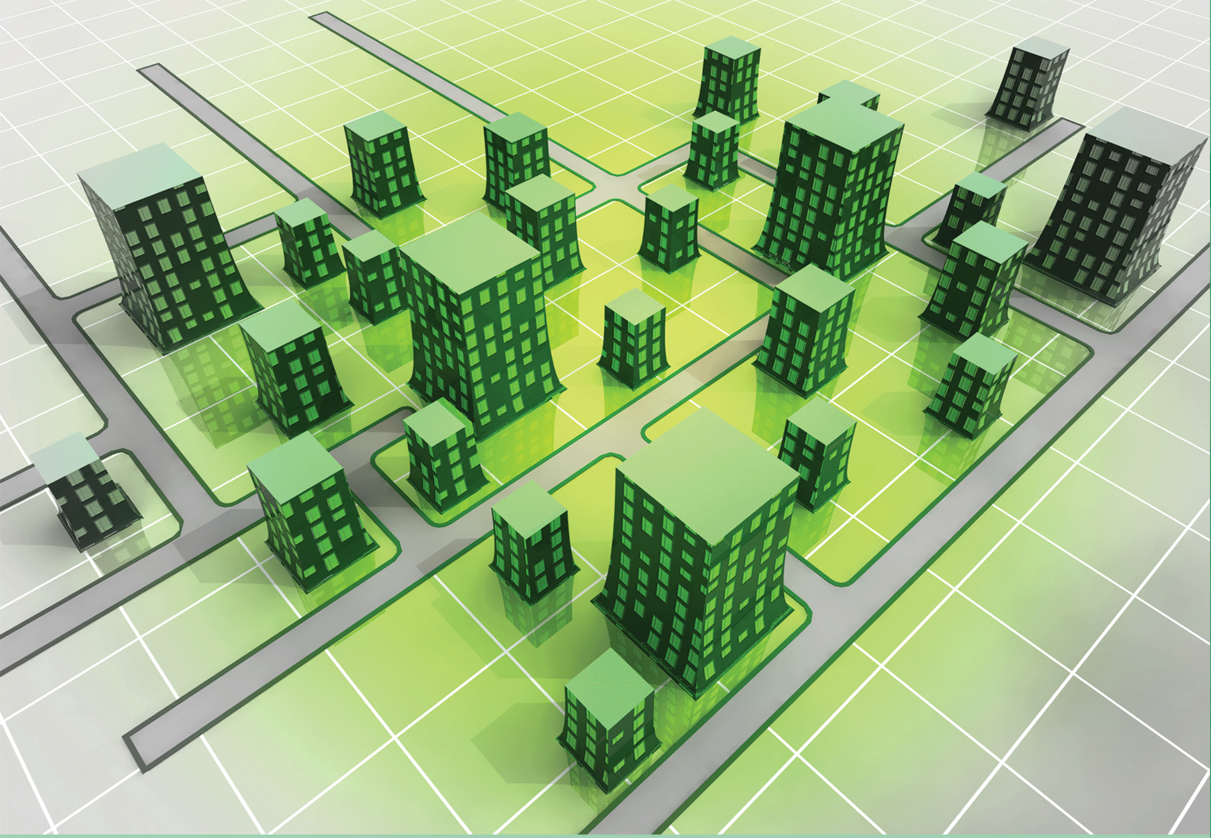

Sustainable Places 2015

Conference Proceedings

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Foreword

Sustainable Places 2016 is the third edition of a successful event that brings together the stakeholders of Energy Efficiency of Built Environment innovation in Europe. The conference is committed to support all players of the Energy Efficiency field, in their clustering and dissemination activities. The event features a strong and sustained relationship with the projects funded by the European Commission under the FP7 and H2020 frameworks, with a particular dedication to those that develop under the umbrella of the Energy Efficient Building Public-Private Partnership.

The need to enhance the sustainability of places – buildings, neighbourhoods, cities – where we live, work and have leisure, is now acknowledged as one of the top contemporary societal concerns. Enabling sustainable places requires a major breakthrough that encompasses many dimensions: evoluting regulatory and policy frameworks, increasing business incentivization, fostering technology innovation and assessing societal impact. The recognition of the multiple dimensions of the issue is at the very heart of the Sustainable Places initiative. The aim at the beginning, back in 2012, was to foster inter-disciplinary dialog between the stakeholders, and in particular to support cross-fertilization between downstream business-oriented innovation and upstream technology-oriented research.

Indeed, in the area of technology innovation, the gap between research and market is often referred to as "Death Valley". It maps roughly to the Technology Readiness Levels (TRL) 4 to 6, i.e. the level at which a prototype has been developed, but has only been experimented in limited scales - wider field deployment and business-oriented technology sharpening is still needed to address market's needs. The need to devote great effort to this gap and bridge it is widely shared, in particular in the H2020 program that puts an emphasis on so-called "Innovation Actions".

Sustainable Places simply aims at being one (among many others) component of this innovation gap-bridging strategy at European level. Bringing together researchers from multiple areas, business stakeholders, local authorities, enabling for projects clustering and sharing market insights, performing wider dissemination of the European knowledge - in a few words, to enable an open, fruitful and constructive dialog – is the main objective of the conference.

This year's edition is particularly attractive, with a large audience (more than 150 registrations) from key on-going European projects, high-profile keynote speakers from diverse backgrounds (industry, research, SME), a wide thematic spectrum (from building energy modelling to district-level energy management), and - last but not least – an outstanding venue (Savona, on the Mediterranean coast)!

The BIM-GIS model for EeBs integrated in healthcare districts: an Italian case study

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Abstract

STREAMER is an industry-driven collaborative research project on Energy-efficient Buildings (EeB) which aims to reduce, using optimised Semantics-driven Design methods and interoperable tools for Building and Geo Information Modelling (BIM–GIS), the energy use and carbon emission of healthcare districts in the EU by 50% in the next 10 years (http://www.streamer-project.eu).
The paper summarizes the developing of a prototype Semantic BIM-GIS model based on the information from the Azienda Ospedaliero-Universitaria Careggi of Florence (AOUC), one of the four healthcare districts that will be used as the main platforms to demonstrate and validate STREAMER's design methods, tools and EeB technological innovations.
The paper deals with the documentation focusing on the project description, outlined planning, requirements, typology model/master plan, and it includes a conceptual building design in open-BIM format The result of this work is the elaboration of a first draft of the BIM model of the use case containing a data deriving from the classification of all the elements regarding the MEP systems and building space and envelope, and on the layout obtained during a desk and field survey carried out on the chosen pilot site building.

Keywords

Healthcare Districts, Energy Efficiency Building, BIM

Introduction

STREAMER is an industry-driven collaborative research project on Energy-efficient Buildings (EeB) with cases of mixed-use healthcare districts.

The main aim of STREAMER is to reduce the energy use and carbon emission of healthcare districts in the EU by 50% in the next 10 years by enabling clients, architects, technical designers, contractors, building operators and occupants to design new and retrofitted energy-efficient buildings integrated in the healthcare district energy systems using optimised Semantics-driven Design methods and interoperable tools for Building and Geo Information Modelling (BIM–GIS).

This paper summarizes the developing of a prototype Semantic BIM-GIS model based on the information from the Italian demonstration project: the Azienda Ospedaliero-Universitaria Careggi of Florence (AOUC), one of the four healthcare districts that will be used as the main platforms to demonstrate and validate STREAMER's design methods, tools and EeB technological innovations.

The nature of the information required depends on the purpose of the case study, practical validation and demonstration. Considering the planning of future interventions on the estate, the AOUC has chosen to use the oncology center named "San Luca", which consists of three buildings, as the case study for validating the research results. Within the plan for the new Careggi, the "San Luca" becomes the key area for the demolition and reconstruction interventions in order to release space to accommodate new buildings.

The oldest of the three buildings, the "San Luca Vecchio", has been built in the 60' and is arranged according to a simple body layout on three floors. The plan is characterized by a core and two opposite wings. This allows a proper distribution of functional areas within the building, and an easy implementation of the MEP systems, which trace the functional organization of spaces. The other two buildings "San Luca Nuovo" and "San Luca Volano" have been built in recent times (15 years ago about the first one, and around 2012 about the second one).

The STREAMER knowledge will be used to achieve the following objectives:

1. The enhancement of the SACS© (a custom Visual Basic software that manages CAD geo-referenced digital maps in order to feed a database that provides structural, technological and organizational information of the Careggi healthcare district) to take into account energy, applied on a single building at first, then possibly extended to other ones;
2. The evaluation of the older building, relying on BIM (definition and planning of building intervention);
3. The development of a better district-level planning and management of energy production.

The work reported here has been settled according to a four-step approach which comprises the identification of the buildings and use cases, the identification and definition of the information for BIM necessary for the uses cases, the choice of the Key Performance Indicators (KPIs) and the mapping of the STREAMER tools and third-party tools that will be used.

Careggi healthcare district

AOUC is a complex system of mixed functions that accommodates care, training and research facilities at the same time. Therefore, there are buildings addressed to care activities and others addressed to the research and training ones.

The Careggi hospital has been built firstly at the beginning of the 20th century as a satellite structure of the "Arcispedale di Santa Maria Nova", the most important hospital of Florence at that time.

Since remote past time, the hill area where it was built has been well-known for its characteristics of being salubrious and healthy. This led some monks coming from other part of Tuscany to set up in 1218 a healthcare institution called "Ospizio del Pellegrino", in an area near where the AOUC hospital was going to be built. The hill has been also subject in the past to the construction of many villas, among which Villa Medicea was built during Lorenzo il Magnifico lifetime, now property of the Healthcare Leadership since 1936.

Since its foundation, the Careggi hospital has been subject to many interventions, both regarding the building structure and the organizational structure. Indeed, as a result of the reforms regarding the healthcare at the end of the seventies, Careggi hospital became independent from the hospital of Santa Maria Nova in 1982. This led the new Careggi to become during the nineties "Azienda Ospedaliero-Universitaria Careggi - AOUC", as we know it now.

Following this, a new strategic plan for Careggi called "New Careggi plan" was elaborated around 2000 to define the future development of the healthcare district. Indeed, this plan still operates to define the continuous renovation and transformation interventions. The "New Careggi Plan" involved the demolition of around the 60% of the existing volumes to allow the realization of new buildings well integrated with the environment and landscape from different perspectives.

The main purposes of the "New Careggi plan" are:

- Renovation of the buildings,
- Reorganization of the transportation network inside and outside the hospital area,
- Concentration of functions (care, teaching and management) to reduce the number of buildings and to merge university teaching and research activities with healthcare activities.

The plan is based on the design criteria of breakdown of hospital functions into sub-systems: internal sub-systems, operating within the facility, and external sub-systems that refer to the non-hospital context relations. Thus, all the dynamics at the level of individual buildings, the relationships between buildings and the interface with the city are considered and stressed. So far, the "New Careggi Plan" enabled (and enables) to tackle the complexity of the healthcare district relations' system within the respect of the landscape and urban situation. (Del Nord, 2011)

The SACS© system

Considering the spatial and organizational complexity of the district, Careggi felt the necessity of elaborating a tool that could gather all the data and information regarding the facility, continuously evolving. SACS© has been created for this reason. SACS© is an informative tool which manages CAD digital maps in order to feed a database that provides structural, technological and organizational information of Careggi.

The SACS© system is a custom Visual Basic software that drives Autocad to manage and analyses digital plans of buildings coded on specific layers. Moreover, the system is linked to the georeferenced Hospital Information System (HIS) designed in Microsoft Visual Basic. The particularity of SACS© is the "everything inside DWG" approach: all data are stored inside the digital maps allowing anytime to rebuild the whole information having nothing but the DWG files. This allows a great flexibility of the system that offers the opportunity to elaborate pre-existing and not specifically SACS© -designed plans. (Luschi et al., 2014)

STREAMER Italian case study

Six months after the beginning of STREAMER project, considering the planning of future interventions on the estate, the AOUC has chosen to use the oncology center named "San Luca", which consists of three buildings, as the case study for validating the research results. Within the plan for the new Careggi, the San Luca becomes the key area for the demolition and reconstruction interventions in order to release space to accommodate new buildings.

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The STREAMER knowledge will be used to achieve the following objectives:

1. The enhancement of the SACS© to take into account energy, applied on a single building at first, then possibly extended to other ones.
2. The evaluation of the older building, relying on BIM (definition and planning of building intervention).
3. The development of a better district-level planning and management of energy production.

The work has been settled according to a four-step approach which lists the steps as here follows:

Step 1: Identify buildings and use cases
Step 2: Identify and define information for BIM necessary for the uses cases
Step 3: Choose the Key Performance Indicators (KPIs)
Step 4: Map the STREAMER tools and third-party tools that will be used

STREAMER, therefore, aims to implement a set of interoperable tools able to support the choices to be taken for a functional and technical improvement of the compound (renovation or demolition/rebuilding of the San Luca Vecchio) based on energy efficiency criteria. To build up the tools, it was firstly necessary to generate BIM and GIS models of the entire health district, and then to model the three buildings that constitute the oncology center, according to different Levels of Detail (LoD). Thanks to the availability of data and plans contained in the SACS© database, a first model has been developed and delivered to the partners of KIT – Karlsruhe Institute of Technology.

In order to get a LoD 1 block model of the complete health care district of the Careggi hospital in Florence, two different approaches have been tested by KIT:

1. Creating a city model according the CityGML standard
2. Creating a set of buildings according the IFC standard

The next stage was about the preparation of the three-dimensional model with LoD2 of the three buildings that constitute the San Luca complex, to be used as the basis for the implementation of BIM. The AutoCAD Architecture 3D model of the three pilot buildings (containing the "architectural" layer and the "windows/doors" layer) was made and transferred into Archicad 18, the BIM software chosen to model the Careggi case study.

The BIM model contains the data obtained during the desk and field survey carried out on the chosen pilot site building regarding the MEP systems and building space and envelope, and on the layout (Table 1). The survey was crucial as the information and data collected provide the basis for the development of the BIM-GIS model for the purpose of case study, practical validation and demonstration. All the data related to energy consumption, dimension, equipment, etc., of the three buildings were listed, the desk survey was done and the field survey took place only for missing data.

Each group of elements has been identified and all the different typologies of each element have been listed and described according to its characteristics. Therefore, a classification of these elements has been realized in order to define a coding system that could inform the space with relevant information for the STREAMER aim (the relevant information are attached to the spaces represented in the BIM). The aim of this work is to create a database of information that informs the BIM elements of the model with the codes defined within the table. Each code is assigned to each BIM element and will then provide useful data for the elaboration of future work such as an energy simulation.

Data	Processing	Software
Topography of the land	Geo-referenced model	Q-GIS 2.8 and Sketch-Up
Network of the roads	Geo-referenced model	Q-GIS 2.8
Network of the technical infrastructure	Geo-referenced model	Q-GIS 2.8
Functional areas and space units (room level)	DWG drawing	SACS
Organisational model (room level)	DWG drawing	SACS
Medical equipment (area of activity level)	DWG drawing	SACS
Shape of the buildings nearby the San Luca complex	BIM model	ArchiCad 18
Structural components	BIM model	ArchiCad 18
Windows and shields	BIM model	ArchiCad 18
Floors, claddings and ceilings	BIM model	ArchiCad 18

Table 1: Data and processing

The description of the hospital state of the art is enhanced by the adopted Key Performance Indicators. This is true both for the strict correlation between KPIs description and BIM approach and for the potential that an evaluation of KPIs supports. The fundamental – and agreed - KPIs are completed with others resulting from a specific procedure that has been developed for the sake of the research completeness to solve some incongruities. The choice of a wide range of KPIs shall be related to the awareness that an acute-care healthcare district is a complex system that always requires a multi-faceted/multi-discipline approach. It is true that from the energy point of view, there are many precise tools available for the designer/energy manager to allow a strict control in real time of the variables that govern the energy balance of the same district.

Finally, one of the main targets in the development of the demonstration case is the opportunity to improve, applying methodology and tools implemented in STREAMER, the SACS© system, including the assessment and management of energy efficiency and, potentially, some others management tools. With this aim the on-going work concentrates on the implementation of the BIM model, currently referred to one of the three buildings of the San Luca Complex, that is based on the information and CAD files available in the SACS© database. During the implementation of the BIM model it will be analysed the possibility to develop its configuration (i.e. classification and level of details of the BIM data) according to the possibility to increase and improve tools and functionalities of SACS© (Figure 1).

Within the plan for the development of the Careggi District, several areas and compounds will be analysed – taking into account both functional and financial aspects – to define strategies and policies. It is expected that the knowledge and the tools implemented in STREAMER will also be used in the interventions to develop in the San Luca Complex, to guide the choice between retrofitting and demolition/rebuilding of the older buildings, considering their energy-efficiency as well. Thus, one of the expected results, working on the San Luca Complex chosen as study case, is the possibility to use STREAMER tools for guiding the choice between retrofitting and demolition/rebuilding of the older building and to assess its suitability for the next destination considering the energy efficiency and the lay-out functionality.

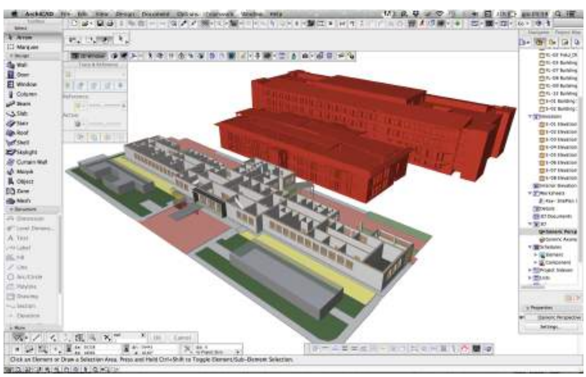

Figure 1: Snapshot of the San Luca BIM model

For the other two buildings included in the study case (and later for the whole district), the aim is to enhance functionalities of SACS© including into its tool box data and procedures for assessing, validating and managing the energy efficiency during the planning and design stage.

The energy efficiency strategies

By shifting the focus on energy, a brief introduction describing the characteristic of the case study may help in identifying its peculiarity: Careggi in fact, is already a leading hospital regarding the "green" features thanks to its natural gas fired Combined Heat and Power (CHP) trigeneration plant. Between CHP plants, trigeneration units show the highest efficiency since their potential to convert thermal recoveries into cooling during summer (assisted by absorption chillers). This lowers the primary energy needed for all the hospitals end uses, together with the associated GreenHouse Gases (GHG) and pollutant emissions. The last finding is particularly desirable, especially in case of hospitals.

Besides, the new trigeneration system, as a part of the plan of global retrofitting of the whole AOUC campus, is already keeping at high-efficiency all the energy transformation processes, directly at district levels, thanks to the thermal energy distribution network that is already in site. The CHP plant is a medium size cogenerator, having been dimensioned to produce 10 MW electrical power and about 15,6 MW thermal power. In the actual configuration the whole output is used to serve the hospital, but in the future a possible integration of the district system with neighbour facilities such as Meyer Hospital, could be achieved and today is under investigation. From the economic perspective, the operation of the CHP plant allows to save more than 1 Million euro per year.

To understand how important is the implementation of the efficiency of a plant like the one built in Careggi, it is essential to consider the considerable energy demand of a hospital of that size, which almost equals the one of a small city. This assumption is not strange if we consider the number of patients, doctors, nurses, employees, visitors, etc. that everyday live and/or just visit the facility.

In general, there is the necessity to define the 'as usual' scenario of the energy demand, at least split into electricity, heating and cooling, before evaluating any possible retrofit actions. Before the CHP plant started, the energy demand of AOUC was entirely satisfied though the operation of conventional systems, electricity from the local distribution grid, heating from boilers and cooling from chillers. The hospitals managers use to keep some energy recordings (e.g. energy bills), however, these data normally refer to the whole hospital campus, or to sectors that do not coincide with the San Luca pavillons; this has led to the necessity of identifying a specific top down indirect procedure to evaluate the energy requirements of the San Luca case study. Thermal energy demand of San Luca has been estimated considering oil/natural gas fired boilers (the systems that operated in Careggi before the start of the CHP plant). Since their primary energy requirements were acknowledged, we weighted them first considering the systems average efficiency and then through a top-down coefficient that takes into account the ratio of the volumes of the occupied areas both at that pavillon and district levels. The same task was easier for electricity since it was possible to evaluate the demand at San Luca pavillons level through specific readings of the local counter. Finally, the cooling demand has been indirectly evaluated by assuming that is has been fulfilled thanks to mechanical air ventilation where the cooling exchangers, used to cool and de-humidify the external hot air, request a continuous and energy intensive operation of compression chillers, themselves fed by electric power. The delta of the consumed electricity between the hot summer months and a standard 'fresh' period (e.g. April, taken as reference), yields the demand, that is likely to be ascribed to compression chillers – cooling end uses. This specific procedure has been assessed in the past in other researches (Bizzarri et al., 2006) giving reliable feed backs. Once assessed the benefits coming from a certain intervention (e.g. the CHP plant, etc) on a specific end use demand (electricity, heating, cooling), the reverse convertion from the same end use demand to the correspondant primary energy was made: for thermal energy simply considering the plant efficiency and for electricity through the application of the average efficiency of the 'equivalent Italian thermoelectric power plant', provided by scientific literature year by year. The findings of these procedures give the primary energy saving expected from every energy policy adopted by the hospitals, together with its related GHG and pollutant reduction benefits.

Finaly a study was made in order to breakdown the total electricity use into major electric end uses. The first step was to establish a list of the typical appliances and systems that normally operate in a hospital. Then a survey was conducted to obtain data about the usage pattern of all those appliances: a fundamental issue was to recognize which end uses was weather dependent (showing seasonal variations) and/or occupancy related (showing different behaviours during the typical working day or between working days and the week end). Then, all these end uses were grouped into five homogeneous categories in relation to the service they concur to provide: heating station, cooling station, ventilation units, lighting and miscellaneous electrical appliances (Bizzarri, 2006). The last study has been of particular help in the policy to reduce electrical requirements and providing fundamental inputs for the BIM platform as well.

BIM philosophy applied to energy simulation has the potential to enhance the possibility of testing preliminary design approach before developing the whole project. The energy demand of a certain portion of a building, in fact, depends on the envelope characteristics (e.g. U value, materials, etc.) and the typology of end uses (e.g. hot floors, industries, hotels, offices, etc.). The first parameters directly influence the thermal energy demand and are site specific, the latter items, instead, are more or less the same in the European countries, depending on the how much energy intensive are the activities that take place in the indoor spaces and can be well modelled once one has found and determined the items described in the paragraphs above.

The construction of a solid BIM platform, coherently with the parameters above, is hence fundamental, allowing to run the energy simulations simply having defined few basic retrofit inputs. Especially in the preliminary phases, this approach is enough accurate to provide reliable results and helps in understandanding if a certain retrofit option is desirable or not.

Conclusion

One of the main aims of the research is to define those parameters able to measure the energy performance of the building during its lifecycle and considering possible changes of usage. Especially during the audit phase, this goal can be achieved processing together typological/dimensional elements of the building (volume of the rooms, typology of the windows, etc.) and functional/organizational data (medical equipment, occupants, etc.)

The model to manage the parameters is a design BIM/GIS-based tool containing the whole lifecycle information of the building, including design, construction, operation and maintenance.

During the first period of the research, three types of data have been collected and processed:

i) geographical data of the district, including the exact shape of the buildings nearby the chosen case study;
ii) detailed dimensional and structural data of the chosen case study;
iii) organizational and management data related to the chosen case study.

Data contained inside the Geo-referenced model of the district (QGis) and data managed by the SACS system (through its own labeling system) have been imported inside a BIM model made with Archicad 18.

Aiming to the interoperability of the tools, processed information will be transfer to the SACS suite to enrich its functionality: SACS – through the AOUC Web portal, the Eureka search engine and the Careggi Smart Hospital smartphone App - is daily used by users and staff of the hospital.

Finally, BIM philosophy applied to energy simulation has a huge potential, especially in the preliminary phases, since it has been demonstrated that this approach is accurate enough to provide reliable results at preliminary design stage and helps in understandanding if a certain retrofit option is desirable or not. The energy simulations that are normally run in the energy analyses, in fact, require the same set of data that are collected and implemented in the BIM platform.

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Information on STREAMER project is available at www.streamer-project.eu.

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