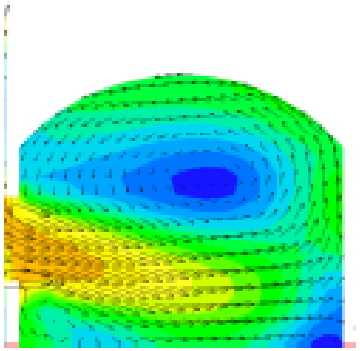


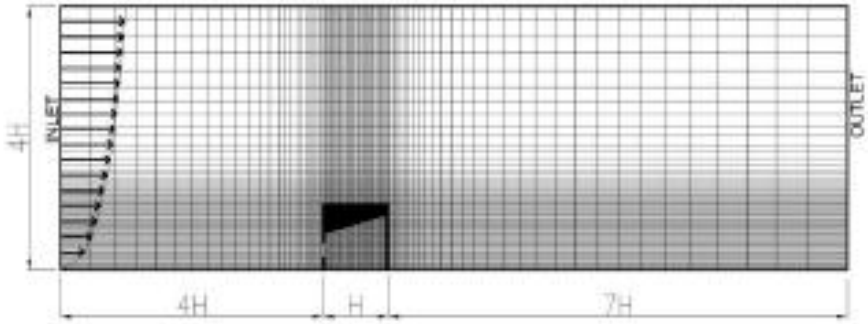
A/ The building scale

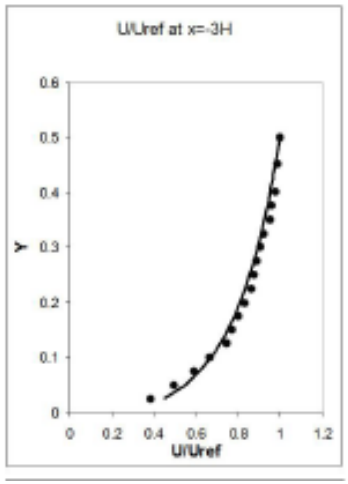
Results

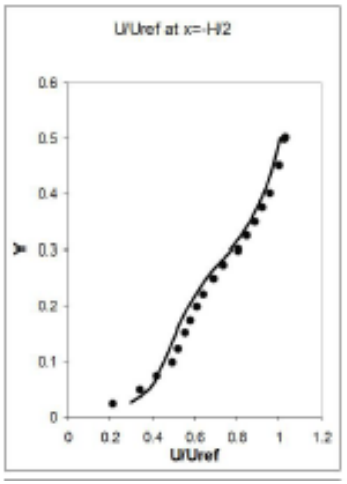
- **PhD Thesis in progress, promotor : Sigrid Reiter (LEMA)**

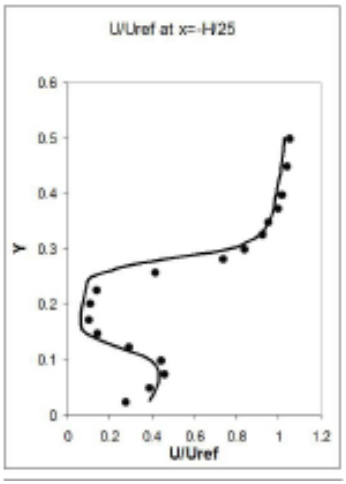












A/ The building scale

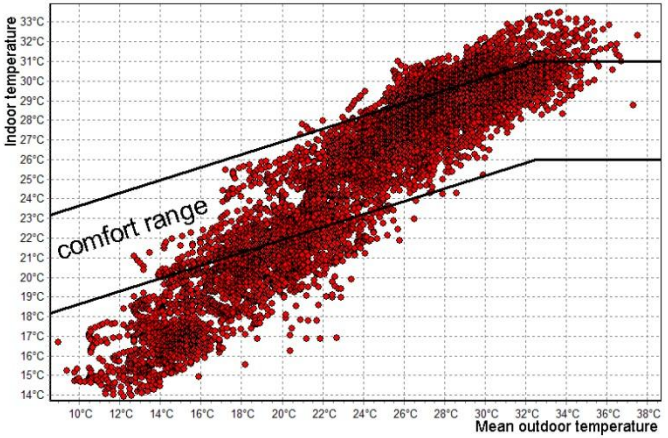
Publications :

Nguyen, A. T, Singh, M. K, & Reiter, S., 2012. An adaptive thermal comfort model for hot humid South-East Asia. Building & Environment, *56*, 291-300.

Nguyen, A. T, & Reiter, S. (2012). An investigation on thermal performance of a low cost apartment in hot humid climate Of Danang. Energy and Buildings, *47*, 237-246.

Nguyen Anh Tuan, Quoc-Bao Tran, Duc-Quang Tran, Sigrid Reiter, 2011. An investigation on climatic responsive design strategies of vernacular housing in Vietnam, Building and Environment 46 : 2088-2106.

Nguyen A.T., Reiter, S. 2010. The effect of ceiling configurations on indoor air motion and ventilation flow rates, Building and Environment, 46: 1211-1222.



Hourly plot of air temperature on adaptive comfort model

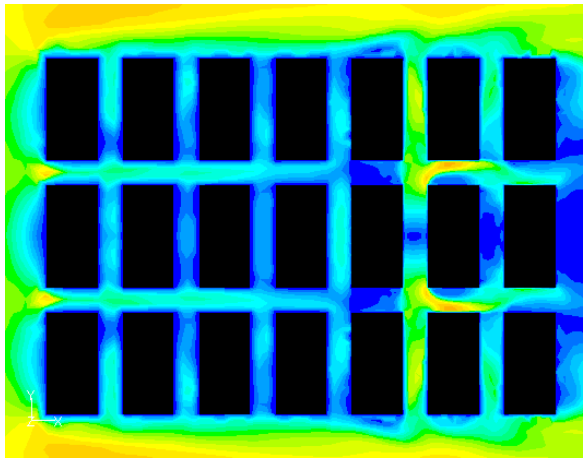
Anh Tuan Nguyen, Sigrid Reiter, 2011. Analysis of Passive cooling and heating potential in Vietnam using graphical method and typical meteorological year weather file, Proceedings of CISBAT 2011, Lausanne (Switzerland)

B/ Modeling neighborhoods and public spaces

- Simulation of energy consumption of neighborhoods, including buildings and transport energy consumption
- Simulations of wind comfort and airflows outside buildings with CFD tools

	HABITAT COLLECTIF DISCONTINU					HABITAT COLLECTIF CONTINU (îlot)							HABITAT INDIVIDUEL DENSE			HABITAT INDIVIDUEL EPARS		
TYPE URBAIN	6,1	6,3	6,5	6,2	6,4	4,4	5,3	5,1	4,3	5,2	4,2	5,4	2,4	4,1	2,3	1,1	2,2	2,1
DESCRIPTION	Habitat collectif discontinu à Cergy ville nouvelle	Habitat collectif discontinu à Suresnes	Habitat collectif discontinu à Beauregard (Poissy)	Habitat collectif discontinu à Cergy ville nouvelle	Habitat collectif discontinu à Le Chesnay	Habitat collectif continu bas à Poissy	Habitat collectif continu bas à Mantes-la-Jolie	Habitat collectif continu haut à Levallois	Habitat collectif continu bas à Le Vésinet	Habitat collectif continu haut à Boulogne-Billancourt	Habitat collectif continu bas à Rueil-Malmaison	Habitat collectif continu bas à Paris, Porte de Champerret	Habitat individuel identique à Colombet	Habitat individuel continu bas Cergy ville nouvelle	Habitat individuel identique à Cergy ville nouvelle	Habitat individuel à Colombet	Habitat individuel identique à Cergy ville nouvelle	Habitat individuel identique à Saint Nom la Bretèche
IND./COL.	COL	COL	COL	COL	COL	COL	COL	COL	COL	COL	COL	COL	IND	IND	IND	IND	IND	IND
PLAN MASSE																		
Date de construction	de 1945 à 1967	de 1915 à 1948	de 1968 à 1974	de 1975 à 1981	de 1975 à 1981	av. 1914	de 1949 à 1967	av. 1914	de 1915 à 1948	de 1915 à 1948	de 1915 à 1948	de 1915 à 1948	de 1968 à 1974	de 1975 à 1981	de 1975 à 1981	de 1915 à 1948	de 1968 à 1974	de 1968 à 1974
U bat W/m².°C	2,385	2,188	2,01	2,25	2,25	2,088	2,388	2,088	2,188	2,188	2,188	2,188	1,789	1,475	1,075	2,04	1,789	1,789
Besoins chauds kWh/m².SHON,an	76,76	73,61	67,99	55,23	51,59	102,31	90,12	86,29	85,75	75,86	75,85	69,39	129,48	59,23	52,07	126,35	139,43	98,66
CLASSEMENT	10	7	5	3	1	15	13	12	11	9	8	6	16	4	2	17	18	14
Besoins froids kWh/m².SHON,an	16,37	23,22	30,34	20,34	22,4	17,97	18,28	18,12	21,06	25,85	21,35	32,53	14,79	23,58	33,8	18,59	17,42	16,48
CLASSEMENT	2	13	16	9	12	5	7	6	11	15	10	17	1	14	18	8	4	3
Apports solaires kWh/m².SHON,an	69,52	68,15	134,76	56,23	80,87	89,25	87,31	75,7	99,54	96,25	86,84	82,36	111,87	93,53	106,46	117,05	139,03	99,87
CLASSEMENT	16	8	2	12	18	11	13	17	7	9	14	15	4	10	5	3	1	6

Table 2 – Heating and cooling needs of the 16 types of urban blocks with potential solar gains



B/ The neighbourhood scale

SAFE (2009-2012) - Suburban areas favoring energy efficiency

Funding source: the Walloon Region of Belgium.

- **focuses on the energy assessment of existing suburban neighbourhoods (buildings + transport)**
- **developing new methods for suburban design and planning to improve their energy efficiency.**
- **creating an interactive tool, comparing different strategies of suburban renewal,** based on buildings and transport energy assessment.

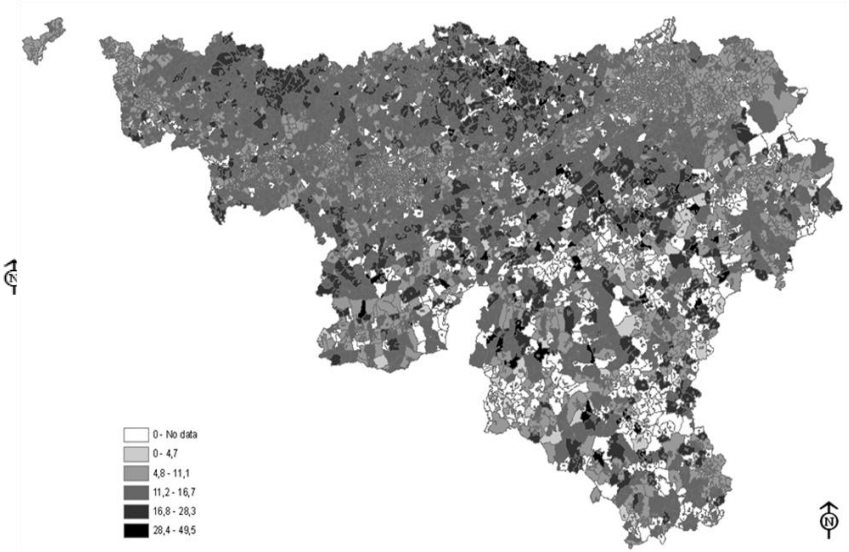
Coordinator of the project : ULg - LEMA (Sigrid Reiter)

Partner: UCL - Architecture et climat (André De Herde)

B/ The neighbourhood scale

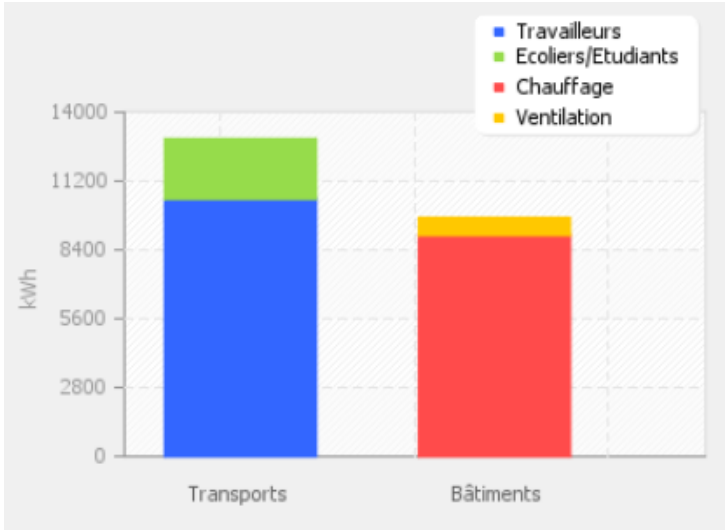
Results

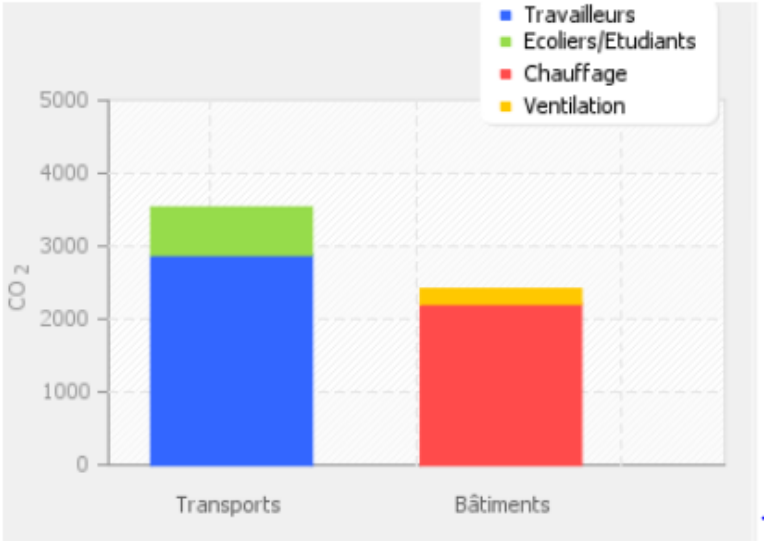
- **PhD Thesis in progress, promotor : Sigrid Reiter (LEMA)**



B/ The neighbourhood scale

http://www.safe-energie.be/





B/ The neighbourhood scale

Publications :

Anne-Françoise Marique, Sigrid Reiter, 2012. A method for evaluating transport energy consumption in suburban areas. Environmental impact Assessment Review 33: 1-6.

Anne-Françoise Marique, Sigrid Reiter, 2012. A Method to Evaluate the Energy Consumption of Suburban Neighbourhoods, ASHRAE HVAC&R Research 18 (1-2), 88-99.

Marique, A.-F, Petel, M, Hamdi, A, & Reiter, S., 2012. Combining Territorial Data With Thermal Simulations to Improve Energy Management of Suburban Areas. *Proceedings of GEOProcessing 2012*.

Anne-Françoise Marique, Sébastien Dujardin, Jacques Teller, Sigrid Reiter, 2011. Urban sprawl and Travel Energy consumption : the Case of the Walloon Region of Belgium, Proceedings of the Irish Transport Research Network Conference (ITRN).

Marique, A.-F, & Reiter, S., 2011. Improving energy efficiency of existing suburban areas through district energy planning. *Proceedings of ISHVAC 2011*.

Marique, A.-F, De Meester, T, & Reiter, S., 2011. Energy requirements and solar availability in suburban areas: the influence of built density in an existing district. *Proceedings of the International Conference CISBAT 2011,* pp. 925-30.

Anne-Françoise Marique, Sigrid Reiter, Towards more sustainable neighbourhoods: are good practices reproducible and extensible? A review of a few existing “sustainable neighbourhoods”, International Conference PLEA 2011, Louvain-la-Neuve, 2011.

Tatianna de Meester, Anne-Françoise Marique, Sigrid Reiter, The influence of occupation modes on building heating loads: the case of a detached house located in a suburban district, International Conference PLEA 2011, Louvain-la-Neuve, 2011.

Anne-Françoise Marique, Sigrid Reiter, 2010. A method to assess global energy requirements of suburban areas at the neighbourhood scale, Proceedings of IAQVEC 2010, Syracuse, USA, 2010.

B/ The neighbourhood scale

SOLEN (2012-2014) – Solutions for Low Energy Neighborhoods

Funding source: the Walloon Region of Belgium.

- **focuses on the energy assessment of existing urban and rural neighborhoods**
- **developing new methods for the integration of renewable energies in different built environments : rural, suburban and urban**
- **solutions for low, very low and zero energy neighborhoods**
- **creating an interactive tool, comparing different strategies of urban, suburban and rural renewal**

Coordinator of the project : ULg - LEMA (Sigrid Reiter)

Partner: UCL - Architecture et climat (André De Herde)

B/ The neighbourhood scale

SUN (2009-2012) - Sustainable Urban Neighbourhoods

Funding source : CEE (Interreg IVa)

- **how to improve energy performance and vegetation integration in old neighborhoods located in urban areas ?**
- **how to integrate environmental, cultural and social issues, as well as economic development ?**
- **Research action on the best strategies to motivate inhabitants to renovate their dwellings**

Coordinator of the project: LEMA (Jacques Teller)

Partners :
Univ. Hasselt (Steven Van Passel)
ICIS (Pieter Valkering)
FH Aachen (Christophe Kûpper)

B/ The neighborhood scale

Results

- **Two PhD Thesis in progress,**
  1/ Innovation in the management and the development of urban environments
  promotor : Jacques Teller (LEMA)
  2/ Strategies of civic motivation for energy renovation of neighborhoods
  promotor : Sigrid Reiter (LEMA)

- **Renovation of fifty dwellings in Liège (Saint-Léonard).**

Publications :

Reiter S., 2009. Les principes de l'Eco-conception, journée d'Etudes "Eco-construction et développement durable", AILg, Liège.

Reiter S., 2009, La rénovation urbaine : une solution pour le développement durable des urbanisations**. Les Cahiers de l'Urbanisme, 72.**

Ruelle Christine, 2009. La qualité paysagère et l'ancrage identitaire des espaces d'activités urbains: un atout pour le développement de l'économie urbaine. in Territoire(s) wallon(s), 3

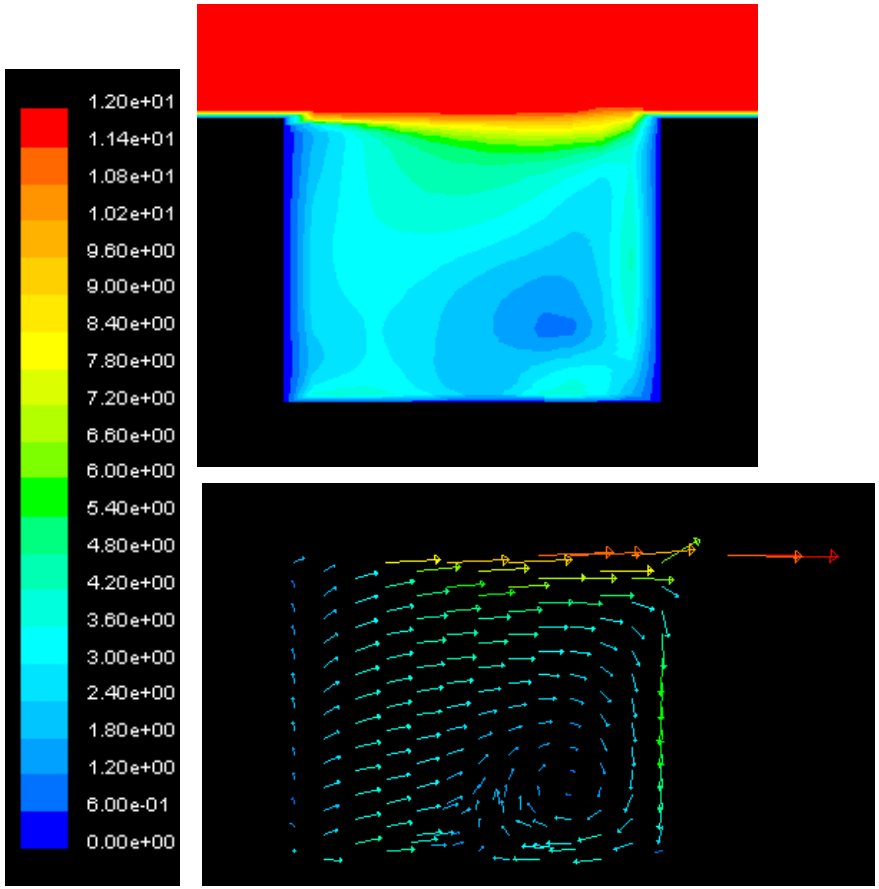
B/ The neighborhood scale

Urban public spaces design (2008)

Funding source : ULg

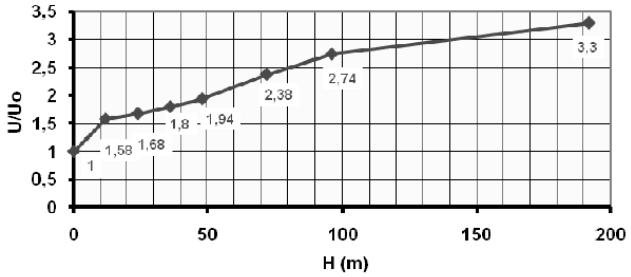
Postdoctoral research at the Martin Centre for Architectural and Urban studies (University of Cambridge)

- **aims to improve microclimatic urban environments**
- **validation of CFD simulations for wind studies around buildings**

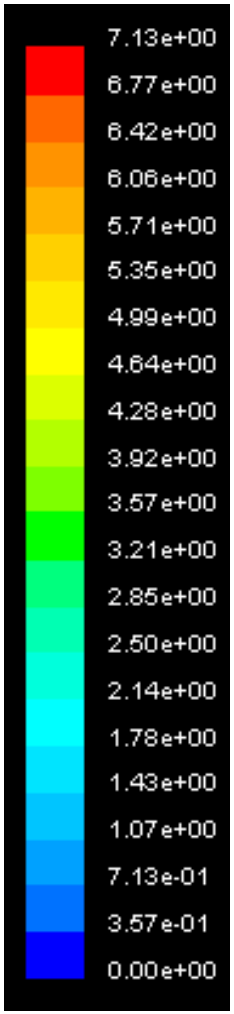


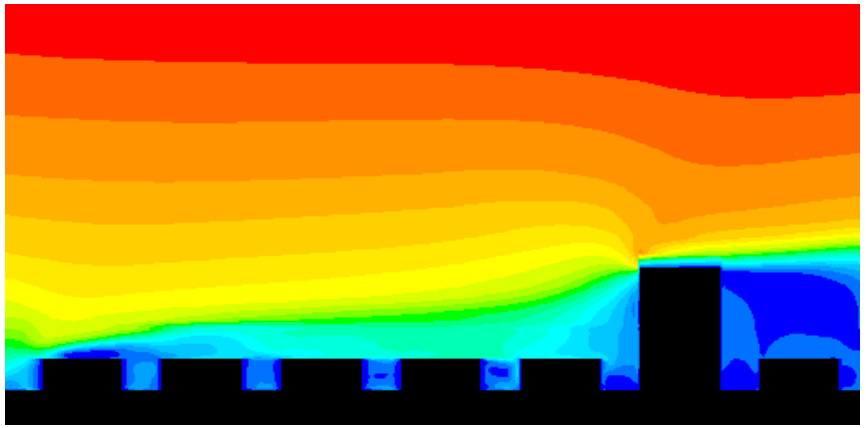
Coordinator of the project:
LEMA (Sigrid Reiter)
>>> International Collaboration:
University of Cambridge (Koen Steemers)

B/ The neighborhood scale

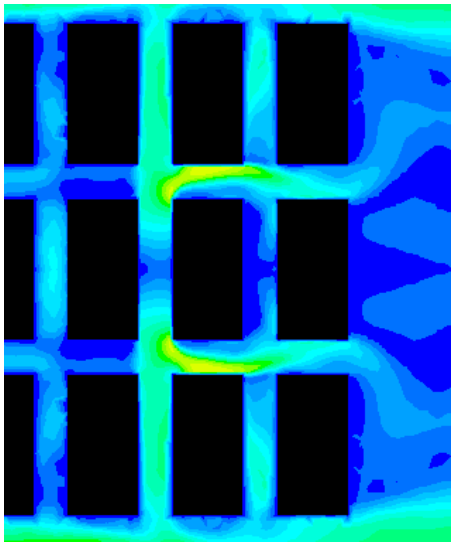


Ratio H/h between the height H of the tall building and the height h of the surrounding buildings	Decreasing factor (%) due to the urban mask effect reducing wind critical effects in urban zones.
H/h=2	55%
H/h=3	85%
H/h=4	90%
H/h=6	93%
H/h=8	97%
H/h=16	98%



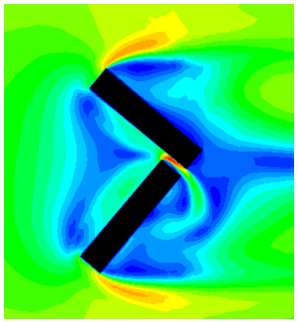


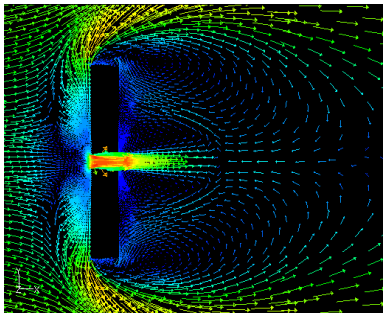
H=76 m



B/ The neighborhood scale

Publications





Reiter, S. 2010. Assessing wind comfort in urban planning. Environment & Planning B : Planning & Design, 37(5): 857-873.

Reiter S., 2008. Outdoor comfort and design decision–making. Martin Centre Wednesday Seminar Series, Cambridge, UK.

Reiter S., 2008. Validation Process for CFD Simulations of Wind Around Buildings, Proceedings of the European Built Environment CAE Conference (EBECC 2008), Londres, p. 1-18.

Reiter S., 2008. Outdoor comfort and Urban design decision-making, Martin Centre Wednesday Seminar Series, University of Cambridge, UK.

Reiter S., 2008. Wind quantification in urban environments, Proceedings of the 25th Conference on Passive and Low Energy Architecture (PLEA 2008) – Towards Zero Energy Buildings, Dublin, p. 1-6.

C/ Modeling the building stock and urban networks

- Modeling energy consumption and environmental performance of the building stock at the city/regional scale
- Modeling energy consumption of home-to-school and home-to-work transport at the city/regional scale
- Optimization of district heating networks
- Optimization of lighting networks
- Optimization of green networks

C/ The city scale

Building stock (2009-2010)

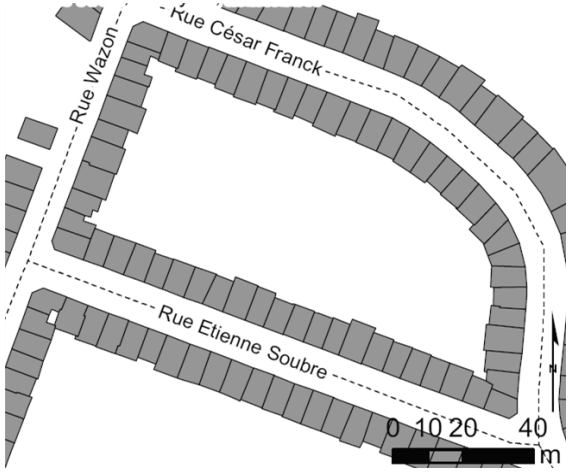
Funding source : ULg - FSR

- **assessing the impact of urban forms on urban environmental performance**
- **developing a dynamic model to characterize the building stock of Liège**
- **using statistical analysis and Geographic Information Systems**

Coordinator of the project :
LEMA (Sigrid Reiter)

Urban block built before 1930 = 12% of the residential building stock of Liège.

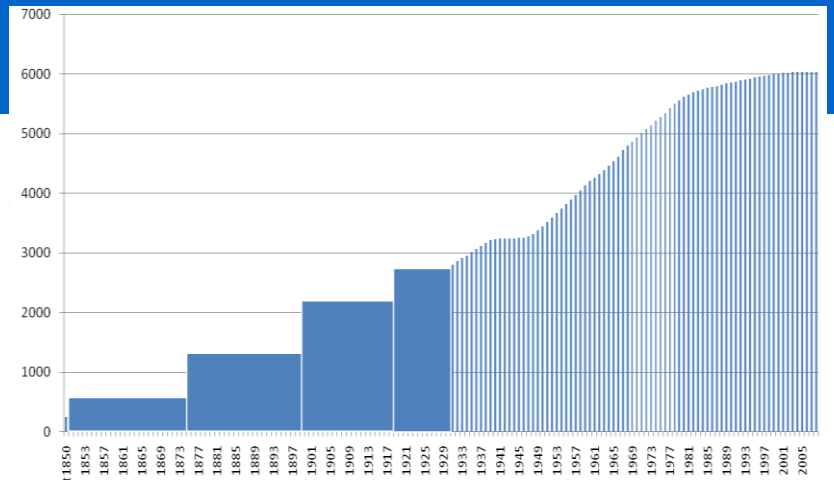
Urban block built after 1970, 7% of the residential building stock of Liège.

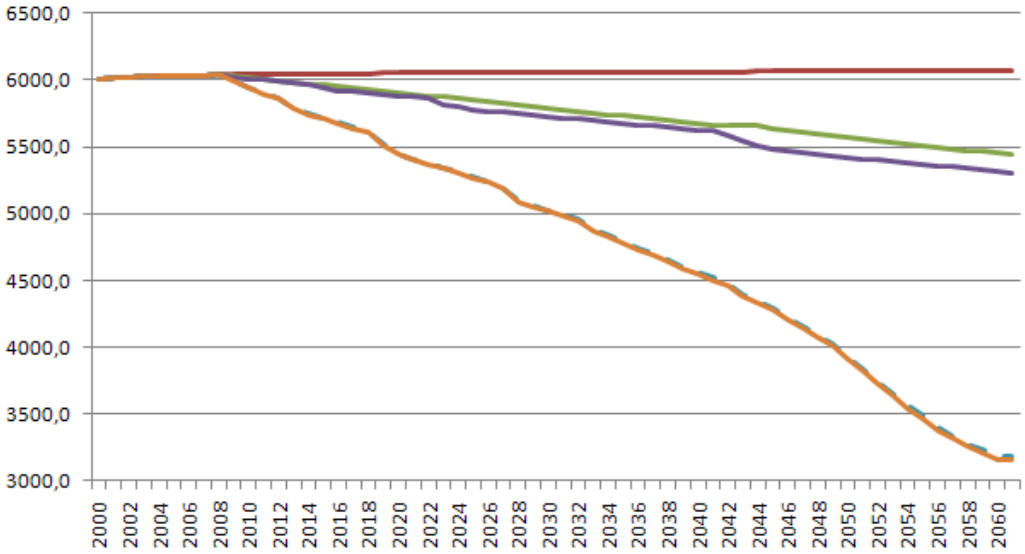


C/ The city scale

Results

- **PhD Thesis in progress, promotor : Sigrid Reiter (LEMA)**





Scénario 1 : tous nouveaux bâtiments PEB

Scénario 2 : stock antérieur à 2008 rénové à 0,6%/an par isolation des combles ; tous nouveaux bâtiments PEB

Scénario 3 : stock antérieur à 2008 rénové à 0,6%/an à la norme PEB ; tous nouveaux bâtiments PEB

Scénario 4 : stock antérieur à 2008 entièrement rénové en 2061 ; tous nouveaux bâtiments PEB

Scénario 5 : stock antérieur à 2008 entièrement rénové en 2061 ; tous nouveaux bâtiments passifs

C/ The city scale

Publications :

Reiter, S, Marique, A.-F. (in Press). Towards low energy cities : a case study on the urban area of Liège. Journal of Industrial Ecology.

Véronique Wallemacq, Sigrid Reiter, 2011. City Energy Management: A Case Study on the Urban Area of Liège in Belgium, International Conference GeoProcessing 2011,France.

Véronique Wallemacq, Anne-Françoise Marique, Sigrid Reiter, 2011. Development of an urban typology to assess residential environmental performance at the city scale, Proceedings fo the International Conference PLEA 2011, Louvain-la-Neuve.

Maïzia M., Sèze C., Berge S., Teller J., Reiter S., Ménard R., 2009. Energy requirements of characteristic urban blocks, in Proceedings of the CISBAT 2009 conference – Renewables in a changing climate : from Nano to urban scale, Lausanne, p. 439-444.

C/ The city scale

UNO - Urban Network Optimization (2010-2011)

Funding source: ULg - ArGEnCo

- **aims to develop a methodology for designing and optimizing the urban energy networks according to the characteristics of the urban fabric.**
- **studying district heating networks, transport networks and potential use of renewable energies.**

Coordinator of the project : LEMA (Sigrid Reiter)

Results

- **PhD Thesis in progress,**
  promotor : Sigrid Reiter (LEMA)

- **MC member of the Action COST TU0902 : « Integrated Assessment Technologies to support the Sustainable Development of Urban Areas ».**

C/ The city scale

Conception d'un réseau

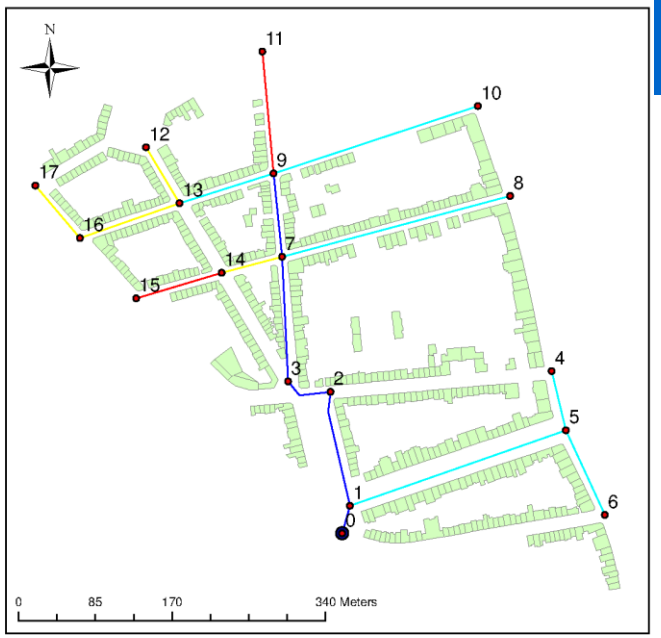
Légende

- Noeuds du réseau
- Chaufferie
- Bâtiments

Réseau

Diamètre normalisé

- DN25 - DN50
- DN65 - DN100
- DN125 - DN150
- DN250 - DN300



Sources : Matrice cadastrale (c) 01/01/2009 SPF finances
Réalisation : Pacot Pierre-Emmanuel - LEMA - Université de Liège

Publications :

Pacot Pierre-Emmanuel, Reiter Sigrid, 2011. District heating and energy indicators: a method to assess the link between urban planning characteristics and energy efficiency of district heating networks , Proceedings of ISHVAC 2011 : the 7th International symposium on heating, ventilation and air-conditioning, China.

Pacot P.-E., Reiter S., 2011. Quality indicators for district heating networks. Proceedings of CISBAT 2011, Lausanne (Switzerland).

C/ The city scale

VALUE (2008-2012)- Valuing Attractive Landscapes in the Urban Economy

Funding source : CEE

- **aims to demonstrate the economic value of green infrastructure at the city/region scale**
- **showing how to target green investments to maximize competitive benefits to communities throughout North-West Europe.**

Coordinator: Sheffield University

Coordinator for ULg : LEMA (Jaques Teller)

Publications

Ruelle C., Halleux J.M., Teller J., 2012. Landscape quality and brownfield regeneration: a community investigation approach inspired by landscape preference studies, Lanscape Research

Boniver V., Cremasco V., Dopagne C. et al., 2010. Un outil en ligne pour évaluer et concevoir des projets d'urbanisme durable, **les Cahiers de l'Urbanisme : 75.**

Teller Jacques, Cremasco Veronica, 2009. Impact des infrastructures de transport sur les paysages ordinaires: application au cas de l'espace périurbain liégeois en Belgique, in Kerbachi, R.; Joumard, R.; Boughedaoui, M. (Eds.) et al Environnement et Transports dans des contextes différents.

Thank you!

Contact: sigrid.reiter@ulg.ac.be

Publications : http://orbi.ulg.ac.be