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GIS, 3D CITY MODELING AND GREEN URBAN CONSERVATION

Domenico Enrico MASSIMO (1); **Antonino BARBALACE** (2); **Antonino MARZO MICALE** (3)
(1) Associate Professor of Urban Appraisal and Economics, SSD ICAR22
(2) Ph.D. in Conservation of Environmental and Architectural Heritage, SSD ICAR22
(3) Ph.D. Student in Conservation of Environmental and Architectural Heritage, SSD ICAR22

with PAU GIS University Laboratory components: Mariangela MUSOLINO; Riccardo M. CEFALÀ, Cinzia FRAGOMENI; Mario GUIDARA; Alessandro MALERBA; Michelangela VESCIO

PAU GIS University Laboratory, Geomatics and GIS Group
Dipartimento n. 1 Patrimonio Architettonico e Urbanistico (PAU)
Università degli Studi *Mediterranea* di Reggio Calabria
Address: D. E. MASSIMO, Dipartimento PAU, 25 Via Melissari, 89124 Reggio Calabria, Italy.
Phones: 39.360.997513; 39.0965.385228; Fax 39.0965.385222; Email: massimo@unirc.it

ATTRIBUTIONS
Domenico Enrico MASSIMO conceived and set up the research and authored paragraphs: 1, 2, 3, 4, 9. Antonino BARBALACE coordinated the research works of PAU GIS University Laboratory components, and authored paragraphs: 5, 6, 7, 8. Antonino MARZO MICALE performed existing GIS and Geodatabase enhancement and development. All GIS applications, cost appraisal, energy quantification, financial assessment, economic valuations of the research are Copyright©1999-2010MASSIMODomenicoEnrico.

ABSTRACT
Given the environmental collapse hanging over Earth due to combustion and pollution, paying attention to specific urban ecological crisis, energy consumption in construction management, among other economic sectors, and consequent CO_2 emissions in the cities ought to be consistently reduced as addressed by the international community commitments.
The goal can be pursued by experimenting at unprecedented city scale the new approach of Green Conservation, in the framework of Green Building strategy, supported by key GIS tools.
Main feature of the research is to design a strategy for energy structural reduction and saving, alternative to inefficient *status quo* in city and building energy management.
Research has built-up a connection between urban rehabilitation strategies and building energy efficiency by integrating within a GIS framework: unprecedentedly detailed 3D city modeling; alternative scenarios for city energy management; cost estimate of investments in alternative scenarios; valuation of energy management in alternative scenario; overtime economic and financial analysis comparing overall costs with related energy impacts in alternative scenarios.
A real world design and social experimentation has been activated. It constitutes the Case Study concerning the fostering-up of an <Sustainable Urban District> in an already existing large urban neighborhood including 6.400 residents in a surface of 490.000 m^2, 125 urban blocks, 840 buildings, 800.000 m^2 of apartments.
First results of experimentation show a possible annual energy reduction around 50% in building management and a consequent total saving of 33 millions kWh per year in the Case Study neighborhood, as positive effect of sustainable urban rehabilitation interventions, just for winter heating. Research future frontier would be the increase of energy saving by experimenting summer air-conditioning with water chillers powered by the sun and solar cooling.

Keywords: 1. New Sustainable Urbanism; 2. Urban 3D GIS; 3. decentralized energy-saving investment; 4. building energy interventions; 5. renewable sources

1. BACKGROUND

States and international organizations are aware of Earth environmental emergency, as well as of urban ecological and energy crisis. One causal factor among several is the disinvestment of existing settlements and the migration of high percentage of rural population to megalopolis where consequent is the urbanization of all available rural land surrounding original built areas and the increase of energy consumption.

Communities and territories are addressed to treasure and re-use the consolidated settlements, not to abandon them, and therefore to save the open and arable land surrounding metropolis and megalopolis, by means of: revitalization of economy in historic towns and villages; physical rehabilitation following their economic revamping; restoration and retrofitting interventions, characterized by ecological and cultural sustainability, over the wide heritage; energy rehabilitation of buildings; adoption of renewable energy sources for decentralized energy production that make local communities energy independent and, as much as possible, self-sufficient.

2. GENERAL OBJECTIVE OF THE RESEARCH

General objective of the research is to design and assess the potential relationship between urban rehabilitation strategies and building energy efficiency within a the Green Building framework and to introduce Sustainable Conservation at urban level. This is by setting-up design of strategies alternative to present inefficient *status quo* in city energy management and innovative <Green Urban Conservation> good practices at large scale supported by geographic information systems.

Furthermore, research aims to set-up a general methodological and valuation framework that might be employed in different contexts, places and situations.

Research deals with New Sustainable Urbanism, specifically faces and confronts the emergency of the growing energy consumption in human settlements, particularly in urban areas.

Research investigates the possible global solution to the inefficient thermal behavior of buildings as well as to the excessive civil energy consumption, caused in particular by the growing use of devastating summer air-conditioning units in hot climate countries.

Research has built-up a connection between urban rehabilitation strategies and building energy efficiency by integrating several elements within a GIS framework: 3D city modeling; design for a Green City; cost estimate for Green City investments; valuation of energy yearly demanded; comparison with the *status quo* scenario; economic analysis over time of operating costs of alternative scenarios; comparative ecological impact analysis of alternative scenarios.

This program is divided into specific steps: from the climatic-energy behavior enhancement of single buildings to the generalization of the interventions at urban scale.

Impacts of the actions should be:

1) **insulation** for structural and forever energy saving *i.e.* thermal “passivation” of existing buildings and hydro, humidity and moisture regulation (perspiration) of constructions;

2) consequent sizeable **reduction of energy consumption** for both winter heating and (more important) devastating summer air-conditioning in the existing buildings;

3) **energy production** (decentralized) by means of solar photovoltaic and thermal panels at building and urban block level;

4) **latest scientific innovations** of solar cooling or\and sun engined water chiller system that finally make possible to produce the today high costly summer air-conditioning from the sun;
5) **reduction of CO_2 emissions**;
6) **curb of total cost** to be assessed over-time, in environmental terms (by summing up all the avoided pollutants), energy term (by summing-up the avoided kWh, *i.e.* not employed) and in monetary terms by summing-up all financial savings including the new interesting monetization (even too low) by European Union that equalizes 30 Euros per ton of CO_2.
To test the methodology, research has developed a Case Study, concerning a Mediterranean region located in South Italy, and its largest town of Reggio Calabria (172.000 inhabitants at 2001) by simulating a <sustainable neighborhood>, i.e. an <urban energy district> in a city quarter of: 6.400 residents; 490.000 m^2 of quarter surface; 125 urban blocks; 840 buildings; 2.500.000 m^3 of constructions; 800.000 m^2 of apartments

3. FIRST OUTPUTS

First outputs of the research, generalized to the entire neighborhood thanks to GIS tools, show a reasonable and interesting time of pay-back of the initial monetary premium of the investment finalized to structural and forever energy saving by ecological insulation and bio-passivation. The premium is largely due to the higher cost of sustainable conservation and to the related better quality of techniques and bio-ecological materials employed, if compared with the ones commonly used in ordinary refurbishment yards.
The higher initial intervention costs are set-back and counterbalanced by a dramatic reduction of the yearly energy management costs due to rehabilitation interventions able to produce high energy efficiency.
First outputs show also a potential grand total energy saving of 33 millions of kWh per year in the entire neighborhood thanks to sustainable urban conservation interventions.
In addition, thermal passivation is integrated with the newest technologies for decentralized energy production from renewable sources such as the solar panels (photovoltaic; solar cooling; sun chiller system) for both winter heating and summer air-conditioning.

4. ALTERNATIVE SCENARIOS OF INTERVENTION: SUSTAINABLE *VERSUS* UN-SUSTAINABLE

As introduced above, research highlights the possibility to intervene on the same kind of decay with alternative approaches (comparative scenarios technique).

Present state scenario
Status quo, do-nothing.

Sustainable scenario
Conservative and high energy efficient, designs and adopts ecological materials to reduce heat dispersion toward the outdoor as well as to cut fossil fuels consumption for heating and conditioning and consequently to lower down CO_2 emissions.
In the case of sustainable scenario: plaster renovation of external wall coating for insulation makes use of “volcalite”, *i.e.* mortar made of natural hydraulic lime (clinker-

cement free) with special inert elements highly insulating, such as pumice, perlite and expanded vermiculite; roof sealing and waterproofing renovation adopts natural perspiring membranes with aerating, ventilating and insulating groove panels made of natural materials such as fluted cork; transparent surfaces with single glass are replaced by double ones with air space.
The physical characteristics of natural hydraulic "volcalite" mortar, designed and used in the sustainable scenario, do not allow the passage of heat through masonry and reinforced concrete and consequently thermal bridges are always reduced, often mitigated and sometime neutralized. During cold winter time, this kind of building material keeps the masonry average temperature high as well as that of the internal walls, insulating and in so doing fostering energy saving and a better indoor quality. Cork then, thanks to its physical characteristics has a high elasticity, it is an excellent thermal and acoustic insulator, it has a high resistance to wear, fire, rats and insects, and it is also perspiring and steam permeable. A special form with groove in the upper part of the panel makes it possible to lower the roof floor temperature during the hot sub-Saharan summer of low Mediterranean cities, by allowing air circulation.

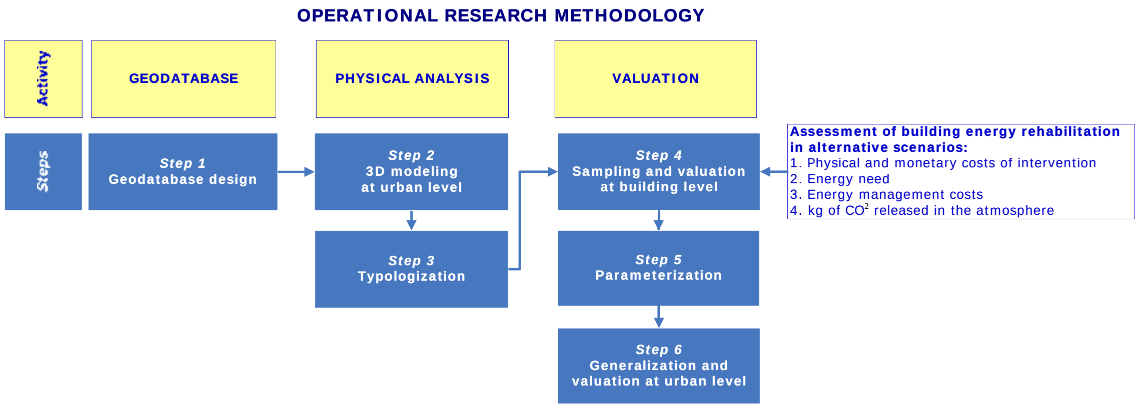
Un-sustainable scenario
Designs and employs popular materials commonly used in ordinary construction yards, characterized by poor thermal behavior and insulating characteristics that sometimes make worse and worse the energy dispersion compared to the *status quo ante*. These materials are on one side cheaper and easier to install, but on the other side they do not help neither building efficiency nor city energy management because the do not have good thermal and low insulating characteristics. To this list belong: mortars made only of sand and cement with a high level of transmittance, applied to vertical surfaces; epossidic membrane without neither any insulating nor perspiring characteristics, in substitution of the old natural asphalt for roofs and balconies waterproofing; single glasses; highly emissive, not-ecological and inefficient metals (aluminum) for doors and windows.

5. OPERATIONAL RESEARCH METHODOLOGY

The global system framework has been set-up, tested in the Case Study and articulated in some main activities such as:

- <Geodatabase> activity *i.e.* design of a dedicated geographic information system;
- <Physical Analysis> activity *i.e.* geometrical modeling and urban 3D information system: 3D; typologization;
- <Valuation> activity *i.e.* behavioral modeling and integrated energy-economic-ecological analysis: sampling; parameterization; generalization.

The intersection of the outputs derived from the different activities make it possible to achieve one of the goal of the research *i.e.* to calculate the rehabilitation costs as well as the energy management costs at single building level, and to generalize the results at the uncommon valuation level of neighborhood and entire urban areas.
Strategy implementation aims to redirect the ordinary maintenance works toward building passivation with specific interventions involving external plaster and roof renovation, natural ventilation and insulation in an original way that allow the works to be done only in the exterior avoiding any resident moving.
The above summarized implementation process is therefore articulated in the steps of the following operational methodology drew-up in the Flow Chart.



Geodatabase
Step 1. Geodatabase design.

Physical Analysis
Step 2. 3D Modeling at urban level.
Step 3. Typologization.

Valuation
Step 4. Sampling and valuation at building level.
Step 5. Parameterization.
Step 6. Generalization and valuation at urban level.

The progressive levels of detail of the steps are described below.

GEODATABASE

Step 1. "Geodatabase design"

It consists in the design of the tailored and dedicated information system and creation of feature classes, tables, fields, relationship classes, raster datasets, subtypes, topologies, domains.

The Geodatabase is the fundamental structure where all the various kind of data (raster; vector; alphanumeric; others) coming from the different steps in which the research has been divided, will be stored, organized, processed and managed.

PHYSICAL ANALYSIS

Step 2. "3D modeling at urban level"

It is sub-divided in two sub-steps: terrain 3D model; building 3D model.

Sub-Step 2.1. "Terrain 3D Model"

Focus is the representation of the Case Study area within a Geographic information system (GIS) in order to calculate the exact extension of the territory of potential intervention and mostly to generate a realistic terrain 3D model. Then, data collection is performed to get precious cartographic maps in raster and vector format, crucial to create the 3D model of the Case Study area. These pieces of information are georeferenced, allowing to create the Triangular Irregular Network (TIN) of the Study Area *i.e.* the 3D terrain model. It represents the basis for all the following quantitative and valuation analyses.

Sub-Step 2.2. "Building 3D Model"

It makes it possible, with growing details and according to the characteristics of each specific step, to know in quantitative terms for the entire city area: built surface; m^3 of buildings; m^2 of external wall coating for insulation; m^2 of flat\pitched roofs; other pieces of information such as m^2 of built unit surface (*i.e.* apartments). These data are finalized to the analytic assessment of rehabilitation costs and energy need of the buildings and the generalization at city scale.

A) "First vector 3D model by extruding the footprints"

It employs georeferenced official vector maps from aerial derivation along with their alphanumeric information. These data, imported into the dedicated Geographic information system, make it possible to draw buildings as generic parallelepipeds by extruding their footprints (ArcGIS®, GoogleSketchUp®). Volumes are then calculated multiplying the built area by the height of each single building (ArcGIS®).

Hard and time consuming is the 3D realistic modeling of the roofs (GoogleSketchUp®). The coverings are then positioned over the parallelepipeds and their volumes are calculated (m^3) by means of allied software.

B) "Quick survey on the field"

The official vector maps and data used to generate the "first vector 3D model" are double-checked performing a "quick survey on the field", in order to verify the general dimensions of buildings, such as: width; height; number of floors; number of windows; covering; other pieces of information useful to better represent each single building. It follows the data entry and calculation within the information system, previously designed and built, of the quantitative data of the buildings.

C) "Photo-realistic 3D modeling of buildings completing the previous vector 3D"

Data derived from official maps are intersected with the information obtained with the "quick survey on the field survey", in order to: represent more accurately each buildings *i.e.* the first vector 3D model; refine the connected quantitative data. Goal is achieved by means of the following sub-steps: photo campaign; 3D modeling of single buildings in a most deepened and detailed way (GoogleSketchUp®); metric photo texturing of buildings (Adobe Photoshop®; GoogleSketchUp®); import in GIS environment *i.e.* in the Geodatabase of the buildings as multipatch feature class; alignment of the multipatch feature classes fields; data entry.

D) "Second vector 3D modeling of buildings from field survey"

The physical representation obtained during the previous steps is deepened, starting from sample buildings (significant in terms of architectural typology and value). In fact, the third step represents the most advanced and accurate representation, more time consuming and energy demanding of the <Physical Analysis> activity: buildings are here represented with their most accurate details thanks to a direct survey finalized to the analytic assessment of rehabilitation costs and energy need.

Step 3. "Typologization"

"Typologization" divides the built environment in typologies on the basis of architectural characteristics. Given the purpose to apply the operational methodology at city level, four prevailing building typologies have been detected within the Case Study Area: Historicist\Neoclassical; Rationalist; speculative; other.

Table 1. Principal building typologies in the Study Area

Typology 1 (NEO)	Buildings of the post-earthquake Reconstruction dating around 1911-1939 and belonging to the Ente Edilizio or to private owners, with Historicist and Neoclassical architectures.
Typology 2 (LIB)	Liberty architectures of 1918-1939.
Typology 3 (RAZ)	Italian Rationalist architectures of 1930-1950.
Typology 4 (SPECUL)	Multi-storey speculative constructions built after the Royal Decree 22.11.1937, n. 2015, with reinforced concrete structure, without collaborating masonry.
Typology 5 (TIP)	All the other as well as special buildings not belonging to none of the previous typologies.

VALUATION

Step 4. "Sampling and valuation at building level"

"Sampling and valuation at building level" selects representative buildings of each typology within the Study Area. At first, for each of them it performs:

– accurate and detailed geometric survey on the field;
– documentation with data archive mining;
– decays and cracks analysis;
– census and list of needed interventions.

Afterwards, for each alternative scenario (present state *i.e. status quo*; sustainable; un-sustainable) the following analyses are designed, simulated and valuated:

- valuation of the physical and monetary costs of intervention of rehabilitation by means of Elemental Factor Analysis (Price Analysis), in alternative scenarios;
- assessment of the energy need and efficiency (kWh), in alternative scenarios;
- valuation of the energy management costs, in alternative scenarios;
- CO_2 released in the atmosphere, in alternative scenarios;
- financial assessment overtime.

Cost assessment of intervention on each building represented by AutoCad®, GoogleSketchUp®, ArcGIS®, PAUGis software® is particularly detailed and it is based on the Elemental Factor Analysis (Price Analysis).
Calculation and estimate of the energy need of buildings is highly detailed, and performed by adopting and comparing different approaches (and related software) of physical-technical calculus (Termo4®; Docet®; BestClass®).
The comparison between the energy need expressed in kWh of the present state, derived from direct analyses, and the correspondent of the rehabilitated buildings makes it possible to obtain the potential differential *i.e.* the energy saving in terms of total kWh, of Euros for family budgets, and last but not least kilograms of CO_2 avoided and not released in the atmosphere, thanks to the climatic rehabilitation.

Step 5. "Parameterization"
"Parameterization" allows to derive parametric data of bio-architectural rehabilitation costs and energy need, starting from the sample buildings chosen and analyzed as prototypes.
Therefore, the "parameterization", when already derived, is used as a feedback tool to perform quick ex-ante valuation and to know the size of both rehabilitation costs and energy need of the buildings in the different scenarios: present state; sustainable; un-sustainable.
Thanks to the results achieved during the "Sampling" step, it is possible to calculate quickly per each sample building: cost per m^2 of front renovation and roof insulation in each typology and for each scenario; energy need per m^2 in each typology and for each scenario before and after works.
These parametric data included in the Geodatabase allow to:
- estimate **for each building** the intervention costs of the energy rehabilitation;
- quantify **for each building** the energy need in each scenario;
- quantify **for each building** the energy saving per year;
- estimate **for each building** the times of the financial pay-back of the higher monetary premium due to the sustainable intervention of energy passivation of buildings;
- assess for each building the avoided kilograms of CO_2 released in the atmosphere.

Step 6. "Generalization and valuation at urban level"
"Generalization and valuation at urban level" calculates the total size of the interventions and assesses their impacts in different scenarios at the uncommon valuation scale of city level. Single parametric data of intervention cost (€) and energy saving (kWh) are multiplied by the quantitative physical data. Then, the assessment at block, neighborhood, and then at city level is achieved.
It allows to know the size of: total costs for thermal passivation of buildings; energy management; ecological effects in terms of CO_2.
Results are summed up providing the costs for both the physical intervention and the energy management of the specific building typology and therefore for the entire neighborhood.
The system allows to:
- estimate **at sustainable neighborhood level** the intervention costs of the energy rehabilitation:
- quantify **at sustainable neighborhood level** the energy need in each scenario.
- quantify **at sustainable neighborhood level** the energy saving per year;
- estimate **at sustainable neighborhood level** the times of the financial pay-back of the higher monetary premium due to the sustainable intervention of energy passivation of buildings;
- assess **at sustainable neighborhood** the avoided kilograms of CO_2 released in the atmosphere.

6. REAL WORLD "SUSTAINABLE NEIGHBORHOOD" DESIGN AND ESTIMATE

New wider eco-urban approach as well as GIS strategic support have been deployed and employed in a real world design and social experimentation, constituting the Case Study,

concerning the fostering-up of an <Ecological Urban District> in an already existing urban area.
Case Study is localized in Reggio Calabria (Italy), in the Northern part of its Liberty reconstruction re-built after the earthquake and subsequent tsunami of 1908.
At present time this area or neighborhood is largely inhabited by university students of four University Schools (Architecture; Engineering; Agriculture; Law) and it has been named "Latin Quarter" *i.e.* "neighborhood surrounding University location". It has been chosen as area of Case Study finalized to design a potential <sustainable neighborhood>.
The neighborhood has been usefully mapped into GIS giving the impressive and sensible extension of: *480.000 m^2 of surface; 125 urban blocks; 840 buildings distributed covering a built surface of 208.000 m^2 with 2.500.000 m^3 of built area; over 400.000 m^2 of fronts to be insulated; about 180.000 m^2 of <black flat roofs> to be aerated-ventilated and insulated; a population of 6.400 residents, plus thousands of University Students living there as non-resident renting rooms and flats privately and unofficially during the academic year.*
Urban Sustainability interventions for the real world Case Study (especially insulation with natural materials) have been designed and valuated in their environmental and energy impacts. Natural insulation and ventilation reduce dramatically the needs and energy consumption for winter heating as well as for more demanding summer air conditioning. Impressive is also the amount of avoided kg and costs of CO_2.
The approach might be applied to different contexts in many cities in the world.

7. BUILDING PROTOTYPE: EXAMPLE FROM REAL WORLD

The real world plan at neighborhood scale has been implemented in a prototype building through a real world construction yard, doing a real "passivation" work.
The reconstruction of Reggio Calabria after the earthquake of 1908 is characterized by high and great urban qualities, among which the most important is represented by its urban pattern with streets and avenues converging in public squares.
Main and peculiar characteristic of Reggio Calabria is the small dimension of its Urban Blocks (about 50x50 meters), and therefore the average footprint is around 2.500 square meters. Among the positive effects of this exemplar pattern there is a richness in articulation of urban spaces and a consequent high street density.
After over seventy years, the most prominent guru and reviews of Architecture re-discovered the quality of the above pattern and this framework is now one pillar of the New Urbanism international movement.
The building prototype Urban Block #128 named Palazzo De Mojà after its designer, includes four main buildings and is located inside the Latin Quarter on the continuation of the Corso Garibaldi (the main street of Reggio Calabria). It was built between 1935 and 1939, and stylistically belongs to the Italian Rationalist architectures. Today this building is the seat of the Regional Court of Administrative Law Judges.
A Global Maintenance Program for Urban Block #128 according to the principles of New Urbanism has been designed. It consisted in: ecological insulation and aeration of the pitched roof by adopting lis natural cork; *restitutio ad integrum* of interiors according to the original identity (loyalty to the original drawings and materials) and spatiality of the project; adoption of bio-ecological materials to improve the healthiness of the building.
The core of the intervention has been the energy rehabilitation of the New Court Room, covered with 15 elegant trusses made of local conifer wood that with its 20x12 meter was the area of higher heat and cold dispersion. Therefore, it has been designed and done a sustainable intervention of energy rehabilitation by introducing in the roof covering,

beside and over the natural perspiring membrane, an insulating and ventilating material *i.e.* the natural cork.
It followed a huge energy saving, and the yearly annual energy consumption (*i.e.* the Primary Energy Need) is reduced by over 50% only with this intervention: from 91,14 kWh/m^2 to only 42,50 kWh/m^2, just for winter heating. Not considering the great saving due to more expensive summer air-conditioning. The first positive effect is a considerable reduction of the energy management costs. Now the building is monitored by temperature data loggers to control the effect of insulation ventilation upon internal temperature constantly compared to external temperature.

8. FIRST RESULTS

Strategy implementation aims to redirect the ordinary maintenance works toward building passivation with specific interventions consisting in external plaster and roof renovation including winter insulation as well as summer natural ventilation.
By operating a generalization in the Case Study area, it is at first considered the passivation of vertical surfaces of 400 buildings (50% of existing), with thermal-insulating plaster made of mortar composed by natural hydraulic lime and inert and optimal insulators such as pumice, perlite and expanded vermiculite. It can be foreseen a cycle of only six or eight years for the completion of a program of 400.000 m^2, 1.000 m^2 per building and an average of 82 m of perimeter and 12 m of height. By considering the thermal-insulation and ventilation of roofs it is estimated a work of 180.000 m^2.
The hypothesis of front passivation for 400.000 m^2, for a maximum cost of €\ m^2 80 determines a potential minimum investment of € 50.000 per building and of € 32.000.000 for the entire neighborhood. By hypothesizing the insulation and ventilation of roofs for 180.000 m^2 with aerating natural cork for a cost of €\ m^2 60 it is possible to quantify the total investment of € 10.800.000.
It follows that the **total cost of passivation for the 50% neighborhood is € 42.800.000**.
These expenses are shortly recovered by the owners of single housing with annual installments constituted by the substantial saving on energy bill, before described and quantified.
The existing total built volumes, assessed by means of the built geographic information system, are 2.500.000 m^3. By considering an average height per unit of 3 m, it is possible to give a first estimate of the built unit surface in the entire neighborhood of about 830.000 m^2 to be managed on energy side.
Sample analyses performed on the different building typologies have shown with reference to the present state an average theoretical energy need per m^2 during one year (the so-called FEP) of 100 kWh\ m^2. By multiplying this parametric data for the total m^2 of all buildings it can be obtained a first rough result of the **total energy need for the entire neighborhood** of about **83.000.000 of kWh per year**. Considering an average cost of energy of 0,15 €\kWh it can be obtained a **total expenses of energy management of about € 12.450.000 per year**.
Research, field work, yard observations, as well as specific experimentations performed on the sample prototypal buildings, assuming an intervention of sustainable energy rehabilitation, have highlighted an average reduction of 40% of the theoretical amount of energy need. Considering the average cost of 0,15€/kWh it can be obtained a smaller total expense per year for energy management of about € 7.500.000
The energy need of the sustainable scenario is likely to be reduced to 50.000.000 kWh every year *i.e.* 50.000 MWh. The total physical differential is therefore equal to

33.000.000 kWh (*i.e.* 33.000 MWh) not consumed and the consequent monetary amount of **year energy saving** is of **€ 4.950.000 (33.000.000 kWh x 0,15 €\kWh)**.
Considering a total saving of passivation equal to € 4.950.000 per year, the correspondent **payback** can be assessed in about **10-11 years**, at steady rate of 4% .

Table 1. Energy rehabilitation of the entire Latin Quarter. Energy consumption in two alternative scenarios and economic pay-back of the passivation costs (assessed 42.800.000 €) in 10-11 years. i=4%

	Yearly Cost of Energy Consumption		Rate i=4%	Actualized Value of Energy Consumption		Balance	
(1) Years	**(2) Status Quo** € *x1000*	**(3) Sustain Scenario** € *x1000*	**(4) Actualiz Coeff** *(1+i)-n*	**(5) Status Quo** € *x1.000*	**(6) Sustain Scenario** € *x1.000*	**(7) Saving** € *x1.000*	**(8) Saving Sub-total** € *x1.000*
						(7)=(5)-(6)	
1	12.450	7.500	0,9615	11.970	7.211	4.759	4.759
2	12.450	7.500	0,9245	11.510	6.933	4.576	9.335
3	12.450	7.500	0,8889	11.066	6.666	4.400	13.735
4	12.450	7.500	0,8518	10.604	6.388	4.216	17.952
5	12.450	7.500	0,8219	10.232	6.164	4.068	22.020
6	12.450	7.500	0,7903	9.839	5.927	3.911	25.932
7	12.450	7.500	0,7599	9.460	5.699	3.761	29.694
8	12.450	7.500	0,7306	9.095	5.479	3.616	33.310
9	12.450	7.500	0,7025	8.746	5.268	3.477	36.787
10	**12.450**	**7.500**	**0,6755**	**8.409**	**5.066**	**3.343**	**40.131**
11	**12.450**	**7.500**	**0,6495**	**8.086**	**4.871**	**3.215**	**43.346**
12	12.450	7.500	0,6245	7.775	4.683	3.091	46.437
13	12.450	7.500	0,6005	7.476	4.503	2.972	49.410
14	12.450	7.500	0,5774	7.188	4.330	2.858	52.268
15	12.450	7.500	0,5552	6.912	4.164	2.748	55.016
16	12.450	7.500	0,5339	6.647	4.004	2.642	57.659
17	12.450	7.500	0,5133	6.390	3.849	2.540	60.200
18	12.450	7.500	0,4936	6.145	3.702	2.443	62.643
19	12.450	7.500	0,4716	5.871	3.537	2.334	64.978
20	12.450	7.500	0,4563	5.680	3.422	2.258	**67.236**
Tot				**169.110**	**101.874**	**67.236**	

Last but not least, the production of a MWh of energy by burning oil releases into the atmosphere about 255 kg\MWh of CO_2. An intervention at neighborhood level, besides a monetary saving of € 5.000.000 per year, with 33.000.000 kWh less every year, produces an ecological benefit of **CO_2 yearly not released in the atmosphere equal to 8.415.000 Kg (8.415 ton) of CO_2 per year**. The economic values of this “avoided damage” can be compared to the cost of international Carbon Capture Storage (CSS) of the same CO_2 amount summed-up to realize saving, expressed by the “avoided energy expenses”.
To this preliminary valuation will be added the extraordinary saving achievable by the summer air-conditioning, which results will be edited in the next-near future.

9. CONCLUSIONS

The experimented research strategy allows to set-up a large scale plan to enforce Urban Sustainability policy and to achieve the objectives and goals of energy saving programs.
The operational methodology allows to: precisely quantify and estimate the general urban plan for energy saving; reduce the necessary times of investigations; provide guidelines to households, Society and to local Governments on the possible results achievable by large urban scale interventions; derive keystone prototype data.
In fact, in the specific research here presented the articulation of buildings per typologies has allowed, by surveying and studying carefully a limited number of paradigmatic

prototype and sample buildings, to obtain reliable results in a reasonable time, to employ less activity, to reduce the costs for the analyses, estimate, assessment and design.
At the end, besides the most relevant outcomes above cited, research has achieved the possibility to: sort out parametric costs and energy data; develop subsequent cross-analysis thanks to the build-up of a Geodatabase within a geographic information system; deepen the assessment for entire urban areas.
All the created data, collected information, performed analyses, are crystallized safely in a stable, querying, flexible and open system.
Finally, intervention simulation in the Case Study area shows that with the building passivation strategy it is possible to achieve an energy saving of 33 million of kWh in the neighborhood, by analyzing just winter heating, taking into account that impact on demanding summer air-conditioning will produce even more benefits.
A real world yard in a prototype real world building tested the methodology, and confirmed the previous performed valuation.

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AUTHOR INFORMATION

Domenico E. MASSIMO
PAU GIS, Geomatics and GIS Group, Department # 1 Architectural and Urban Patrimony (PAU), *Mediterranean* University of Reggio Calabria, Italy

Address
Dep. PAU, 25 Via Melissari, 89124 Reggio Calabria, Italy

Contact information [Rome time]
+39.360.997513 (mobile); massimo@unirc.it; massimo04@unirc.it

Additional contact information [Rome time]
+39.0965.385228 (University Office); 0039.331.6279.568 (mobile); +39.0965.385222 (fax); paugis@unirc.it

SHORT BIOGRAPHY

Domenico Enrico MASSIMO is Associate Professor of Urban Appraisal at *Mediterranean* University of Reggio Calabria, Italy.

Since 1995, he is member of PAU Department # 1 (Architectural and Urban Patrimony).

Since 1995, he has been Faculty member in the Graduate Programs in Environmental and Historic Preservation in both Master and Ph.D. levels.

He is 2008-2010 Research Affiliate of the Department of Urban Studies and Planning at Massachusetts Institute of Technology (MIT) in Cambridge, Ma, Usa.

Since 1999, he has been teaching Urban Appraisal, Economics of Project Evaluation, Environmental Appraisal and Economics, Sustainability Valuation at the School of Architecture in the following Graduate and Undergraduate Programs: Environmental and Historic Preservation; Architecture; Construction Management; Urban and Regional Planning.

Since 1995, his institutional research in Appraisal and Valuation has been focused on: urban sustainability enhancement and energy optimization of existing buildings and districts; cultural (urban, architectural, archaeological, historic, artistic, folk) and environmental (landscape, natural, bio-ecological) heritage total census and account, also helped by GIS; project monetary and non-monetary evaluation by the mean of appraisal methods as well as ordinal multi-dimensional assessment approaches linked to GIS tools; heritage treasuring for local economic development; real estate market analysis.

Before, he has been trained from 1988 to 1992 as research fellow at MIT, Department of Urban Studies and Planning and Department of Economics in the joint Special Program in Urban and Regional Studies (Spurs) with Prof. Karen R. POLENSKE and Prof. Jerome ROTHENBERG, and at Northeastern University (Boston, Ma, Usa), Department of Economics with Prof. Gustav SHACHTER and Prof. Gregory H. WASSALL.

He has: Master of Art in Architecture (1986, University of Rome, Italy); SPURS Diploma in Urban and Regional Studies (1991, MIT, Cambridge, Ma, Usa); Doctorate in Territorial Planning (1991, University of Reggio Calabria, Italy); Master of Science in Economic Planning (1992, Northeastern University, Boston, Ma, Usa).

He studied environmental analysis at Harvard University (Cambridge, Ma, Usa, 1990-1991: Carpenter Center for Environmental Studies; Harvard School of Public Health) and professional ESL at Boston University and Berkeley College of Music (Boston, Ma, Usa, 1997-1998).

Since 1995, he has authored about one hundred of: published articles; book chapters; papers presented at international and national referred scientific conferences; research reports.

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FIGURES

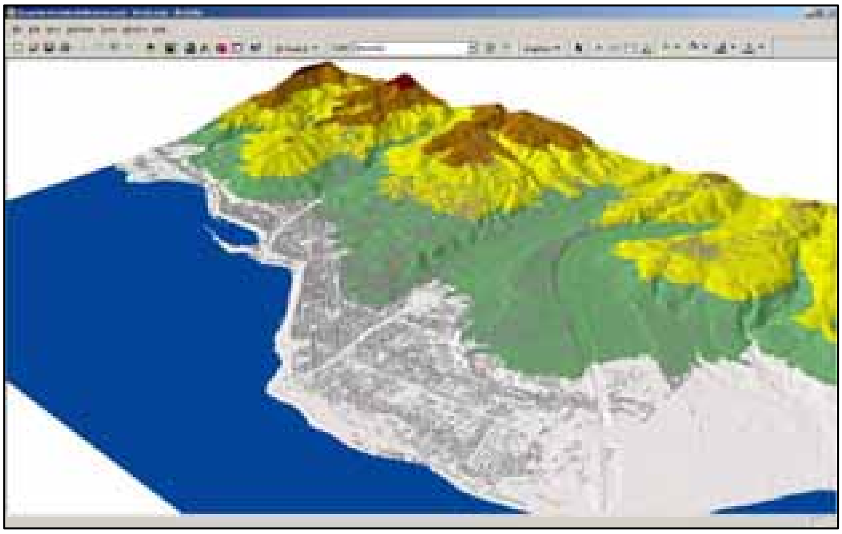

Figure 1. Case Study, Reggio Calabria, Italy. Geometrical modeling of urban spaces. Large scale 3D terrain model

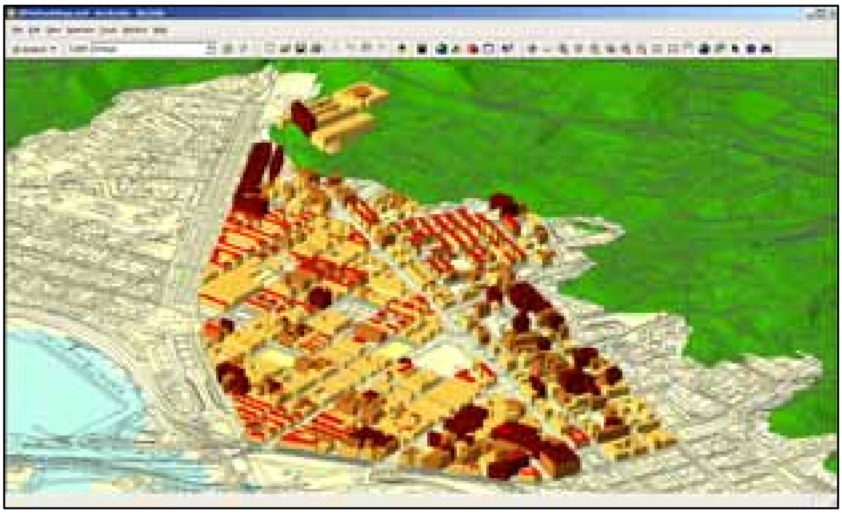

Figure 2. Case Study, Reggio Calabria, Italy. Latin Quartier. Geometrical modeling of urban spaces. Urban scale 3D city model. “First 3D modeling at urban level”

Figure 3. Case Study, Reggio Calabria, Italy. Latin Quartier. Example of Rationalist Architectures: 1) National Museum; II World War “Casa del Mutilato di Guerra”; 3) Regional Court of Administrative Law Judges, i.e.

Figure 4. Case Study, Reggio Calabria, Italy. Geometrical modeling of urban spaces. Block scale 3D city model. "Photo-realistic 3D modeling of buildings from field survey". Sample: urban block #128

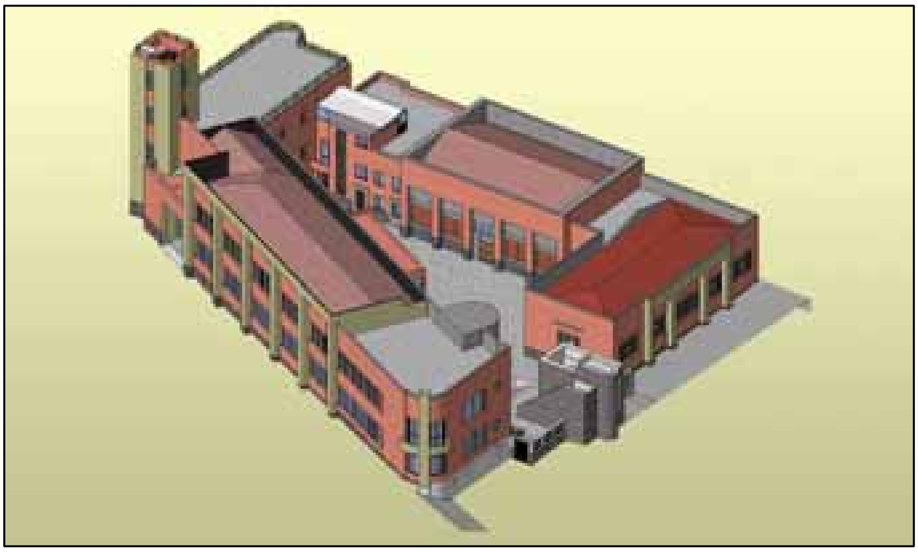

Figure 5. Case Study, Reggio Calabria, Italy. Geometrical modeling of urban spaces. Building scale 3D city model. "Photo-realistic 3D modeling of buildings from field survey". Buildings prototype: Urban Block #128

Figure 6. Case Study, Reggio Calabria, Italy. Building prototype: Urban Block #128. Example of insulated and ventilated roof thanks to natural cork lis for energy saving ©LIS

Figure 7-8-9. Case Study, Reggio Calabria, Italy. Buildings prototype: Urban Block #128. *Chantier* for real world implementation with adoption of bio-ecological cork

Figure 10-11-12. Case Study, Reggio Calabria, Italy. S Buildings prototype: Urban Block #128. From top: interior design; design done; immediate re-use of sustainable Court Room