URBAN FABRIC PERFORMANCE IN MEDITERRANEAN CITY: A TYPOLOGY BASED MASS-ENERGY ANALYSIS

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ABSTRACT

The link between urban form and building energy demand is a complex balance of morphological, constructive, utilization and climatic factor. Especially in European compact city where existing areas prevail on much more energy-efficient new settlements, it is evident that operative ways to transform efficiently the building stock have to be found. Moreover, it is now widely accepted that urban scale has a first rate importance in the building design process and its correlated energy performance. It has been observed that scaling laws are useful in describing the complex structure of urban systems: modern cities have a "metabolic rate" that approximately follows the living organism scaling laws. Nevertheless, it has not been entirely verified that this connection remains the same while studying the phenomena at the urban and building scale and what kind of relationship between mass and power exists (i.e. energy) depending on typologies and urban form. This study suggests an approach for using mass parameter - representative of built-form - as energy performance evaluation tools on a homogeneous urban texture. Mass is connected to both built-form and technology and these determine, to a great extent, the energy use. In Mediterranean climate, it has been observed that mass has strong relevance on energy demand playing an important role in reducing heating and cooling consumptions. Our work aims at validating this relationship, focusing on widespread urban fabrics of the Mediterranean compact city. Tests on different case studies from Barcelona and Rome (analyzed independently in terms of their energy demands and their masses) are carried out. Mass evaluation is based on calculation of effective mass of built elements. Building energy demand is assessed by modelling on multi space dynamic thermal analysis tool. Results presented and discussed point out that heating and cooling energy demand are related to urban fabrics mass and, starting from typological based analysis, it's possible to estimate it. This work is a broader treatment of a research study about one possible way to comprehend "metabolic rate" scaling law concerning urban fabric. Such knowledge-base could giving hints to conscious and effective built environment transformations towards more efficient conditions.

Keywords: Urban fabric energy performance, Built-form, Building mass, Building energy demand.

INTRODUCTION

In the last few years the EU has introduced Directives and has promoted different studies on the topics of renewable energy, GHG emissions reduction and energy performance in buildings and recently admitted that it's an inevitable need and an opportunity to obtain complete self-sufficiency through renewable energy by this mid-century [1, 2, 3]. In this extremely complex process - where, besides, we notice an urban population growth associated with urban areas expansion - the built environment has a central role, regarding both energy and emissions (69% global consumptions - 75% GHG emissions overall) both in terms of its reduction possibility [4]. As an example, EU government undertook to reduce CO_2 emissions by 80% by 2050 compared to 1990 levels. It has been estimated that this drop overall implies 95% reduction in the building sector [3]. This goal needs innovative design strategies and technological solutions for new settlements and it requires a simultaneous improvement in energy performance of existing urban fabrics too, in order to reduce global energy demand. Especially in European compact cities of Mediterranean climate - where existing areas prevail on much more energy-efficient new settlements - it becomes crucial to deal with the existing building stock whose housing is the main part and is responsible for 65% of final energy consumption in buildings [5]. Moreover it is now widely accepted that urban scale has a first rate importance in building energy performance: urban form, due to the obvious connection with morphology and building systems, both at the urban and building scale, mostly affects these performances [6]. Our aim is the study of urban fabric energy demand, beginning with building aspects. Estimation of the effects of built-form on mass and energy demand is the main goal of this paper. In Mediterranean climate regions, it has been observed that mass has strong relevance on energy demand, playing an important role in reducing heating and cooling consumptions. This work aims at validating this relationship, focusing on typical urban fabrics. Apart from testing its existence depending on built-form, our aim is to establish some key elements of a knowledge-base for future analysis on conformity with the “metabolic rate” scaling law at urban scale.

BACKGROUND

Despite numerous studies carried out in the last years on the influence of complex environmental interactions occurring in the urban context that allowed to develop methods and techniques for energy simulation at this scale, more research efforts are necessary to comprehend the interaction between built-form typology and energy performance of different urban fabrics. A number of results emerged on the relationship between city textures and energy consumption, proving the accuracy and consistency of different geometrical parameters and the impact of urban geometry on energy [6]. The incidence of built-form features in this interaction has been ascertained at building scale suggesting a typological classification based on chronological, dimensional and morphological factors [7]. Furthermore, under the description of the complex structure of urban systems through scaling laws, it has been observed that modern cities have a metabolic rate (mass-power ratio) that approximately follows the living organism scaling laws [8, 9]. Studying the phenomena at the scale of urban fabric in Mediterranean climate, it has been found that mass plays an important role in reducing energy demand (for heating and cooling) [10]. Once established that mass is a parameter strictly connected to built-form, it can also be the connection between housing types and energy performance. This aspect is even more relevant in the context of European compact city where we can easily find urban fabrics consisting of fundamentally uniform morphological and typological elements.

METHODOLOGY

The methodology of this study focuses on morphological aspects relating to mass and energy performance. Building mass evaluation is based on calculation of effective mass of built elements excluding associated mass due to the construction process, which is not part of the building. Results shown are expressed in metric Tons referring to thermal conditioned areas as specific weight (Tm/m^2). Energy demand was evaluated by modelling on *Lider 1.0* [11] that provides energy demand measured in kWh/m^2year where the considered surface refers to a thermally conditioned area. Thanks to the similar climatic conditions of the cities involved in this study, it has been possible to take the Mediterranean climate of Barcelona as climate of reference. More details about this procedure could be found in [10].

CASE STUDIES

This study compares nine different conventional housing types located in the metropolitan areas of Barcelona (ES) and Rome (IT) - where we can reasonably assume very similar climate conditions [15]. They represent the basic components of typical urban fabrics built during various historical periods (Fig. 1, Tab. 1). Cases A÷E (Barcelona) are described in [10] while cases F÷I (Rome) are analysed here as follows:

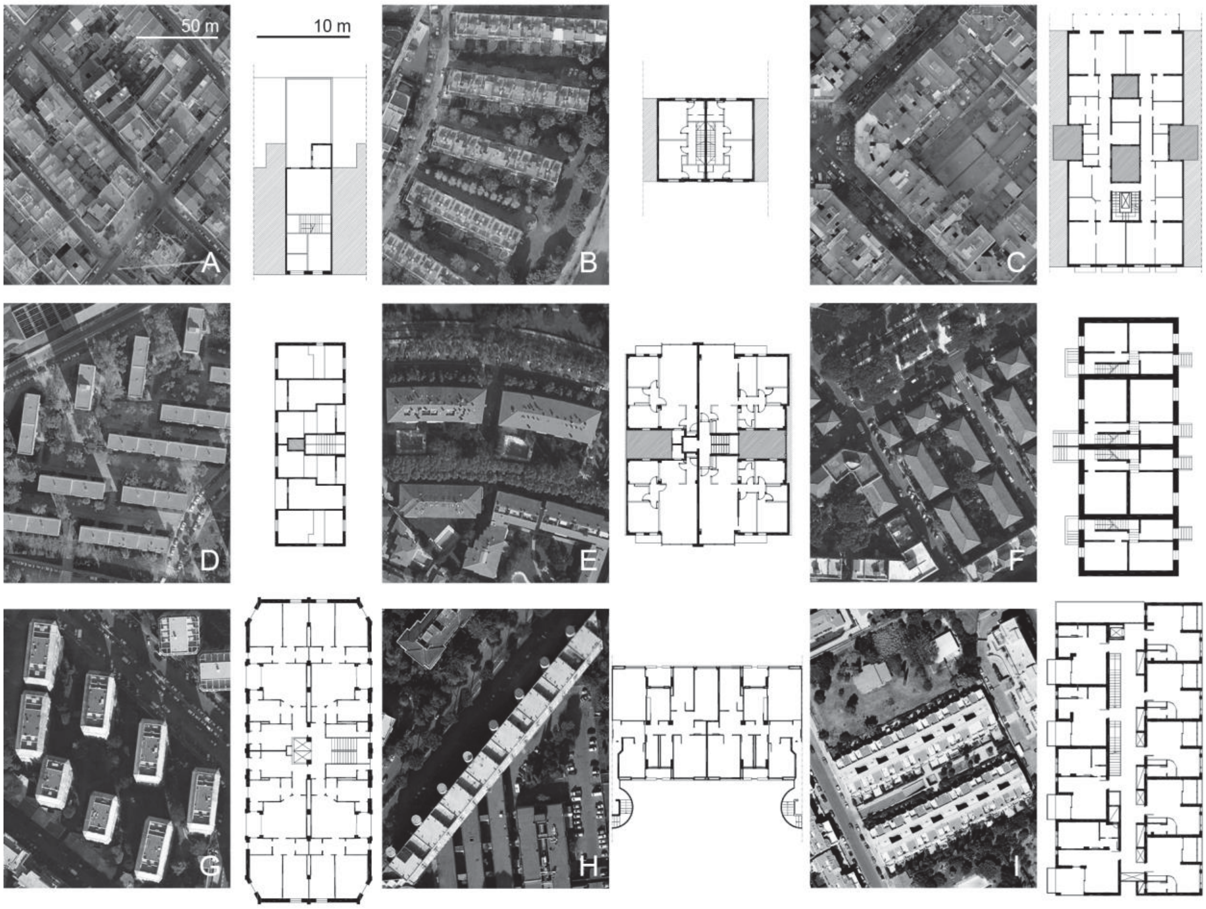

Figure 1: Aerial images and typical plans for case studies (A÷E Barcelona, F÷I Rome).

F - Row house (1920) - Two-level dwelling (plus one basement) with load-bearing walls, above-ground masonry continuous foundations and dry stone drain; vaulted floor at ground level, floors with iron beams and hollow bricks for other level; ventilated hipped roof without thermal insulation.

G - Apartment block (1960) - Nine-level apartment block with basement and floor service on top. The construction system is based on concrete frame, shallow footing and dry stone drain; floors with one-way reinforced concrete slab and ceramic filler blocks; external hollow brick cavity walls and flat roof without thermal insulation.

H - Apartment block (1975) - Seven level apartment block with floor service on top, based on concrete frame construction system and shallow footing; floors made by hollow-core concrete slab and partially by reinforced concrete slab; external precast concrete wall panels with cavity and flat roof without thermal insulation.

I - Apartment block (2010) - Five level apartment block with basement made up of concrete frame and slab-on-grade foundation and floors with one-way reinforced concrete slab and ceramic filler block; external hollow brick walls with thermal insulated cavity and flat roof thermal insulated.

More detailed descriptions of case studies could be found in [12, 13 and 14].

	Year	Location	Housing type	$H/W_{x,y}$ ratio	GSI*(m2/m2)	FSI**(m2/m2)
A	1900	Barcelona	RH	0.77-1.47	0.45	0.87
B	2000	Barcelona	RH	0.30-1.22	0.16	0.62
C	1900	Barcelona	AB	1.21-2.83	0.49	2.92
D	1960	Barcelona	AB	0.41-1.27	0.13	0.77
E	2000	Barcelona	AB	0.45-0.83	0.37	2.43
F	1920	Rome	RH	0.39-1.02	0.35	1.07
G	1950	Rome	AB	1.08-2.56	0.21	2.35
H	1975	Rome	AB	1.14-1.90	0.13	0.89
I	2010	Rome	AB	0.56-1.11	0.24	1.48

*Table 1: Case studies data. * Coverage: built up area/base land area, ** Building intensity: gross floor area/base land area - RH: row house, AB: apartment block*

RESULTS AND DISCUSSION

Table 2 shows the built mass referring to useful floor area and annual energy demand (heating and cooling). The computation of energy takes into account eight possible orientations whose mean, minimum and maximum values are given in Table 2.

	Housing type	Thermal insulation	Mass (Tm/m^2)	Heating (kWh/m^2y)	Cooling (kWh/m^2y)	Heating and cooling (kWh/m^2year)		
						Average	Min.	Max.
A	RH	No	1.53	86.88	3.22	90.10	86.57	92.12
B	RH	Yes	2.58	21.85	13.32	41.04	33.17	47.01
C	AB	No	1.11	79.33	8.17	87.50	85.48	89.28
D	AB	No	1.24	77.52	5.74	83.26	78.29	89.28
E	AB	Yes	1.65	22.34	11.75	39.64	25.74	47.23
F	RH	No	2.64	67.19	2.95	70.14	66.17	73.50
G	AB	No	1.56	66.19	5.19	71.38	67.36	75.58
H	AB	No	1.69	79.30	6.68	85.98	81.25	90.31
I	AB	Yes	2.96	36.52	10.96	47.48	28.88	56.92

Table 2: Built mass and energy demand. RH: row house; AB: apartment block

In general terms, recent buildings tend to be heavier (in specific weight terms) than those constructed before 1980. The mass of the recent cases (Tm/m^2 of thermal conditioned areas) is greater than old ones, mainly because of mass properties in construction systems based on concrete and also because of more unconditioned spaces in the buildings - especially underground car parks. With regard to energy demand, it is possible to observe a clear distinction between traditional buildings (A, C, D, F, G and H) and recent buildings (B, E and I). The former have no thermal insulation envelopes, while the latter are built according to thermal regulations that restrict heat transmission coefficient. Recent cases show a mean conditioning energy demand of between 40 and 50 kWh/m^{2}y, while the traditional cases one between 70 and 90 kWh/m^{2}y.

	Housing type	**Thermal insulation**	**Specific Mass (Tm/m^2)**	**Inverse specific Mass (m^2/Tm)**	**Heating and cooling (kWh/Tm year)**
A	RH	No	1.53	0.65	58.9
B	RH	Yes	2.58	0.39	15.9
C	AB	No	1.11	0.90	78.9
D	AB	No	1.24	0.81	67.0
E	AB	Yes	1.65	0.61	24.1
F	RH	No	2.64	0.38	26.5
G	AB	No	1.56	0.64	45.8
H	AB	No	1.69	0.59	50.9
I	AB	Yes	2.96	0.34	16.0

Table 3: Specific built mass and energy demand. RH: row house; AB: apartment block

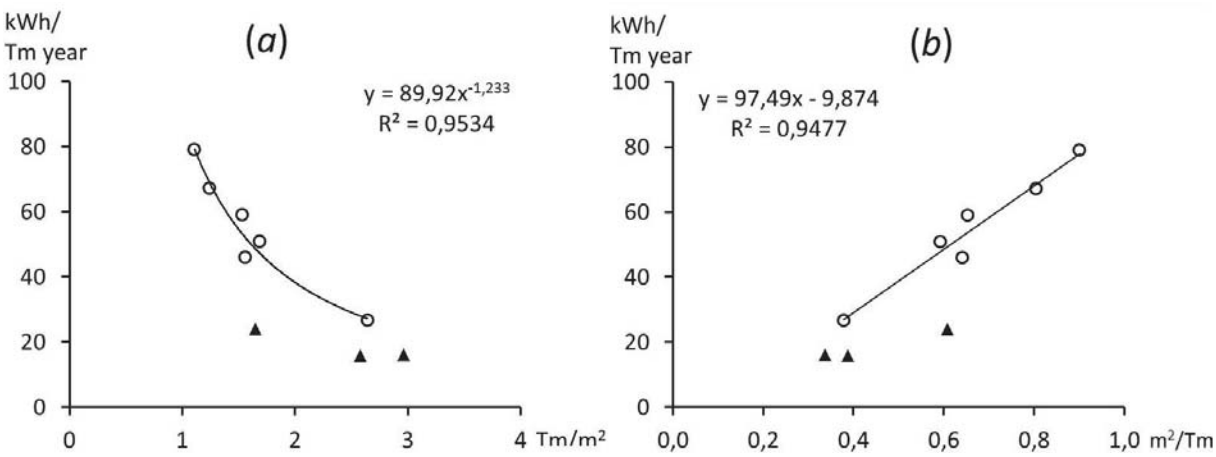

Figure 2 (a) Demand energy versus specific mass. (b) Linear fit of demand energy as a function of inverse specific mass. Empty circles: experimental values of traditional buildings; triangles: experimental values of recent buildings; continuous line: computed fits of traditional buildings.

Table 3 and Figure 2 show the existing tendency between mass properties and building energy demand. Referring to thermally conditioned areas, results point out that mass has strong relevance on energy; for traditional buildings (empty circles), may be approximated by the fitting as formula (1):

$$\boldsymbol{y} = \mathbf{89.92}\ \boldsymbol{x}^{\mathbf{-1.233}} \quad (1)$$

where ***y*** represents the energy demand (kWh/Tm year) and ***x*** the built mass (Tm/m^2 of thermal conditioned area) (Fig. 2 (a)). The proximity of the exponent to -1 suggests the trial of a linear fit using the inverse of the specific mass, which is presented in Figure 2 (b). Hence, greater the mass per conditioned square meter of an urban fabric is, less its energy demand for heating and cooling per mass unit is, as in [10]. Recent urban fabrics have heavier building systems (mass per conditioned unit area) and at the same time (because of thermal regulation) they have a lower energy demand. Then the points corresponding to cases built form since 1980 approximately - triangles in Figure 2 - have less energy demand and give different trend than the older buildings. This trend could also depend on the large amount of mass corresponding to unconditioned spaces such as underground car parks. Moreover Figures 2a and 2b show that greater the mass per conditioned square meter is, more similar is the relation between mass and energy is, in both traditional and recent urban fabrics.

CONCLUSIONS

The analysis carried out in this study confirm that a relation between mass and energy demand (for heating and cooling) of different urban fabrics exists in Mediterranean climate, as we guessed at [10]. Results show a clear tendency of this relationship in buildings built before the introduction of thermal regulations. However, in recent buildings the relation between mass and energy demand, till today it has not been so investigated. Building thermal regulations imposes a minimum performance, which strongly influences energy demand. Moreover, the presence of more unconditioned spaces and basements in contemporary buildings, affects this relation.

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MAPPING THE "TERRITORY-LESS" CITY: A CRITIQUE ON THE ESTABLISHED "AIRPORT CITY" STRUCTURE

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ABSTRACT

"In the UK and the EU, design practise and government policy aim to mitigate the impacts of aviation, but not at the expense of aviation growth. Sustainability should not be taken to mean a realised commitment to environmental impact reduction, but a consideration of environmental and social impacts alongside environmental and financial performance". (Urpham, P. A comparison of sustainability theory with UK and European airports policy and practice. Journal of Environmental Management. 63, 237-248)

The contemporary debate on airport planning and design aligns with the increasingly troubling concerns regarding economic growth and its impact to the natural and built environment. In terms of the city and region's future, under the pressure of both dense urbanisation of metropolitan areas and environmental and social sustainability, prosperity cannot be achieved through the exploitation of transportation growth and transportation inter-connectivity opportunities alone.

In this fragile environment of overlapping or dispersed authority, policy and momentum, "airport cities" emerge as new trade centres and, by attracting a proportion of the area's population to dwell or work within this new platform, they are becoming new urban and regional centres as well, yet of a debatable quality and with no distinct territory or population.

Nevertheless, regardless of the ongoing innovation in the fields of urban theories and construction technology, transportation policies and building regulations have so far failed to fully exploit such an advancement's potential and dilute the controversy over airport design priorities, in respect to both economic development and environmental protection, especially in the scale of the city or the 'airport city'.

As an essential first step towards a more sensible approach, this paper will try to map this "territory-less" platform's elements, and serve as a reference base for a future in-depth research on the establishment and development processes of such a new urban environment.

Key words: Airport city, Kevin Lynch, urban planning, sustainable development

INTRODUCTION

The contemporary debate on airport planning and design aligns with the troubling concerns regarding urban development, economic growth, and the impact to the natural and built environment, especially in terms of the city and region's future under the pressure of dense urbanisation of metropolitan areas and environmental and social sustainability.

It has been proven that transportation networks are of essential importance to the city's evolution. The trend particularly for airports to expand dramatically in area, intensity and variety of activities can significantly affect them very quickly and in very little time.

In this fragile environment of overlapping or dispersed authority, policy and momentum, "airport cities" emerge as new trade centres and, by attracting a proportion of the area's population to dwell or work within this new platform, they are transforming into a new urban hybrid. Nevertheless, regardless of their obvious advantages in terms of accessibility to transportation networks, concerns about environmental and social instability and degradation still lead to scepticism around this urban structure's quality, territory and population.

By discussing about the city's structure as analysed by Mumford, Lynch and a number of other researchers, this essay will attempt to identify essential characteristics, highlight typological patterns, and map this "territory-less" platform, investigating its urban structure through the comparison of six distinct cases.

In order for the airport city to be recognised as a model of sustainable regional development, its structure must be defined and understood first. Towards that, this study will provide the theoretical background and support the further development of an in-depth field-research.

THE CITY'S STRUCTURE AND ITS SUSTAINABLE DEVELOPMENT

Describing the shift in urban development from the city centre to the periphery, Howard, Kropotkin, Gedes, Soria y Mata, Stein, Wright, Fuller, Soleri, Gruen, Le Corbusier and others proposed various forms of urban development [1,2]. From an *organic* to a *mechanical system*, the city was always perceived as a complex spatial, political and social entity which supports human identity and continuity, avoiding an "aimless and formless" expansion. Regardless of any morphological variations however, they all agreed on the importance of transportation networks and travel patterns in ensuring sufficient links within the region.

Similarly, Kevin Lynch [3] interprets the city as "a multi-purpose organisation, [...], the form of which must be plastic to the purposes and perceptions of its citizens". Focusing on the city's structure he identifies its essential elements: *the path, the edge, the landmark, the nodes, and the regions*, and highlights the importance of people being able to easily understand the space and its characteristics through them.

Analysing further these arguments, several researchers [4,5,6,7,8,9,10,11,12] locate delicate relations between city and region, following the urbanisation's natural life cycle stages "from urbanisation to counter-urbanisation, to re-urbanisation", highlighting the transport-oriented qualities of a polycentric development model. They particularly stress the impact of a community's history to the region's structure, and emphasize the need for establishing the city's development framework within such a scale, presenting several advantages and weaknesses and the importance of local characteristics in promoting sustainable development.

THE ROLE OF AIRPORTS IN THE CITY'S SUSTAINABLE DEVELOPMENT

As nodes of major transportation networks, similarly to train stations, airports are "influencing the growth and shape of the city, through the shift of economic activities from its centre to its periphery" [13]. In a regional scale, highly accessible through a variety of modes, the airport's rail or bus station serves as an interchange station, but usually fails to provide adequate accessibility within its platform. On the other hand, in a decentralised system, Fasone et al. [14] describe the promotion of more flexible mobility patterns. As they and other researchers [13,14,15,16] note however, this development usually happened without a clear planning framework, or as the result of a controversial planning process, causing the rearrangement of local transportation networks, with significant consequences to the form and evolution of the surrounding region.

Due to this "complexity of organisation" accompanying the airport's operation, its area is developing into "a form comparable to that of a city", a new urban hybrid that emerges among other regional centres; something that Güller and Güller [13] explain as: "In terms of territorial definition, the airport city is, in principle, the more or less dense cluster of operational, airport-related, activities and other commercial or business concerns, on and around the airport platform. However, this cluster is an airport city only if it shows the qualitative features of a city (density, access quality, environment, services)". In the US, this term is used by Kasarda and Lindsay [17] to signify even a broader municipality. Both these research groups clearly describe the importance of a structured land use policy and distribution within or near the airport's area, and understand that the growth of an airport city "is not always inevitable, necessary, or desirable".

These two definitions, however, have two weaknesses, especially when progressing from the business park to the city level identification. The European approach considers essential the *qualitative features of a city*, not mentioning that of a permanent and vivid population, while the American one refers to an actual community, yet to that of the suburban residential enclave; with the reason for that lying probably behind the (un)suitability of the airport's platform as a receptor of residential development, as previously discussed.

Therefore, under the framework of principles established so far to describe the city's structure and evolution, it is difficult to identify the 'airport city's hybrid' as an emerging prototype of contemporary urbanism, substituting already established centres. Even if not a 'city' per se however, handling the airport's area as a distinct form of the built environment brings about some of the clearest practical challenges to achieving the right balance between economic, social and environmental sustainability.

SIX EXAMPLES

Following the previous discussion, six 'airport cities' (Spruce Creek, Berlin-Tempelhof, Denver, Frankfurt, Athens and Helsinki) will be compared, attempting to identify typological patterns, planning characteristics and urban qualities. These examples, even though constitute a small sample, present a variety in characteristics, and their further analysis could provide a valuable insight over elements of urbanity within the airport's platform, often neglected or disregarded, progressing the relevant discussion initiated in the existing literature.

For this comparison, an investigation based on Kevin Lynch's proposed elements of the city (*the path, the edge, the landmark, the nodes, and the regions*) will be attempted. This is an essential first step in the research on this urban hybrid's integration into the city's sustainable evolution. Due to the spatial dispersal of these examples however, the present analysis will be based on satellite images, maps, and the information from relevant authorities. Even though results, as detailed and accurate as possible are presented in the following tables, a future field- research, could supplement the theoretical conclusions, and evaluate and re-adjust them.

Resulting from this comparative examination, it can be argued that all cases show extremely similar path and node patterns and forms, mainly associated with road infrastructure. They also tend to be defined by very sharp external and penetrable internal edges, which also affect the area's segmentation into distinct regions. As for the landmarks, they interestingly seem to be associated with either the road network, or very distinct public buildings and open spaces, the latter only in cases where significant residential levels can be observed as well.

As it appears, a single-use development is often preferred to a mixed-use one, and in almost all cases the airport city is significantly less accessible by public transport than the main airport site. Cultural/Community activities emerge, obviously, only within larger residential areas, while heavy industry is not a preferred use at all, probably due to the high land value. Green areas, in various forms, are unexpectedly common. A relation between the area's size, location and land uses could exist but needs further investigation.

		Spruce Creek	Denver	Tempelhof	Frankfurt	Athens	Helsinki
Airport City		A small community organised around a central airport runway	Suburban residential development far from the airport / planned business park	The airport is built within the city	Commercial park at the edge of the airport's platform	Retail and conference park, built within the airport's platform	Business and retail park at the fringe area between the city and the airport
Path	Main	Airport runway	Main street	Main street	Highway	Highway	Highway
	Secondary	Suburb's streets	Secondary streets	Secondary streets	Secondary streets	Secondary streets	Secondary streets
Edge	Internal	Between the residences and the runway	No hard edges apart from between the main street and back streets	Between the main street and back streets / dense urban block	No distinct edges apart from a light urban block	Between building and parking lot	Secondary streets dividing the area
	External	Green belt	Outer fence	Between the airport building and the city buildings / urban fabric	Highway network	Highway and airport's fence	Highway, forest and airport's fence
Landmark		Runway, commercial area, golf course	School, church, park, golf course, community centre, convenient store	Square, subway station, esplanade	Central roundabout	Central roundabout, individual buildings, chapel, bus stop	Highway exit, forest, individual buildings, museum
Nodes	Main	Airport runway	Main street – side streets crossroads	Main street crossroads and square	Highway exit	Highway exit	Highway interchange and exit
	Secondary	Suburb's streets crossroads	Side streets crossroads	Side streets crossroads	Side streets crossroads	Side streets crossroads	Secondary streets crossroads
Regions		Clear distinction between the residential and commercial / administrative areas	Large uniform residential area with dispersed landmarks	Mixed-use urban fabric with higher densities at local central points	Small uniform area with a slightly different central point	Two distinct sub-areas in the opposite sides of the airport's platform	Uniform business and residential areas with retail development in their periphery

Table 1: Urban characteristics of the airport city

	Spruce Creek	Denver	Tempelhof	Frankfurt	Athens	Helsinki
Airport's land ownership	Private	Public	Public	Mixed	Public	Public
Airport city's land ownership	Private	Private	Mixed	Mixed	Public	Public
Airport's area (mil. m^2)	5.2	137.3	6	11.3	16.8	7.3

Airport city's area (mil. m^2)	5.2	10.5	-*	0.5	0.3	2.8
Airport's distance from traditional centre (km)	8	37	4	12	20	17
Airport city's distance from traditional centre (km)	8	20	4	10	18-22	16
Airport's accessibility	Car	Car, Local and regional bus (+internal underground light rail)	Car, Subway, Local bus	Car, Local and regional bus, Suburban, regional and national train, High-speed rail (+internal light rail)	Car, Local and regional bus, Subway and suburban train (+internal bus service)	Car, Local and regional buses, +High-speed rail (from 2014)
Airport city's accessibility	Car	Car, Local bus	Car, Subway, Local bus	Car, Local bus	Car, Local bus	Car, Local bus
Residential development	Y	Y	Y	N	N	Y
Commercial development	N	N**	Y	Y	Y	Y
Industrial development	N	N**	Y***	N	N	Y****
Green / public areas	Y	Y	Y	Y	N	Y
Cultural/Community facilities	Y	Y	Y	N	N	Y

Table 2: Area accessibility and land uses

*Tempelhof airport is incorporated in Berlin's urban fabric. The airport city's area is not therefore distinct from the city. **Commercial and Industrial uses are developed in nearby locations within other single-use suburban enclaves. ***In parts of the airport's building, heavy machinery factories were operating until some years prior to the airport's closure. ****Light industrial uses are permitted.

DISCUSSION - CONCLUSIONS

The aim of this essay was to map the "territory-less city", the contemporary urban hybrid widely known as "airport city". Its purpose was to investigate the existence of any urban qualities within it, which would explain the arguments regarding its viability as a model for sustainable urban development. Its focus point was on the city's qualities, as an *organic structure of complexity and order,* as described by Kevin Lynch, Lewis Mumford, and others.

In this process, it has been proven that the city's evolution relies on a structural mechanism of correlations, uniquely shaped by each environment's special characteristics. As an integral part of this, transportation networks, and airports in particular, provide the opportunity for significant economic growth, but impose intense stress to the city's environment at the same time, as their recent evolution from simple buildings to urban hybrids implies.

It has been claimed that the sustainable city would be *an environmentally attractive, safe city, of high quality, in which people will want to live* [18], yet the present structure of the airport city is still quite distant from this ideal form. The main weakness of the existing models is the fact that this new city is a place where no one wants to live, and when it is not, then it retains a form similar to the suburban enclave, alienating it from the urban core and the airport itself.

In order to enlighten the case around this controversial territory, an analysis of six examples was attempted. Even though limited in breadth, it approaches those new urban forms with relevant detail, and proves that, even though of a diverse morphology, most of them do share certain common features, and that in many cases an airport can coexist sustainably with a community, as an integrated part of its urban fabric and structure.

Among all of them, strong similarities can be observed in terms of their paths' characteristics, nodes and hierarchy, as well as of the sharpness of their external edges compared to the penetrability of their internal ones. The latter is probably due to the large uniformity of uses and the less common pattern of segmentation. A relation between the area's size, location, land uses and accessibility by public transport, could exist but needs further investigation. The nature, form and dispersal of landmarks within the area seem to depend on all these factors, in addition to other cultural and economic parameters.

It is therefore understood that, even though in some cases certain principles and characteristics of urbanity can be identified, the diversity in this urban hybrid's form and structure is imposing the clearest practical challenges to identifying it as a city per se, and achieving the right balance between economic, social and environmental sustainability.

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THE BEHAVIOUR OF ENERGY BALANCE IN A STREET CANYON, CASE STUDY CITY OF BISKRA.

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ABSTRACT

This research studies the heat flow exchanged between paving of two different types (concrete and asphalt) and the urban environment in a street canyon. A method which takes into account all fluxes is established. A numerical approach is made in order to assess the modification of energy balance and its impact on air warming according to the geometry of canyon streets. The proposed approach provides assistance in the identification of important parameters resulting in the phenomenon of air warming, which can explain the thermal phase between the ground surface and the urban environment in summer. The extensive sunshine duration and the large mineral surface exposed to direct sunlight combine to generate a large storage of heat during the day and its return at night, which contributes significantly to overheated air during a summer night. This systematic research constitutes a significant step during interventions in the urban fabric or even in new urban developments. The heat flow density is determined by the heat transfer between the urban canopy and the atmosphere. A set of field measurements is performed using "multmeter" equipment to measure the temperature of the under soil: the air temperature and the wind speed using a measuring instrument called "thermo-anemometer with propeller LV 110", the temperature of the ground surface by an instrument called "Infrared Thermometer", the relative humidity through an instrument called "Thermo-hygrometer HD100". The time interval between measurements is two hours. A total of two measuring stations, representing street canyons with two different ground coatings (asphalt and concrete), are chosen in the city of Biskra. Such research is needed to find reliable ways to determine accurately the energy balance in an urban environment in the future. Finally, all of this can contribute to refresh the air and sustainable cities of tomorrow.

Key words: Heat flow, energy balance, numerical approach, air warming.

INTRODUCTION

A primary objective of environmental design in an urban context is the creation of comfortable spaces. The built environment has a significant impact on air warming. We will try to demonstrate clearly in the canyon streets in the city of Biskra the impact of the change in energy balance on air warming.

PROBLEM

In recent years urban climatology focused primarily on air warming. [1]. Heat flux exchanged between the soil and urban environment play an important role through their contributions to this air warming. Various authors have conducted studies on these exchanges. The synthesis of bibliographic work shows that the authors discuss the phenomenon of exchange considering that the daily net radiation is divided between latent heat and sensible heat [2] [3] [4]. To limit air warming in an urban environment, mastery of the energy balance should be a priority. Cities must anticipate this new climate data.

OBJECTIVES

Determine the change in the energy balance where the ground is covered by concrete and asphalt in an urban environment defined by the geometry of the street (canyon shape) and its impact on air warming. This study uses a numerical approach including a monitoring methodology.

The parameters of the energetic balance as follows:

Rn	ENERGY BALANCE	W/m^2
H	Sensible heat flow	W/m^2
LvE	Latent heat flow	W/m^2
G	Heat flow into the soil	W/m^2
J	Heat flow absorbed by vegetation	W/m^2
E	Mass flow of water vapor	W/m^2
h_c	Coefficient of thermal convection	
T_a	Air temperature	K
$T_{surf\ sol}$	Soil surface temperature	K
V_{vent}	Wind speed	m/s
K_E	Coefficient of convective mass transfer	
ρ	Density of air	ρ_{air} = 1.18kg.m^{-3}
c_p	Specific heat of air	c_p =1004J/kg.K
L_V	Latent heat of vaporization of water	L_V = 2.4*10^6 j/kg
M_W	Molar mass of water vapor	M_W =18,01g*mol^{-1}
R	Gas constant	R=8.32j.K-1.mol-1
P_{VS}	The saturation vapor pressure	kPa
P_V	The vapor pressure	kPa
Hr	Relative humidity	%
K	Thermal conductivity of the soil	W/m/K
ΔT	Coldest and Hottest temperature	K
e	Level of ΔT	m

Site Description

This study applies to the city of Biskra, located in an arid region with a warm and dry climate in Algeria. Its arid climate is characterized by significant annual and daily fluctuations between maximum and minimum temperatures. Between the coldest month and the hottest month, the temperature range exceeds 20°C. The daily range for the hot season is around 22°C. Solar radiation is intense about 10h/day. The average relative humidity is 47%, not exceeding 60% in winter. Rainfall is irregular and low (120 mm)

[5]. The measurements of the different climatic parameters were made at two measuring stations (Figure 1). Thermal and physical characteristics of the ground are: rough ground in asphalt,whose thermal conductivity is k=1.90W^{-1}.m^{-1}.k, the emissivity about 0.90 to 0.98, and the color black; and a rough ground in concrete, whose thermal conductivity is k=1.80W^{-1}.m^{-1}.k, the emissivity varies between 0.71 and 0.90; and the color is greenish gray.

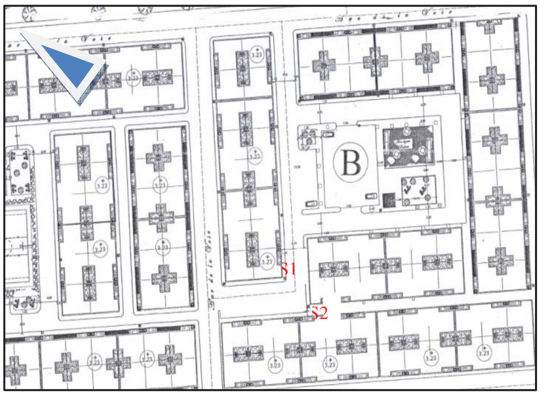


Figure1: The streets where the stations were placed. Source: Author.

Geometric details of each station are shown below (Figure 2).

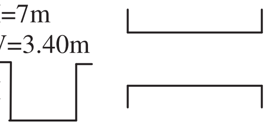
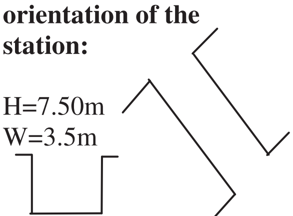
Station N°1 : Canyon Street H >2W		
View of the station: 	**Geometry and orientation of the station:** H=7m W=3.40m 	**Type of soil:** asphalt 
Station N°2: Canyon Street H >2W		
View of the station: 	**Geometry and orientation of the station:** H=7.50m W=3.5m 	**Type of soil :** concrete 

Figure2: The geometric details of the stations. Source: Author

MONITORING CAMPAIGN AND CLIMATIC CONDITIONS

Studying the effect of energy balance on air warming begins by drilling through the asphalt and concrete and measuring the underground temperature using a measuring instrument called "multmeter", with two accurate sensors to measure the temperatures T1 and T2 and a small handheld portable digital multmeter with LCD display, M890C. The instrument is product conform with the IEC 1010 and the CE certificate. The temperature measurement range is -20°C to 1370°C with an accuracy of ±0.5%, in measuring stations belonging to a similar climatic environment. A campaign pilot was addressed to determine at what level the fluctuation of temperatures starts according to the ground level in asphalt with a thickness of 7cm, and in concrete with a thickness of 5 cm. A level of 5 cm measures T1 as the coldest temperature, and 10 cm measures T2 as a hottest temperature for asphalt. Then a level of 4 cm measures T1 as a coldest temperature and 8 cm measures T2 as the hottest temperature for concretel. The air temperature and the wind speed are measured using a measuring instrument called "thermo-anemometer with propeller LV 110", the temperature of the ground surface by an instrument called "Infrared Thermometer" and the relative humidity by an instrument called "Thermo-hygrometer HD100" with a capacitive humidity sensor and a temperature sensor integrated.

THE ENERGY BALANCE EVALUATED

A portion of the net energy arriving on the ground is heating it by conduction, another by evaporation of water and another changes the atmosphere by convection. Because our investigation site lacks vegetation, the photochemical processes of chlorophyll assimilation of plants are neglected in our case; therefore the energy balance is defined by the following equation:

$$Rn = H + LvE + G + J \qquad (1)$$

The measurements were performed for three hot days under typical conditions of summer on 8, 9 and 10 July 2012 (days included in the overheating zone in the city of Biskra). Assuming that there is a permanent regime; the sensors will be fixed with no changes during the measurement period.

A) Sensible heat flow H:

This heat flow is calculated by the following equation:

$$H = h_c\,(T_a - T_{surf\ sol}) \qquad (2)$$

$$h_c = 0.5 + 1.2\sqrt{v_{vent}} \qquad (3)$$

hc is the convective transfer coefficient.

B) Latent heat flow LvE:

It is calculated by the relationship of Stefan based on the theory of mass transfer, also called film theory given by:

$$L_vE = \frac{L_v.K_E.M_w}{R.T_a}\left(P_{vs}\left(T_{surf\ sol}\right) - P_v(T_a)\right) \qquad (4)$$

$$P_{VS}\,(T) = \exp^{(25,5058-(5204,9/T))} \qquad (5)$$

$$P_V\,(T_a) = Hr\,P_{VS}\,(T_a) \qquad (6)$$

The assumption of Louis asks that is:

$$K_E = \frac{h_c}{\rho * c_p} \qquad (7)$$

C) Conductive heat flow G:

The heat flow in the soil is defined by Oke by the following equation:

$$G = -K\frac{\delta T}{\delta x} \approx -K\frac{\Delta T}{\frac{\Delta e}{e}} \qquad (8)$$

By replacing each quantity in the energy balance equation (1), we can finally write the energy balance as follows:

$$Rn = \frac{L_v.K_E.M_w}{R.Ta}\Big(P_{vs}\big(T_{surf\ sol}\big) - P_v(T_a)\Big) + h_c.\big(T_a - T_{surf\ sol}\big) + K\,\frac{\Delta T}{\frac{\Delta e}{e}} \qquad (9)$$

RESULTS AND DISCUSSION

Figures 3 and 4 show that at the two measuring stations, a high correlation exists between the energy balance and latent heat flow determined by evaporation.

A first field measurement result gives value fluctuations between the air temperature, ground temperature and the relative humidity at the measurement stations, as well as the values of the wind speed for day and night periods. It can be seen that for Station N°1 the measured values of air temperature are higher than those recorded in Station N°2 from 08h00 to 20h00 and from 02h00 to 10h00. In Station N°1, it is clearly noticeable that the measured ground temperatures are higher than the air temperatures. The mean value for the ground temperature is 47.6°C, and then comes the air mean temperature with 43.5°C. This can be explained by the fact that the ground surface pavement is of a dark colour with high absorptivity. The soil surface temperatures are remarkably higher for Station N°1 than those for Station N°2, because of its large emissivity due to the presence of asphalt which heats up quickly during day time. For Station N°2, the decrease of wind speed appears from 08h00 to 16h00 and from 20h00 to 08h00. For Station N°1 the observed decrease of wind speed is from 08h00 to 20h0 and from 00h00 to 08h00. The wind speed recorded at Station N°2 became higher than that of Station N°1 after midnight, due to the street orientation (North west-South-east), which is attributed to the hot prevailing winds in summer blowing from SE. Decrease in relative humidity before 16h00 and at night from 00h00 to 04h00 fluctuated between 11% and 23.2% in Station N°1, while the recorded values in Station N°2 for these periods fluctuated between 11.6% and 22.9%. This can be explained by the presence of traffic, air-conditioning systems and ground absorptivity characteristics.

STATION N^{O}.1:

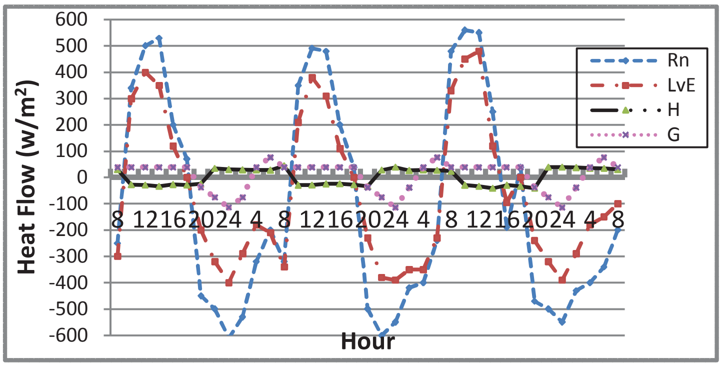


Figure 3: cycle of latent, sensible and conductive heat flow, and energy balance in a canyon street, asphalt ground. Source: The

The extent of the (LvE) is large, which represents more than 80% of the (Rn). Changes in flow between (Rn) and (LvE) indicate that the energy balance (Rn) s significantly with a maximum difference between the two flows equal to 180W/m^2 (at 14h00 during the day time) (Figure 3) . The maximum value of Rn is 564W/m^2. At night time the difference between the two flows equals 220W/m^2 at 22h00. The sensible heat flow (H) is contributed in the presence of the urban heat island. It is powered by both the release of anthropogenic heat and the heat stored in the ground (G). This last allows (H) to stay positive during the night from 20h00 to 08h00.

The energy balance (Rn) and latent heat flow (LvE) can progress: at 14h00 in a canyon street oriented East-West with an asphalt ground cover, LvE reaches a maximum value equal to 480W/m^2 and Rn equal to 564W/m^2 (Figure 3).

STATION N .2:

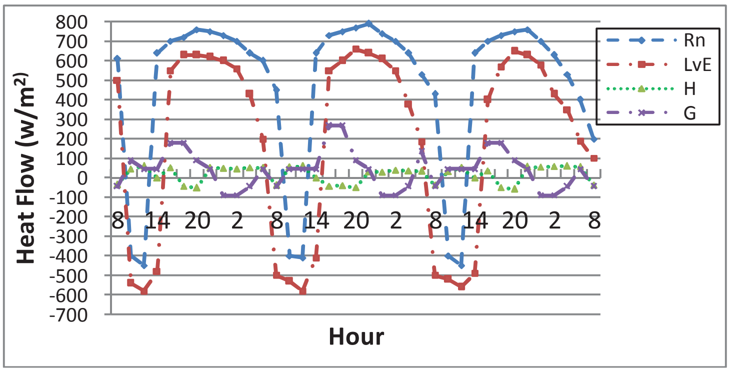


Figure 4: cycle of latent, sensible and conductive heat flow, and energy balance in a canyon street, concrete ground. Source: The author

The influence of the prevailing wind from the North West - South East appears on the energy balance (Rn) and latent heat flow (LvE), from 08h00 to 06h00. (LvE) and (Rn) drop gradually. This wind favoring the rejection of heat in the atmosphere during the night and therefore sensible heat flow (H) becomes positive. In the canyon street with concrete ground, the energy balance reached its maximum value at 16h00 (720W/m^2) during the day. The energy balance is generally increased, the latent heat flow also increased and the extent of the conductive heat flow (G) often delayed especially in the transition to negative values in the early evening from 20h00 until 04h00.

CONCLUSION

This research has a role to perform in the analysis of the extent and the behavior of the energy balance in a canyon street and its impact on thermal fluctuations. This document focuses on field measurements of the temperature of the air, temperature of the ground surface, of relative humidity, the wind speed and the temperature under ground at two levels within two stations situated in canyon streets, which were conducted from 8 to 10 July 2012, at a bi-hourly intervals. At 14h00 in the canyon street oriented East-West and ground covered with asphalt, the latent heat flow (LvE) constitutes 80% of the day flows exchanged within a highly urbanized site. In the canyon street with concrete ground, the energy balance is increased, it reaches its negative values in the morning, from 09h00 until 13h00.

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GIS BASED TOOLS TO ASSESS LOCAL SELF-SUFFICIENCY

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ABSTRACT

An analysis and design method to elaborate self-sufficiency urban scenarios is presented, where energy and material flows related to residential sector, food consumption, and private transport have been considered.

The method uses open-source Geographic Information Systems (GIS) and is articulated in the following processing phases:

1) Identify the territorial boundaries defined as local
2) Assessing the Renewable Local Energy Potential - Analysis of contextual conditions and local renewable energy potential.
3) Assessing Local Energy-Matter Demand and Supply for residential, agricultural/food consumption and (marginally) private transport activities. Quantification of aggregated impacts through the environmental impact indicators adopted (GWP100 - CO2eq emissions, NRE / RE MJ non-renewable and renewable primary energy).
4) Assessing local self-sufficiency scenarios based on best practices transfer, filtered on the basis of local factors mapped on the GIS (climate, use, existing buildings shape and technology).

The effectiveness evaluation of good practices is carried out using specific tools, called "user histograms". These are used to verify the choices adopted by calculating the local demand for energy and materials through three specific indicators and related reference thresholds :

- Accounting productive land demand compared with the locally available land.
- Accounting CO_2 emissions per capita, compared with reference value of sustainability (in a range between 1000 and the 2000 kg CO_2 eq/ person*year).
- Accounting primary renewable and non-renewable energy consumption, compared with threshold values, characteristic of the 2000Watt-Society program (1500W coming from renewable sources and 500W from not renewable ones).

The results describe the application of this methodology in the context of a settlement of about 5000 inhabitants in the province of Milan, Albairate. They show how local self-sufficiency can be achieved in the categories of food and energy supply related to residential buildings. The main actions taken into consideration, concern an adequate use of renewable energy in the built environment, interventions on existing buildings to reduce energy consumption in the residential sector and a readjustment of the inhabitants diet towards local low energy productions (i.e. vegetal versus animal proteins).

Keywords: CO_2 accounting, local self-sufficiency, GIS.

METHODOLOGY

The text presents the current state of development of the applicative tools of ELaR, which stands for Ecodynamic Land Register, a methodology to assess different design choices on the basis of their contribution to achieving self-sufficiency with regard to energy and material flows, in a context defined as local.

ELAR aims to highlight and rethink energy and materials flows which feed people activities through analysis carried out by Geographic Information Systems [1, 2]. It highlights the dynamic relations between energy and matter demand and local renewable potential which should necessarily be maintained in equilibrium in a self-sufficient system. Local demand for energy and materials and the local renewable potential supply are assessed from the information gathered and processed. The local demand for energy and materials analyzes the consumption categories of housing, food and marginally of private transport; data are expressed in terms of general amount referred to the local context or in terms of per capita data.

The collected and processed information is organized in order to enable the transferability of good practices oriented to local sustainable self-sufficiency, and to measure their effectiveness in terms of dweller environmental impacts reduction.

TOOLS

The ELAR methodological approach allows to aggregate the data processed in graphic format easily understandable to local actors (general users, local administration, designers, producers)

The elaboration and communication of the results are provided by two basic tools:
" Resources / impacts geographies."
" User histograms"

RESOURCES/IMPACTS GEOGRAPHIES

Resources and impacts geographies are obtained by collecting on the same territorial information support data on Local Demand of Energy and Matter (LDEM), and on the Renewable Energy Technical Potential (RETP).

Information on Local Demand of Energy and Matter (LDEM) is collected in the form of impact geographies, while information on Renewable Energy Technical Potential (RETP) is collected as resources geographies concerning local supply.

Impacts geographies represent the supply chains of production and consumption through geo-referenced vectors which locate supply chain different nodes. Two different indicators quantify the environmental impacts associated to the different nodes of the supply chain:

- the use of primary non-renewable/renewable energy sources, expressed in MJ equivalent;
- accounting of CO_2 equivalent emissions, expressed in kg of CO_2eq.

Figure 6 shows an example of impact geography related to primary energy accounting, where energy consumption values are graphically represented as colored circles of different sizes.

Resources geographies are obtained by collecting in specific thematic maps quantitative data related to the locally available renewable resources. Once the boundaries of the local context have been defined, this phase of the methodology processes and stores in the same Geographic Information System data concerning local physical and biological/agricultural environment. This data-base provides descriptive information on the climatic conditions (solar potential mapping at different scales [3], pluviometric conditions, windiness, humidity and air temperature throughout the year), on actual land uses, on geo morphological aspects etc..

(Figure 1). The main goal of such a data archive is to provide useful information to identify the current local renewable potential supply and develop possible local sustainable scenarios for good practices transferability.

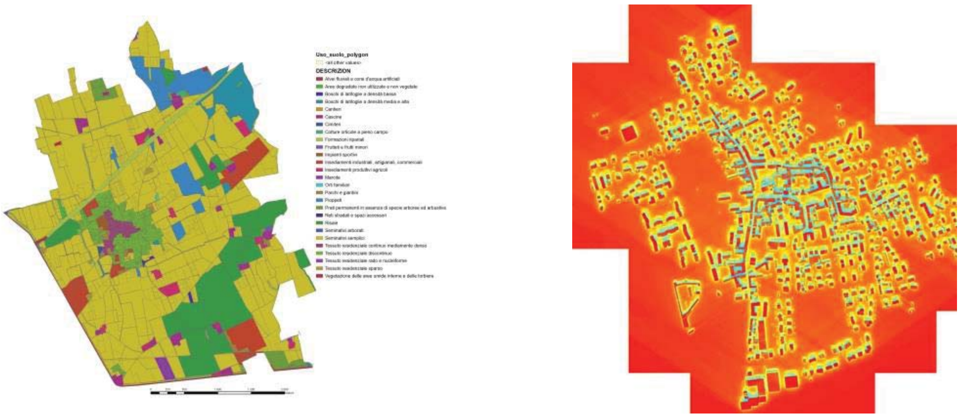

Figure 1: Some maps that make up the resources geographies of Albairate (Lombardy region), to the left a land use map, to the right a solar radiation map.

Good practices transferability depends on the assessment of similarity between territories under analysis and good practices territories. This information, as part of one single Geographic Information System (GIS) can be associated to different portions of land, as example a cadastral land or urban parcel.

The association of such information to geometric particles using GIS, enables identifying the vocational characteristics of each portion of the local territory.

USER HISTOGRAMS

The user histograms build the connecting structure between the information collected in the geographies, in order to check different design choices. They report in terms of per-capita flows energy and matter local demand and relate them with the extension of productive land per-capita. The user histogram general structure can be easily understood looking at the following diagram (Figure 2).

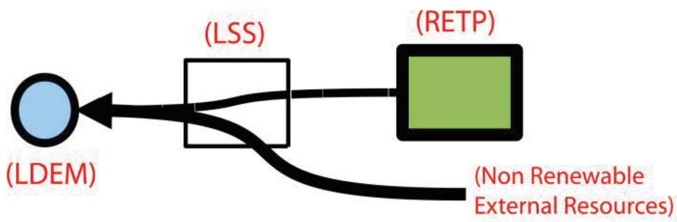

Figure 2: General synthetic structure of a user histogram

As shown by the arrows, the histogram describes energy and matter flows direction from the right to the left. Consequently, the right side of the histogram contains information on the resources supply (RETP Renewable Technical Potential, locally available), where information on local renewable supplies are given. The left side shows information about Local Demand of Energy and Matter (LDEM). The central part houses strategies as possible design choices in between local renewable energy/matter supply and demand (LSS Local Self-sufficiency Scenario). They perform the main function to connect local demand and supply. The image below shows an example of user histogram describing the main components. The extreme left of the graph shows data of energy and matter demand expressed in terms of the indicators adopted, in this case the CO_2 equivalent emissions. The quantities of energy and materials are aggregated into the consumption categories of housing, food and, marginally, of private transport, to compose the total amount of energy and impact (NRE, GWP 100) per person (on the extreme left) (Figure 4). Such option gives the possibility to compare the data with reference threshold values per person (15800MJ of primary non-renewable energy per year as sustainability goal suggested by the 2000W Society program, and between 1000 and 2000 kg of CO_2 equivalent emissions per year) [4].

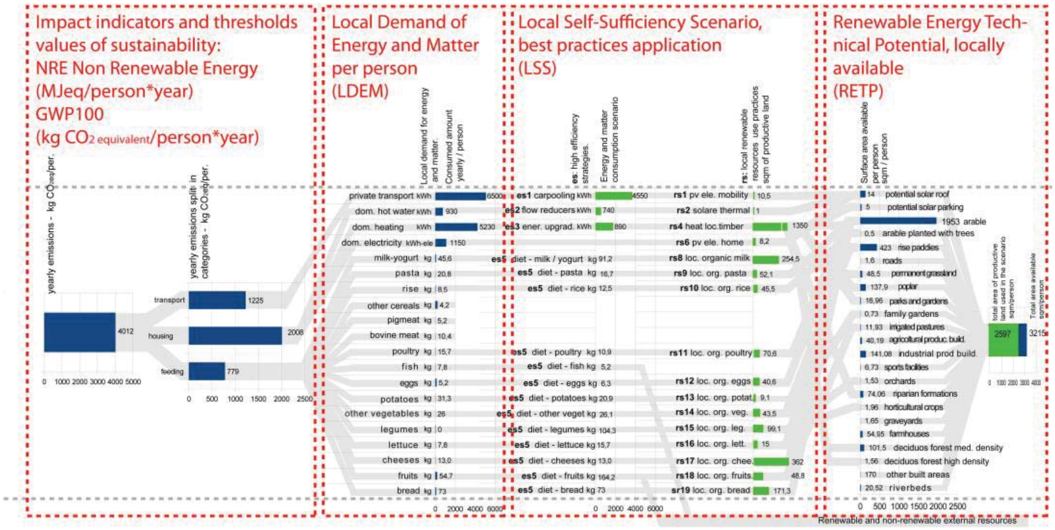

Figure 3: Example of user histogram describing the main components

The right part of the graph represents the local renewable supply, it shows the extension of the productive surfaces in the local context, expressed in square meters per person (Figure 5). The productive surfaces are intended to be the productive portions of land for agriculture and forestry, as well as the built-up portions that show relevant features such as high solar vocation surfaces.

The far right part of the histogram brings together the extensions of productive land per capita identifying the amount of productive land available. The different colors of blue and green refer to the extension of productive land available per person (in blue) and the extension of the available productive land interested by the application of good practices assumed in the scenario (in green) (Figure 5).

The structure of information allows in the design phase to operate a useful and immediate comparison between productive land necessary to local self-sufficiency and land actually available. Such condition of immediate comparison drives the design choices among the good practices, in order to find out the ones more suitable to the real conditions of the territory.

The central part of the histogram is representative of best practices application, and identifies two specific application steps. The first, in the column to the left, refers to strategies to improve efficiency (es), both in terms of energy use and matter consumption. The main function of this phase is to reduce the amount of energy and matter shown in the part related to the current demand (Figure 5, on the left). For example, the main strategies adopted in the case study of Albairate (Figure 4, 5, 6) concern the energetic upgrading of the building envelope, the adoption of low animal proteins diet and the spread of carpooling practices. The second application step, in the column to the right, refers to the application of good practices on renewable energy use (rs), with the purpose to mediate between the energy and matter reduced demand and the potential renewable supply (Figure 5, central column). The data shown in the histograms translate the amount of energy expressed by the demand, in the amount of productive land required in order to compare the result with the quantity of locally available productive surface per person (Figure 5, right column).

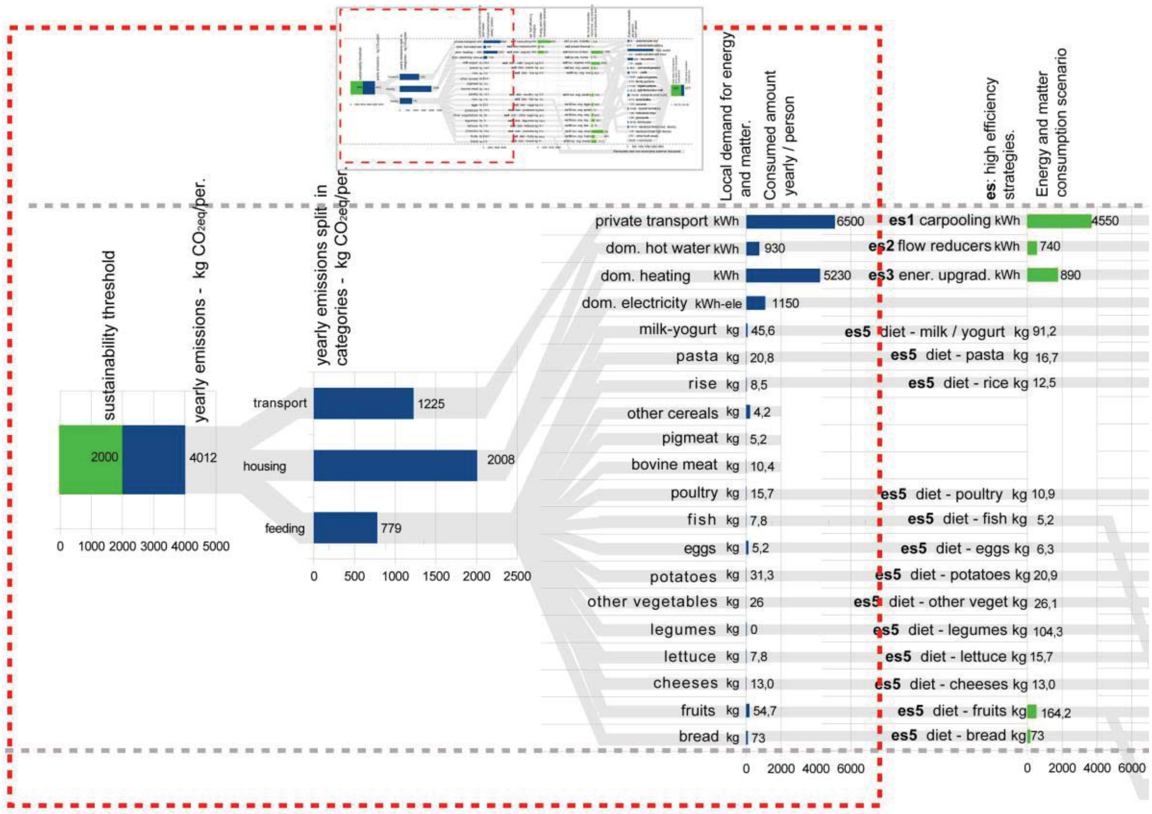

Figure 4: Part of the user histogram concerning Local Demand of Energy and Matter (LDEM), Albairate (Lombardy region)

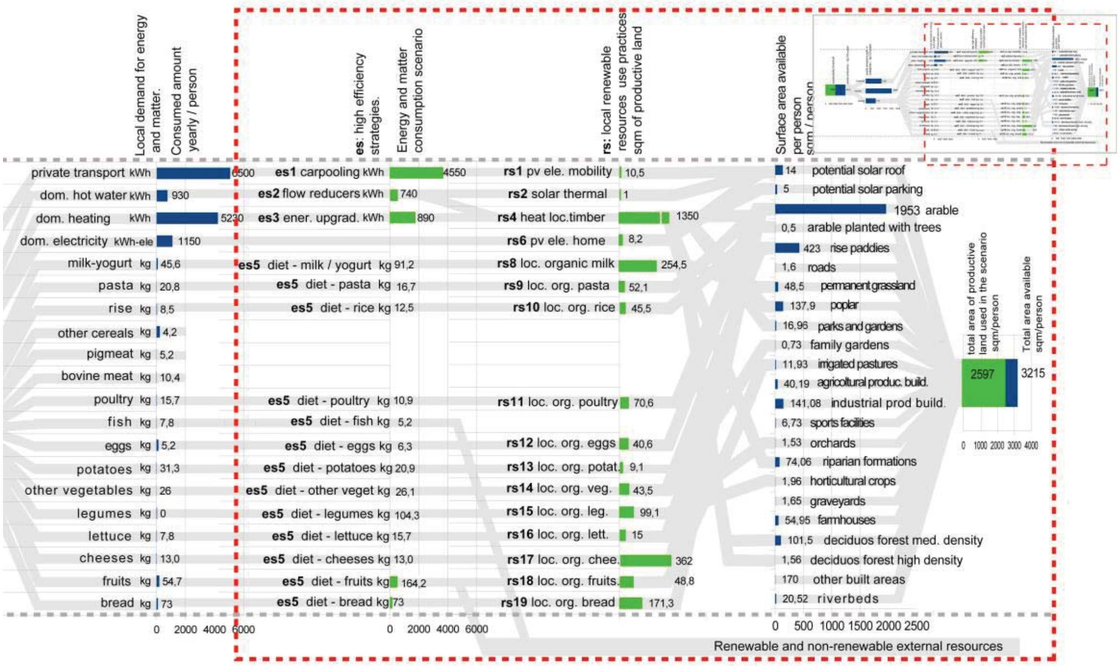

Figure 5: Part of the user histogram concerning the strategies adopted in the proposed Local Self-sufficiency Scenario (LSS), Albairate

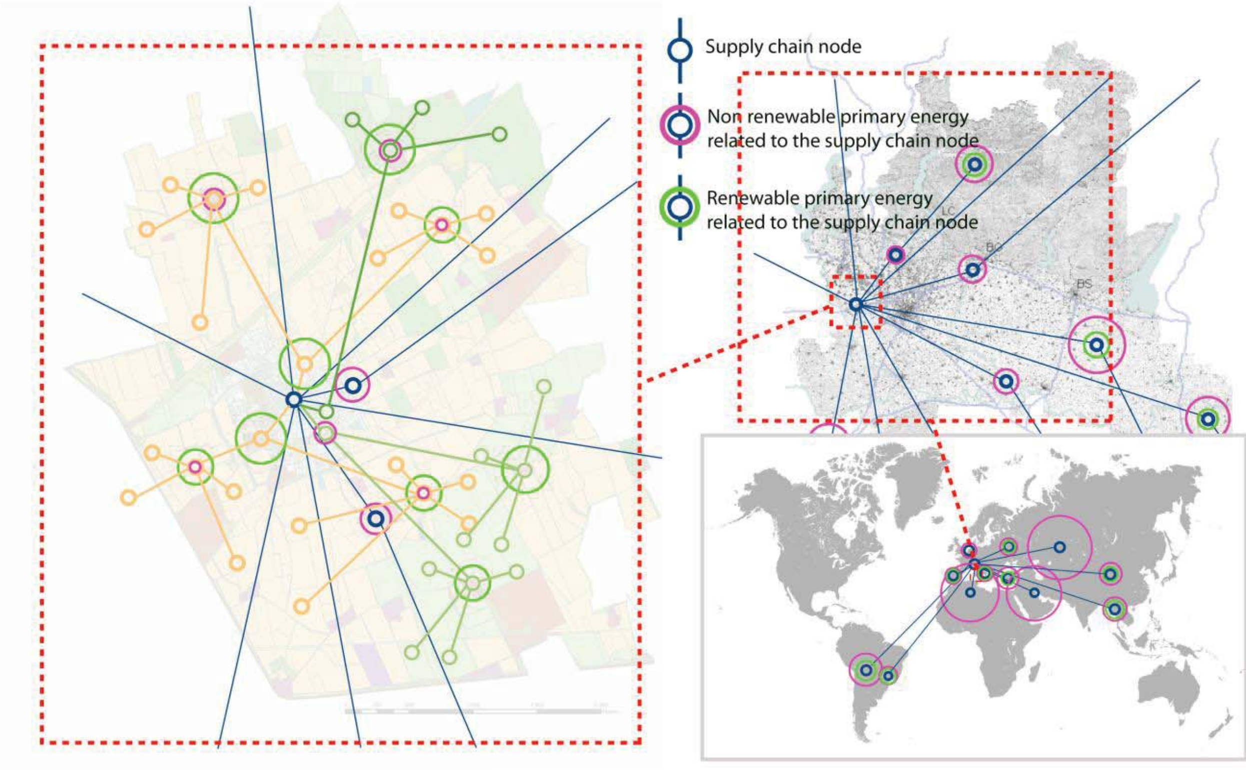

Figure 6: Extract from the impact geographies concerning the adoption of good practice on local supply chain of bread (sr19) inside di LSS, Albairate

CONCLUSION

The GIS based tool was tested in the context of the Albairate region to assess local self sufficiency. The data presented in the resulting histogram (Figures 4, 5) claim that the local territory can sustain local demand using 2600m^2 of productive land. Among the main practices to be adopted the following emerged: electric mobility powered by grid connected photovoltaics, changing the diet of the inhabitants (see previous “es” strategies description) and energy requirements reduction of dwellings by approximately 80%. Future developments concern the online publication of a good practices database so as to allow a better fruition and an easy implementation of data by the users.

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DYNAMIC CONSUMPTION EVOLUTION OF BUILDING MATERIALS IN THE HOUSING SECTOR IN THE NETHERLANDS: TOWARDS A MATERIAL METABOLISM?

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ABSTRACT

The Netherlands has moved a long way from a landfill to a waste processing society. In 2008 the European Waste Framework Directive signalized the wish to step up on the material hierarchy. This paper is based upon investigating how this process could take place and includes a renewed look on the 'urban metabolism' and the role of environmental technology, urban ecology and environment behavior focus for the field, focusing on material flows. Relevant aspects continue transformation, economic-technological innovation before, during and after design and construction.

Industrial ecology principles have shown to be powerful tools to track economic and environmental characteristics connected to specific flows. To step up on the material hierarchy towards waste prevention it will be necessary a more qualitative evaluation of the building industry related waste flows, which both the government and the companies involved in the industry should be prepared. Moreover even for a "recycling" based society as the Netherlands aims to become, there are challenges in specifying consumption trends and connecting national material accounting to product consumption. How to plan future capacity in an integrated system is a challenge for the waste management chain that has to be in tune with fluctuations of consumption trends in early stages. This paper has investigated dynamic consumption evolution of building materials in the housing sector through Domestic Material Consumption, waste accounting and dynamic stocks. The results show that traditional waste accounting does not bring enough relevance to evaluate waste prevention based on quantitative analyzes. Finally, an unprecedented qualification of material flows shows to be necessary to classify materials not only for waste prevention measures but for a drastic improvement in the material recycling chains, waste treatment and at last design of new products.

Keywords: material metabolism, waste hierarchy, accounting flows, dynamic housing stock

INTRODUCTION

According to de Bree (2005)[1] the Dutch overall waste industry is young and has rapidly become a large-scale operation. The most important changes of the Dutch waste industry in recent years include scale increase, consolidation / vertical integration, the formation of multi-utilities and the entrance of other European waste companies. In addition, the liberalization of the European energy industry has had an important influence on the Dutch waste industry. Waste prevention has to be included one way or another in such structure, formed mainly by large-scale players. Within this context, the government position has been to create policy structure that defines what needs to be avoided in accordance with European rules. In this group the focus will be mainly on landfill, incineration and export of waste. Within this framework private companies will have to formulate the management of waste themselves including technology, logistics and costs. With this background, the government has also abstained from other “controlling” forms, which includes further improvements of waste accounting flows. Nonetheless without a clear and consistent evaluation of the development of waste flows the long term effects of such policy structure is questionable in regard to building capacity for future waste treatment, assessment of environment impacts and setting goals to improve waste management.

With the attempt to step up in the waste hierarchy treatment, different ways to process waste are needed rather than incineration, and a better measurement of waste flows is necessary. In this regard, a quantitative and qualitative evaluation of the waste flows, building stock and consumption trends are crucial for future waste treatment building capacity, design guidelines of new products and building systems and consequently a more clear environment assessment of waste production. This qualitative accounting has to include, besides volume, a better characterization of waste that ideally connects large-scale waste flows to the accounting of products including physical evaluation.

For a small country as the Netherlands, building waste, has critical effects in the carrying capacity to provide adequate treatment; more so with the increase of import waste bans raised by neighbor countries, such as Germany imposed in 2005. In a report published in 1999[2], the Netherlands was the only EU member state that expressed concerns that the supply of Construction & Demolition (C&D)-derived aggregates may one day match the construction industry’s capacity to substitute them for primary aggregates. The same report includes the observation that the rush towards full recycling treatment should not disregard that full substitution of primary aggregates by secondary material may never match equivalent quality. Hence, the importance of improving accounting systems also illuminates related consumption of material flows by increasing and opens possibilities to substitute primary resources.

METHOD

One of the measures to implement in the waste hierarchy according to the European Waste Framework is to avoid recycling through the reusability of components and materials that are included as waste prevention resolution. Within this context this study evaluates the proportion of materials that are potentially reusable within construction waste in the housing segment and the prognostics through time. According to these materials, the study investigated 3 different levels of data:

i. The consumption trend to evaluate if materials combined with component design and building systems would be more prone to be reused in the future according to technology and management structures.

ii. The evolution of the building stock as a reservoir of present and future reusable materials.

iii. The development of waste production to assess the volume and speed which these flows occur, including the ways the extraction of these materials happen at this phase of the building life.

Within these three datasets the material types were described according both to the current national accounting systems and to information acquired from the private sector.

RESULTS

I. Consumption

For the purpose of this paper, consumption trends will be described instead of absolute numbers. Information on consumption of building materials described in this study was derived from private industry but with the exception of cement based products, the data is very inconsistent and when available it was not easily shared by sources. There is also disaggregated information available at the national accounting system, but not entirely available for the public. The information is organized by goods (e.g. triplex, clay brick) and by the industry types that consumes and supply goods. Most of the existent data is classified by monetary value rather than volume and in both cases dated within an average of 10 years. The classification does not prioritize between residential and non-residential consumption rates, instead within industry (e.g. construction materials, site preparation, construction installation). Steel consumption is available since 2000 and has been mostly stable until 2009 followed by drop in 2010 as most of the construction sector developments decreased. Rate of wood consumption was the most challenging to estimate, mostly due to lack of cooperation within the wood chain and in general it has seen a slight growth within the same time frame of the other products mentioned. Currently the government is compiling new datasets with the goal to assess national economic performance, although not national reserves through the environmental perspective, neither future waste production.

According to current building deconstruction technology available and the context of the market demand for reusable materials, the list of materials was selected as being the best candidates for reuse. The evolution of recent building material consumption trends indicates that the new housing stock is more concrete intense than constructions before the 1950's; more precisely at the structural level, floor structure and roof tiles. These components will be better candidates for *downcycling* or recycling if new technologies prove to be feasible. For roof structure, wood remains to be the primary material used in the housing sector. For framing of windows and doors wood based production still dominates compared to plastic components such as PVC. Consumption of ceramic components has steadily decreased with exception of external façade, which still has the largest share of ceramic-based products. Plastic products are in volume represented by pipes and frames with the largest share being PVC products. There is an important growth among insulation materials. The consumption of materials is also divided into products for new construction and products for renovation works. The latter group has been re-shaping the building material manufacturing and in the future regarded as the largest consumption activity.

II. Building stock

The forecast for building waste is generally problematic as demolition rates are based on assumed life span of buildings. Reasons for demolishing buildings are also not entirely understood, but construction year, building typology, tenure and building methods have been pointed to be partially define demolition trends (Hoogers et al, 2004; INTRON and RIGO, 2006). The concept of life span of buildings needs further research. Kohler and Hassler (2010) mention that such estimations in Germany have assumed average life span of 50 years resulting in 2% demolition rate when in practice the demolition rate was in average 0,5% while in the Netherlands the average life span is considered to be 90 to 120 years (Itard et al 2008; Van Nunen, 2010). Very little is known about demolition dynamics and even less about renovation cycles, where in the Netherlands demolition represents only partially the total building stock while renovation projects have a large participation in the waste production of the housing sector as well. Renovation until recently was not regarded as significant but has increasing importance in the housing stock dynamics in most of mature urban centers and northern Europe.

According to TNO[3] (Koops, 2005) within the period 1990-2001, nearly 120,000 homes were removed and over 1 million new homes were added to the stock. He concludes by saying that "demolition is a small phenomenon that occurs spatially very uneven", and suggests that demolition often occurs in areas with large-scale concentration of inexpensive buildings.

Deriving data from INTRON and RIGO[5] it is estimated that within a period of 8 years 1995-2003 in the Netherlands there were 7 new houses built for every 1 demolished. Between 2004 and 2011, however, the ratio was 3,7 new houses for 1 demolished. The reduction of demolition and construction of new buildings is a current trend indicating that C&D waste flows in the housing segment are not only defined by demolition, but also largely affected by renovation cycles; which is still a poorly measured phenomenon. Despite the decreasing ratio between demolition and new construction, there has been an absolute increase of demolition rates from 0,17% in 2000 to 0,25% in 2008.

For this study the housing stock was divided according to construction year and typology. By comparing previous housing stock reports, it was possible to identify which housing groups were more prone to be demolished. Highest demolition rates were from gallery flats before 1964, terraced houses before 1964, and semi- detached from the same period all mostly from the social housing segment. The type of classification defines the quantities and quality of the material composition in the stock. A more detailed description of materials has been made according each group and then compared to the recovered material rates derived from demolition companies. The results show that different materials and different amounts of materials will be recovered from different building groups. The general average recovery rate among products will range from 30% to 70% (interviews with different demolition companies). The proportion of these materials present today in the housing stock was in this paper exemplified by one group of buildings (free standing, terraced, semi-detached and duplex before 1964), representing 29.2% of the total existing housing stock. Recoverable materials: 4,232,161 tons of wood (roof structure, floor & frames); 17,052,149 tons of ceramic (roof tile and brick façade[1]); 979 ext. doors; 9600 int. doors; 1199 wash basin; 1460 wcs. Interviewed demolition companies also extract different products from housing stock as lamps, balcony fences, staircase handrails, kitchen systems as cabinets, mirrors, handles, sockets, etc. that have not been included in this calculation.

III. Waste production

Today, development of C&D waste production is periodically published by two major sources of information: by the Agentschap NL (NL Agency, Ministry of Economic Affairs) and the National Registration Centre for Waste (LMA). Reporting of waste is dependent on the company that disposes the waste, which in most cases is a transportation company, either private or public. There is not a clear relation between the waste generator and ownership of waste in waste registration (Koppert et al, 2010)[4]. Even though currently the code description for waste registration at the LMA is based on the Euralcode system, previous code(s) systems are at times still used to classify waste. Regular accounting using this new coding system is more consistent since 2002 with improvements made in 2008 describing construction and demolition waste by material type and origin which LMA aggregated into three categories: building, infrastructure and utility; while the Agentschap database uses 14 different

[1] Recoverable façade bricks today are mainly extracted from constructions dated until 1930s that more often employed lime based mortar rather than cement based mortar, which increase deconstruction of these bricks.

categories. Hence, one barrier is that not all companies register their waste properly according to the Euralcode. At times companies may mismatch material categories, which will influence at final waste accounting. Another issue confronted is double accounting. The waste will be accounted by the transportation companies and at times also by the waste processing companies.

The accuracy of the data provided as a total is therefore still questionable since not all disposals need to be reported (*e.g.* small businesses do not have to register waste and processed waste that is classified under a different Euralcode). The lack of "control" that reinforces the registration practice allows companies to by-pass registration of " unknown" waste derived from demolition and construction (Afvalbeheer, 2011).

Currently the National Demolition Association in the Netherlands (VERAS) works with a set of forms which demolition companies are asked to complete. These forms are actual inventories done in two phases before and after demolition as an evaluation of the material flows content in the project to be demolished. This documentation is essential as part of tenders offered by these companies in large-scale demolition projects. Nonetheless, there is no official requirement that this documentation is submitted. These documents are however precious source of information about waste production (from source) and possible assessment for the entire building stock when comparing waste production with building typologies and construction year.

The overall evolution of waste streams shows that cement-based products have progressively substituted consumption of ceramic products. Internal walls, roof tiles and floor systems are the best cases that evolved from this substitution. Nonetheless, waste fractions are still evolving according to older fraction of the stock. A consistent database for ceramic-based products in C&D waste stream started in 2002 and its volume has slightly decreased in absolute numbers. Wood streams have drastically increased in the same period, while all metals can be considered as relatively stable since 2002; plastics presents a surprising continuous decline, which is a very small percentage from the current consumption rate. Total C&D waste production has increased from 1995 to 2009, stony fraction waste production has a very similar evolution. Housing demolition rates in the same period have increased in the same period, which coincides with the evolution of total C&D waste production and stony fraction waste production.

DISCUSSION

There are several benefits when integrating an accounting system in these three levels as described in this paper: the input of materials, the analyses of stock and output as waste production over time. It has been shown that it is possible to connect these scales (primary resource consumption to product) and evaluate which products are, or will be, critical to waste production and consequently treatment. This type of information can give feedback to product development, building design and waste treatment solutions that could better process certain waste flows. Such initiative of tracking materials from waste back to material consumption, product manufacture and back to waste production is part of a new trend seen in both recycling industry in the Netherlands and partially in small scale micro business deconstruction and recover of materials for retail previous recycling. Without such qualitative analyses fractions of waste that today are being incinerated or generally *downcycled* could be upgraded in the waste hierarchy as *upcycle* and reuse. In the Netherlands here is already an existent structure in the accounting national systems that could be improved in order to make this integration happen. Savings in data assessment as prevention measures may lead to future higher expenditures in repairing long term consequences both at the primary extraction material level and at the waste production and treatment level. The case of quick and large scale implementation of incinerating plants around the country in the past showed that with lack of more detail information waste treatment solutions are leveled from the minimum standards while technology and consumer behavior evolves resulting in technological *lock-in* effects, or have to be long term support of outdated solutions instead of shifting to better ones.

The liberalization of the waste market should not hinder the legitimacy of a centralized national accounting system based on compulsory waste registration flows and reinforcement of measures that are today voluntary or "ungoverned".

CONCLUSION

The findings from this research concluded that there is already an existing structure in the Netherlands able to organize the information of construction and demolition waste production that can support integrated material metabolism bringing large advances in waste management and qualitative improvement of material consumption. Nonetheless, this structure is not yet effectively applied, the organization of the data is not easily comprehensive and the data sharing is not public available. Despite the progress made of waste flows accounting since 1995, towards standardization of accounting methods in the Netherlands and in Europe tracking material flows through codes and origin, there are still challenges in evaluating the development of waste production as constant changes occur in the classification of material flows, origin, and waste registration. In three different levels (input, stocks and output), an existent effective structure able to improve the evaluation of waste production was found that could directly support waste treatment improvements, environmental assessments extending to evaluation of product development and construction systems and the a review of the entire construction mechanism that is currently intertwined to the final material choices.

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HOW TO GIVE AN ADDED VALUE TO URBAN ENERGY DATA: TWO COMPLEMENTARY APPROACHES

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ABSTRACT

Cities will play a major role to achieve the energy-climate objectives adopted by the European Union, and its member states. Many have adopted ambitious objectives and elaborate associated operational strategies: increasing energy efficiency, reducing CO2 emissions and increasing renewable energy production. The achievement of such objectives implies that cities dispose of reliable energy-climate data, ensuring that local authorities are able to control their energy consumptions and productions, thus able to develop concrete strategies, and measure the effect of the implementation of these strategies.

Two approaches of energy data collection and valorisation are presented, with two complementary aims consisting of urban energy flows monitoring and energy planning. In the first approach, we consider the city as a global and unique consumer. The data must be derived from actual and dynamic measurements, in order to benchmark with reliability the effect of actions undertaken by the city. Consumption data are aggregated by services and by sectors, and then plotted on a flow diagram incorporating energy conversion processes at the city-scale. In the second approach, we consider the city as a set of different consumers. Calculation of heat and electrical consumptions and needs of each territorial element such as building is made through the use of several statistical models. The potential of local renewable energy resources is determined based on resources availability, regulations and technological models. Geo-referencing all of these data provides a multi-scale vision of the energy situation. Furthermore, the simulation of several future scenarios allows to represent and to analyse the local energy situation with different temporalities.

The global approach of energy data collection and valorisation, aiming at “energy flow monitoring”, has established a first draft of an urban energy information system called SIEU, while the multi-scale approach lead to the development of the PlanETer energy planning tool. The latter, designed for local decision-makers, has been tested in over 10 municipalities allowing us to complete and validate our method and scientific approach. The use of this tool has helped to launch major projects related to the energy supply and consumption of territories.

Keywords: Urban data management, energy flow monitoring, infrastructures and networks, synergies between consumptions and resources, regional energy strategy and planning, GIS tool.

INTRODUCTION

In order to define and implement most efficiently their energy policies, cities need to know the specific characteristics of their territory in terms of energy needs, consumptions, production and resources. This implies that they will have to collect a large amount of data, structure them and make them “available”; they will then feed tools that help decision making through relevant indicators. Monitoring and planning tools represent two examples of such data valorisation. Since the objectives of these two later are clearly distinct, the methodological and technological approaches used to collect, process and represent data are also different. However, it is relevant to put these two data treatment approaches in parallel, not only to present their specificities, but also to identify points of convergence, with the perspective of developing global tools integrating the two approaches.

METHOD

Monitoring approach

Frameworks having already been suggested to represent urban energy flows [1, 2], the main challenge consists on making the monitoring reliable, in order to benchmark as accurately as possible the actions undertaken by municipalities; it is thus essential to dispose of multi-energy data based on current and dynamic measurements [3]. The objective is therefore to identify and implement the most appropriate approaches to obtain high quality data. It has been identified that the consumption data can be collected through multiple sources:

- Automated measurements at the final consumer level. These can be done by smart-meters (for electricity, gas and district heating consumption), sensors (for solar thermal consumption) and gauges (for fuel tank level).
- Import of existing databases. Actors that can provide local data consumption are variable: utilities (electricity, gas, district heating), oil and wood suppliers, companies specialized in the oil supply logistics for housing, local municipalities, departmental and national services.
- Recording and transmission of information by the final consumer, through occasional surveys (mail, phone, mail), online questionnaires, or energy social networks.
- Assessment of consumption, based on installed systems (boiler power, solar panel surfaces), through the identification of needs, or through the extrapolation of regional statistics.

The quality of these collection methods and of the data gathered is then analysed through performance criteria to select methods that best meet the specifications of the monitoring approach. These criteria are: the compatibility with the specific requirements of the approach (dynamic representation of the energy situation and evolution); the quality and reliability of methods, measurement systems and data collected; the methods and measurement systems implementation potential (simplicity and speed of implementation, acceptance, ...); the human and material costs.

Planning approach

The success of sustainable energy planning depends on the ability of local decision-makers to integrate a number of complex and dissociated elements which are exclusively dependent to the concerned territory. The main challenge is to bring these elements together giving decision-makers an overview focused on added-value in terms of energetic and sustainability aspects. Up until now, geographic information systems (gis) were mainly used to inventory and to evaluate the potential of renewable energy resources in specific case study [4, 5, 6]. With our approach of energy planning, the use of a geodatabase enables not only to evaluate local energy resources but also local energy demands and possible synergies between them. Our energy planning approach is based on the following steps:

- Evaluation and geo-referencing of local renewable energy resources potential mainly based on resources availability, regulations, technological models and existing energy network infrastructures.
- Calculation and geo-referencing of heat and electrical consumptions and needs of each building made through the use of several statistical models related to federal and regional building registers for household, industry and services. The statistical model is continuously updated with real values if available and provided by local energy distributors.
- Estimation and geo-referencing of future heat and electrical consumption depending on possible future scenarios mainly based on time horizon, rate of new or renovated building, stricter energy policies and climate objectives.
- Evaluation and geo-referencing of possible synergies between energy resources and demands at different geographical scale from the building itself to the city as a whole.
- Analyse and geo-referencing of technical and economic opportunities, which take in account the local synergies and constraints. Design of the energy system.

RESULTS AND DISCUSSION

Monitoring approach

This approach has resulted in a first draft of an urban energy information system, called SIEU. The first component of SIEU represents the energy production and consumption flow diagram, incorporating conversion processes at the city-scale. Consumption data are aggregated by services, such as electricity, heating / cooling and transport, and by sector, such as building, transport and industry. The second component contains sets of indicators representing the overall performance of the city as well as their evolution in terms of energy consumption, greenhouse gas emissions, and quality of supply. These energy indicators are furthermore complemented by the display of demographic, socio-economic and weather indicators. The data collection methods were evaluated according to their performance (reliability, quality, cost, etc). The results are summarized in figure 1. In this figure, the width of discs refers to the compatibility of the method with the specifications of SIEU, and the darkness represents the overall application potential considering the different criteria.

The main conclusions of the evaluation are the following, for the most relevant methods:

- Consumptions databases that already exist, belonging to utilities, municipalities or private companies, reveal a very high application potential for SIEU. However, if existing, they are not necessarily available or usable in the state: their use requires the establishment of strong multi-stakeholder collaborations, but also data mining operations to translate data into useful information.
- Telemetry based methods also have a strong potential for SIEU: high quality data can be obtained (frequency, accuracy, granularity) on actual consumption. However, both for economic and social acceptance reasons, these meters can hardly be deployed exclusively in the perspective of the establishment of a SIEU; the aim can therefore be to exploit meters installed by local actors (energy suppliers).
- Data collection through online questionnaires or energy social networks may be useful: data can be obtained quickly, easily, at low cost, and for specific consumption. This method enables to collect all data in the same format which no measurement systems allows (e.g. kerosene). However, the approach can only be used in support of the first two

approaches, since the data are of low quality (low frequency of update, risks of error) and the reliability of the approach, its implementation (acceptance) and long term use (the user could give up) are not guaranteed.

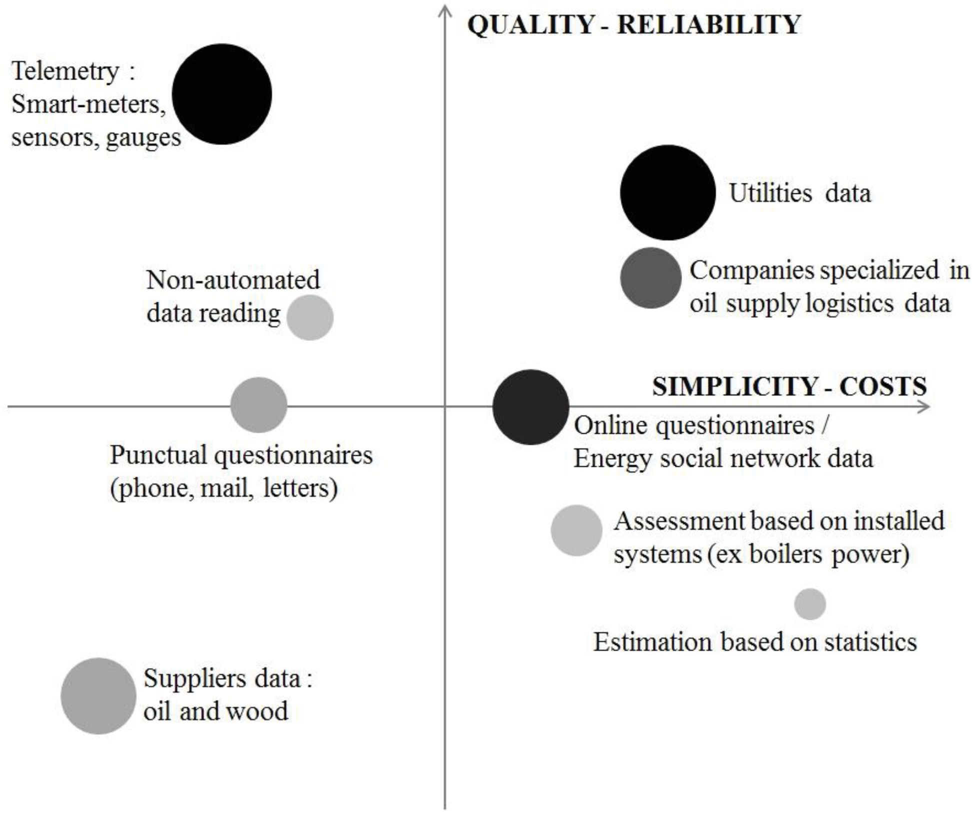

Figure 1: Evaluation of data collection methods

Planning approach

This approach as resulted in the development of a new GIS- tool for regional energy planning, called PlanETer. To give more accuracy to this planning approach, the developed GIS-tool was tested in more than 10 Swiss pilot cities. These cities differ from one to another by their size, their natural resources availability, and their energy need. This variety offers a solid background to develop and validate our methodology, which can be reproducible in other urban area. The developed geodatabase enable us to give detailed answers to their energy planning territory related questions. Is district heating an energy- and cost-effective solution for my region? Which buildings should be connected? What is the required temperature level? How many geothermal probes should I install, where and at which depth? What is the return of investment I could expect? The answers based on our GIS-tool were convincing and highly considered by local authorities. One example, amongst many others, is the launch by one of the pilot municipality of a 100% renewable district heating project.

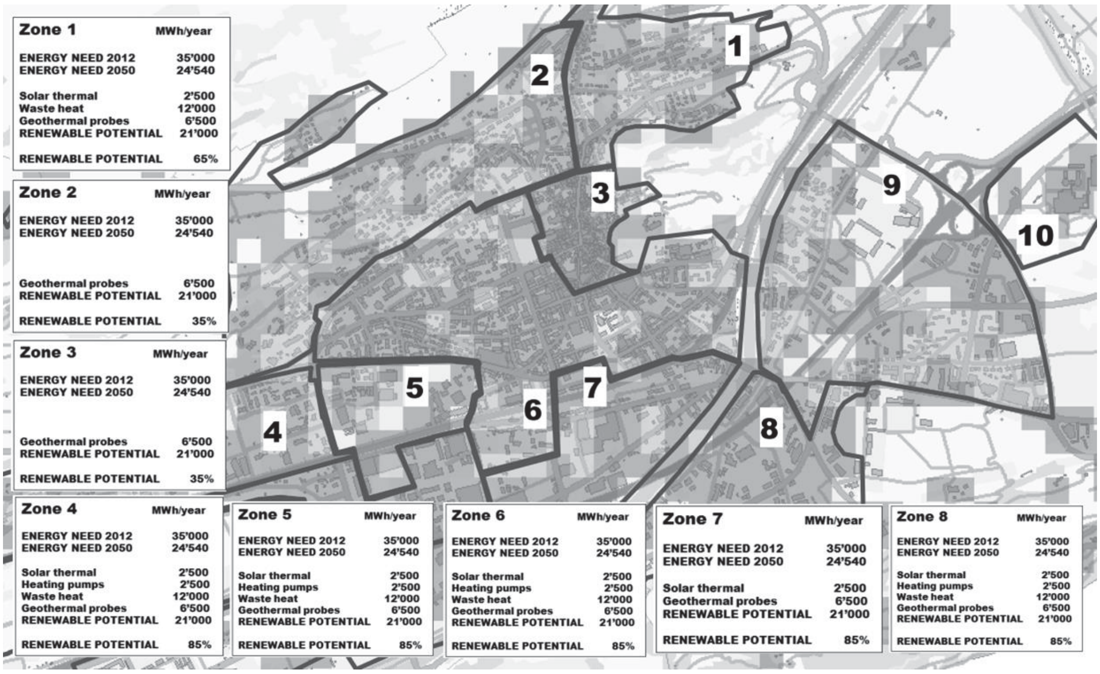

Fig. 2 : Synergies between energy resources and future energy needs on specific areas of a city with 30'000 inh.

CONCLUSION

Cities around the globe want to control their energy costs, to take advantage of their local energy resources, to reduce their carbon footprint. Since 2008, more than 4'000 European cities has set themselves ambitious goals by signing the Covenant of Mayors[1]. On one hand, it's an enormous difficulty for cities to get reliable, structured and sufficient energy data of their territory. On the other hand, energy management is driven and impacted by many local actors, such as municipalities, energy providers, consumers and urban planners. Furthermore, they all have different approaches and responsibilities on this common thematic, mainly based on their own professional competencies, abilities and specific objectives.

In this context, the challenge consists on the development of a unique and multifunctional information system, based on reliable and dynamic urban energy data, which enables all actors to reach their objectives but also to interact with each other's. Such a development requires an intense collaboration between the local actors, particularly in terms of data sharing. This implies to overcome information transfer barriers such as the problems of acceptance and protection of data. For this, economic and social gains leading to promote and sustain the exchange of data should be identified. From an economic perspective, new business models, especially based on the use of ICT infrastructure, must be found to enable stakeholders to generate mutual benefits through the sharing and valorisation of data. On the other hand, one should also integrate the final consumer in the development and operational stages of energy services, rather than leaving him at the end of the energy chain. The objective is to identify his real needs in terms of energy information and, on this basis, to establish an energy data sharing that would benefit to all.

The resulting multi-partners information system, fed by reliable and dynamic multi-energies data, will then be an appropriate tool leading to a more efficient energy management at the city level.

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[1] Signatories of the Covenant of Mayors voluntarily commit to increase energy efficiency by 20% and the use of renewable energy sources by 20% and to reduce their CO_2 emissions by 20% on their territories by 2020.

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THE MODEL OF THE RESILIENT CITY BETWEEN THE TRADITIONAL AND MODERN MODEL - THE WATER CYCLE

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ABSTRACT

The study is focused in the relationship between water and the urban form specifically in pre and post industrial Milan.

Resilience is not an absolute capacity of the ecosystem but a reply to a determinate traumatic event. It is linked to the city and to the lack or alteration of the flows that feed it. This means that it is necessary to model a resilient city.

Milan is the case study: its evolution from the traditional to the post-industrial model. The elements of crisis are deeped in the analysis of water cycle. It is not a casual choice because water is one of the fundamental elements in human life, one of the deepest matrixes of the human teachings. This character is recognized in the traditional model that is the one of a resilient city in full harmony with the surrounding environment. In this city water plays a decisive role. It is the element that shapes and structures the urban form -surface and groundwater. It is the key element for modelling the urban form and defining of the quality of the anthropized space. In the modern age, in the Western world, water was used as an element for aesthetic embellishment, not as a functional one.

Therefore, starting from the traditional urban layout related to its hydrography, the hypothesis is that there was an unsustainable change because of the industrial age. This is necessary to identify characters of urban resilience in order to evaluate the resilient level in the water cycle of the current city. This is made with the analysis of some strategies that have been already developed.

The case study is Milan that was named water city for its abundance of good quality water. The urban morphology evolution is based on the drinking water supply, how water is collected, as energy source and also as a nutrient for cultivated land.

Keywords: urban resilience, water cycle, urban morphology

INTRODUCTION

From the definition of urban resilience as «(...) the whole of adaptive capacities of a urban system when facing stress factors and particularly climatic change phenomena and energetic lack» (UNEP, 2005), a resilient neo-ecosystem is able to «absorb shocks and/or perturbation without suffering relevant alterations in its functional organization, in its structure and in the characteristics of its identity» (UNEP, 2005).

Therefore the concepts of resilience and sufficiency are tightly linked so we can understand which is the dimensional limit of the analysed neo-ecosystem. As a matter of fact, the important element of sufficiency is de capacity of using only the necessary quantity of elements so welfare is guaranteed for the individual and the territory he inhabits. As Sachs says «meanwhile efficiency means doing things in the right way, sufficiency is equivalent to doing what is fair» (Sachs, 2007). The concept of sufficiency is linked with «the fair measure seen as an equal system and as the art of life» (Sachs, 2007) and also with a «new way of interacting with goods and services» (Sachs, 2007), this not only regarding the quantity and the efficiency of technology, but mostly the quality of life and the decrease of the charge in the natural capital. It is sure that the efficiency in the use of resources remains an essential element in the discussion, but this efficiency must be together with a sufficiency perspective regarding the natural and social capital.

This capacity, typical of the natural ecosystems and now lost in those that are man-made, can be focalized and discussed in the analysis of the relationship between water and the urban form, most of all if it is analysed in the relations between the pre and post industrial model and the elements that led to the crisis of the traditional model.

Water is a main element of the urban metabolism not only as part of the essential properties for the survivorship of humans and vegetables, but as a critical element for the metabolism of the city influencing in as source of energy and as vital nutrient. Is this way water has been always a fundamental vector of modelling and balance of the urban form.

METHOD

Milan and the crisis of the traditional model

Milan is located in the middle of a plain and it is very rich from the hydrographical point of view because of the abundant ground water and also for the proximity to numerous rivers that arrive from the Alps to the Po Valley. The pre-industrial Milan, as a matter of fact, profited from good quality water supplying without too much complications. Almost every block had a well, private or public, that warrantied the access to a high quantity of **potable water** even for domestic use. The potable water public fountains arrived later to the city. The first one is located in Fontana Square, built by Piermarini in the second half of the 700 century with the same supplying system of the public and private wells that already existed.

Rainwater helps to preserve the nutritional balance of the cultivated land. The first works of sewerage are from the imperial era. The emissary channel of the network followed the course of what today is Torino Street ending in the Carrobbio. With the dawn of the Roman Empire we have to wait until the end of the Middle Age to see how channelling sewage projects were resumed, but not as organic and efficient as the roman ones. This was caused by the absence of a general plan that led to the realization of conducts that tried to solve the contingent and specific problems of every single street for then carrying the water to the antique defence channels: Seveso and the intern pit. In any way this conducts were only used for meteorological water. The “problem” of the disposal of black water and the use of organic wastes and excrements for agriculture was easily resolved. In fact, from the first roman expansion, the city was equipped with a lot of channels and pits realized for transportation, defence, agriculture, sewage water and, later un time, for the production of energy. Some of them drew the water from near rivers (Seveso and Olona mainly), other ones from the naviglio of the Martesana that entered Milan form north and, as the name of intern Fossa, flowed along most part of the urban perimeter. In its way collected the private and public discharges delivering them later in the Vettabbia channel that was uncovered. The houses nearby the channels had to build the underground discharge conducts for wastewater and latrines mandatorily; meanwhile in the intern zones without looking out the channels had a black wells system.

The morphology and hydrography of the Lombard territory facilitated the creation of mills so that they could profit water **energy**. As a matter of fact, in the Middle Age we can find numerous mills in the Lombard territory that were a fantastic instrument of control for the authorities upon surrounding territories. However the apex of development of the mill activity is dated in the XVII century.

Post-industrial Milan

With the Industrial Revolution the water demand grows exponentially and so it does the pollution of this good. The population in the 1881 census was 321.000 habitants. That's why the city was forced to take actions as the construction of the sewerage network and one aqueduct.

The potable water supplying changed radically with the Industrial Revolution not only because of the quantity needed, but also because of the demand of a hygienic control substantially diverse. The choice was to build deeper wells that reached the groundwater in order to warrantee the purity and sanity of the **drinking water**. At the beginning of 1889 the first pumping plant was built –called Arena– and it started its service at the end of the same year. To regularize the water delivery pressure two great storage tanks were build in proportion: one of steal in 1893 and the second one in 1903 of reinforced concrete. These ones were placed inside the towers of the Sforzesco castell. The success of this system determined the technical setting of Milan's aqueduct.

As for the draining of **meteorological water** it was until 1868 when the first real project of modern sewerage was presented in the town council. This one included a widespread network, but an unorganized one, of 123 channels partially covered and partially uncovered with a longitude of 153 km. A "mixed system" is adopted that collected in a unique conduct the meteorological waters and the wastewaters. In 1884, with the expansion of the Beruto plan, it was possible to deal with the problem of the sewer network in a more organic way in the expansion areas. The new network of conducts, that choses the "mixed system" anyway, was determined by the morphological structure of the city and led with his evolution to the formation of a system "in terraces". Therefore, there were done concentric zones related to the central core of the city in decreasing proportion and served each one with its own and autonomous collector located in the intern zone (diagram). In this expansive phase they bet again for the biologic natural depuration of the campaigns irrigated south of the city. Only in 2001 they were realized three poles of depuration (San Rocco, Nosedo and Peschiera Borromeo).

The Industrial Revolution involved a radical change in the relationship between water and **energy**. As we already said water is energy, the cycle of water, in deed, allows us to maintain biotic balance saving a lot of energy. In particular, with the introduction of coal and new machines that made the development process more efficient and fast, Milan at the end of 1800 decides to build the first thermoelectric central in Europe. Italy, generally speaking, is a country with a lack of fossil fuels so the technicians of the Italian Society of Electricity, in 1884 when it was born, decided to push the studies related to the hydroelectric production of energy. From that moment in Lombardy will continue in that direction. The number of centrals built continues to grow specially during the wars that did not allowed the coal importation. Between 1966 and 1967 the hydroelectric energy covers almost the 50% of the national requirements.

The crucial element of this change was the conviction that one city with such water wealth in the underground and in the surrounding territory could not do anything else that profiting the new technologies and the new materials available for industrial development, for creating a modern image, that wants to disclaim its evolution as city of water. The element of the crisis resides in the same objective that has persecuted, and stills do, the post-industrial city: the idea of a development that today only adds the adjective sustainable creating a profound antithesis.

What do we understand indeed as (un)sustainable development? What is development and what does it entails? To answer these questions is helpful to reed a passage from *Scritti corsari* that seems that was written today and give us light about some contradictions.

«There are two words that frequently come back in our conversations: on the contrary, they are the keywords of our speeches. These two words are "development" and "progress". Are they synonyms? Or, if they aren't synonyms, do they indicate two different moments of the same phenomenon? Or do they indicate two different phenomena that are integrate with each other? Or, even, do they suggest two only partially similar and synchronic phenomena? Finally, do they indicate two phenomena that are opposed between them and which only appear to coincide and complement themselves» (Siti, 1999). In fact Pier Paolo Pasolini specifies that «the progress is an ideal (social and political) notion but the development is a pragmatic and economic fact» (Siti, 1999).

Starting with this definition, the sustainable model that is called to solve the post-industrial crisis, is only partially effective. In fact, to manage a change of the model, it is necessary to consider the transmission of natural capital. It is feasible introducing the possibility of losing natural resources but acquiring the ability to compensate with other one that has the same function.

«(…) A self-sufficient system that is truly homogeneous and where the climatic fluctuations are reasonably limited, a complex adaptive system» (Holling, 73) is a model that can be opposed to neo-ecosystems contemporaries model. It is a dynamic, sensitive to external changes and unexpected changes system and it is focused on the connections between them, and between the species of the system and the external environment with the specific components of the system.

RESULTS

A resilient neo-ecosystem «tents to keep an integrity of functions during a impairment» (Common, Stagl, 2008). This resilient system is able to work with species that modify its function or replace some of other one. This means that a resilient system can be composed of species that tend to zero during the shock and return to a normal activity after waiting a time. Therefore resilience is a system property and not a property of its components.

The resilient capacity depends on the shock and on the evaluation of the primary productivity of the system and the recovery time.

Major threats of the urban neo-ecosystem			
Climate change		**Welfare state**	
Scope of impact	**Threat**	**Scope of impact**	**Threat**
Energetic model Water management model Material management model	Resource depletion because of greenhouse	Equipment Home	Provision of basic services low (education, health, home)
Territorial occupancy model Biodiversity Species protection	Biodiversity loss	Public space Urban mobility	Loss of urban space quality
		Activities Population Economy Participation	Low social cohesion

Table 1: Relation between threats of neo-ecosystem and impacts.

The second step is to specify the elements of urban resilience that depend on its scope of impact respect water cycle. It emphasizes that water cycle is linked to the urban metabolism, the territory occupancy, the biodiversity, the urban form and space and welfare.

Urban neo-ecosystem components	Elements of the resilience linked to the climate change	Elements of the resilience linked to the welfare state
Physic structure	Adapting to a model of efficiency and passive capacity of the urban form (buildings and open space)	Ecological urban planning
Processes	Measures to improve the efficiency of the urban metabolism	Ability to self organization (social and economy activities)
	Dematerialization of the resource management	
	Urban biodiversity conservation	
Society	Awareness Reduced demands	Habitability of urban space Awareness Individual’s relationship with the (rural and urban) environment

Table 2: synthesis of the resilient elements

Therefore, a resilient system has three basic features: diversity of the elements of neo-ecosystem, modularity and feedback capacity.

A resilient system is, in fact, characterized by a diversity of elements capable of reacting in different ways to different challenges. Overall, ecologists think that the diversity of elements in the resilient system is key because a complex ecosystem has a proper number of species and connexions of the food chain. Complexity does not depend only on the stability of the system. In fact, as Common and Stagl explain, if a shock impacts the key specie, it is not always a loss of resilience. For example, if the function of the key specie x is to disseminate seeds, the system can be composed by other species able to do the same function. This means that a system with another specie able to do this function may react to the shock without collapsing. Its starting organization can change and continue to work, although not without modifying itself.

It is modular because the components of the group are well connected to each other inside and they can create a community able to isolate themselves during a shock. The modularity is a typical feature of computer networks. It evaluates the network division into modules (community). A module works independently from the contribution of the others modules. Increasing modularity, therefore, the collaboration between the different modules is stimulated, but the dependency between them is eliminated. Finally, a resilient system is characterized by a good feedback. It is the ability to store the obtained results and uses them to modify the characteristics of the system. It involves the cause-effect chain and allows the system to perceive the consequences of their actions in a short time and so it is able to activate a solution.

The feedback capacity brings out the fundamental problem of our times: globalization and the loss of an overview at a global scale able to evaluate our territory and to keep it productive. Speaking about the water cycle, the productivity challenge of the surrounding area is closely linked to modern sewerage system. From on side the organic matter can be used as fertilizer and from the other one urban rainwater can runoff and carry nutrients to farmland. Therefore it would be necessary to specify at a neighbourhood scale to recover and use these nutritional elements. It allows rediscovering the use of underground water and sewerage system to improve the permeability of urban areas, because water can be functional to the process described.

Finally, the modularity is directly linked with the concept of dimensional limit, explained above. We cannot think to look for effective solutions only for small cities that maintain an important link with the countryside or important waterways. Therefore this approach attempts to work at a neighbourhood scale to redefine the urban form so that green and water are not only a decorative supplement that needs constant and expensive maintenance, but elements that shape this change.

DISCUSSION

The traditional model is the one of resilient neo-ecosystem and it cannot be reproduced in the contemporary model because of its technological, social and economic changes. Therefore a comparative analysis between the urban morphology of the modern city and traditional city is required to define and evaluate the elements of resilience and to propose improvement strategies of water cycle at the urban scale.

The resilient concept is connected to the *ascendenza* (Ulanowicz 1986) that is a quantitative attribute of the ecosystem and, especially, a natural condition of it. It is the product of two elements: the information contained in ecological network and the data transmitted by the system. It includes the evaluation of the complexity of the elements of the system and its relations with environment. The interesting thing in the approach of Ulanowicz is the focus on the system organization and dimension. So each system can grow without limits. Its limit is the self organization habitat that is able not to «make difficult but rather facilitate food production, water supply, climate protection, protection of private and collective property organization of social relations and aesthetic satisfaction of each one» (Friedman 2009).

This definition of habitat by Friedman is based on the idea of «critical group» (Friedman 2009). It is connected to capacities, biologically determined by man, for wich «each structure of a group has a limited size (…) able to react fast to attacks from outside» (Friedman 2009).

Therefore the concept of physic limit of an urban sprawl is reflected in some problems of the urban grow of Milan. Surely the modern city exceeded this limit because it has created a clear separation between the city and its territory. Therefore, speaking about the diversity of components, it is important to implement and protect the variety of sources of supply abundant in the city and that we discussed above.

The first one is rainwater, its collection, its ability to transport and channel organic matter and nutrients, not only to the countryside -now too far away from the urban centre- but also to the parks and brownfield sites. They can be converted into gardens or green areas that can be a link between the built-up and the surrounding area.

The second one is the channels network that can be used for transporting materials and nutrients and that, with water sources inside the city and green spaces, can help to mitigate the urban microclimate, especially in the summer.

And finally the *fontanili* can contribute to the drainage and agricultural development of the Lombardy territory. Furthermore they can be used to produce energy, using the many mills in Lombardy or the hydroelectric power plants.

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THE SMART NODE: A SOCIAL URBAN NETWORK AS A CONCEPT FOR SMART CITIES OF TOMORROW

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ABSTRACT

Smart Cities are a very important topic that researchers, politicians and planners are facing nowadays. Due to the necessary multidisciplinary approach, still today the smart city definition is not univocally given, and this gives us food for thinking.

What is a smart city in reality, and how can the concepts that it implies transform into benefits for the social life of a city community? To answer these questions ENEA is participating in several research programs. Among these, the European Energy Research Alliance (EERA) - Joint Program Smart Cities that was launched in 2011, which investigates the highly complex structure of a future smart energy system on an urban level by applying innovative solutions in an interdisciplinary manner based on a clear long-term research strategy. Furthermore, in the framework of a national funding program (City 2.0) ENEA is experimenting at the scale of a medium town with the development of a proper model of smart city, which focuses on the social dimension.

An interdisciplinary team (researchers, architects and engineers) is working on the design of what we call a *Social Urban Network* (SUN), which will find an iconic tangible expression (the contact point between the community and the city) in an interactive micro-architecture named *Smart Node*. The *SUN* is a co-ordinated system of interventions that develops both in the digital scene (web, social network, etc.) and in the real scene (interactive installation, social events). The aim is enhancing the development and wholeness of the social capital (the stock of competencies, knowledge, social and personality attributes, including creativity, embodied in the ability to perform labor so as to produce economic value) of the social network of the community. If in general a *SUN* might focus on several topics (welfare, health, relationship between the citizen and the public administration, etc.), the one ENEA is developing focuses on *cultural processes*. The *Smart Node* is an iconic and technological object, with a dimension that encompasses both city elements and people (micro-architecture), able to represent the idea of connectivity for people. In particular, by being a space where people can meet each other, and integrating interactive output and interaction devices such as touch screens, beams, and other interactive technologies, it will represent for people a node where information can be shared and exchanged. This way, the social capital of the city can thrive thanks to the possibility of introducing creative contents and sharing them with the community.

The ambition of the project is placing the first prototype of the *Smart Node* in L'Aquila, a city whose historical centre was greatly destroyed by an earthquake in 2009, to help city and citizens to re-set up a common sense of identity.

Keywords: smart city, smart community, interactive architecture

INTRODUCTION AND APPROACH

In order to experiment with Smart City concepts and models, ENEA decided to work on a specific reality in Italy, L'Aquila, where the need of improving the "city performance" is very high, due to a natural catastrophe occurred in 2009.

L'Aquila is a medium size town (about 66000 inhabitants), located in the region Abruzzi (Central Italy). Famous in the past thanks to its architectural and historical heritage, the city historical city centre was widely destroyed by an earthquake in 2009. Since that date many buildings have been secured by means of scaffoldings and several different kinds of structure. To preserve the citizens security, the inner part of the historical city centre has been designated a so-called "red zone", where the access is not allowed (Figure 1). People who used to live in the city centre have been living in "new towns" placed out of the inner city for five years now, with a consequent progressive loss of identity of the city itself .

Figure 1: Historical city centre of L'Aquila before and after the 2009 earthquake

This condition of "emptiness" of the city centre has several implications on the relationship between the citizens and the city. Some of them are ascribable to concrete evidence of a discomfort (e. g. difficult or impossible accessibility of private and public buildings), some others are more ascribable to a social dimension (e. g. lack of a "centre" where it is possible to have a social life). Despite the works in progress, it is unlikely that a kind of "new L'Aquila", preserving its traditional and strong identity, can be built in the near to medium term. The "suspended", "uncertain" condition in which the city is today seems to be more permanent than temporary, and looks like an image for the psychological condition of the citizens themselves.

All these premises seem to suggest that L'Aquila can be a good domain where to experiment with Smart City concepts, just because there is an urgency to re-build not only the functional city, but also the sense of the city itself. In such a situation, any reconstruction, to be "sustainable" should take into account the buildings, but, also, services for citizens, the social wholeness and the cultural heritage preservation.

In order to structure a possible reference model that the reconstruction might follow, ENEA is experimenting with a *Smart Ring*, a specific application of the Smart City.

The *Smart Ring* is conceived as the main core of the Smart City, a connection point of both utilities and citizens. It is a system of different interventions related to the integration of urban networks, controlled and managed by a centralized City Control Room, where all the data coming from the city's monitoring system are collected. The single interventions that have been conceived and are under construction/development are coherent with the *Historical City Centre Reconstruction Plan*, approved by the Municipality of L'Aquila. In particular: public mobility and info-mobility; intelligent public lighting; buildings energy diagnostics and analysis; environmental monitoring; last but non least, a *Social Urban Network*.

THE SOCIAL URBAN NETWORK AS A POSSIBLE MODEL OF DEVELOPMENT FOR A SMART CITY

The *SUN* is an experiment with a Smart Community aimed to strengthen the sense of wholeness through the collective production of contributes related to the cultural heritage and to the cultural processes of the city. The general goals of the project are: enhancing the social capital of the community in L'Aquila; moving the society from a digital dimension to a hybrid/physical one; overcoming the social dismemberment due to the effects of the earthquake; re-building a cultural identity, by bridging over the past and the future; contributing to re-build the city from the social capital.

To enrich and to build-up the cultural processes we focused on two main aspects: strengthening the identity of the community (history, memory, cultural material heritage and immaterial identity heritage); supporting the creative act as a continuous element of construction of the cultural heritage, as well as having an impact on the social sharing and wholeness. Having set these premises, the SUN can be seen as an aggregator of experiences, and as an incubator of the social processes that take place in the city, aimed to strengthen the social wholeness.

From a methodological point of view, the structure of the SUN is articulated in several tools, performing different functions (Figure 2).

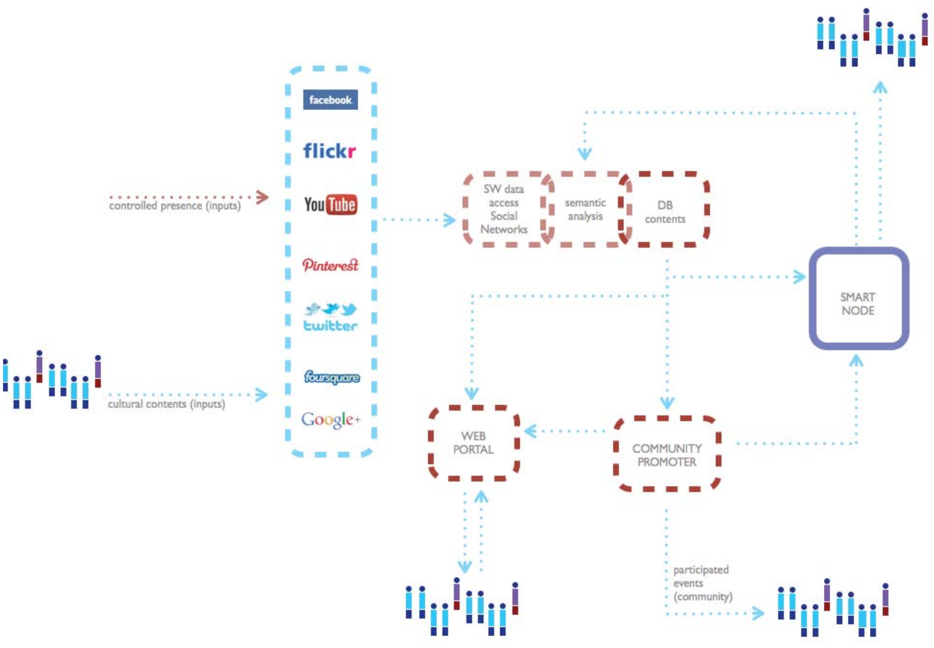

Figure 2: The Social Urban Network (SUN) functional structure

The first tool of the SUN is the Social Network. We will ensure a structured presence on the main social networks where citizens insert cultural contents.

The second tool works on the cultural contents collected in the social networks. After a contents analysis done by means of a semantic analysis system, the cultural contents are classified and stored in a "contents database". The semantic analysis system selects indicators related to the social exchange that happens in the social networks, with regard to cultural heritage, creative contents, the community experience and membership, emotional states (emotional city, discomfort, etc.). These indicators will be built up on the social network model (web theory), and from them the attempt is trying to characterise a possible evolution of the connectivity features (intensity of connections, web model, possible presence of hubs on specific topics).

Some of the indicators will be visualised on a web portal. The web portal helps in explaining and showing the content of the project, in creating galleries of creative contributes; in sharing a kind of picture of the community, based on the most communicative indicators of the semantic analysis. The main aim of the web portal is, therefore, showing a structured representation of the city of L'Aquila.

The whole system of the SUN is supervised by a Community Promoter (CP), a person who is very much familiar with the city of L'Aquila (may be from cultural city associations). The CP is the entertainer of the Social Network and of the cultural processes; at the same time the CP can manage information coming from the database, both easing and filtering actions. The contents will be managed so as to work as inputs for the web portal and/or for the *Smart Node*, being presented to the public through output tools (e. g. videos, projections, etc.). The CP can also organize events for the community to focus on the most interesting contents proposed by the community.

The whole project has a physical representation in the shape of a *Smart Node*. It is an interactive micro-architecture that works as a kind of window for sharing creative contents collected in the database, as well as some contents that can be chosen either by the CP or by the community itself (the citizens can vote their favourite contents). More creative contents sent by the semantic database could be shown in the *Smart Node*.

THE SMART NODE

The Smart Node is shaped in the form of three different spatial domains, made out of three identically sized tube-shaped cells, named "tubes". They are arranged around a central void, so as to be placed at the same distance from each other; the whole system can be seen as made out of three tubes, connected by means of an open air space (Figure 3).

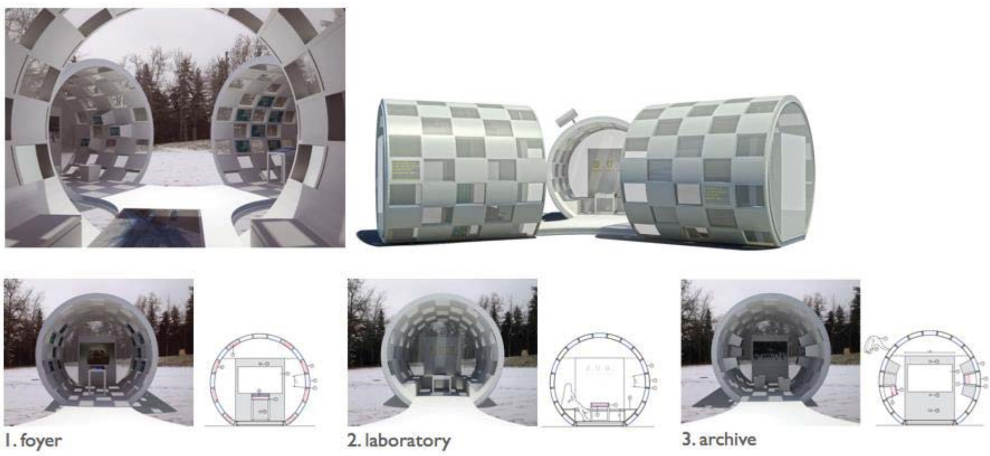

Figure 3: The Smart Node. The main parts (cells) are: an open air space; a foyer, a laboratory, an archive.

The three tubes perform different functions. The first one, the *foyer*, is a welcoming space, where people can meet each other, getting informed on the cultural processes of the city and sharing information. It is a kind of home page of the system SUN, that shows its contents, aims, and approach. The second one, the *laboratory*, is a space devoted to creating and elaborating proper contents (e. g. videos, pictures, installations, etc.). Here people can go and insert the contents that the CP will analyse and, if indicated, promote and share with the community, either by means of the web or/and by the output devices of the Smart Node. The third tube, the *archive*, is the space devoted to collecting materials that people can access.

The *open air space*, in between the three tubes, plays a communicative role as well as the other parts of the system, since on its skin, thanks to visualization devices, there are traces of not-filtered activities coming from the social networks (e. g. tweets).

More in detail, the tubes are equipped with different technological system and furniture; the approach to the use of technology is primordial and playful at the same time.

In the *foyer,* a continuos seat along the wall welcomes the visitor/s, who can watch the display on the wall, which visualizes information, or can interact with the touch screen integrated into the small table in the centre. This touch screen is the interface for accessing the information on the SUN and on the cultural processes of the city.

In the *laboratory* some interactive monitors hang over the walls. On the deep end wall there is a space with an interactive board. Touch screen monitors connected to computers are integrated in the circular wall as well. They are available for those performative activities that do not require a big display (such as writings or audio recordings). Here, in the laboratory, it is supposed that people enter one by one, or in small groups, so as to perform a creative activity with a certain degree of intimacy. Audio-video materials, as well as graphic-painting digital works can be produced and recorded here, thanks to the technological equipment of the room. Appropriate software will be available for the public to help in their creative interactive actions. All the contents created, elaborated and recorded here, are sent to the CP, who selects the ones suitable to be showed and shared with the community through the web portal or the smart node itself.

The *archive* is the space where all the materials that the SUN produces are collected and preserved, to be accessible to the public. Close to the entrance there is a bookstand that integrates an interactive monitor, from which it is possible to control and to select the outputs of the other monitors integrated in the deep end wall and into the circular walls.

The outdoor space is a communicative/exhibitive space itself. In the external skin of each single tube there are LEDs displays that visualize messages coming from the social networks, from the web community, or from the SUN. A beamer, placed upon one of the tubes, can project images on the walls of the surrounding buildings, or on the ground. The idea is that the creative contents that people insert in the smart node can be shared with the community through the smart node itself. This kind of functioning enables a physical relationship between the digital city and the real one. The Smart Node is a small architecture that people can use, and a technological device at the same time, that can collect inputs from the community and give them back to the community as cultural contents after a controlled process managed in the framework of the SUN. Sensors and webcams placed on the Smart Node, work as security devices and support interactive actions in the community: for instance sounds, lights, images, can be produced by the smart node when someone is stepping close to it.

PRELIMINARY RESULTS AND CONCLUSIONS

A multidisciplinary team has been working on a proposal for the development of a real experience of smart city, to help a city almost destroyed by an earthquake to re-build its social identity and to enhance its social capital.

Together with ENEA researchers, architects and engineers have been working on the Smart Node design (4M Engineering). At the same time an analysis of the social networks has been carried out by a group of researchers in Clinic Psychology (University of Chieti) to understand how to design the SUN so as to enhance the social capital of the city of L'Aquila. Researchers and professionals experienced in the field of social media (the Vortex) have been working to understand how the SUN had to work in order to enhance the cultural processes. We consider the experience we made as a good starting point for experimenting with smart citiy concepts, that very often suffer from different disciplinary approaches as well as from the use of different languages. The development of the SUN, and of the Smart Node are occasions to verify possible trans-disciplinary approaches to smart city.

We consider the experimentation in L'Aquila as a validation of our approach and tools. In particular we would like to verify that both the technological and methodological tools are appropriate for the project goals; the tools we develop are appropriate to be used correctly by the social operators; the project is effective in terms of citizens involvement (quality and level), and its effects on the social network.

Right now the project of the SUN, and the project of the Smart Node are completed, and we are discussing with local administrators to better understand how to realize them in reality in L'Aquila.

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