May 2016

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European research on energy-efficient healthcare districts

NEWSLETTER STREAMER

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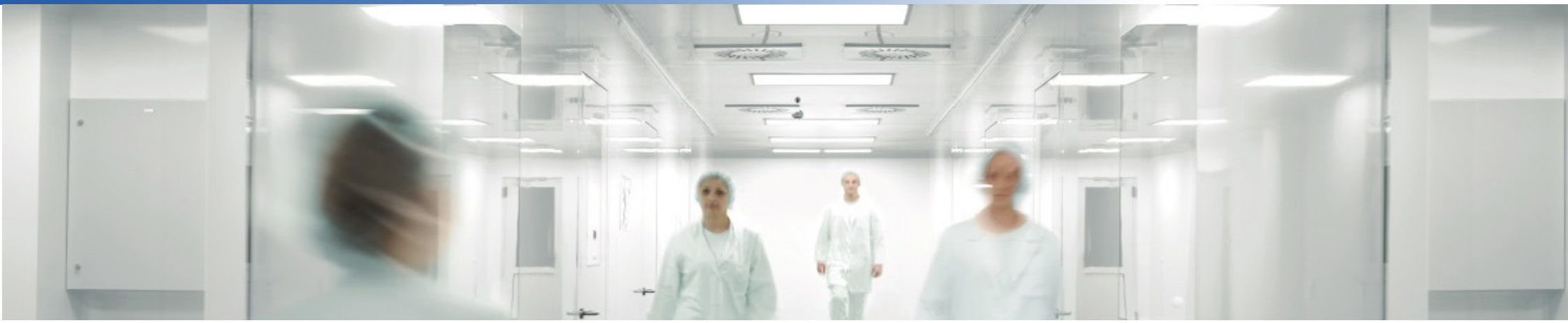

1. WORD FROM THE COORDINATOR OF STREAMER

This is the second broad newsletter from the STREAMER project. The project results are becoming clearer so expect to hear more often from us, with more exciting results. The STREAMER project is now focusing more and more on the elaboration of the end results, after the groundwork has been laid in the first two years.

One of the STREAMER challenges is to support the design process in an early stage. This is a difficult task because in such an early stage, almost everything is unknown. To quote Donald Rumsfeld: "There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know."

For experienced designers, the early design stage is mainly a matter of "known unknowns", but still it is not an easy task. Many people firmly believe though, that in this early design phase the room for optimization is much larger than we think so it is crucial to take the right decisions here. The STREAMER researchers have created a number of concepts that help decision makers in this situation: the STREAMER semantic labels, the Early Design Configurator, and tools for early assessment of energy, quality and cost KPIs. You can find more on these concepts in this newsletter.

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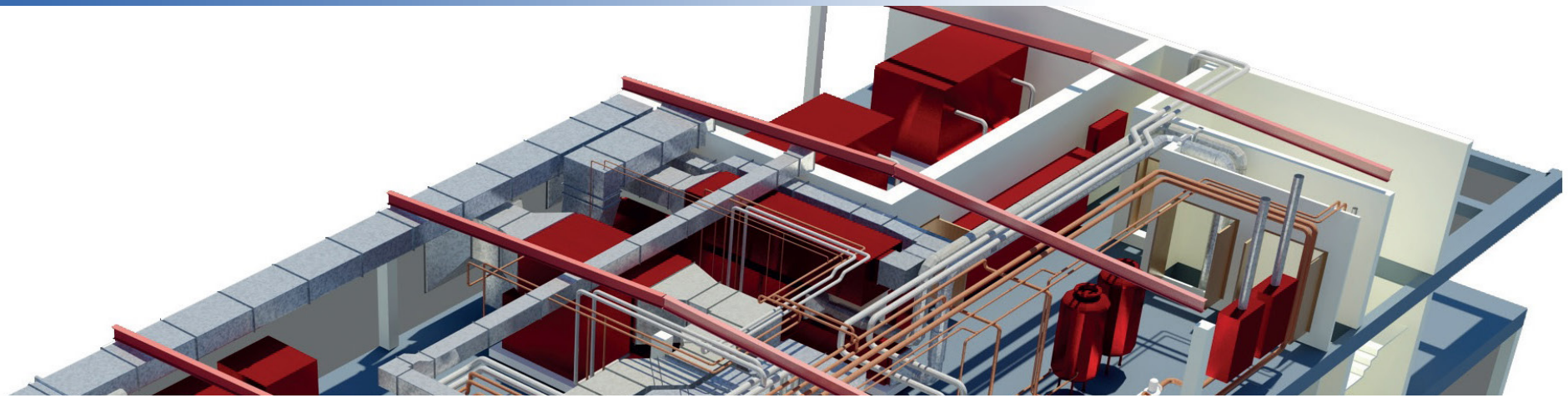

2. OVERVIEW - WORK RESULTS Description of main results achieved

General Overview

STREAMER aims at 50% reduction of the energy use and carbon emission of new and retrofitted buildings in healthcare districts. Healthcare-related buildings are among the top EU priorities since they play a key role for a sustainable community, but their energy use and carbon emission are among the highest of all building types. Take for instance a typical hospital building that is part of the healthcare district. It uses 2.5 times more energy than an office. In the EU, there are some 15,000 hospitals producing 250 million tons of carbon per annum. The EeB design complexity is extremely high; and therefore, both holistic and systemic approaches are crucial. STREAMER will resolve this by optimizing Semantics-driven Design methodologies with interoperable tools for Geo and Building Information Modelling (Semantic BIM and GIS) to validate the energy performance during the design stage. STREAMER will enable designers, contractors, clients and end-users to integrate EeB innovations for: 1) building envelope and space layout; 2) medical, MEP and HVAC systems; and 3) building and neighborhood energy grids. STREAMER results will be validated in the 4 real projects involving Implementers Communities. The outcome will be used to extend the standardization in EeB design and operation, open BIM–GIS (IFC–CityGML), and Integrated Project Delivery (IPD).

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Work performed and main results achieved so far

Within the STREAMER project so far we have investigated the criteria and methodologies to implement a taxonomy of healthcare districts focused on energy-efficient buildings morphology and features: how do we see and categorize the built environment in healthcare districts This comprises methodologies to define and develop a model-based classification of hospital buildings and spaces that will become the basis for the development of semantic BIM 'templates' for models. STREAMER extends the existing high-level Layer Model into Semantic Labels, that are used to characterize hospitals at level of buildings, functional areas or space units, and therefore fills the gap between the high level and detailed approaches. In this way, the design process can incorporate energy efficiency effects of design decisions in a much earlier stage.

Work has been done to expand and integrate the knowledge on hospital technologies for Mechanical, Electrical and Plumbing systems (MEP). Many energy efficient solutions for installations are available on the market, but this is not enough to reach the overall goals, so the project has to define additional measures. Also, an analysis of energy optimization possibilities at inter-building level by considering the interaction of buildings within a healthcare district and in relation with the surrounding neighborhoods has been made.

A set of KPIs relevant for hospital design has been defined. This is the basis for a dashboard that informs all stakeholders during a design process on the expected performance of a specific design, and gives an early indication of the impact of a design decision. The most important category is the energy performance; for this, a number of energy simulation software packages have been assessed on their suitability to be incorporated in the STREAMER platform, especially regarding their level of integration with building information models (BIM). A second group of KPIs is in the Life Cycle Cost field, and the third group of KPIs addresses the (operational) quality of the building.

The design of complex buildings like hospitals needs to take into account many different viewpoints from different stakeholders. This calls for a well-defined process that has been defined by STREAMER.The project has defined methods to make the knowledge of all stakeholder groups explicit, so that it can be turned into verifiable requirements.

To verify the requirements during the design process, it must be possible to process them automatically for a specific design. For this, an analysis of semantic technology has been conducted, both for technology development and standardization. For incorporating neighborhood designs, techniques to integrate BIM (build-

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ing level) and GIS (neighborhood level) have been explored and demonstrated. Tools are created to apply the rules (expressed in semantic models) to a design, in order to validate a design against requirements and design rules. Tools that are able to store requirements have been assessed on their suitability to adapt them into STREAMER. Additionally, software concepts have been created that assist the designers, by making automatic configurations of design elements that conform to the requirements and design rules. Each of the four pilot hospitals (in NL, UK, IT and FR) has selected and described the buildings that will be the subject of demonstrations during the project, refined the case studies that will be considered for STREAMER, and defined the expected improvements, including the KPIs chosen in each case. Additionally, BIM models have been developed for the selected buildings.

Expected final results, impact and use

The STREAMER results will be validated in the 4 real projects involving Implementers Communities. The outcome will be used to extend the standardization in EeB design and operation, Open BIM-GIS (IFC-CityGML) and Integrated Project Delivery (IPD). The demonstration cases are: NHS Rotherham (UK), Rijnstate healthcare district (NL), University Hospital Campus of Careggi (IT), Assistance Publique – Hôpitaux de Paris (FR).

The knowledge dissemination and valorization towards the exploitation of projects results will take place in and through the Implementers Community (IC). The flagship projects – the 4 large scale projects - are the most important vehicle to commit current and future stakeholders.

EeB solutions, ICT approaches, design methods and tools to be integrated and optimized in STREAMER are based on reliable technologies and prototypes, which have been proved to be on Technological Readiness Level (TRL) of 6 to 8. The STREAMER results will be exploited in 4 levels, from the individual product development to the market and value-chain integration in the field of EeB. At the end of the project, all energy efficiency goals will be met, and the follow-up towards energy neutrality can commence.

The result of tool and software development will be an operational prototype that is to be tested by consortium partners and other potential users. The prototype will be further developed after finishing the project. The exploitation model will use the contributions of launching customers and development partners to finance the remaining work.

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SOME RESULTS PRESENTED IN MORE DETAIL

In this section, some results are described in more detail. Of course, the underlying deliverables provide much more information – most deliverables are public so these can be downloaded from the website. *click here to go to the website*

3a. THE STREAMER LABELS

One of the conceptual innovations from STREAMER is the labelling approach that forms a semantic bridge between the everyday practices of healthcare design, and the ICT tools that optimize designs in BIM. Labels can be used for assessment of energy performance and KPIs calculation in the early design process. The label methodology can help the design by identifying problems and optimization opportunities and design rules can be expressed using labels.

STREAMER has created a semantic model of existing healthcare buildings and districts containing the morphology of buildings/districts and the multi-dimensional representation of existing objects.

During designing, these semantic models will be used as a baseline design, adapted and enriched with as-built information the actual, performance data, and the building operators' and occupants' knowledge.

The semantic typology model is built up by all the elements that define a healthcare district at the different levels.

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Looking at the spatial organization and the functional aggregative configurations of the existing typologies, five main different levels can be considered to build up a Healthcare District within STREAMER. These levels are: District level (level 5), Building level (level 4), Functional area level (level 3), Space unit level (level 2), and Component level (level 1).

The breakdown of healthcare districts in different levels is crucial for the definition of a semantic typology model as at each level, inherent parameters and factors can be identified. Thereby it is possible to operate design decisions at the most appropriate level and to identify the different KPIs in order to tackle the energy-related issues.

Within the scope of STREAMER, the specific characteristics of the elements of the semantic typology model have been identified by the use of the labels, which allow each element to be informed by the performance requirements (boundaries, minimum or maximum values, acceptable levels) it should meet.

By attaching (using the labels) properties and characteristics to the different spatial entities of the semantic model, it will be possible, in the early design stage, to understand the implications of design choices, when optimizing for instance those ones influencing the energy efficiency of the buildings.

Thus, the main aim of the semantic model is to provide design teams, building operators, clients and occupants with a common set of references for evaluating and assessing the performances expected from healthcare districts. Considering the main objectives of the STREAMER research project, it is crucial to highlight the factors that most influence the energy consumption of a healthcare district.

The data will be then implemented in the model as semantic information that allows the professionals in an early design stage to:

- highlight the incoherencies between performance requirements of functions and actual performances of spaces and identification of possible retrofitting intervention in the case of existing building;
- make use of knowledge from other important KPIs and boundary conditions to influence the outcomes of the energy performance optimization;
- make use of the knowledge on the developed MEP compliance matrix to find out which type of solutions are or are not available in specific situation for specific levels and label combinations;
- be provided with guidelines for the design of energy efficient healthcare districts.

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Therefore, the objects of three levels (Level 2/Space Units – Level 3/Functional Areas – Level 4/Buildings) have been analysed and listed through specific characteristics, since those levels are suitable to be labelled and listed as objects of a semantic model. The list of labels has been re-arranged as well, defining how the labels can be applied to the objects at the different levels.

Levels / Labels	DISTRICT Level 5	BUILDING Level 4	FUNCTIONAL AREA Level 3	SPACE UNIT Level 2	COMPONENT Level 1
Bouwcollege layer	not applicable	not applicable	applicable	applicable	not applicable
Hygienic class	not applicable	not applicable	applicable	applicable	not applicable
Access and security	not applicable	not applicable	applicable	applicable	not applicable
User profile	not applicable	not applicable	applicable	applicable	not applicable
Equipment	not applicable	not applicable	not applicable	applicable	not applicable
Construction	not applicable	not applicable	not applicable	applicable	not applicable
Comfort class	not applicable	not applicable	not applicable	applicable	not applicable
Layout	not applicable	applicable	not applicable	not applicable	not applicable
Compactness	not applicable	applicable	not applicable	not applicable	not applicable
Mass	not applicable	applicable	not applicable	not applicable	not applicable
Form typology	not applicable	applicable	not applicable	not applicable	not applicable

Fig.1 Applicability of labels to the objects of the five levels

This table will generate a set of tables, one for each level if applicable, which will cross the semantic objects of each typology level with the labels indicating the corresponding scale and values through knowledge collected from case studies.

It is important to consider that these lists are a work-in progress inventory. It means that they are not fixed and that, during the development of the research project, they could be subject to changes according to the work and results of the other WPs.

CATEGORY	OBJECTS	LABELS			
		B	H	A	U
DIAGNOSTIC TREATMENT	Diagnostic imaging	HF	H2	A3	U3
	Nuclear medicine	I	H3	A3	U4
	Radiotherapy	I	H2	A3	U1
	Pre-hospitalization	O	H3	A3	U1
	Endoscopy	O	H3	A2	U1
	Blood sampling/testing	O	H3	A3	U1
	Transfusion centre	O	H3	A2	U1
	Rehabilitation	O	H2	A3	U4
	Outpatient department	O	H2	A2	U1
WARD	Intensive care ward	HF	H4	A2	U4
	High care ward	H	H3	A2	U4
	Low care ward	H	H3	A2	U4

Fig.2 Extract of the table analysing the relationships between functional area objects and labels

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Since the Component level (including building components and the MEP components) is not a "spatial level" the objects cannot be related to the labels in the same way used for the other levels.

The technical MEP solutions will be used to verify how much they contribute to the performance requirements of spaces. The designer will use the STREAMER tools for comparing the possible solutions looking (also) at their effect related to energy efficiency.

Thus the technical characteristics of the components will be interfaced with the class of the labels assigned to spaces as "coefficients" able to upgrade or downgrade their condition.

To be able to do that we should give to the technical solutions a "coefficient" that determines an improvement or a reduction of energy efficiency through specific labels (and scores) assigned to the technical solutions.

In order to attach label's value to objects of the semantic model, it is crucial to define how rules and values of labels are established. In order to do so, the link between the calculation of the KPIs, the design itself and the semantic label approach, should be established.

The labels have a number of different categories adding a value to the room for that specific category (label level). With these label levels a specific room in a hospital can be defined based on the activities that will take place in that room. If however additional information is available the default values of the labels can of course be adapted and the information enriched.

The labels can play an important role in identifying problems and optimization opportunities. Shortly, when the semantic labels are attached to buildings, functional areas and rooms, these activities and properties are allocated to a specific location. Visualization provided by BIM software makes all this information easily accessible, which enables the design team to identify problems. Design rules can be used to identify optimization opportunities.

The label methodology can be used to find out whether certain functional areas can be accommodated by a certain building structure.

Design rules are used by the design team to support design decisions. Some design rules are related to names, others to the labels. Design rules related to names allow the formalization of relations that cannot be expressed by the labels.

The relation with the KPIs is input to prioritize design rules. This leads to a very important conclusion: by varying the KPI importance values, different designs can be made which are all based on the same design rules.

These outcomes cannot yet be considered as fixed results. The system defined should be first applied and tested in the model in order to validate its use and expanded for other KPIs that co-determine the boundaries for the optimisation of the energy performance. Depending on the functionality of it within the software, it might undergo changes in the next research steps.

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3b. PARTICIPATORY DESIGN PROCESS

Healthcare district refurbishment or new construction projects are usually both complicated and complex. Not only are there technical challenges to be faced, the different actors involved represent different perspectives and each with different agendas. The traditional design process is characterized by a relay of handing over results and documents to the next actor in line, often leading to a non-transparent decision making process and loss of information as well as minimal learning between teams and projects. The STREAMER project addresses these challenges through a collaborative, semantically-driven design process framework. The goal of this is to support the key actors (i.e. client, facility managers, designers and engineers) in making the right design decisions at the right time, using the right information and informing them about the consequences of design decisions. The framework focuses on POP, i.e., the product (the building(s)), the organization (the actors and their roles in defining, designing, constructing and operating the product) and the process (how the organization collaborates and the steps necessary to reach the aims).

Participatory design reflects a process in which envisioned users of the end result are being actively involved in designing. In case of health care districts, the end-users are not easily listed and not a mono-disciplinary group of people. Nevertheless, the active in-

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volvement of end-users in the design process means careful organization and preparation of the involvement of various end-users groups or representatives. The crucial questions are: Who are the end-users, what level of involvement is being pursued, what information is crucial in the design process? It holds the premise of resulting in more robust, sustainable and cooperative way of designing, taking into account the expectations of particular users that involve in care and cure operations logistics, maintenance etc. (i.e. patients, staff, visitors, facility managers etc.). An interesting finding in our work, based on a case-study from the activities of partner Locum, was the use of a special clinic design unit which worked as a link between different actors (real-estate management organization, hospital staff, designers and specialists). By understanding and translating the different needs, a design that was more cost effective as well as added value (shortened treatment time, improved staffs' working condition, improved patient safety etc) was obtained.

As mentioned above, effective collaboration and communication are essential in order to obtain the objectives of the project. The number of actors involved is one of the complications of the design process. Indeed, this number could lead to inconsistencies and wastes in terms of time and money during the design phases when the collaboration among professionals is usually not well structured from the organizational and technical perspective. But, in complicated and complex situations, decision-making support tools will help decision-makers making the optimal decision. BIM and GIS models form the back bone in such situations and can generate a visual conceptualization at an early stage that helps also non-experts understanding technical problems. By digitalization, the process not only becomes more transparent and structured, it also has the possibility to generate a design that fulfills the important necessities of a multi-actor group.

The above considerations on design processes, especially when information becomes even more abundant than it used to be with more traditional design tools, have been applied to a framework for management of information flow, design actors and collaboration in virtual construction environments.

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3c. TECHNIQUES FOR KNOWLEDGE RETRIEVAL

In order to design an optimal health care building, the exchange of information and knowledge in the design process is evidently one of the most essential conditions for incorporating all relevant perspectives in the design models. The partners of STREAMER have carried out a study generating an overview of the current state of the art of the techniques that help to retrieve relevant information and knowledge from experts and users by the design team. The form and type of information can range from legislation, codes and directives, up to experience levels of various end-users (i.e. patients, staff, visitors, service providers such as caterers, maintenance operators etc.). Each of the techniques is elaborated by relevant partners who use, develop or enhance the technique in the STREAMER project.

The essential questions that were dealt with are: How can crucial information for the design process be gathered, and, how can knowledge be retrieved by design team members, codified and used throughout the design process?

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Six techniques were elaborated based on their ability to retrieve knowledge, from experiences or information sources elsewhere, and feed this knowledge into the design process. The automation of a traditional Programme of Requirements (PoR), helping design team to validate and interpret the actual design layout of a hospital, use of prediction models that calculate the performance of the design layout against selected criteria (i.e. patient well-being, staff efficiency, and safety), and procurement methods in formalizing the collaboration act of design team are examples of such techniques.

Successful application of techniques requires a particular cooperation and social practice between design team members themselves, as well as the client and representatives. For example, the application of state of the art software for developing a PoR requires the design team to make use of compatible modelling software, and also some agreements on the way of cooperation and validation. This example is a good illustration of how techniques for knowledge retrieval are of added value for the design process only if the implementation of the technique in working culture, procedures and cooperation is organized effectively as well. It is not just about novel software for transforming the PoR into graphical outline, but it requires that design disciplines work together with regard to interpretation of the outcomes and how to optimize the inputs. In the end, the changes in design procedure, the iteration cycles, and interpretation of results produced by a particular technique are as essential in the creation, integration and re-use of knowledge and experience as is the technique itself.

What can we learn from the discussion of applying knowledge retrieving techniques, is that experience from contributing partners implies that the using a technique in itself is not going to be knowledge retrieving automatically. It needs agreement on ways to do things, or even organization commitment of certain process steps. Knowledge retrieving and management of information flows require more than just installing a certain software tool, or saving your design in a specific output file. It requires a change in approaching cooperation between partners in a design team for instance, or the way to formulate the strategic requirements with representatives of patient, staff and visitor organizations.

A further abstraction of the above findings teaches us that the knowledge retrieval techniques are addressing different aspects of Knowledge Management. The aspects considered are:

- Tools / Applications
- Physical settings
- Procedures
- Social practices

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4. DEMONSTRATION CASES

UK demonstration site:

This demonstration case includes two areas, namely: Outpatients Department and Ward B6 (Ophthalmology). The hospital already has a building management system (BMS), which is currently being upgraded, and major improvements of the overall building fabric are being planned. Currently, energy models are being developed and energy data is being collected using an acquisition model.

Implementer's Community (IC) workshops are being formulated where specialists from the design, construction and engineering fields will be invited and it is intended to encourage the exchange of knowledge between these specialists and other stakeholders whilst also incorporating Building Information Modelling (BIM) and newly developed software from the Streamer project.

SBEM_AnnualEnergyDemand_UK - SBEM Delivered energy demand per m2 UK (IfcPropertySet)

Name	Value	Description
HeatingAnnualEnergyDemand	2815.87 MJ	Heating energy demand per m2
CoolingAnnualEnergyDemand	0 MJ	Cooling energy demand per m2
AuxiliaryAnnualEnergyDemand	18.9216 MJ	Auxiliary energy demand per m2
LightingAnnualEnergyDemand	920.142 MJ	Lighting energy demand per m2
HotWaterAnnualEnergyDemand	136.791 MJ	Hot water energy demand per m2
EquipmentAnnualEnergyDemand	1428.98 MJ	Equipment energy demand per m2
CHP_DisplacedAnnualEnergyDemand	0 MJ	Displaced combined heat and power energy demand per m2

SBEM_FuelAnnualEnergyConsumption_UK - SBEM Fuel energy consumption per m2 UK (IfcPropertySet)

Name	Value	Description
NaturalGasAnnualEnergyConsumption	2952.67 MJ	Natural gas energy consumption per m2
LiquidPetroleumGasAnnualEnergyConsumption	0 MJ	Liquid Petroleum Gas energy consumption per m2
BioGasAnnualEnergyConsumption	0 MJ	BioGas energy consumption per m2
OilAnnualEnergyConsumption	0 MJ	Oil energy consumption per m2
CoalAnnualEnergyConsumption	0 MJ	Coal energy consumption per m2
AnthraciteAnnualEnergyConsumption	0 MJ	Anthracite
SmokelessAnnualEnergyConsumption	0 MJ	Smokeless energy consumption per m2
DualFuelAnnualEnergyConsumption	0 MJ	Dual fuel energy consumption per m2
BiomassAnnualEnergyConsumption	0 MJ	Biomass energy consumption per m2
GridSupplyAnnualEnergyConsumption	939.065 MJ	Grid Supply Electricty energy consumptions per m2
WasteHeatAnnualEnergyConsumption	0 MJ	Waste Heat energy consumption per m2
DistrictHeatingAnnualEnergyConsumption	0 MJ	District heating energy consumption per m2

SBEM_ACTNOT_UK - SBEM Actual and notional kgCO2 equivalent per m2 UK (IfcPropertySet)

Name	Value	Description
AnnualCarbonDioxideEmission	312.542 Kg	Actual kgCO2 equivalent annual emission per m2
NotionalCarbonDioxideEmission	231.267 Kg	Notional (baseline) kgCO2 equivalent annual emission per m2

Figure 1: Preliminary results collected at the UK demonstration site

NL demonstration site:

The NL case includes a new wing, an outpatient department of 5000 m^2 surface and the replacement of MEP systems for the hospital. This life case is a so-called 'shadow engineering' project. This means that the actual design has been done in 2D, and this design is done over again in the STREAMER project in BIM. Requirements have been collected for the new building in order to be able to execute the energy simulation. Simulation tools are being used for the MEP. The Program of Requirement (PoR) has been uploaded in the Early Design Configurator (EDC) and an IFC file has been produced using the EDC. By using the EDC different lay out alternatives can be tested. At present the building has been realized.

Figure 2: Rijnstate hospital site

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5. IMPLEMENTERS COMMUNITY

As part of the STREAMER project, the four participating hospital organisations, supported by other partners from the STREAMER consortium will create a local STREAMER Implementers Community. The four hospitals will then set up local workshops, known as the Implementer's Community (IC) workshops to further discuss the topic in a wider audience. Dissemination of knowledge, and in particular the discussions and outcomes of the IC workshops, is an integral and important part of the process for the STREAMER project. Invited specialists and stakeholders will be involved in the IC workshops and it is intended to connect researchers, practitioners and policy makers through formal and informal collaborative activities. The Implementer communities will serve as prime and sound examples of energy efficient healthcare districts, addressing both new development and retrofitting. Hereto the four hospital organistions invite you to join the local Implementer Communities for a workshop in 2016.

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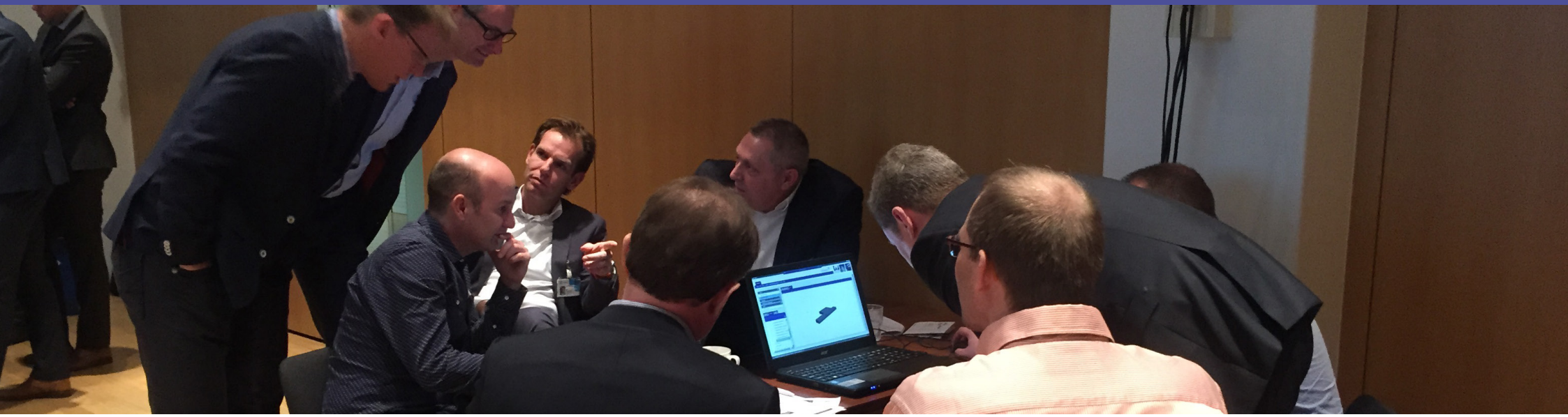

Objectives of the workshops:

1) To illustrate to the professional specialists and building operators of health premises the opportunities provided by BIM, boosted by the newly developed Streamer software

2) To encourage the exchange of knowledge between partners of the demonstration cases and other companies with expertise in BIM, showing new design processes, the new instruments and the relationships between them especially IFC (Industry Foundation Classes) – the standard format for exchanging data in the construction industry

3) To utilise a scenario where each group are allocated a notional sum of money and are requested to invest in areas that will, in the group's opinion, maximise energy and carbon reduction and provide best value financial return

Programme and type of the workshops:

The local IC workshops will comprise of meetings in the respective national languages. Although all four case studies differ substantially the methodology to verify all or part of the solutions that are required is the same; i.e. to validate and share the results

Future Events

The other local IC plan to host their respective workshops.

Please *click here* for detailed information.

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6. MAJOR EVENTS (dissemination)

The knowledge received within two years of research has been valorized through the participation of STREAMER partners in conferences, publication of results in journals and peer-revied publications. Among the most important dissemination events during the last year were:

- 27th Forum Bauinformatik in Aachen, September 2015
- Impact of the Energy-efficient Buildings Public-Private Partnership (paper) – Brussels July 2015
- STREAMER semantic BIM design approach for hospitals: research case of Rijnstate Hospital in Arnhem, The Netherlands (Sustainable Places 2015 – in Savona)
- 3D GeoInfo 2014 in Dubai , November 2015
- Zorgtotaalbeurs 2015 in Utrecht, March 2015
- Introduction to STREAMER for the final event Green@Hospital in Ancona, February 2015
- Presentation Energy optimization in hospital buildings - the project STREAMER in Warsaw, May 2015
- Il caso studio italiano nel progetto di ricerca europeo Streamer: l'Azienda Ospedaliero-Universitaria Careggi - HPH journal (year VII, number I, January-June 2015,
- Energy storage in smart hospital districts seminar in Warsaw, September 2015

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