

D1.5 Coherent state-of-the-art design guidelines for energy-efficient healthcare districts



Deliverable Report: 1.5 - Final version

STREAMER - Optimised design methodologies for energy-efficient buildings integrated in the neighbourhood energy systems. The STREAMER project is co-financed by the European Commission under the seventh research framework programme FP7.EeB.NMP.2013-5; GA No. 608739)



D1.5 Coherent state-of-the-art design guidelines for energy-efficient healthcare districts

Main author	Stefan van Nederpelt, de Jong Gortemaker Algra
Co-authors	Rizal Sebastian (DMO), Roberto di Giulio (IAA), Costanza Quentin (IAA), Beatrice
	Turillazzi (AOC), Anna Rockicka (MOW), Oscar Verhoeff (TNO), Mikael Nustsos
	(LOC), Bartosz Dubinsky (MAE), Marc Koster (RNS), Kevin Violant (APH), John
	Cartwright (RNS)
Dissemination	Public

Document history

Version	Date	Status	Produced/Reviewed by	Comments
0.8	2015/01/30	Draft	Produced by T1.3 members	
0.9	2015/02/03	Final draft	Reviewed by WP1 leader	
1.0	2015/02/19	Reviewed	Reviewed by MOW and AOC	
1.0	2015/03/04	Accepted	Marc Bourdeau (TC)	
1.1	2015/03/19	Approved	Freek Bomhof (PC)	

Colophon

Copyright © 2015 by Streamer consortium

Use of any knowledge, information or data contained in this document shall be at the user's sole risk. Neither the Streamer Consortium nor any of its members, their officers, employees or agents accept shall be liable or responsible, in negligence or otherwise, for any loss, damage or expense whatever sustained by any person as a result of the use, in any manner or form, of any knowledge, information or data contained in this document, or due to any inaccuracy, omission or error therein contained. If you notice information in this publication that you believe should be corrected or updated, please contact us. We shall try to remedy the problem.

The authors intended not to use any copyrighted material for the publication or, if not possible, to indicate the copyright of the respective object. The copyright for any material created by the authors is reserved. Any duplication or use of objects such as diagrams, sounds or texts in other electronic or printed publications is not permitted without the author's agreement.



The Streamer project is co-financed by the European Commission under the seventh research framework programme with contract No.: 608739 - FP7-2013-NMP-ENV-EeB. The information in this publication does not necessarily represent the view of the European Commission. The European Commission shall not in any way be liable or responsible for the use of any such knowledge, information or data, or of the consequences thereof.

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS



Abstract

The main objective of the STREAMER project is the development of design methodologies which will enable a 50% reduction in the amount of energy consumed by hospitals. These methodologies rely heavily on Building Information Modelling (BIM) and the availability of expert knowledge in a useable format in an early design phase.

In this Deliverable, an effort is made to identify, capture and structure this expert knowledge so it can be used by the design team in an early design phase, in both refurbishment and new build situations. This is referred to in the description of work as "the conversion of existing energy-efficient building guidelines into semantic rules for BIM".

Five research fields of expert knowledge have been selected:

- 1. KPI's; Including them in this task ensures a balanced approach between energy saving measures and a safe, user-friendly, and cost-effective environment.
- Hospital questions; all four hospital partners of STREAMER have been asked to provide research questions (called "hospital questions") that to them are important within the scope of STREAMER.
- 3. Labels; these provide a strong theoretical basis for enriching space-related elements in the BIM, such as rooms and functional areas, with knowledge.
- 4. Energy; this research field has been incorporated to split the main objective of the STREAMER project (energy reduction) into more specific aspects.
- 5. GIS/BIM; this essential part of the deliverable and is included in order to relate the other knowledge fields to individual neighbourhood and hospital components.

In total, 964 relations between topics within these five research fields have been described in a datasheet. These relationships and their descriptions are the basis for BIM design template development in D1.6 and will provide suggestions for the development of EeB solutions (WP2), KPI's (WP3), knowledge retrieval techniques (WP4), parametric modelling techniques (WP5) and requirement models (WP6).



Publishable executive summary

The main objective of the STREAMER project is the development of design methodologies which will enable a 50% reduction in the amount of energy consumed by hospitals. These methodologies rely heavily on Building Information Modelling (BIM), the availability of expert knowledge in a useable format and energy consumption calculation, all in an early design phase.

Although energy performance calculations performed during the final design stages are complex because they take a lot of detailed information into consideration, it's actually much harder to perform energy performance calculations in an early design stage. Reason behind this is that the person(s) performing the calculation in a final design stage will be provided with accurate and detailed input, which can be processed by software capable of processing this complex information. In an early design phase, the information is simply not present. Expert knowledge is needed to fill in these "information gaps" in order to perform any calculation (or: estimation) at all. To make matters even more complex, the energy efficiency should not conflict with a safe, user-friendly, and cost-effective environment.

To put it simply; it would be unacceptable to not place windows because glass is too thermally conductive, or to lower the air change rate in the operation rooms because it uses so much energy. To make the right choices in complex buildings like hospitals requires an extremely high level of expert knowledge in architecture, engineering and construction.

In this Deliverable, an effort is made to identify, capture and structure this expert knowledge so it can be used by the design team in an early design phase, in both refurbishment and new build situations. This is referred to in the description of work as "the conversion of existing energy-efficient building guidelines into semantic rules for BIM".

The expert knowledge collected in this deliverable originates from five research fields:

- 1. KPI's; in STREAMER deliverable 3.1, Key Performance Indicators (KPI's) have been researched. Including them in this task ensures a balanced approach between energy saving measures and a safe, user-friendly, and cost-effective environment.
- 2. Hospital questions; The hospital questions hereafter listed have been provided by each hospital involved in STREAMER and address issues they directly experienced when designing, maintaining and managing their healthcare districts and buildings. The questions elaborated are of three different kinds; strategic, functional and environmental. These questions have been included in this deliverable to relate the developed theory to "the real world".
- 3. Labels; the labels as developed in D1.1 provide a strong theoretical basis for enriching spacerelated elements in the BIM, such as rooms and functional areas, with knowledge. The labelling concept has been tested within STREAMER in WP7 and so far has proven useful in enriching the BIM with valuable STREAMER-related data. In this deliverable the list has been significantly expanded. The AOUC Careggi has been taken as example to test and validate the new labels and system.



5 - 43

- 4. Energy; The selection of energy aspects and instances has been done to split the main objective of the STREAMER project (energy reduction) into more specific aspects and allow relations to the other research fields within the scope of STREAMER.. A distinction in scale level has been made to allow accurate descriptions when describing relations with scale- dependent aspects, like BIM elements.
- 5. GIS/BIM; the four research fields mentioned above have to be related to geometrical representations of (existing or new) elements. Both GIS and BIM are databases containing these elements, so they have been combined in the same knowledge field. This research field contains elements on all scale levels as defined in STREAMER: neighbourhood/district, building, functional area, spatial unit/room and component.

To structure the data within this document, the information contained within the five research fields has been subdivided into "aspects", which in turn can contain multiple "instances". Two examples:

Research field: GIS/BIM Aspect: room Instance: patient room

Research field: energy Aspect: ventilation (on building level) Instance: natural ventilation

All this information has been captured in a datasheet. On the X- and Y-axes, the aspects and instances are listed and described. At the intersections of these rows and columns, a text has been provided to describe the relation. There are three different text options:

a) description of the relation

b) "no relation"

c) relation to be determined in STREAMER T (task number) + explanation

The sheet contains 1955 fields that have been provided with information.

991 fields (51%) are "no relation"

0 are relation to be determined in STREAMER WP1

29 are relation to be determined in STREAMER WP2

13 are relation to be determined in STREAMER WP3

0 are relation to be determined in STREAMER WP4

8 are relation to be determined in STREAMER WP5

0 are relation to be determined in STREAMER WP6

0 are relation to be determined in STREAMER WP7

914 fields (47%) are described relations



KNOWLEDGE FIELD				KPI	KPI	KPI	KPI
	ASPECT				Energy performance and efficiency	Financial analysis based in whole life costing	Quality of the environme and operational efficienc
		INSTANCE					
			DESCRIPTION	Key Performance Indicator			
Hospital Question			question relevant for hospital organizations within the scope of Streamer				
Hospital Question	Which aspects are related to the integration of the hospital into the surroundings?				Reduction of emission and potential distribution of surplus of energy production	Financial issues related to the distribution of surplus of energy production	Satisfaction of users' needs and improvement operational efficiency
Hospital Question	Which aspects are related to the integration of planting/nature?				no relation		Satisfaction of users' needs and improvement quality of environment
Hospital Question	Should we consider automated transport?		self-navigating vehicles / transport carts			relation to be determined in Streamer T3.3 (D3.6)	Improvement of the operational efficiency
Hospital Question	What should we consider to lower the total cost of ownership?				Evaluation of the energy performance and efficiency	Data related on the whole life costing gives information on the waste of money that could be avoided and savings that could be obtained	Improvement of the operational efficiency

Fig 1: A screenshot of the datasheet (as in the appendix).

An example:

One of the hospital questions is: "Which systems can we implement to improve comfort conditions for patients in summer and winter?" Related aspects from the datasheet are: (descriptions of the relation are between brackets):

Labels:

- Indoor quality (Indoor quality requirements will set comfort conditions and will frame possibilities for improvement).
- HVAC and lighting (HVAC and lighting requirements will set comfort conditions and will frame possibilities for improvement).

Energy:

- Ventilation on room level (Ventilation system can improve comfort condition in the room).
- Lighting (Better lighting conditions improve comfort conditions all year long).

BIM:

- \circ The PoR (Requirements related to patient comfort should be in the PoR).
- Building envelope (Building envelope properties are related to patient comfort (e.g. openable windows).

KPI:

• Financial analysis based on whole life costing (Financial sustainability of measures to improve comfort condition)

This information will help the stakeholders to understand which information and responsibilities are related to one specific aspect of the design, in this case a hospital question. Some conclusions that can be drawn from this example:

- At least two labels should be incorporated in the design.
- The MEP engineers should pay special attention to lighting and ventilation aspects.
- The recommendation for the hospital is to include requirements related to patient comfort in the PoR.
- The architect should pay special attention to the building envelope.

These relationships and their descriptions are the basis for BIM design template development in D1.6 and will provide suggestions for the development of EeB solutions (WP2), KPI's (WP3), knowledge retrieval techniques (WP4), parametric modelling techniques (WP5) and requirement models (WP6).

List of acronyms and abbreviations

BIM: Building Information Modelling
EeB: Energy-efficient Building
GIS: Geographic Information System
HVAC: Heating, Ventilation, Air Conditioning
KPI: Key Performance Indicator
MEP: Mechanical, Electrical, Plumbing technologies
PoR: Programme of Requirements
WPx: Work Package (no.)
Tx.x: Task (no.)
Dx.x: Deliverable (no.)
Label: property tag attached to spatial component
Research field: topic within STREAMER
Aspect: topic / item within a research field
Instance: subtopic / subitem of an aspect

Aspect : room Instance: patient room

Definitions

"Semantics is the study of meaning. It focuses on the relation between signifiers, like words, phrases, signs, and symbols, and what they stand for, their denotation". (Source: Wikipedia) In the STREAMER context, examples of signifiers can be: a wall, a room, a KPI, the concept of natural ventilation etc.

Semantic (baseline) design model: a collection of design guidelines and the relationships between them.

Ssemantic rules for BIM: relationships between objects and/or information within the BIM environment.

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS STREAMER

Contents

AB	STRAC	CT CT	3		
PU	BLISH	ABLE EXECUTIVE SUMMARY	4		
	List of acronyms and abbreviations				
	Definitions				
СС	NTENT	ſS	9		
1.	INTRO	DUCTION	10		
2.	FRAM	EWORK	11		
	2.1	Research fields	11		
	2.2	Scope	11		
	2.3	Aspects and instances	11		
3.	INFOF	RMATION: RESEARCH FIELD CONTENT	12		
	3.1	GIS/BIM	12		
	3.2	KPI's	20		
	3.3	Hospital questions	21		
		3.3.1 TRF (United Kingdom)	23		
		3.3.2 RNS (Neherlands)	24		
		3.3.3 AOC (Italy)	24		
		3.3.4 APHP (France)	25		
	3.4	Energy	26		
	3.5	Labels	28		
4.	KNOW	LEDGE: CONNECTING THE ASPECTS	38		
5.	CURR	ENT AND FUTURE DEVELOPMENTS IN STREAMER	41		
	5.1	Implementing knowledge from D1.5 into the BIM	41		
	5.2	Challenges in BIM workflow	41		
	5.3	Dependencies and recommendations for other STREAMER work packages	41		
RE	FEREN	ICES	43		

1. Introduction

Connected information tells us more than stand-alone information. For example, within a multidisciplinary BIM, the amount of information exceeds the information contained in the individual aspect models. The connections, or relations, allow us to verify the quality of the individual models. A basic example of this verification is a clash control between the building services and structural BIMs. If there are no clashes, the individual models are correct. But we can only tell after the models have been put together and analyzed.

When we consider analysis of the BIM, validation based on geometrical properties as mentioned above is relatively straightforward.

It is more complicated when we want to know if the design, as represented by the BIM in an early design stage, is energy-efficient. Although energy performance calculations performed during the final design stages are complex because they take a lot of detailed information into consideration, it's actually much harder to perform energy performance calculations in an early design stage. Reason behind this is that the person(s) performing the calculation in a final design stage will be provided with accurate and detailed input, which can be processed by software capable of processing this complex information. In an early design phase, the information is simply not present. Expert knowledge is needed to fill in these "information gaps" in order to perform any calculation (or: estimation) at all. To make matters even more complex, the energy efficiency should not conflict with a safe, user-friendly, and cost-effective environment.

To put it simply; it would be unacceptable to not place windows because glass is too thermally conductive, or to lower the air change rate in the operation rooms because it uses so much energy. To make the right choices in complex buildings like hospitals requires an extremely high level of expert knowledge in architecture, engineering and construction.

In STREAMER, expert knowledge is captured and structured so it can be used in the BIM in an early design phase. The design will become more energy-efficient because the design team can make use of increased and improved analysis possibilities based on this knowledge. In the description of work this is referred to as "design methodology".

The question that is addressed in this deliverable is: which knowledge is relevant for this purpose, and how is it related to the BIM? The answer to this question is referred to in the description of work as "the conversion of existing energy-efficient building guidelines into semantic rules for BIM".

2. Framework

2.1 Research fields

A first step to answering the question mentioned in the introduction is to determine which research fields contain this desired knowledge. Five research fields have been selected:

- 1. KPI's; in STREAMER deliverable 3.1, Key Performance Indicators (KPI's) have been researched. Including them in this task ensures a balanced approach between energy saving measures and a safe, user-friendly, and cost-effective environment.
- 2. Hospital questions; all four hospital partners of STREAMER are involved in this deliverable. They have been asked to provide research questions (called "hospital questions") that to them are important within the scope of STREAMER. These questions have been included in this deliverable to relate the developed theory to "the real world".
- 3. Labels; the labels as developed in D1.1 provide a strong theoretical basis for enriching spacerelated elements in the BIM, such as rooms and functional areas, with knowledge. The labeling concept has been tested within STREAMER in WP7 and has proven useful in enriching the BIM with valuable STREAMER-related data.
- 4. Energy; this research field has been incorporated to split the main objective of the STREAMER project (energy reduction) into more specific aspects.
- 5. GIS/BIM; the four research fields mentioned above have to be related to geometrical representations of (existing or new) elements. Both GIS and BIM are databases containing these elements, so they have been combined in the same knowledge field.

2.2 Scope

Scale level

This deliverable will cover all major scale levels defined in STREAMER; neighbourhood/district, building, functional area, spatial unit/room and component.

Existing and new buildings

Both retrofit and new build situations are incorporated in this deliverable.

2.3 Aspects and instances

To structure the data within the document, the information contained within the five research fields has been subdivided into "aspects", which in turn can contain multiple "instances". Two examples:

Research field: GIS/BIM Aspect : room Instance: patient room

Research field: energy Aspect: ventilation (on building level) Instance: natural ventilation

3. Information: research field content

3.1 GIS/BIM

A common definition of GIS:

A geographic information system, or GIS, is a computerized data management system used to capture, store, manage, retrieve, analyze, and display spatial information. A GIS differs from other graphics systems in several respects. First, data are georeferenced to the coordinates of a particular projection system. This allows precise placement of features on the earth's surface and maintains the spatial relationships between mapped features. As a result, commonly referenced data can be overlaid to determine relationships between data elements.

(http://nerrs.noaa.gov/doc/siteprofile/acebasin/html/gis_data/gisint2.htm)

A common definition of BIM:

Building Information Modelling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder. (NBIMS¹).

Almost all information in the BIM is attached to geometrical objects which are created using modelling software. These geometrical objects always contain some form of data (semantics). For example, a specific floor in a project has geometrical information (length, width, thickness, position) and identity data (so we know it's a floor). This identity data is created by the modelling tool. Even though the geometrical properties of a floor can be the same as a roof, they can be recognized by their identity data.

The objects can be enriched with more data. This is necessary for purposes of model analysis. There are several types of analysis, of which cost, structural and energy performance are most common. To be able to make an analysis, the objects in model should contain the correct information on the chosen topic. For example, a roof can contain information about costs, structural capacities and thermal insulation values. Further research on which information is important for BIM elements in a certain design phase is done in STREAMER task 5.1.

Some information is not created within the modelling environment. For example, data about the loadbearing capacities of the soil can be contained in a PDF file. It is neither possible nor desirable to insert this information to the data structure of the modelling software, or IFC file. However it is possible to attach

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS STREAMER

¹ National BIM Standard – United States. National Building Information Model Standard Project Committee, <u>http://www.nationalbimstandard.org/faq.php#faq1 (</u>accessed: 2014-01-20)

a hyperlink to the geometrical site component which links to the PDF file. The PDF file thus becomes integrated within the BIM.

Obviously, when building a database of aspects to be related to each other, one must anticipate to the establishment of relations by choosing aspects that are likely to allow relations. The choice of BIM elements should support the scope of design validation and the aspects related to energy, labels, KPI's and hospital questions.

The list of BIM aspects (underlined) and instances (bullets) that have been selected for this deliverable²:

Programme of requirements (PoR)

The PoR can contain plain text or separate documents that are related to the building or building process in general. Several online tools provide a way to structure this information and make it easily accessible. Also, connections between data from the PoR and geometrical modelled objects can be made (these concepts are explained in STREAMER D4.3), effectively integrating the PoR with the BIM. The PoR can contain instances of:

- Project management (planning, tender procedure)
- Ambitions (includes information on sustainability-targets, costs)
- Comfort and safety demands (temperature, air quality, glare ...)
- MEP components performance specification (mechanical, electrical, plumbing)
- Material performance specification (based on a coding structure such as NL-SfB)
- Project administration (includes minutes of meeting, planning)
- Standards/guidelines (includes links to building regulations)
- Context (includes maps, drawings of surroundings, existing situation)

Functional area- and room-based information can be attached and synchronized to matching elements in the model using specifically designed add-ons within the modelling software. It is important to realize that the requirements are not always met in the design (especially the room surface area, which depends largely on the architectural layout.).

- Room-related information (includes functional, technical, furniture and facility management brief)
- Functional area-related information (includes functional, technical, and facility management brief)

<u>GIS</u>

GIS data relevant for a project is obtained from external sources, rather than modelled or created specifically for the project. Information in the GIS includes:

² An attempt has been made to provide universal naming of BIM elements. However, specific terminology is based on Autodesk Revit because this is currently the market leader in BIM modelling software for architects.

- Data related to soil composition (includes load-bearing properties, groundwater data, etc.)
- Data related to energy (includes energy profiles on building- and neighbourhood scale)
- Data related to buildings (includes information about other buildings, such as size, function, age, etc.)
- Data related to traffic (includes public transport, road capacities, noise pollution, etc.)

<u>Mass</u>

A mass can be used to model the expected size and volume of the project, and test how it fits on the plot and urban setting in an early design phase. Often the building context is also modelled as a collection of masses.



Fig. 2: Representation of the Rijnstate extension by a mass.

Functional area

A functional area is usually modelled as an "area". Although an area is a modelled component, it does not represent any geometrical element in the "real world". Areas can be connected to functional area-related information in the PoR.



Fig. 3: representation of a functional area in the Rijnstate extension

All functional areas listed below have been selected and explained in D1.1. They have been added as instances.

 $\mathsf{D}1.5\,\textbf{C}\text{O}\text{H}\text{e}\text{rest}\,\textbf{s}\text{tate-of-the-art}\,\textbf{d}\text{e}\text{s}\text{ign}\,\textbf{g}\text{u}\text{i}\textbf{d}\text{e}\text{i}\text{i}\text{e}\text{s}\,\textbf{f}\text{o}\text{r}\,\textbf{e}\text{s}\text{e}\text{f}\text{i}\text{e}\text{i}\text{e}\text{s}\text{i}\text{e}\text{s}\text{i}\text{s}$

Diagnostic treatment:

- Diagnostic imaging Nuclear medicine Radiotherapy
- Pre-hospitalization
- Endoscopy
- Blood sampling/testing
- Transfusion centre (blood bank)
- Rehabilitation
- Outpatient department

Ward:

Intensive care ward

- High care ward Low
- care ward Medical
- day hospital
- Oncological day hospital
- Day surgery
- Maternity ward

Operating block:

- Operating theatres
- Interventional radiology

Accident and Emergency:

Accident and Emergency (A&E)

General facilities:

- Medical testing laboratory
- Anatomical pathology laboratory
- Internal pharmacy
- Sterilization centre
- General storages
- Kitchen
- Canteen
- Medical archive
- Admission (reception, information, reservation)
- Garbage room and special materials disposal
- Mortuary
- Dressing rooms for staff
- Health physics
- Cleaning spaces

Public facilities:

Central hall Cafeteria / restaurant Stores

Space-Unit / Room

"A room is a subdivision of space within a building model, based on elements such as walls, floors, roofs, and ceilings." (Autodesk³). Just like functional areas, rooms do not represent any geometrical element in the "real world". Rooms can be connected to room-related information in the PoR.



Fig. 4: Visualisation of room properties in a floor plan (Rijnstate extension)

All room instances listed below are based on a work-in-progress inventory of common room types and standards in Swedish hospitals, put together by 17 of 21 county councils. For the purpose of this deliverable, some changes to the list have been made. These changes include:

- Including important room types such as central hall
- Deleting rooms that are not relevant for the scope of STREAMER. For instance, office for 1 person, office for 2 persons and office for x persons have been combined into "office".

Selected room instances are:

- Air lock
- Ambulance hall
- Analysis room
- Ante-room
- Archives
- Basement
- Canteen
- Central hall
- Changing room

(personnel)

- Conference room
- Conservation room
- Consultation + examination room
- Corridor

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS

³ Autodesk Revit 2015 help, <u>http://help.autodesk.com/view/RVT/2015/ENU/?guid=GUID-DD74A51D-A0B0-4461-A4BA-0F9CCC191CDB</u> (accessed: 2014-12-04)

- Day room
- Delivery room
- Disinfection room
- Dialysis
- Examination room
- CT Examination room
- ECG Examination room
- Endoscopy Examination room
- MR Examination room
- Triage Examination room
- Ultrasound Examination room
- X-ray Exercise rooms (revalidation)
- Group room
- Holding
- Kitchen
- Kitchen cleaning room
- Kitchenette
- Laboratory
- Laundry room
- Medication room
- Non-sterile washing room
- Nursing station
- Observation room
- Office
- On-call staff room
- Operation theatre
- Operation theatre, Hybrid
- Patient room
- Patient room (birth suite)
- Patient room (day hospital)
- Patient room (Intensive care)
- Personnel room
- Pharmacy
- Photocopier room
- Prayer room
- Preparation room
- Radiotherapy
- Reception
- Recovery room
- Recycling room

- Relatives room
- Resting room Patient
- Resting room Personnel
- Resuscitation/Children's ER
- Sanitation room
- Shower
- Shower for disabled people
- Sterile store, Infection control
- Store room
- Technical room
- Toilet
- Toilet for disabled people
- Trauma room
- Treatment room ER
- Unpacking room
- Waiting room

Outer building shell

The outside shell of a building contains the thermal envelope. From the energy perspective, its main function is to act as a buffer between the inside and outside climate. In the modelling environment, the thermal envelope contains the following instances:

- Exterior wall (structural wall layer not included)
- Window (window and frame)
- Curtain wall (window and frame)
- Roof (structural roof layer not included)
- Lowest insulated floor (structural floor layer not included)
- Door (to outside)
- Sun shading

Although it is possible to attach very detailed information to these elements, not all properties are included when exporting to IFC. A detailed example of information transfer included in a wall is provided in STREAMER deliverable 5.1.

Structural elements

Load-bearing elements are usually modelled by the structural engineer in a structural BIM. For the design process, the most influential instances in the model are:

- Structural column
- Structural wall
- Bracing
- Structural roof
- Structural floor





Fig.5: Structural model of the RIjnstate extension

Building services

Building services elements are usually modelled by the MEP engineer in a MEP BIM. For the design process, the most influential instances in the model are:

- Building management system
- HVAC zone
- Windmill
- Solar thermal panel
- PV panel
- Underground thermal storage
- Shaft opening
- Radiator
- Active ceiling
- Thermal active concrete floor
- Air conditioning unit
- Powerplant
- Boilerplant
- Sewage treatment recovery system
- Extended energy supply
- Chiller
- Air handling unit
- Pump
- Sprinkler installation
- Elevator
- Personal climate control (heating, cooling, ventilation)
- Vent (mechanical)
- Vent (natural)
- Plumbing fixture
- Lighting device
- Lighting fixture
- Electrical fixture



20 - 43

- Pipe
- Duct

User equipment

Non-medial user equipment such as computers, coffee machine, etc. can be modelled within the interior or architectural model. User equipment consumes a significant amount of energy, which is the reason it is incorporated in the scope of this deliverable.

Medical equipment

Specifications of medical equipment can have a significant impact on the design of medical-intensive areas of a hospital. For example, the size of medical imaging rooms is determined by the size of the medical imaging equipment.

Interior finishes

These relatively thin layers (finishes on walls, ceilings, floors) within the architectural model have a considerable impact on building and maintenance costs, people-friendliness and energy performance of a building.

3.2 KPIs

The KPIs for STREAMER have been developed as part of research in Work Package 3, and the results are presented in Deliverable D3.1 (publicly accessible).

The KPIs addressing Energy Performance and Efficiency use a "Layers" approach which considers that an acute hospital will consist of four definable usage types:

- Hotfloor
- Hotel
- Office
- Industry

They are used to identify the occupant usage characteristics which can, with the aid of a thermal model, help us understand the energy that can be used in each layer. An initial energy target can then be applied to each layer to enable the design process to progress within the parameters of the energy target. The areas of each layer combined with the energy modelled through the design process will offer the user the total theoretical energy use for the building.

The STREAMER KPIs on Energy Performance and Efficiency are:

- 1. Reduction of primary energy and carbon emission
- 2. Energy and carbon targets within country regulations
- 3. Energy and carbon targets within EU regulations
- 4. Energy and carbon targets developed as industry benchmarks
- 5. Energy and carbon targets developed through international best practice
- 6. Passive system integration



- 7. Active system integration
- 8. Use of renewable energy sources and technologies
- 9. Resilience risk (considered and managed)

When the energy model, energy target, building age and climate differences are taken into account we could consider the following matrix as a preliminary example of the manner in which the data may be represented for each project option.



Fig. 6: template matrix for determining energy consumption on building level

It would be easy to develop KPIs that focused only on an energy target and compare the options against the quoted target. However, we have applied a more balanced approach to our process, not least of all because the selection of optimum solutions now more than ever depends on extremely complex multifaceted/multi-discipline decision making processes. The simple intervention that makes significant change that is satisfactory to all stakeholders no longer exists.

The KPIs selected for STREAMER involve: 1) the efficient use of energy through an energy targeted approach; 2) the capital and operational costs through a whole life cycle cost; and 3) the development of the highest quality of environment and operational effectiveness through the development of a therapeutic environment. By considering these 3 types of KPIs, we believe that significant lower energy and higher quality environments will be achieved within the acute healthcare district/campus site.

3.3 Hospital questions

The hospital questions hereafter listed have been provided by each hospital involved in STREAMER and address issues they directly experienced when designing, maintaining or managing their healthcare



districts and buildings. The questions elaborated are of three different kinds. Therefore, all the questions have been clustered according to the kind they belong to.

A first cluster of questions includes all the design considerations of strategic nature. Indeed, these questions aim to identify a strategy in order to solve issues at the level of the whole district in terms of operational efficiency and energy performance.

A second cluster of questions includes all the design considerations of functional nature. These questions aims to solve issues related to the lay-out of buildings in terms of distribution, accessibility, circulation, quality and use of spaces.

Last but not least, a third cluster of questions includes all the design considerations to be made from the environment perspective. The questions relate to the energy efficiency and to the requirements that guarantee the comfort conditions of spaces, thus heating/cooling, acoustic, lighting and ventilation systems.

The complete list of the hospital questions elaborated by the four hospitals (TRF, RNS, AOC, APH):

- 1. Strategy:
 - Which aspects are related to the integration of the hospital into the surroundings?
 - Which aspects are related to the integration of planting/nature?
 - Should we consider automated transport?
 - What should we consider to lower the total cost of ownership?
 - Should we build new or refurbish?
 - Should industrial services be outsourced?
 - Which energy saving measures can be taken when upgrading MEP/technical solutions?
 - Can we use part of the affected area during refurbishment process?
 - Which energy saving measures can be taken when renovating the building envelope?
 - Which connections to the existing infrastructure do our technical systems require?
- 2. Layout:
 - How to humanize the medical units so we can meet the expectations of the patients and their families?
 - How can we determine the optimum room configuration within a department?
 - How can we determine the optimum functional area configuration within a building? Are the building and its systems flexible?
 - Which distribution system layout will be most energy-efficient?
 - What should be considered to manage logistics/patients/personnel flows (inside and outside)?
 - Which factors contribute to improved security in a hospital which is per definition public?
 - Can we change 2-person to 1-person rooms?
- 3. Environment:
 - What are the options when considering renewable energy systems?
 - How to manage hygiene and safety rules?
 - Which systems can we implement to improve comfort conditions for patients in summer and winter?



- What is the optimal building orientation from the energy point of view?
- What will be the energy consumption of the new building?
- What is the availability of the primary energy sources and capacity?
- What should be the thermal performance of the building envelope?
- Are there spaces with comfort requirements?
- Do we want natural ventilation?
- Which energy performance level should be prescribed?
- Which systems can we implement to monitor the energy consumption?

As already stated, all these questions have been elaborated starting from the specific issues each hospital has to face or the requirements they experienced. In order to provide a framework to better understand the role and purpose of the hospital questions, a short text has been developed by each hospital regarding the considerations that lies behind the elaboration of the questions.

3.3.1 TRF (United Kingdom)

When analyzing the options available to TRF for renewable energy, several methods were considered. Solar PV was most noteworthy but the long payback period did not make it a viable option. Wind turbines are not suitable for this site due to the large amount of trees in the vicinity. Bio mass boilers were another option considered but due to the layout of the site and the concentration of services and buildings around the boiler houses, it was felt that it would not be practical or cost effective to store bio mass pellets remotely and discharge them to a boiler several hundred yards away. It would also involve costly alterations to accommodate a bio mass boiler into the existing heating infrastructure.

The main focus of this project for TRF is a retrofit solution for an existing building (or parts thereof) so the emphasis has not been directed to renewable energy options.

If TRT were to design and build a new healthcare premise then everything related to renewable supplies would be included at the design stage, eg Solar PV, Solar Thermal, etc., but finances dictate the investment for an existing building refurbishment.

TRF were involved in a project several years ago where a refurbishment would revolve around the design and build being devolved into a "pod" design, where as much as possible of the room / ward / bay would be constructed into kit form off-site, and the off-site works would greatly reduce the on-site building works, lessening the number of trades on-site, the length of the building works and having the desired effect of reducing Health & Safety and hygiene issues.

TRF is currently undertaking an upgrade of heating controls, rolling out a programme of automatic local adjustment in ward bays / cubicles etc. The environment will be greatly improved for both staff and patients and energy savings will also be made due to achieving optimum heating and cooling levels.

Rotherham Hospital is designed in such a way as to maximize as much natural daylight as possible, but obviously it is not possible to have all areas benefiting from the orientation. Typically, wards are set up in a south to south easterly or south to south westerly facing manner as far as possible.

TRF is in the process of installing electricity monitoring of both the areas selected for this project down to circuit level. This will give an accurate data set going forward. Previously these areas had not been metered.



Rotherham Hospital utilizes a CHP that when running at its optimum efficiency will generate approximately 66% of the site base load. The remainder is purchased from the national grid network and the available capacity is currently 2155 kVA.

The refurbishment of any part of the building should meet with the requirements of BREEAM (The Building Research Establishment Environmental Assessment Methodology) and aspire to achieve a rating of Excellent or Outstanding. Certain areas (mostly clinical) where patients change or lay / sit in bed wear or treatment robes require more definitive temperature levels. Other examples are Special Care Baby Unit (SCBU) and Theatres. It is the intention to use natural ventilation or free cooling wherever practicable; however this should never be at the expense of environmental performance.

In the UK energy performance of a building can be assessed by the scoring in a Display Energy Certificate (DEC), where real energy data is fed into a software programme that will grade the building against a benchmark score of a "typical" similar type building.

Local sub metering, preferably web based or integrated on to the BMS, would be the desired option. This would provide the ability to analyze a location / area and drill down to establish the cause of any major variations, e.g. extended opening hours, installation of new energy hungry equipment etc.

3.3.2 RNS (Netherlands)

The Rijnstate Hospital is situated in a complex environment: close to the neighborhood and the housing around it. Rijnstate has developed a masterplan in which a first step is to add 10.000 m2 to the existing facility, while at the same time substantially cutting emissions of greenhouse gases. Also, a renovation of existing MEP systems is prepared and some of the high care departments such as the intensive care and the operating theatres will be renovated in the near future. Creating added value for the workers, the visitors and the neighbourhood in such a complex environment is a constant challenge.

Rijnstate is looking forward to implementing innovative design solutions which will ensure a balance between an improvement in the quality of healthcare, the processes behind the primary process and energy reduction. The extension and part of the existing hospital have been modelled in a BIM specifically made to test and evaluate Streamer knowledge and methodologies. The BIM is enriched with data from the programme of requirements, which includes the labelling system as explained in this deliverable. The research questions provided by Rijnstate therefore have a strong focus on the possibilities of spatial layout configuration, based on information from the PoR.

3.3.3 AOC (Italy)

The questions that Careggi hospital takes into account are the ones deriving from both the analysis and application of the "New Careggi Plan", the instrument that has been defining all the interventions to be made in the district since 2000. This plan was conceived in order to, on one hand, prevent the surrounding unique landscape to be destroyed and, on the other hand, to modify the functional model in order to tackle the lack of operational efficiency, difficulty of management and bad logistic organization within the whole system.

Therefore, the main purposes of the "New Careggi plan" were:

- 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 merge university teaching and research activities with healthcare activities.

Today, Careggi is facing some important problems that still need to be solved, which led to formulate design considerations within the scope of D1.5 on three different levels.

First of all, the "New Careggi Plan" has so far entailed the demolition of high numbers of buildings to allow the realization of new buildings well-integrated with the environment and landscape and more efficient from the energetic and operational perspective. Today, Careggi is looking for an intervention strategy to be adopted regarding some of the buildings that needs to be either refurbished or demolished (e.g. San Luca Vecchio). For this purpose, many aspects require to be analyzed in order to provide the better solution: advantages of improving the MEP solutions, quality of the environment (safety, hygiene, etc.), level of operational efficiency within the buildings (e.g. logistics, flow), possibility to adapt the layout to the new demand, etc..

In addition to this issue, Careggi hospital continuously has to face the problem of communication and transport within the complexity of the district. For this reason, the aspects and circumstances that entail problems of inefficiency have to be analyzed and tackled; and design considerations about the inside and outside flows of patients and staff, logistics management, position of facilities and services and transports' organization always have to be made.

Last but not least, Careggi is facing today's problems concerning the operation and possible use of the trigeneration plant, which produces at the same time electricity, heat and water for conditioning with a minimum degree of energy use and environmental impact. The plant, which has been in operation since a few months, foresees the possibility to sell the energy to the surrounding facilities outside the Careggi hospital. Of course, this possibility requires an attentive analysis of related aspects in order to be realized which lead to questions regarding the integration with the surroundings, the LCC, the total cost of ownership, etc.

3.3.4 APHP (France)

The question of integrating a healthcare building in its immediate surrounding is an important issue when building a new site or when refurbishing an old one. Consequently, a lot of aspects have to be carefully considered:

- Analysis of the urban context for obtaining the building permit; especially regarding the potential contestation and opposition of the residents. That is the reason why the integration into the landscape is very important: the building has to be visually integrated, that is to say it must not differentiate from the other buildings of the neighbourhood, especially in an urban context (material, colour, architectural style, etc.). Besides, it has to integrate, as far as possible, green areas in order to improve the patients' comfort and quality of life. Discussions with the project's stakeholders and particularly with the state-appointed architect responsible for the protection of monuments are then necessary to clearly identify the main aspects that have to be tackled to ensure an appropriate integration and avoid strong opposition of the project.
- Accessibility of the construction site for the trucks, workers, etc that has to be quite easy.
- Connectivity to transport: the building has to be easily reachable by different means of transport and this aspect covers at the same the connectivity to public transport (are there any bus, train,



26 - 43

subway or tramway lines which serve the hospital, do they often run and how late do they run, are there within a walking distance, etc.) and the connectivity for cars (are there highways or just simple road nearby, are they one-way or two-way streets, how many parking spaces will be necessary, is there any risk of traffic jam outside and inside the hospital that could lead to the blocking of an ambulance for example, etc.).

- Accessibility of the building: all the facilities have to be easily available to all the hospital's users (patients, families, staff and suppliers without creating disturbances for the hospital functioning regarding these different flows) and particularly to persons with limited mobility, for visually impaired persons, etc. and also for the different fire and rescue services.
- Connection with energy systems: the proximity of existing energy systems (urban heating or cooling systems for example) can facilitate the integration of a building. As a matter of fact, if the new building is far from any source of energy, the related costs to connect the site can be very important. Moreover, the way the energy is produced (renewable or fossil energy) also has to be taken into account.

3.4 Energy

The selection of energy aspects and instances has been done to split the main objective of the STREAMER project (energy reduction) into more specific aspects and allow relations to the other research fields within the scope of STREAMER.. A distinction in scale level has been made to allow accurate descriptions when describing relations with scale-dependent aspects, like BIM elements.

The list of energy aspects (underlined) and instances (bullets) that have been selected for this deliverable:

Ventilation (on room-level)

- Natural
- Mechanical
- Personal
- Special
- Individual regulation
- Local regulation

Ventilation (on building-level)

- Air preparation in AHU
- Air distribution

Heating (on building / neighbourhood level) Production

- Distribution
- Regulation
- Storage

Heating (on one or more room-level)

• Water system



27 - 43

- Air system
- Radiant
- Convective
- Local regulation

Cooling (on building / neighbourhood level)

- Production
- Distribution
- Regulation
- Storage

Cooling (on one or more room-level)

- Water system
- Air system
- Radiant
- Convective
- Local regulation

Lighting (on room-level)

- Incandescent
- Fluorescent
- LED
- Automatic control
- Manual control

Hot water Heating (on building / neighbourhood level)

- Production Renewable
- Distribution
- Storage
- Water treatment

Production

- Electricity
- Cooling
- Heating

Medical gases

Communication

Outside climate

- Heat
- Cold
- Wind
- Solar radiation



3.5 Labels

In STREAMER Deliverable 1.1 a set of parameters for labeling the lowest level of space unit has been proposed. This method introduces a set of codes and references that allows us to identify the spaces through the relations between spatial, functional and energy related features. The labels enable us to attach properties and characteristics to the different spaces and thus carry implicitly a lot of semantic information.

By adding this information through the labels it will be possible to, on one hand, optimize the (energy) performance of the buildings and, on the other hand, to understand the implication of design choices in an early stage.

The labelling method as developed aims to identify parameters and information and transfer these aspects into the semantic BIM model database. The main parameters and categories have been defined in the D1.1 report and were further analysed and optimized in D1.5 for the finalization of the semantic labelling system. As part of this deliverable the labelling system has been subject to an attentive assessment and improvement in order to achieve the implementation of a clear and complete "labels' matrix".

The labelling system here defined has been applied and tested on the AOUC Careggi in order to validate its efficiency. This exercise has proven to be crucial to highlight the potentials and advantages of the system, as well as the incoherencies and inconsistencies of it. The last part of the paragraph shows a brief exemplification of this application.

Furthermore, the labelling system will be tested in the Rijnstate Hospital for WP7. In WP7 RNS and DJG are creating the BIM model of the demonstration case and are including the information regarding the labels within it. This test will be crucial to validate the compatibility with the tool and to assess the accomplishment of useful results.

As stated the careful preparation of labels and the corresponding parameters provide the design with the necessary information at all levels and gives insight into opportunities for optimization and design implications. The first step of this preparation consisted of defining the labels and adding levels to the labels.

It can be assumed that the initial labels cover the optimal properties of the spatial units and that, for this reason, these labels should be assigned to spatial units when preparing the PoR, thus at an early stage of design.

Considering the wide range of possible labels that could provide the space with valuable information, a few criteria have been identified to define the list of labels. The labels finally selected must respond to the following requirements:

- It must be objectively measurable
- It has to have a relation with physical aspects of the space
- It has to have a relation with the use/function of the space
- It has to have a relation with energy

These criteria led to the removal of some of the labels from the list as defined in D1.1 as they do not respond to the criteria identified above. The removed labels indeed turned out to be ineffective for the purpose of the labelling system in the STREAMER project, focusing rather on performance optimization or analysis of the design choices. Among these were the labels "Flexibility of space" and "Routes". On



the other hand, some other labels have been introduced as they are considered useful for the BIM database.

The remaining fifteen labels have been grouped into eight clusters. The way the labels are grouped depends on their scope and features:

- The cluster "Layering labels". This cluster includes the "Bouwcollege layers" label, which defines the performance requirements for each typology of accommodation or building type. This label is crucial within the design process as it provides the information to assess the validity of the design solutions adopted (e.g. adjacency between different typology of accommodation, preliminary energy analysis, etc.).
- The cluster "Functional labels" includes the label "Connectivity, adjacency". This label is an
 important design tool as it describes the rules of the relationship among different functions and
 space, which consequently give information to develop the functional layout of the healthcare
 building. Nevertheless, this label has critical aspects that should be assessed in order to be
 operative within the semantic BIM tool, as described in this chapter later on.
- The cluster "Operational/usage labels" includes all those labels which deals with the
 operational efficiency of spaces and functions. They operate as rules to be respected in order to
 guarantee the healthiness and safety of patients and staff, as well as to optimize the efficiency
 of the hospital in terms of use of space and energy. Among these are the labels "Hygienic
 class", "Accessibility", "User profile" and "Safety".
- The cluster "Equipment labels" consist of the "Equipment label" which defines the level of equipment necessary within a space in order to allow a proper development of the activity related to the type of space. This label has implications on the energy use of the whole hospital, as , for instance, it defines for which spaces extra power is needed.
- The cluster "Technical/structural labels" involves the "Construction" label which has an important role during the design process, as it provides information for designing hospital spaces according to the most suitable constructive characteristics.
- The Cluster "Environmental labels" includes the labels "Indoor quality" and "HVAC and lighting". These labels contain all the comfort requirements of a space or a function, which consequently define the preconditions for MEP solutions, which will directly affect the energy use of the building. Therefore these labels play a crucial role within the STREAMER scope, as they provide information on the energy consumption of spaces.
- The Cluster "Architectural labels" includes all those labels which have a relation with the geometry of buildings and their volumetric and architectural characteristics. Among these: "Layout", "Compactness", "Mass" and "Form typology". The information provided by these labels appears to be relevant from the energy and the operational efficiency perspectives.
- The cluster "Specific labels", which contains labels that are defined specifically for each healthcare organization. For instance the "Organization" label which describes the coding system applied by each hospital to classify spaces and function. An example is the classification of spaces created by AOUC Careggi according to the S.A.C.S system.



Within each label a number of "levels" can be defined. Using these labels and levels it should be possible to define most of the requirements related to a specific activity and related space. Considering the complexity of healthcare districts requirements, the labelling system is applicable to each of the three main scale levels that build up healthcare districts: buildings, functional areas and space units. Therefore the labelling system could provide each level with parameters and factors that would inform the semantic BIM model on spatial, functional and energy related features. Table 1 shows a complete list of the labels, the clusters they belong to and the levels that build up the label.

LABELS CLUSTER	LABEL	LABELS'S DEFINITION	LEVELS	DESCRIPTION OF THE LEVEL
			HF	Hot floor layer: capital intensive high-tech functions that are unique to the hospital
Layering labels	D	This label has a relation with the typology of	н	Hotel layer: Patient accommodations
	Bouwcollege layers	functions and the requirements related	0	Outpatient units, accounting, management and training functions
			I	Industry layer: laboratories, kitchen, etc.
			CA1	not necessary
Functional	Connectivity /	This label has a relation with the distance between functions and the	CA2	strong functional connection between activities
labels	aujacency	spatial/functional relationship required between activities	САЗ	strong spatial connection with another activities required
			CA4	emergency connection with other activities
Operational/ Usage	Hygienic class	This label has a relation with amount of ventilation, air tightness, cleaning, materials necessary to meet the hygienic conditions requirements	H1	hygienic requirements related to reception activities
labels			H2	hygienic requirements related to office activities
			НЗ	hygienic requirements related to medical examination and treatment activities
			H4	hygienic requirements related to surgical activities
			H5	hygienic requirements related to laboratory activities
			A1	public
		This label has a relation	A2	accessible to patients, staff and visitors
	Accessibility	hospital, safety/protective/security	A3	accessible to patients and staff
		device	A4	accessible to staff
			A5	accessible only to specific staff members
	User profile	This label has a relation	U1	Monday to Friday 08:00 - 18:00



		with the usage time of spaces and the operating	U2	U1 extended till 20:00
		nours	U3	U1 with emergency function outside timetable
			U4	24*7
			S1	ordinary safety expedients
		with the expedients	S2	extra-ordinary safety expedients
	Safety	safety of people in relation to the activities/functions	S3	supervisory control expedients
		developed	S4	dressing up expedient
			EQ1	office
			EQ2	office+ medical gases
		This label has a relation	EQ3	Office + extra electric power
Equipment	Equipment	with the type of function, high electric power needed, medical gasses, ICT data points	EQ4	Office + extra ICT data points
labels			EQ5	medical gases + extra electric power + extra ICT data points
			EQ6	high electrical safety
			EQ7	special equipment
			C1	office requirements
	Construction	This label has a relation with floor strength, shielding against radiation, floor height, air tightness	C2	Office + extra floor strength
Technical/			Сз	office + extra floor height
Structural			C4	office + extra floor strength and height
labels			C5	accessibility from outside with heavy load
			C6	shielding against radiation
			C7	high level of tightness
Environmental			IQ1	daylight
labels		This lobal has a relation	IQ2	daylight and view out
	Indoor Quality	with the needs for daylight, view outside and natural ventilation	IQ3	daylight, view outside and mechanical ventilation
			IQ4	daylight and mechanical ventilation
			IQ5	mechanical ventilation
	HVAC and lighting	This label has a relation with the thermal, acoustic.	HL1	office and laboratory activities
		lighting, ventilation, etc.	HL2	special laboratory activities



		requirements		
			HL3	medical examination and treatment activities
			HL4	surgical activities
	Layout	This label has a relation	L1	deep plan configuration
		with the depth of the plan configuration	L2	narrow plan configuration
	Compactness	This label has a relation	CO1	high level of compactness
	Compaciness	building	CO2	low level of compactness
		This label has a relation	M1	high % glazing
	Mass	with the property of the mass in terms of	M2	balance between walls and glazing
Arabitaatural		walls	МЗ	low % of glazing
labels	Form typology	This label has a relation with the possible arrangements of healthcare districts	FT1	Linked pavilion or finger plan
			FT2	Low-rise multi-courtyard or checkerboard
			FT3	Monoblock
			FT4	Podium with one or more tower
			FT5	Street
			FT6	Atrium/Galleria
			FT7	Unbundled
			FT8	Campus
			FT9	Layered
Specific labels	Organization	This label has a relation with the specific organization which each healthcare district classifies activities, spaces and functions with (e.g. S.A.C.S in Careggi healthcare district)	code	organization coding system

Table 1

While developing the matrix above, it became clear that the labels could be divided into two different groups: labels that require a "check" and labels that require a "number". The first kind includes labels which inform the space with a property, a characteristic. For instance the label "User profile" which does not require the definition of a parameter value as it operates as sticker with information regarding the space. Labels of this kind are: Bouwcollege layers, Accessibility, User profile, Layout, Form typology, Organization. This in contrast to the second kind of labels that inform the space with a specific value, a parameter. If we consider the label "Hygenic class", for instance, it entails the definition of a value to



each level of the label. Among this kind of labels: Connection and Adjacency, Hygienic class, Safety, Equipment, Construction, Indoor Quality, HVAC and lighting and Compactness and Mass.

D1.6 will deal with the specific information that build up each level of a label. For the labels of the first kind, it will define the meaning, requirements and the implication of each property, while for the labels of the second kind it will provide the values to be considered as "standards" to be met. The information generated will then be assessed while validating the design choices through the design configurator.

Despite the different nature of these groups of labels, mostly all of them are structured and developed according to the same structure. All the levels within those labels are defined as "scores". This means, on the one hand, that the choice of a level is unambiguous and the assignment of multiple levels within one label to the same spatial unit is not allowed, and, on the other hand, that the levels are displayed on a scale of increasing (or decreasing) values, rather "scores".

At the moment, there is one label in particular for which the rules as described above are not valid. This label is "Connection and adjacency". This label includes different levels that do not exclude each other. It is highly possible that one space could be linked to more than one level of this label. For instance, a functional area or a space requires an emergency connection with a specific activity, but also a functional connection with another at the same time.

The question at this point is whether the BIM database could support the possibility of applying multiple levels within the same label. Further steps within the research should confirm the validity of this type of label by test and confirm whether the multiple levels are applicable in the semantic BIM model or not.

		CA1	not necessary
Connectivity / adjacency	This label has a relation with the distance between functions and the spatial/functional	CA2	strong functional connection between activities
	relationship required between activities	CA3	strong spatial connection with another activities required
		CA4	emergency connection with other activities

Table 2: example of label that entails multiple choices

Another important observation is the fact that the label "Connection and adjacency" as formulated in table 2 can only work as a requirement if it is expressed in relation to another room or functional area. But this kind of relation within a label cannot be tested in a design validator. The same consideration applies to all the architectural labels (table 3) which cannot be tested the same way as the other labels, but still provide useful information regarding the design and the energy use of a building. In addition, these architectural labels all act on the building level, while the other labels could be applied to space units and functional areas. The latter could probably be assigned when preparing the PoR, while there is probably no need to have an architectural design at that stage.

According to this, it is important to establish the suitability of this group of labels.



		This label has a relation	L1	deep plan configuration
	Layout	with the thickness of the plan configuration (??)	L2	narrow plan configuration
	Compostação	This label has a relation	CO1	high level of compactness
	Compaciness	building	CO2	low level of compactness
			M1	high % glazing
		This label has a relation with the property of the	M2	balance between walls and glazing
	Mass	mass in terms of percentage of glazing and walls		
Architectural			МЗ	low % of glazing
labels	Form tonology (FT1	Linked pavilion or finger plan
			FT2	Low-rise multi-courtyard or checkerboard
			FT3	Monoblock
		This label has a relation	FT4	Podium with one or more tower
	i onn typology	with the possible arrangements of healthcare	FT5	Street
			FT6	Atrium/Galleria
			FT7	Unbundled
			FT8	Campus
			FT9	Layered

Table 3: example of label that express a requirement but cannot be tested in a design validator

After defining all the labels according to their levels, the elaboration of the labelling system focused on the definition of the relationship between the labels and the different scale levels (building, functional area, space units). The matrix in Table 4 shows which label could be applied at which level and how.

LABELS CLUSTER	LABEL	APPLICATION OF THE LABELTO THE SCALE LEVELS			
		Building	Functional area	Space units	
Layering labels	Bouwcollege layers	x	x	x	
Functional labels	Connectivity / adjacency		x	x	
Operational/Usage	Hygienic class			х	
labels	Accessibility		x	x	

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS STREAMER



	User profile	х	x	
	Safety			х
Equipment labels	Equipment			x
Technical/Structural labels	Construction			х
Environmental	Indoor Quality			x
labels	HVAC and lighting			x
	Layout	x		
Architectural	Compactness	x		
labels	Mass	x		
	Form typology	x		
Specific	Organization	v	×	×
labels	Organization	^		^

Table 4: application of the labelling system to the scale level

The black boxes displayed in the matrix explain the suitability of the labels to the scale levels. It does not mean that it is not possible to define the label-level at the scale level highlighted in black, but rather that according to the intended STREAMER approach, we try to define the scale level for which it is most logical to apply the label.

Indeed, it is possible to define some labels at the scale levels for which the matrix displays a black box through a "transferring properties" effect. This effect will be explained hereafter.

It is possible that in some cases multiple spaces with different label-properties will be concentrated in one single functional area or building. When this occurs there could be the effect of transferring properties of the predominant label to (all) other space units. This effect will be explained by a fictitious label "Ceiling height". We could concentrate space units with different label-properties for ceiling height into one functional area: a single floor with rooms that require at least a 2,5 m high ceiling together with rooms that require a ceiling height of 3,5 m. This will often lead to constructing the building according to the predominant requirements: in this case the building area will be likely to be constructed with a ceiling height of 3,5 m. The effect of replacing the original optimal parameter of some of the rooms (a ceiling height of 2,5 m) with the inherited parameter (a ceiling height of 3,5 m) tells us something about the implications of this design choice on the single space units.

This means that when a large number of space units within a functional area (or functional areas within the building) is characterized by the same label's parameter (most of the spatial units have the same label-level) or when a space unit (or functional area) has a predominant requirement, a process of "inheriting properties" could take place, through which the assignment of the label is homogenized to all the space units within a functional area (or a functional area within the building). According to this method, it is implicit that some labels



are expected to be directly assigned, while others are supposed to be defined by the "inheriting properties" process.

The Bouwcollege layers, for instance, seem to be applicable at all scale-levels. But this does not necessarily mean that the spatial units have the same layer label for a certain function at each scale level. An office room will most likely have an office label at the space unit level, but when realised in a hot-floor functional area (like an office room in the operating department) it will probably 'inherit' the hot floor characteristics. Another example: the essence of a delivery ward is a hotel-function and can best be combined with other functions fitted in a hotel-like building. But when, for instance, from a process-view is decided to place the delivery ward as close to the operating room as possible, and as a result of that decision the delivery ward is placed on the same floor in the same building as the operating room, it is more likely to have hot-floor characteristics than hotel characteristics.

Of course, considering the fact that the original label reflects the optimal situation for a space, a functional area or a building, the inheriting properties process determines a deviation from the optimal situation. Therefore, in order to calculate this deviation, judge the effects of the chosen design and test alternatives, it is crucial to preserve information of its original properties.

As stated, the AOUC Careggi has been taken as example to test and validate the labelling system as described in this chapter. Here follows an exemplification of the labels assignment to one building, San Luca Building C ("San Luca nuovo") and a functional area and the spatial units within that building. The example traces the breakdown chosen in D1.1 to describe the STREAMER approach. The following table has also been used in D7.5, where it is more elaborately described.

LABELS CLUSTER	LABEL	APPLICATION OF THE LABELTO THE SCALE LEVELS				
		Building	Functional area	Space units		
		SAN LUCA NUOVO	OUTPATIENT CLINIC	ERGOMETRICS AREA		
Layering labels	Bouwcollege layers	Hot floor (HF)	Office (O)	Office (O)		
Functional labels	Connectivity / adjacency		CA2	CA3		
	Hygienic class			H3		
Operational/Usage	Accessibility		A2	A3		
labels	User profile	U4	U1			
	Safety			S1		
Equipment labels	Equipment			E4		
Technical/Structural labels	Construction			C1		
Environmental	Indoor Quality			IQ3		

D1.5 COHERENT STATE-OF-THE-ART DESIGN GUIDELINES FOR ENERGY-EFFICIENT HEALTHCARE DISTRICTS



labels	HVAC and lighting			HL3
	Layout	L2		
Architectural	Compactness	CO1		
labels	Mass	M2		
	Form typology	FT3		
Specific labels	Organization	16_C	Chest physiopathology outpatients	16_C_077

Table 5: Labelling system applied to Careggi

According to the nature of this deliverable, which is a guideline, the idea is to keep the matrix as it has been defined so far, including all the labels listed. In the near future, the task would be to define the method to enrich the system through the use of semantic rules within the tool. This method would allow testing the critical aspects of the labelling system here highlighted. This work should determine whether some of the labels are not compatible with the BIM model or not necessary for its objectives.



4. Knowledge: connecting the aspects

The relations between aspects and instances of the knowledge fields mentioned in the previous chapter are of key importance to this deliverable and have been captured in a relations sheet.

	KPI	Hospital Question	label	energy
Hospital Question	IAA			
label	TNO	TNO		
energy	MOW	MOW	IAA	
BIM element	DJG	DJG	DJG	MOW

Fig. 7: Image showing how the knowledge fields are placed in the relations sheet. The STREAMER partners responsible for describing the relationships are also mentioned.

In rows and columns, the aspects and instances of the knowledge fields are listed and described.

KNOWLEDGE FIELD				KPI	KPI	КРІ	КРІ
	ASPECT				Energy performance and efficiency	Financial analysis based in whole life costing	Quality of the environmen and operational efficiency
		INSTANCE					
			DESCRIPTION	Key Performance Indicator			
Hospital Question			question relevant for hospital organizations within the scope of Streamer				
Hospital Question	Which aspects are related to the integration of the hospital into the surroundings?				Reduction of emission and potential distribution of surplus of energy production	Financial issues related to the distribution of surplus of energy production	Satisfaction of users' needs and improvement of operational efficiency
Hospital Question	Which aspects are related to the integration of planting/nature?				no relation	no relation	Satisfaction of users' needs and improvement of quality of environment
Hospital Question	Should we consider automated transport?		self-navigating vehicles / transport carts			relation to be determined in Streamer T3.3 (D3.6)	Improvement of the operational efficiency
Hospital Question	What should we consider to lower the total cost of ownership?				Evaluation of the energy performance and efficiency	Data related on the whole life costing gives information on the waste of money that could be avoided and savings that could be obtained	Improvement of the operational efficiency

Fig. 8: Screenshot showing a fragment of the relations sheet with rows and columns (appendix).

At the intersections of these rows and columns, a text has been provided to describe the relation. There are three different text options:

a) description of the relation

b) "no relation"

c) "relation to be determined in STREAMER T (task number) + explanation



The sheet contains 1955 fields that have been provided with information.

991 fields (51%) are "no relation" 0 are relation to be determined in STREAMER WP1 29 are relation to be determined in STREAMER WP2 13 are relation to be determined in STREAMER WP3 0 are relation to be determined in STREAMER WP4 8 are relation to be determined in STREAMER WP5 0 are relation to be determined in STREAMER WP6 0 are relation to be determined in STREAMER WP7 914 fields (47%) are described relations

The relations to be determined in other WPs involve WP2, WP3 and WP5. This information will be communicated to the responsible task leaders for consideration.

To improve readability, conditional formatting has been applied to the sheet: when there is no relation, the cell is grey. When a relation is to be determined in another STREAMER task, the cell is green.

Fragman for call other are plotted to compare the failed optimized for concerning	Annual terration of a state of the second se	Paga tas sell a barrar apito in in lagato colorada i setupol	Paraprine address of registering registering of registering registering	A sector and after the relation		Populacial district optical la strapporter p contrato	Paramite adjuster galaxie berne de reg oblighter d'arrange	Proposition and of each fra- regions for energy-control monomers	A que to confit al set to a constant concernant de la con- cernant qu'il se facilitat		Page to all the schedules congrates	Paga tao ati attor spina a basin di anos ati gastas	Restatived a labor bacterial area if your consultation for property for property.	The properties required in the second	Pauja ka adhirikana Mgalar produje sa sati kasa artis ta taking	Angelin all charas agine is each an mailer is a set	Papat to all of Instances for plant charge later plant	Page to all uses optime to the second consultance of	The properties will write the particular conditions for particular discussion for the boundary of the particular the trappent and data	The spin-alcosing matching colors of the first in program in part in again and in part	The properties and writtle former and another metalation for many metalation of the matting		Assessment of at a sector	The properties will induce an aprice for ordination of both	The properties will write - Second to which performance the following the determined	
											The laps supraw is defining to shad any tao lans lapator with the same she without its	The last supramits data, including data last lagellos adi de sana idenation ha	The layer equivalence of the second s		The lag or approach social affine ground disc is affine ground disc is the strong of the characteristic at the strong of coloradic and the strong of coloradic affine is successed at the strong											
	Papets equivalents on Their equivalence is use don't many			Program report of the op- brain to the decision of the balance of the minimum of the second second second to the second second second to being the of should be	Ngenis den se le s esta la mana e labora entre la labora entre la reporterio se altre se protector ne se la balance						Ny generalista di anaga t adi adita hari di mgainna si adita hari di mgainna dagarina saring mina adite adigarina kana nga mana di Marana Ny generalista ang berdaj general Lagrica	Figure stars of a factorial size of colors for aphrone square enright in stars in the balance stars and balance and spin- size stars applied proprior prime	Rode enviropente optimiset la clading la parte de la clading la cladin de la clading la cladin de la clading la cladin de la cladina la cladin de la cladina la cladi											Figure to the representation of the sec- tor production of the sec- ence of the total of the		
Occurs incomendation and data observations are all owners of the data in the result products. In factor by address path- ication by address path- ing a Marinalism.		Redeation incomobility adjaces in a bottom on the map as historical classical of 1 and the coal	Chaine increase with Algorithm of the control of th	The accessed by the second accessed by the second accessed accesses into access accesses into access accesses into access accesses into access accesses into accesse								Annual Milly address for splittered space and go determined a biology and control of the splittered and and provide splittered by particular bigging	Positive environment of a product on the court of the off of the strength the second office and the second office and the		As an oddly, or gate and strength of the strength fragments for participation of these	Anne dilli Jacondari shi as ali uday ari as algoti patenti										
			Annae of social are d social and barries of Ryber production (Ryber production) are discussed by			WOFF all and oblight drawn is to provide the period						She political alor for spinor upor original spinor balance and the policity proved policity proved highles	Rock and case of a													
			Rest produces making mine advance app product of the second second second second path second second second path second second second manufactures of the second second second connecting	And all an appropriate sector of the sector of the descent of the back of the descent of the first sector of the descent of the the sector of the descent of the the sector of the descent of the sector of the descent of the sector of the descent of the	Adding an approximation of independent systems for the independent of the system of the system of the system of the independent of the system of the system of the independent of the system of the independent of the system of the system of the independent of the system of the system of the system of the independent of the system of the system of the system of the independent of the system of the system of the system of the independent of the system of the system of the system of the system of the independent of the system of the system of the system of the independent of the system of t		Parad attributes a process to kinder to be denoted to attribute to be denoted to attribute to attribute at observations metally of the attrib				Botty polls selected - to grow called a structure calles a spinor calles bottom calles polls and polls and polls and bottom b	Relative profile self-school - The application school and genders with the self-self-school profile profile and profile applies	Readin according to a little ingle of the little of the state of the s		Ballip exclose with add of the lip direct frame. Unput of the second second second with a general second second provide from a second	References to the second secon										
			Factorial equipmental advances to inductions of the system, but day title equipment at the single experision of the singl			Become stary reported to the second starting prototed	Energy of the d basis of an degeneration of the method of the second of the second second second of the second second				Engineer's of all the Theoptimic space and pointed could be a depointed could be for some and pointed to one price off, pointer of Register	Engineer first all d'hol the address taans oorligation all the bibling areas all the some sequentil to do so policity proport togeto	Reads and to study a representation of the study of the second second second second representation of the second representation r	No representation and searching advances interview spin in the contemp advances for the spin in the searching spin in the former spin in the searching spin in the former spin in the spin in the spin in the hyperbolic searching spin in the spin in the spin in the hyperbolic searching spin in the h							The applicant many set of the de- ring and is an art of fragment of the set of the provider of the					
			Res energy: An exp de solvers energie modeline a sergier modeline a sergier modeline and modeline for other and modeline addresses for a fill of the solution of the solver addresses for a fill of the solver fill of the solver the solver f			The second second period with an end of the second					Bernet balanced atta	Processing to call of all places of classified critics	Recentration of tem increased in a basis of a basis with spinors	Non-antine for providing to the model of the second second and self the second second							Taken of the labeling with					
	Internet and a manifester of the second data space of the second data space of the second data second data second data second second data second data second da			Information interview and a second to the descent on the descent descent on the descent and a second to the descent interview and the descent		Information mathematical mathematical and material address to add material address to add the production for the data composition and her data compo- ments material		biter a diy second a sind with tribuly r or of all sind r distant for all local formation of a single rest. Since rest. Since		Waterspeer's closes are in the model and a site consist for the district for the second sys- escentration of the site of the fitting light and sites are (particulate address for (particulate address for (particulate address for	Information materies to address for endpotential address data local called andirius for between agrees to produce and to a single	bian andig aquation de adacted de collige decadore i bializar a quite a productore a quite a productore i collige	Readin according to a set option of the sequences in additional to be sequences and provide the set of the second programments	Recenter golfy replaced to self a deal to the larger of the self spins larger of the self many different direction					hine gaily spannet deut white and on a bit- hine and on the other history and the state		hine andy represent addressly observing an		Index quality prime by Malacian In an orbital composite and a	biter andly og territori bard indetecto pendid y to e dire acte de estimos		
				Patha and typing regions the second to be assessed to the design of the second to the second state with the second second state with the second secon		Print out taking internet of these for all the second second internet second second second internet second second second internet second second second second internet second second second second second internet second s		FOR an Ming separate and taxe to produce an approximate	WAS and ball on aspector to be de- de- outer of the second control of the second of second best		NVIG appoint of all charter protocol and charter protocol and charter protocol and protocol p	FILE operation that is generating being associations being associations providing association providing association providing providing association provid	Rodik soročnost s opratoval to obskog ingesti od tobskog ingesti od to obskog ingesti od tobskog ingesti od to obs					Recolution is cost Distinguisting requirements address when is receip considering splates	PERSONAL AND INCOME. Page and the second second Income and the second second Income and the second second Income and the second second Income and the second s	The acceleration of the index goal relations more of J Constanting magnetic the magnetic the ma	nationing of the second	The located age second and after the second facility second at the location of the	Hand and Advise many series and a series and a series of response of a	WAT approach and obtain tarbats and an inclusion and an inclusion	national programs	
													ingoni wilach o te Bedilji trona d te Bedilji trona d te Bedilji trona derosti ostropostorosti teo ostropostorosti teo seno ostropolitikati bedilji teo teo teo teo teo teo teo teo teo teo	The logist of the coding of the local studies optime logist splices							Robins for ogt hor de brieder og der ber sont i bleftinger sonte foregi in de den fore ginn de den in her de de den arbeitigting traj					
			A second fielding code base code of determine transport do search base by granter do arts											The generative of the basic system for an other system for spinst.	The generic of the being of the constraints with a state of the state of the manage from											
Cost affective on partici- tionage social efficiency								hayanatap diging ari nda dinih olariya araya talapanan n di kamalap										Percentage of glocing and address of the control case on the state of the second secon	Providings of giving and address of solid at the solid solid at the solid solid at particular of solid particular backing		Annexety of the processing of the ray reason for the set of the article displaying there is a relative set of the second of the ray also second of the ray also second of the ray also second of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the ray of the ray of the ray of the second of the ray of the second of the ray of the second of the ray					
Free lighting on the state of t		Teripakg silakat ke pastilika di atarata tata pr				Face backing a block of back to be a constraint to an an address of the back for an architect							Free Carring with the The Backing of Bac Saddings and the spaces	Norsi yakiyo di ku taki yaki si ku ataki si kupa taki si	Non Loning chick is shifter more acts as for an electromy fun-				Participanting self-serve advances integration of a method services							

Fig. 8: Screenshot of the relations sheet showing how concentrations of relations can be visually identified (appendix 1)



An example:

One of the hospital questions is: "Which systems can we implement to improve comfort conditions for patients in summer and winter?" Related aspects from the relations sheet are: (descriptions of the relation are between brackets):

Labels:

- Indoor quality (Indoor quality requirements will set comfort conditions and will frame possibilities for improvement).
- HVAC and lighting (HVAC and lighting requirements will set comfort conditions and will frame possibilities for improvement).

Energy:

- Ventilation on room level (Ventilation system can improve comfort condition in the room).
- Lighting (Better lighting conditions improve comfort conditions all year long).

BIM:

- The PoR (Requirements related to patient comfort should be in the PoR).
- Building envelope (Building envelope properties are related to patient comfort (e.g. openable windows).

KPI:

• Financial analysis based on whole life costing (Financial sustainability of measures to improve comfort condition)

This information will help the stakeholders to understand which information and responsibilities are related to one specific aspect of the design, in this case a hospital question. Some conclusions that can be drawn from this example:

- At least two labels should be incorporated in the design.
- The MEP engineers should pay special attention to lighting and ventilation aspects.
- A recommendation for the hospital is to include requirements related to patient comfort in the PoR.
- The architect should pay special attention to the building envelope.

The relationships between the BIM and the other aspects (In the description of work, this is referred to as "the conversion of existing energy-efficient buildings guidelines into semantic rules for BIM") are the basis for BIM design template development in 1.6.



5. Current and future developments in

STREAMER

5.1 Implementing knowledge from D1.5 into the BIM

In current practice, some of the aspects related to BIM can be easily implemented into the BIM. To summarize:

- The labels can be attached to the PoR, mass, functional area and room components. This has been demonstrated in WP7.
- How and if the labels should be attached to building envelope, structural elements, building services, medical and user equipment and interior finishes is to be researched.
- How and if the KPIs and energy aspects should be attached to the BIM is to be researched.
- The hospital questions should not be attached to the BIM. Hospital questions have been added as knowledge field to this deliverable for the purpose of relating the other aspects to real-world design considerations.

5.2 Challenges in BIM workflow

File formats: the IFC format used for BIM exchange is currently not used as a modelling file format by common architectural BIM software; IFC files are generated by export only. Most analysis software is IFC based, which means that the analysis will not take place in the modelling environment itself. The designers would profit from an immediate response from the analysis software while modelling.

Conversion/mapping from native file formats to IFC sometimes results in a more complicated workflow. For example, functional areas and rooms (in Revit and ArchiCAD, these coexist within a single model/file) are both converted to IfcSpace. In the IFC format however, IfcSpaces are not allowed to overlap. This means separate IFC files must be generated to represent the spatial elements in a single Revit/ArchiCAD file.

Data compatibility: Not all data in the IFC file is recognized by all (energy) analysis tools. To be researched is if it is relevant to create property sets especially for STREAMER, if these cannot be "read" by the analysis tools.

5.3 Dependencies and recommendations for other STREAMER work packages

Deliverable 1.5 will provide input for:

- WP2: relations between energy and BIM aspects might provide suggestions for further development of EeB solutions.
- WP3: relations between the KPIs and other aspects might provide suggestions for further development of the KPIs.
- WP4: relations between the PoR and other aspects might provide suggestions for further development of the PoR.



- WP5: knowledge related to the BIM aspects will help to determine which properties should be used in the BIM family template.
- WP5: the information and relationships will contribute to capturing and formalization of requirements (who is responsible for which information at which stage of the design).
- WP6: relations between the PoR and other aspects might provide suggestions for further development of the requirement model.
- WP7: the labelling system can be incorporated in the test cases on the short term. We can test for which purpose they can be used.

STREAMER deliverables that have provided input for D1.5:

- D1.1: the labelling method has been re-used and updated.
- D3.1: the KPIs have been re-used.

In STREAMER D1.6, research will likely focus on:

- Possibilities for integrating the sheet developed in this deliverable into the REQCAP system developed by AEC3.
- Conversion of the relations sheet to a database structure.
- Expansion of the database with knowledge developed in other STREAMER deliverables.
- Visualization of relationships, making the data more easily accessible.

Deliverable 1.6 will provide input for:

- WP6: values associated with BIM aspects will be used to develop rules for design validation / configuration. An example: design validation on room properties can verify if a patient room categorized as "hygiene class H3" (this information is provided in D1.6), is accordingly labelled in the model.
- More relationships with other STREAMER deliverables are to be determined.

References



n/

ASPECT	Energy performance and Financial analysis based in Quality of the environment efficiency and operational efficiency	Not second as a relation of the second as a relation of th	property label Bouwcollege layer Connectivity / adjacency Hygienic class Accessibility User profile Safety Equipment Construction Index Quality HVAC and lighting Layout Compactness Mass Farm hypology Organization
	Performance Indicator Performance Indicator within the sco	ner for excedures ge of tananget or tan	here a relation of the service of th
suestion relevant for hospital tal Question devices within the scope of Streamer			Enteren schriftes conditions fligutements and generation of the second
Which alsoleta are ball Question integration of the hospital into the surroundings? Which aspects are tal Question related to the	Reduction of emission and prevacula issues related to Statistation of user in each subitat distribution the distribution subparts of an antiprovement of production energy production operational efficiency production energy and statistication of user if media and improvement of quality		
Integration of an environment of the environment of	of environment relation to be determined in improvement of the Streament 73.2 (D3.6) Data related on the whole life costing gives		
tal Question total cost of "man" ownership? tal Question Should we build new or	performance and efficiency money that coade te avoided and avoids the divergent terms of the divergent coade te obtained relation to be determined in relation to be determined a statistication and operational Streamer (7.3. 2(3.6) Breamer (7.3.2(3.6) efficiency supports the		
Should Industrial tai Question services to a outsource?? White energy soving measures on teal and Question when supprading	relation to be determined in relation to be determined statistical and operational Streamer T.3. (10:6) Streamer T.3. (10:6) efficiency supports the deficiency supports the deficiency supports the deficiency approximation of the streamer T.2.1 (10:2) and the support of streamer T.2.1 (10:2) and the support of stream		
MEPActificial solitors? Can we use part of the fail Question affected area during process? Which energy saving	12.2 (02.5) MEP technical solution service instance no relation remains no relation remains restance no relation remains restance restanco restance restance restance restance restance restance restance		
tal Question when revoluting the building envelope? Which connections to tal Question Infrastructure do our technical systems	reliation to be determined in Financial sustainability of environmental conditions Breamer 72.2 (12.5) energy saving measures depending on the energy saving measures no relation to relation to relation		
require? How to humanize the medical units we tal Question expectations of the palients and their families?	no relation no relation Improvement of the environmental conditions and operational efficiency		
the optimum room in the optimum functional all Question of the optimum room optimum room optimum room optimum r	no relation no relation increases improvement of the environment and constrained efficiency and operational efficiency improvement of the environmental conditions and operational efficiency		
tal Cuestion Are the building and its systems fexable? Ial Cueston system layout will be most energy efficient? distribution	Compatibility between flexability and metal- performance and efficiency lives relation to the determined of the determined performance and efficiency lives relation to be determined of the det		
What should be considered to manage all Question logistics/patientlyping outsidered to manage outsidered to the which factors contribute to improved	relation to be determined in relation to be determined in relation to be determined in Streamer T3.3 (D3.6) Streamer T3.3 (D3.6) Streamer T3.3 (D3.6) University of the streamer tables		
tal Question security in a hospital which is per definition public? Tal Question person hange 2. tal Question person hangers. woma ? What are the options	entiation measures to improve statisfaction and operational measures to improve statisfaction and operational finitence on measures to improve statisfaction and operational efficiency entities of the statisfaction entities of the statisf		
tal Question, when considering respectively energy How to manage tal Question hypere and safety rates? Which systems can we	readion to be determined in intructor of vision ine Streamer 7.2.3 (22.8) Influence on management satisfaction and operational efficiency		
tal Question control control in size patients in summer and writer? What is the optimal fall Question building orientation fall Question building orientation of view?	Influence Program		
What will be the energy lackston consumption of the new building? What is the availability tal Question consumers and capacity? What should be the	Evolution of the energy Evolution of code due to performance and efficiency energy consumption regretation regretation are relation relation to be determined in Evolution of code due to		
tal Question thermal performance of the second seco	Streamer 12,1 (102,2) and trace of the stream performance of memory of the dual to building envelope spaces with control tensosativ of energy performance requirements tensosativ of energy performance relevance of the stream performance relevance of the stream performance relevance of the stream performance relation to be determined in Influence on whole for Hallon to be determined in		
a Gostoni ventation? Which energy all Guestion performance level shifuld be prescribed? Which systems can we which systems can we all Guestion the energy	Streamer T3.0(30.6) costs Streamer T3.0(30.6) Energy and cation targets Influence on whole Me satisfaction and environmental condition relation to be determined in relation to be determined in Streamer T3.3(20.6) Streamer T3.0(3.0)		
consumption? Labels selected for the scope of breamer any of the specific	the properties of the labels the properties of the labels the properties of the labels will be the framework will be the framework (requerements) which (requerements) in which (requerements) which	The properties will affect be accounted for the properties will affect the count of the properties will affect the count of the properties will affect the p	
This label has a	the energy performance in the costs and life cycle. The quality of the energy performance is a shape and the expectancies set in the shape and the set of	Description	
Bouwcollege layer hydroxia with the bouwcollege layer hydroxia day environment related related	the relation while the officer house while the officer house the o	No make in the last of a make in the last of	
This label has a relation with the function and the selfacency selfacency between additions between additions	adjecnory of the fact a big impact on operational intervention. Net instance intervention intervention intervention by adjust and instance and the spatial relationship to provide cating and provide	cost leads to the needs spatial Android cost-chird	
This label has a training the second second second second second of ventilities, air Hygienic class Hypitenic class to meet the hygienic condition	The hygenic conditions Hygenic class requirements requirements is not have a red class y connected by performance and efficiency, dimeter contrast the hygenic class dictates the relative through amount and the have a through y reconsent to efficiency and the second seco	Hyperic class can be a can be a condition of the cancer build end with and and the cycles of the data can be a condition, with makes a condition, with make	
requirements This label has a relation with the	1000000,	Ocides in accessibily codd ato infances of follow in accessibily codd ato infances of follow in accessibily codd ato infances of follow in accessibily codd ato infances of follow infances infancessibily codd ato infances of follow infancessibily codd ato infances infancessibily codd ato infancessibility codd ato infances infancessibility codd ato infancessibility codd ato infancessi codd ato infancessibility codd ato infanc	
Accessibility postero in the hospital. broken with the with the hospital broken with hospital hospita	No reason No reason No reason	hinder hynkling und hogs in her buldig und ho	
This label has a relation with the usage time of spaces a space state of the hours sensitif	There is a discussion of the provided of the p	A non-Menalysia and spaces could get a base with the performance p	
This label has a relation with the expedients Safety the safety of popular the safety of popular	Exiting safety requirements could requirements could requirements could requirements could requirements and to more extensive leads to more extensive leads to more extensive leads to more extensive use technical experiment to environment. The way of technical equipment to an other more inclusion to environment and to send in case of medical influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send influence or environment and the send in case of the send in	Subject generation of the second seco	
achites/ancions developed This label has a relation in the type	mergency mergency texture and costs for mandain and mergency mergency the data for mandain and mergency	pelicifications, with acception analosis with acception and analosis with acception analosis with acception analosis with acception analosis with acception and analosis with accepting and analos	
Equipment electric power meeted, medical gases, ICT data points	and the anisolit of an line is used in Supported Typestibilities of activities requipment medical matters with influences in the solution of	The papers, building services, by relations of the example quarter equation equations of the example quarter equation equations of the example quarter equation equations of the example quarter equarter eq	
This label has a relation with floor grant and the set of the set	Volume of appace units and "The lyne of construction," Picor strength, floor hight lyne of building much has is defaulto with the cost of exiliance the site will influence energy and the cycle of the performance building, family and the cycle of the building, family and the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the strength of the cycle of the family and the cycle of the strength of the cycle of the cycle of the strength of the cycle of th	possibilities to any of the construction will advises and met including scalements the dots the scale of the	
This label has a relation with the indoor Quality interest for display, view out and natural vertilation	Index quality meeting index quality requirements requir	ndor qually requirements out all a specify the use out all a specify t	
This label has a relation with the thermal, accustic.	performance instructions in the space unit for long ferm stay of patients. HVAC requirements can be net a space unit for long ferm denty induces the space instruction of the space of the space energy performance passive and active the space of the space of the space of the space of the space the space of the space of the space of the space of the space the space of the space of the space of the space of the space of the the space of the space of the the space of the sp	The possibilities near the state of the stat	
efc. requirements	(br instance active wrvva. dosis and the Hespan or sequencinced quality of the passive solutions). The chose solutions, and environment seems thus the file typic costs. The usuality of space for different functions can Relation through the offs for building of the building of the Relation through the top for the building of the building of the format of the building of the building of the building of the Relation through the state of the building of the building of the format of the building of the building of the building of the format of the building of the building of the building of the format of the building of the building of the building of the format of the format of the building of the format of the format of the format of the	costs. farey your or lead to determine the solution of leading metry solution cost interfuences in advances of the solution cost interfuences of the solution cost interfu	
This label has a relation with the "Bickness" of the between facades)	between volume and deep plan configuration facade, as well as the medic confrains retainively large to full integratements (mendmacal working) with the second of hotory space (mendmacal working) with the second of the artificial lighting etc.) the solutions in the second of the second of the second of the artificial lighting etc.)	The plant of the building and plant of the b	
This label has a relation with the geometry of the building	use of the building in fature Relation through the radio between volume and facade (assuming this is a series and the series of facade (assuming the thin is a series of the series of the series of the collection series of the	Low kerd of compactness could lead to ling out dictation coulds, which were and to be applied to a make a m	
This label has a relation with the property of the mass a percentage of glazing and walls	Assuming a high percentage of glazing percentage of glazing reduces the need the second sec	The servicit of glating affects the visual stations Could affect the integration the station affects revery instation the space heating as an entry instation the spac	
This label has a relation with the possible	cooling or heating capacity. The choice for a typology will influence the feabling of the building complex and the possibility to be readed building to the typology building to the typology bu	The handle of a local and a lo	
anagements or the heathcare distribution of the second distribution of the second distribution with the specific organization	span. This grady influences the feeds on renovation and explosition costs.	* The build environment manufactorial point real-point real-point process. * The build environment manufactorial point real-point process.	
Organization healthcare district classifies activities, spaces and functions district district)	no relation no relation no relation		
y Ventilation (on room- level)	Energy performance and type of units influences in quality of the environment and type of installed units operational efficienty	Next restance of the control of the	the properties are used to the properties the prope
		Heat Roomy for Re Readout normal line. Upgade control functions. Control exclusions	amount of ventilations and the state of the
y Ventilation (on building-level)	Energy performance and Type of system influences system influences the efficiency are influences the bet.CC to be the top of ventilation system and operational efficieny and operational efficieny	hreased demains on the register to the bugging of the register to the register to the bugging of the register to the register to the bugging of the register to the bugging of the register to the bugging of the register to	he type disput disput a type disput d
		addivisit in the Trader systems to Trader bat monophy in yellidan heat monophy in yellidan heat addivisit ad during the liday dock ad during the	
y Heating (on building / nelighbourhood level)	In relation, Type of heating system and type of system influences the guality of the regulation influence the LCC envolvest and building performance operational efficieny	be verified as a large state as a large	The space of layer of
y Heating (on one or more form level)	In relation. Type of delivery and regulation system : influence influences the quality of the influence overall building the LCC environment and environment and	Heading phases and pha	The properties are crucial to a type of the stating requirements the type configuration of the stating requirements and type configuration of the stating requi
	percuntance operational efficieny	Pacebally for dating Pacebally	Implementation Impleme
y Cooling (on building / neighbourhood level)	In relation with Direamer pythem Influences Labeling percomance. Type of type of system influences that LCC Case and Classifier System Case and Classifier Sustaing service	every strates with there shares with there shares as a field in the last in th	be properties as could to cooling performance tables and the performance tables and tables and tables tables
V Cooling (on one or more room-level)	In relation "Type of last statements the statement of the pythem references to the statement of the pythements of the statement of the stateme	Accel and activity of indicative control in the service of a strategy of the set in th	The properties are crucial to the cr
y Lighting (on room- level)	in relation. Type of lighting Type of lighting influences influences the quality of the influence the building the LCC environment and performance.	Reglacement of control regressions, Reglacement of control regress	the properties are crucial to the proof is are crucial to
Hot water Heating (on houteney / neighbourbood (new)	In relation DHW gradem influences building percentarios he LCC https://doi.org/10.0001/	Cosider the possibility for detect hearing system. A consider the possibility for detect hearing system. A consider the possibility for back-up detect hearing system. A consider the poss	Bet poor of sport dames the could be exported as crucial biological the entry of could be entry of coul
	outing service and OtsBibl building service	Conder the possibility for activity bar and or detect basing y states activity bar and or detect basing y states activity bar and or detect basing y states activity bar and activity bar and act	The Induity Symp meanness or spaces meanness used of the space and the scription and overspace space unit he space unit to contribution of energy space unit space unit to contribution of energy space unit to space unit to contribution of energy space unit to space unit to contribution of energy space unit to space unit to contribution of energy space unit to space contribution of energy space unit to space unit to space energy space unit t
y Production	Influents CO2 emmission type or source influences neuronautore influences neuronautore influences neuronautore influences	Instrume of electron Become of electron Becom of electron	decaults fe performance. universe mergy write: byen generation and the mergy write: building on the tent state with the state of the state special on the tent state with the state of the state
y Energy loss	relation to be determined in Quality of the instalation Streamer 13.1 enturing the maintenance costs	As at halfs ystem. Needs be bit ble for hour costs built out of the hour costs built o	A statute an attention any point
y Medical gases industri Hiham, ovygen, CO2, Nitrous cuide, N2	No instant Type of units and systems in relation with CIS-BM medical exponent and streamer lables exponent datas	In relation Performantial space	the type of bype of b
y outside climate	Inflaences size of Instataction Should not Inflaence of total He relation performance		he safey sepadents thold enter the potents and an an operation of the control of
contains aspects belonging to the Information System and the Bulking Information Nobel		Regulation for related to Regulation for rel	
IIM PoR programmed requirements (client brief)	Desired energy performance levels shared to autility of bedring another than the shared to autility of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the elevance of the relation of the elevance of the elevance of the elevance of the elevance of the relation of the elevance of the	Registrements index 0 bis herefords bis here	Requirement properties are Requirement propertie
una peogaphical peogaphical elocaration system	data relevant to information i	Numerican Approx The space/s - The match is a state or a state o	
Language usually represents an	The mass is a very important Bills doment has the second	Description Description envice in the conjunity envice in the conj	Instanto to to determined in Information about layer Islanding about Islanding
IIM mass core an abstraction of or an abstraction of generation of (architectural mode)	eatry to menyclastic so attentiative design submitted can be made fadarowy data can be attached to the made in the attached to the attached to the attached to the attached to the made in the attached to the attached to the attached to the made in the attached to the attached to the attached to the made in the attached to the attached to the attached to the attached to the made in the attached to the	All de la de	extracted 13.1 bits to be reacted to be type can be attacked to be type can
generally represented by an enveronment are to be an area and an and an and an area and an and an and an area and an and an and an and an area and an and an and an and an area and an and an and an and an and an area and an and an and an and an and an and an area and an and an and an and an and an and an area and an and an and an and an and an and an and an area and an and an an and an and an and an an and an and an area and an and an an an and an an area and an	Long to a particular of the resolution of the second	Functional isolation is surroutlygic lobits with a bij conterning with b i j conterning is surroutlygic lobits in surroutlygic lobits with a bij conterning with b i conterning is surroutlygic lobits in surroutlygic lobits in surroutlygic lobits with a bij conterning with a bij contern	Nettion to be determined in the second and the function a
	whow use walkering to the functional area in the and and the set of the set of the afferent draws have different draws properties, performance properties, decisions related to the execution set of the execution s	In a cettain location (e.g. height asis) (e.g. height asis) (e.g. height asis) Functional relations between the hexpolat and metalent defaund gazes Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relations relations to factors relations to factors Functional relations (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relations Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis) Functional relation (e.g. height asis)	Index to be determined in the formation can be Label information can be attended to the norm.
work component within the architectural model	positioning of them more in the second secon	where a constrained with a const	determined if light phase for the second or set to
IIM building envelope the architectural model.	usuing envice properties have a dia windowithm a dia data performano. These performance. These performance. These performance is a set of the set of the kP1 is to be determined if the kP1 exclusions. These properties should be have a set of the set of th	networks without of granting networks without	no malation
IIM structural elements components within the structural model	in the Bild. Heavy structural elements prosas, and herefore influence energy characteristics efficance the possibility the structural configuration before the structural configuration costing methodology.	Succard densets layor ngate et al. Dors, and a layor	Shuckara letimetrika and ledie stroad malicity
IIM building services components within the MEP model	Building services properties of a structure properties of a structure properties Choices for building Choices for building the structure properties structure and the structure structure the structure on energy properties structure to performance.	Every water cache systems of the locality and cache possibility and cache possibility an	no matura Bulding services and bad proved match as matura no matura n
IIM medical equipment within the interfor or an architectural model	Included in the MEP model. In the Internet of	anour d exchange and an ender a real and an ender a	en malados no malados no malados no malados no malados de malados no malados es estados no malados
non-medial user equipment within the satisfies of the satisfies of the computer, coffse machine, etc.)	performance. Whole be costs even of the cost of the costs even of the costs of the costs of the costs of the costs of the costs of the costs of the costs of the costs of the costs of the		ne mater
IIM Interior finishes finishes finishes finishes finishes file statutes	transmission structure is a fail of a second structure is a s	Related manual language and be realized manual language and be	no malaton



includes Hellum, pressurized alr, oxygen, CO2, Nitrous oxide, N2

 Label
 every
 <th

