Chapter 4
A Multidisciplinary Sustainability Evaluation System for Operative and In-Design Hospitals

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Abstract The Sustainable Healthcare project developed an original multidisciplinary evaluation tool, specifically designed to assess and improve a hospital's global sustainability by considering together the environmental, social and economic issues, so to give a comprehensive evaluation of the hospital, according to an appropriate concept of sustainability. The system, which aimed to be simple, light and easy-to-use, includes the main weighting to enhance sustainability, organized in a hierarchical way: specific indicators are contained in a series of criteria, which represent the most critical factors and the most effective starting points for hospital's sustainability improvement. They are finally divided into the three macro-areas of sustainability: social, economic and environmental sustainability. In order to take

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into account the different interrelationships among the various components of the system, a weighting process was carried out according to the Analytic Network Process method by Saaty in 2005. This allowed to take into consideration different users' points of view and, most importantly, the human factor, thanks to the development of a weighting system based on the opinions of specific focus groups, which included experts and professionals from different healthcare sectors. The evaluation system's application to a hospital allows the structure's global sustainability to be assessed.

Keywords ANP · Susthealth evaluation system · Macro-areas · Criteria · Indicators · Focus groups · Interviews · Economic sustainability · Social sustainability · Environmental sustainability

System Structure

The problem of promoting sustainability in hospitals and creating a new model to be used as reference for new realizations was also analysed by prof. U. Veronesi (Capolongo 2001), with a commission directed by arch. R. Piano, who stated 10 principles that should inspire the hospital of the future, considering mainly the social sphere and partially the environmental sphere, but not taking into account the economic field. In particular, the themes of patients' comfort, the correct position of the building inside the urban context, the medical staff-patients relationship, the perception of sense of belonging and solidarity inside the hospital and a good and efficient organization (in terms of effective diagnosis therapy and rehabilitation) are emphasized. Moreover, attention is focused on the adequacy of the technologies (plants and medical appliances), the flexibility of the system building-plant for future improvements and the role of the hospital as a research center.

Regarding operative hospitals, in many countries a considerable part of the healthcare system is made up by structures, which date back to several years ago. For instance in the northern Italian region of Lombardy, almost 45 % of the hospitals are more than 65 years old (Capolongo 2006). Decades ago they were built according to regulations, typologies of medical treatments, technological possibilities and community's needs which deeply differ from the current ones, and with no hint about neither flexibility nor sustainability. Nevertheless such hospitals are often operative and largely used, as they can still accomplish their main duties and give a contribution to the local community. Even though a new sustainably designed hospital would work better, adding more value and with fewer drawbacks for the community and the environment, its construction would be very expensive (even more if added to the demolition of the old one) and, most of all, controversial. The construction of a new hospital is indeed a matter of public concern, involving numerous stakeholders with different (sometimes opposite) interests which, as taught by prof. (Dente 2011), will be settled only with proper strategies and long time frames, after which success, intended as the building of the new healthcare structure, is still not guaranteed. Moreover, many years will pass between the design, the construction and the functioning phase, turning a modern project into an old-fashioned one, despite its initial innovativeness and flexibility. Changing times and changing needs therefore continuously hinder true sustainability once the hospital becomes operative.

The aim of this project has been to develop a solution that could improve hospitals' sustainability while they are operating, independently from how old they are. Though the Piano–Veronesi Hospital concept (Capolongo 2001), the realization of a blueprint of a sustainable hospital is not suitable to deal with issues concerning existing hospitals since it requires a global and abstract vision which cannot easily fits the constraints given by existing structures and which is unlikely to propose concrete and readily viable solutions. Therefore the possibility of identifying sound, scientifically-based guidelines to the realization of sustainable hospitals from existing ones was analyzed. This kind of tool can be useful, but limiting and limited according to different points of view, mainly due to the fact that it is impossible to point out best practices, which could fit to every context. Best solutions could deeply differ depending on local environment, on climate, on mix and size of the served community, on available resources and on the starting point, with a best practice example for a certain case being negative for another one. The need for a tool capable of giving case-specific results, also if employed by non-experts, thus clearly arises.

The new tool has to be easy-to-use and able to propose and foster specific solutions to improve sustainability in operative hospitals that, for economic, structural and functioning reasons, cannot undergo radical renovations. Moreover, the identified solutions should be as effective and low cost as possible. So an innovative, multidisciplinary, scientifically-based evaluation system has been developed to allow the study of case-specific solutions, including the blueprint's and guidelines' advantages, while overcoming their limits. According to the previously mentioned features, the components of the system, i.e. the identified indicators should themselves include some solution proposals and be SMART: *Specific*, *Measurable*, *Attainable*, *Relevant* and *Timely* (Doran 1981). Moreover the indicators should be *upgradable*, in order to fit to future technologies and regulations, *clear* and *easy-to-use* so that their evaluation will neither allow ambiguities nor require excessive efforts in terms of time and human resources.

These indicators' specifications will also belong to the whole system by transitive property. Thanks to the given tool it would therefore be possible for each healthcare structure to evaluate itself, to identify the areas of most effective intervention and to develop specific sustainability plans, based on the elementary suggestions that could be found in the criteria's definitions.

Structure Definition

The sustainability of a healthcare structure should be determined considering its three principal dimensions: economic, environmental and social. The Sustainable Healthcare evaluating system is implemented bottom-up: the basis of the pyramid is formed by these fundamental and interconnected *macro-areas* (Buffoli et al. 2013). Each of these areas is evaluated through a hierarchic framework of C&I

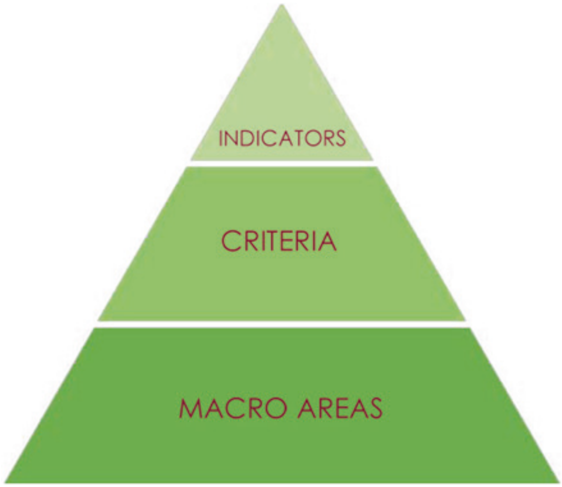

Fig. 4.1 Hierarchical organization

type: *criteria* and *indicators*. This framework is used by many government agencies, non-governmental organizations and academic researchers to define sustainability monitoring and evaluating programs (Wright et al. 2012). The macro-areas have different relevance in the evaluation system according to the importance and the impact they hold on the sustainability of an operative healthcare structure or an in-design hospital (Fig. 4.1).

The macro-areas are evaluated through different *criteria*, which are the elements concurring to the sustainability of the specific aspect. Each criterion relates to one key macro-area of sustainability, and may be described by one or more *indicators*. The hospital performance, concerning the specific criterion, is given by direct information obtained through the indicators' evaluation. According to the definition of the standard UNI 11097 an indicator is:

> The qualitative or quantitative information that is able to evaluate its change during the time and to verify the defined quality goals, in order to take the correct decisions and choices. (Ente Nazionale Italiano di Unificazione 2003).

The identified indicators therefore not only allow to compare different operative or in-design healthcare structures, but also to evaluate how the performances of those specific hospitals subject to evaluation are changing over time, thanks to the indicators' periodical measurements. The objective is to define a balanced assessment tool useful to find the most affordable solutions for a project proposal and understand possible lacks in hospital structures and services in order to improve them. The system therefore can help the choice among different alternatives and suggest corrections to increase the sustainability of the chosen one.

Since the object of study is a hospital, the indicators should be able to describe its actual current situation, related to the specific year of evaluation. They are either quantitative or qualitative: e.g. the evaluation of the flux of resources is made according to quantitative data, while questionnaires to evaluate and improve the social macro-area give qualitative information which is then quantified and classified. The assessed hospital obtains a quantitative result for each criterion; the score relative to each macro-areas is then obtained by summing the criteria's results according to the multi-criteria decision model. The score assigned to the criteria is computed thanks to the ANP method (see next paragraph), by aggregating information from various indicators.

Sometimes criteria do not have indicators and in this case the assessment is directly made at the criterion level; this happens because the issue tackled by the criterion is sufficiently specified and does not need to be further divided.

The achievement of a certain score for a selected criterion requires the fulfillment of compulsory *pre-requirements*. If they are not met, the specific criterion cannot be scored since these pre-requirements represent the minimum standard requested to an operative healthcare structure, in terms of aspects ranging from the economic, social and environmental points of view, such as technology standards or compliance to laws and regulations. It can occur though that local and national regulations are not fulfilled, because of exemptions from which the hospital can benefit.

The differences occurring in the analysis of an operative hospital or of an in-design structure bring to an ad hoc allocation of different reference values. In the case of existing hospitals the following indicators and criteria are not included: *Materials and Resources*, *Risk* and *Site physics* indicators in *Urban Planning*, *Construction Waste* in *Wastecare*, *Building Equipment* in *Watercare*, *Constructive Technology* and *Passive and Active Technologies* in *Envelope Technologies* and *Build in Quality Process* in *Managerial Waste* (Buffoli et al. 2014b).

As far as the *Materials and Resources* criterion is concerned, the choice is due to the great importance that the selection of materials has on environmental performance of the building under construction. This situation does not occur in the building already built, where this condition cannot be changed and where the environmental impact of the employed materials is already settled.

The indicators relating to the location and design of the hospital's outer area cannot be addressed in the evaluation of existing hospitals as they relate to policy choices. The policies are developed in the early stages of the design of a hospital and cannot be modified. Their importance, instead, is relevant in the case of new design hospitals.

Build in quality process is specific of the sustainable in-design hospitals system. It assesses the cost-effectiveness of the design phase with respect to the achievement of certain performance, highlighting the propensity for innovation. This one is characteristic of the design phase, while it is not relevant in the assessment of operative hospitals. In the in-design hospital evaluation system, instead, are not present the *Lean process* indicator in *Managerial Waste*, *EducInformation* in *Saving with Efficiency*, *Waste Generation* and *Hazardous Waste* in *Wastecare*. In fact they are intrinsic factors of the operative hospitals (Figs. 4.2 and 4.3).

The scores for each macro-area show the performance of the hospital in each domain of sustainability. These scores are added up according to their relevance to give the final score on the overall performance of the hospital as far as sustainability is concerned.

The assessment of criteria and indicators is developed through a series of evaluation forms where many features, aims and evaluation methods are considered (Bottero 2011). For each criterion the forms represent:

- **Pre-requirements**: it is an optional feature, pre-requirements are listed just for some criteria. Pre-requirements are usually related to the satisfaction of standard requirements or to the presence of specific elements needed to produce the performance measured by the criterion. If a pre-requirement is not met it is impossible to evaluate the criterion; sustainability points cannot be attributed if a hospital does not even satisfy the minimum standard requirements.
- **Definition**: it is a description of the criterion in a clear and shareable way.
- **Aim**: it explains the strategy encouraged by the criterion and so the expected output.
- **Description**: it defines the evaluation rules and the indicators which form the criterion, as well as the employed aggregation method.

As far as indicators are concerned, forms are organized in this way:

- **Definition**: as for the criterion a shared description of the indicators is presented.
- **Aim**: also in this case the desired output is cited to highlight the encouraged development strategy.
- **Description**: it indicates the method to evaluate the indicator and so the thresholds used to give credits.
- **Unit**: it defines the units of measurement for each assessed performance.
- **Time reference**: it states the application mode of each indicator; some can be assessed once or in different design steps, particularly if a new assessment is needed in the changing of framework condition.
- **Initial data availability**: it defines the data sources needed to carry out the assessment.

Score Evaluation

The *Indicators* are the first step of the whole evaluation system since they directly measure the hospital's performances. By means of questionnaires, interviews or quantitative evaluation a score ranging from 0 (worst performance) to 5 (best-in-class) is assigned to each indicator. As far as those indicators based on a direct evaluation of the users' (hospital users include not only patients, but also staff and visitors) satisfaction and opinion, the maximum score is assigned if a high percentage of the interviewees give positive answers, with the obtained score then decreasing together with the users' satisfaction. Indicators that are evaluated through interviews or quantitative measurements obtain instead points in a cumulative or progressive way. As far as the first method is concerned, the indicator's

Fig. 4.2 Global SustHealth system for operative hospital according to the structure of the macro-areas, criteria and indicators

total score is given by the sum of the points assigned if different technologies/ solutions are adopted. Concerning the second one, the score obtained implies the compliance to the previous requirements belonging to the indicator, which are given in ascending order.

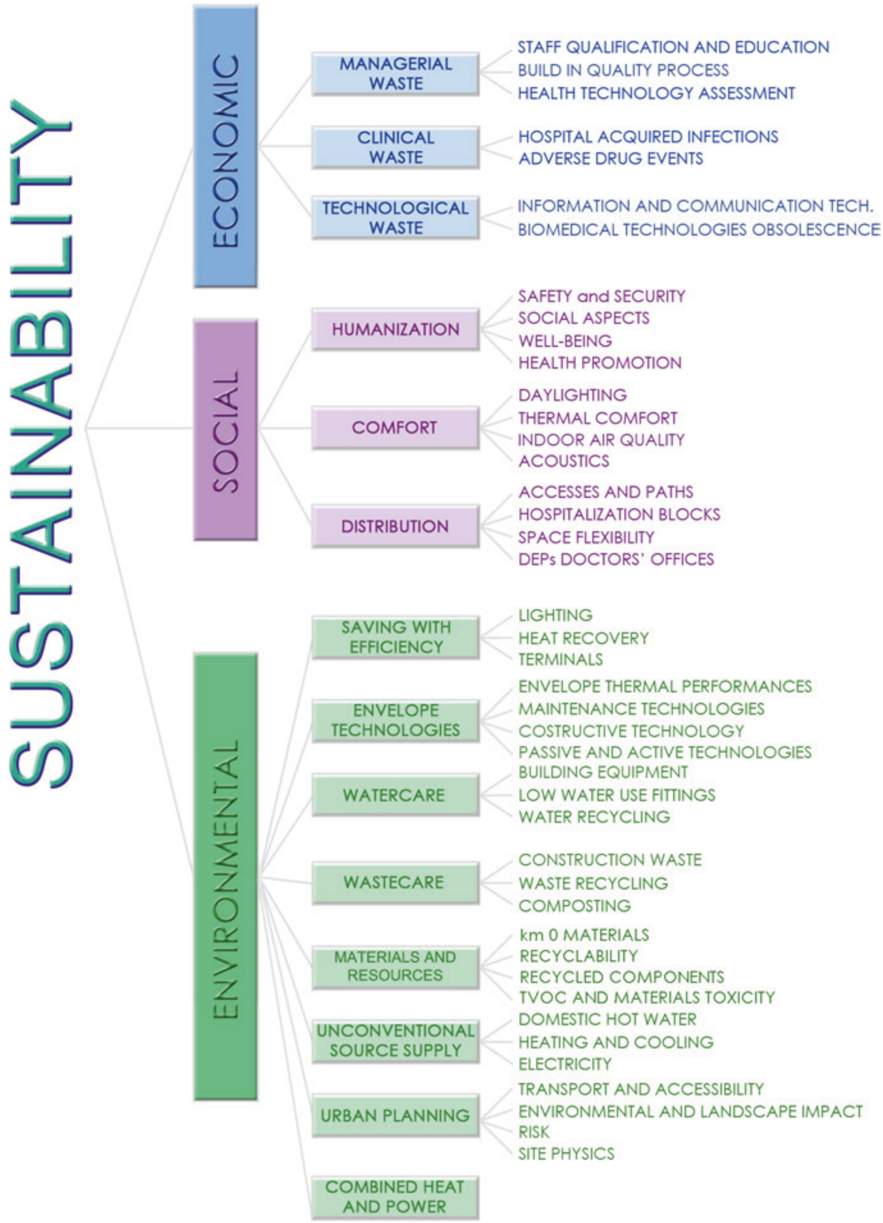

Fig. 4.3 Global SustHealth system for in-design hospital according to the structure of the macro-areas criteria and indicators

Indicators though are just at the top of the hierarchical scale that forms the evaluation method of this study. The scores obtained in the different indicators are then used to evaluate the *criteria*, that then concur to define the sustainability performance in the three macro-areas.

The criteria's obtainable points range from 0 to 100 and are given through a weighting system that quantifies the importance of those indicators constituting the specific criterion. Furthermore, even if all the indicators of a criterion obtain a positive score, failure to satisfy one of the specified pre-requirements entails the non evaluation of the specific criterion meaning zero points for it.

Referring back to the example made in the previous paragraph, the evaluation method for the *Comfort* criterion is expressed below:

$$Comfort = \frac{a * IAQ + b * Lighting + c * Acoustic + d * Thermal}{5}$$

where:

$$a + b + c + d = 100$$

On a similar basis, the weighting system is used to define the scores obtained in the different sustainability macro-areas by assigning different levels of importance to the various criteria.

Following the previously illustrated example, the evaluation method for the Social Sustainability area is described below:

$$Social\ sustainability = e * Humanization + f * Distribution + g * Comfort$$

where:

$$e + f + g = 1$$

To finally define the global sustainability of an existent or in-design hospital the points obtained in the three macro-areas are weighted according to the following formula:

$$SustHealth = A * social\ s. + B * economic\ s. + C * environmental\ s.$$

where:

$$A + B + C = 1$$

As a result, global sustainability is defined with a score ranging from 0 to 100. The hospital object of evaluation is then comparable with other hospitals and its performance evolution can be determined by analyzing score obtained in different years.

In this perspective, a correct evaluation of the healthcare structures' sustainability requires a coherent and consistent definition of different weights for each level (*indicators, criteria, macro-areas*). The Analytic Network Process (ANP) is the method used in this study to define the employed weighting system. ANP is a generalization of the Analytic Hierarchy Process (AHP), since it allows to consider the dependence and interaction between the elements of the hierarchy. The main characteristics of the method are briefly described below; for its complete theory, refer to (Saaty 2005).

To evaluate priorities among different *indicators/criteria/macro-areas*, opinions are gathered by means of pairwise comparisons: verbal preferences are then converted into numerical coefficients through to the *Fundamental Scale* given in Table 4.1.

The scale represents the points to be assigned when comparing A to B. If inverse comparison is done, B with A, reciprocals are used. The vector obtained through

Table 4.1 Saaty's scale used to convert verbal statements into numerical preferences

Saaty's fundamental scale	
1	Equal importance
3	Moderate importance of one over another
5	Strong or essential importance
7	Very strong or demonstrated importance
9	Extreme importance
2 4 6 8	Intermediate values

assigned priorities works as the principal eigenvector of the matrix network. The inconsistency concept, which is strongly related to that of the matrix network, then requires the inclusion of an inconsistency index through which the pairwise comparison's consistency is evaluated. Saaty suggests a maximum inconsistency level of 10 % (inconsistency is judged as a fundamental part of the ANP method, since, when different from zero, it implies a non conventional way to assign preferences) (Saaty and Ozdemir 2008). Differently from hierarchy, ANP considers a network mode of clusters of elements that can be connected to entities either in another cluster (*outer dependence*) or in the same one (*inner dependence*). Such a configuration fits well to the purpose of the study since it allows to consider the relations between criteria belonging to different areas of sustainability, the so-called *outer dependence*.

In Fig. 4.4 the ANP model network to define weights of macro-areas and criteria is shown. Arches from different areas indicate outer dependences; a loop in a component indicates inner dependence. Priorities calculated from pairwise comparisons form the so-called *supermatrix* and are used by the software to give the results of the weighting method.

A coherent evaluation of the weights in the three macro-areas requires the constitution of a high skilled team, formed by different experts both from the fields of healthcare structures planning and management. The focus group was formed by leading academic experts in the hospital architecture and management fields, together with experienced professionals coming from the healthcare environment. The focus group's direct knowledge about healthcare structures problems allowed to define the main and most effective areas for intervention. The inspiring philosophy on which the weighting system is based concentrates on those aspects that ensure better performance of the existent hospital with the less invasive *structural changes* (structural refers to significant architectural, technical and managerial changes) and the best practices for the in-designing hospitals.

A deeper analysis of the criteria's weights within a specific macro-area and of the indicators' weights inside a criterion required contribution from experts (at least three per each different weight definition) on the different subjects considered in the hospital evaluation both in existing operative structures and in-design ones. Once again the experts involved in weights' definition came from both the academic and professional field.

Results obtained from pairwise comparisons were elaborated with *Superdecision*: Fig. 4.5 shows examples of implementation phase of the software.

In the following pages are reported all the weighing systems referred to the macro-areas, criteria and indicators, respectively for the existing operative hospitals and the in-design ones (Figs. 4.6 and 4.7).

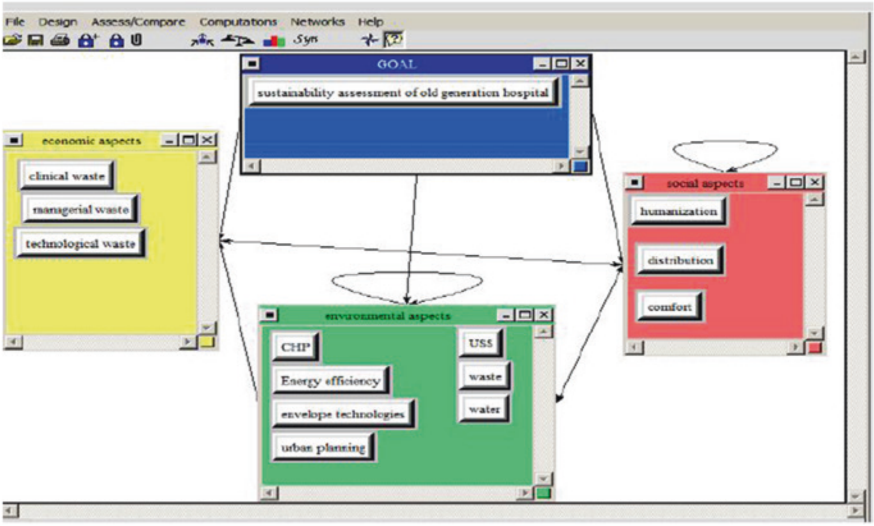

Fig. 4.4 Clusters and nodes of the model to establish the weighing system for operative hospitals' sustainability

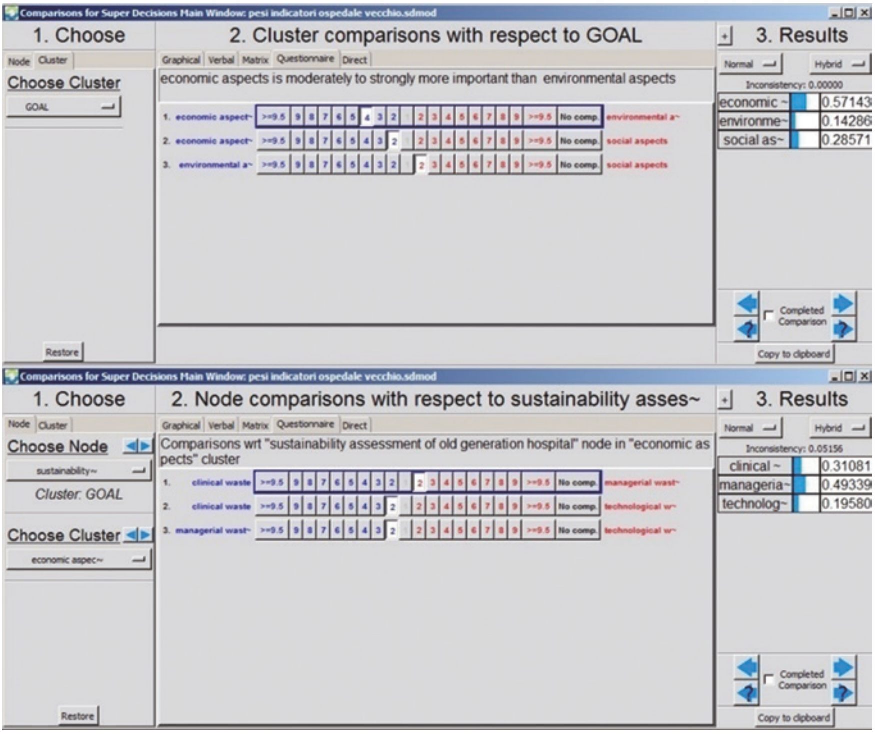

Fig. 4.5 *Superdecision* software implementation

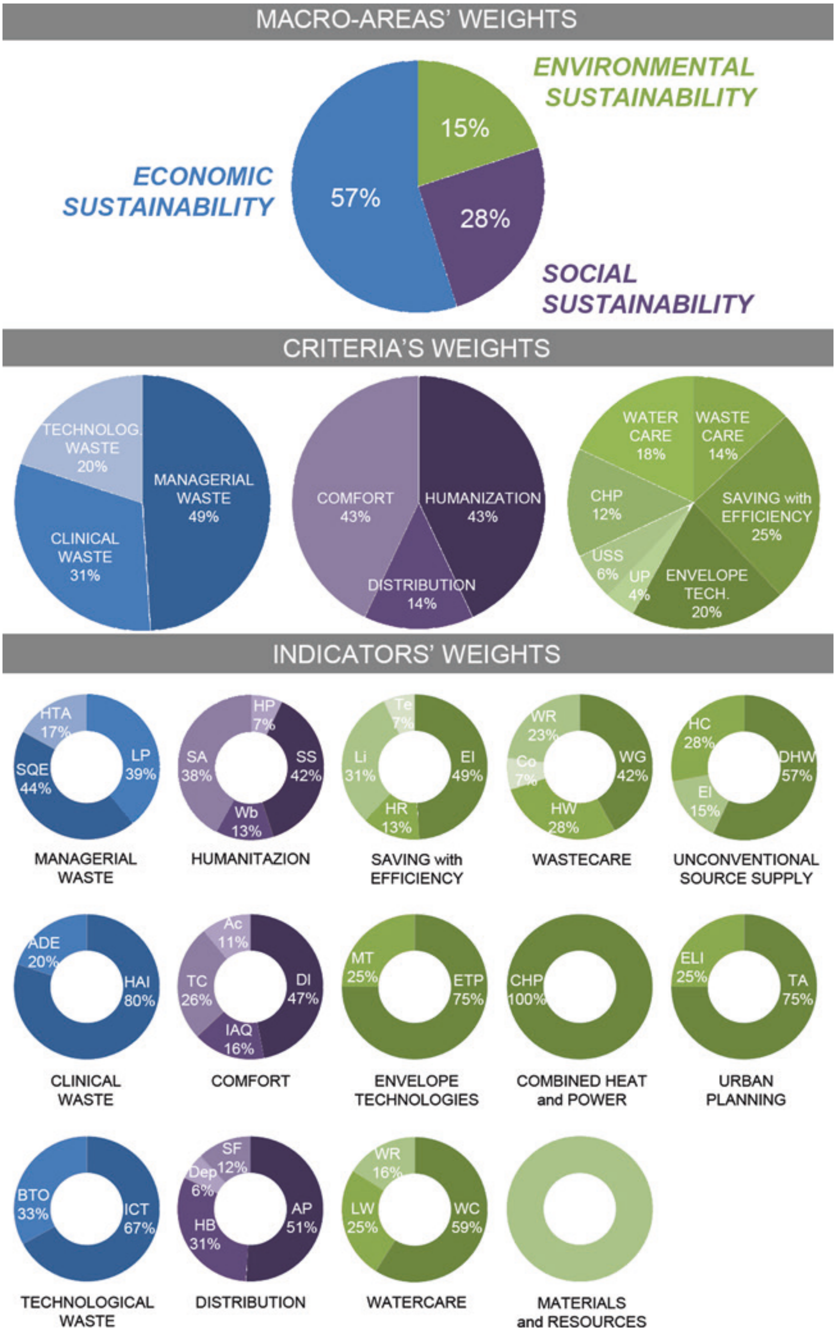

Fig. 4.6 Weighing system for operative hospitals referred to macro-areas, criteria and indicators

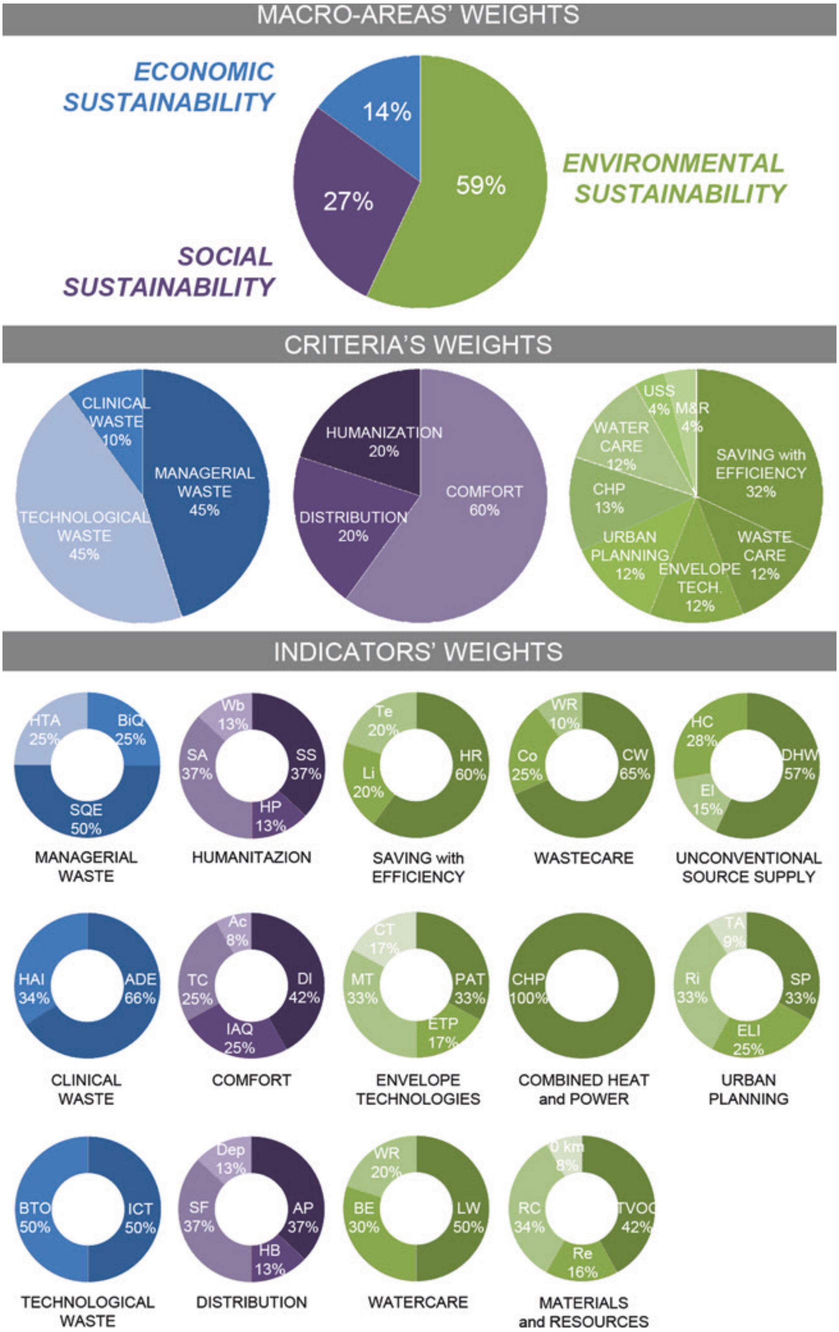

Fig. 4.7 Weighing system for indesigning hospitals referred to macro-areas, criteria and indicators

Economic Sustainability[1]

Few would contest that despite it is not the first goal for a healthcare system, its *Economic Sustainability* is necessary to assure the capability to deliver safe, high-quality healthcare services to patients and citizens of both the present and the future generations. The capability of being sustainable from an economic perspective becomes even more urgent in periods of crisis as today, since it deeply affects its country's economy (Young 2006). This capability is the result of efforts paid at the different levels within the healthcare system, ranging from macro-level to micro-level decisions. In this chapter, our attention is focused to healthcare providers and to their capability to do more with less. Each single healthcare organization has to cope with increasing demands from patients/citizens for safe, high-quality services as well as with shrinking economic, human and environmental resources.

In this regards, healthcare managers have the ethical responsibility to design and implement strategies and initiatives aimed at improving the capability of the organization to do deliver societal value efficiently. This capability is affected significantly from managerial, technological and clinical factors. With respect to management, the research focused on three key managerial practices that are diffusing nowadays in healthcare organizations aiming at providing managers and professionals with clear guidelines to improve service quality and achieve savings. They are: Health Technology Assessment, Lean Process implementation in the work flow, and staff qualification and education. Concerning clinical issues, the research group analyzed the capability of the healthcare organization to cope adequately with some specific, relevant adverse events. This leaded to take into account facilities appropriateness, procedures correctness and quality of the delivered service at one time, also including health outcomes and the consequently related expenses. Finally, technological solutions implemented by the healthcare organization are comprised in the evaluation as indicators of modernity and tools to facilitate and improve healthcare services delivery, saving time, money and environmental resources.

MANAGERIAL WASTE

Pre-requirements (only for operative hospitals)

- **Budget respect**: the hospital structure's actual expenses do not exceed the originally defined by more than 20 % meaning it adequately manages and allocates its financial resources limiting wastes.

[1] Written by Emanuele Lettieri (Department of Management, Economics and Industrial Engineering, Politecnico di Milano), Andrea Bellagarda (Politecnico di Torino), Giulia Gherardi (Politecnico di Milano) and Lia Volpatti (Politecnico di Milano).

Health technology assessment (HTA): presence of (or consultancy from) a HTA and/or clinical engineering unit and/or of a technical office able to deal with technical requirements of biomedical technologies and to consider correlated economic and clinical aspects.

Definition
The criterion evaluates the adoption or design of proper management strategies, which are the basis for the hospital functioning and allow to increase the provided services' effectiveness and efficiency, minimizing waste and optimizing resources allocation.

Aim
To improve the appropriateness of the healthcare structure's management strategies, in order to minimize waste, optimize workflows and improve service quality.

Description
The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Managerial Waste} = \frac{(x \cdot SQE + y \cdot LP + z \cdot BiQ + w \cdot HTA)}{5}$$

where
SQE Staff Qualification and Education
LP Lean Process (only for operative hospitals)
BiQ Build in Quality process (only for in-design hospitals)
HTA Health Technology Assessment

References
Azienda Provinciale per i Servizi Sanitari di Trento 2006; Goodman 2004; Graban 2012; Hailey 2003; JCI 2010; Kristensen and Sigmund 2007; Lettieri and Masella 2007, 2009; Lettieri 2009; Lettieri et al. 2008; Ministry of Health 2009; Ricciardi et al. 2010; Toussaint et al. 2010; Velasco-Garrido et al. 2005.

MANAGERIAL WASTE—staff qualification and education

Definition
This indicator measures the staff qualification and education level.

Aim
The indicator aims to provide recommendation in terms of creating an appropriate staff mix in line with the hospital needs and European standards. It also evaluates staff qualification and education level of pertinence together with staff involvement in improving working processes.

Description
Scores are assigned based on:

SCORE	STAFF QUALIFICATION and EDUCATION
1	A pertinent staffing plan has been developed, based on the structure needs and on the recommendations from department and service directors. To be defined as pertinent, the staffing plan should be in line with the European standards of hospital's workforce: n° of physicians and density (per 10,000 population); nursing and midwifery personnel and density (per 10,000); health management and support workers density (per 1,000)
+1	Physicians, nurses and staff are involved in the organization's quality improvement activities of the hospital
+1	The health organization has an effective process for gathering, verifying and evaluating the candidates' credentials (license education training competence and experience). All the activities related to recruiting evaluating and appointing candidates are accomplished through a coordinated efficient and uniform process for the following staff categories: medical staff permitted to provide patient care without supervision; nurse staff; other health professional staff members
+1	The hospital involves the staff in educating and training their colleagues. The employees are allowed, for example, to develop teaching materials and courses to divulgate their expertise and knowledge
+1	The healthcare organization provides staff with opportunities to learn and advance personally and professionally. Thus, in-service education and other learning opportunities are offered to the staff

Unit
[–].

Time reference
Carried out once during planning phase, then annual follow-up.

Initial data availability
National Classification of Healthcare Structures (if available); data provided by the Board of Heath; hospitals documents; surveys.

MANAGERIAL WASTE—lean process—only for operative hospitals

Definition
This indicator evaluates a hospital structure's ability to organize its activities in such a way to maximize the efficiency of its most important and costly resources: people.

Aim
The indicator aims to obtain detailed information on the existing proportion between added value and non-added value activities and how this impacts the different types of human resources and in what wards these criticalities are most frequent.

Description

The following steps allow to implement the process required to recognize and quantify the activities which do not provide added value in terms of health services, to prioritize areas of intervention and to obtain effective results in terms of increasing the structure's productivity without increasing its operating costs (efficiency increase):

1. Understanding of the economic and operational differences between the different types of human resources (doctors staff nurses etc.):
   (a) Definition of the different staff categories and of their job descriptions, which allows to clearly differentiate roles and tasks avoiding risky overlapping or inappropriate activities
   (b) Knowledge of the average cost per hour for the different staff categories enabling a careful prioritization of the areas of intervention
   (c) Distinguish and define for the different types of human resources (doctors staff nurses etc.) those activities that add value (VAA—Value Added Activities) and those which do not add value (NVAA—Non Value Added Activities). It is important to understand that the same activity can be classified differently according to what human resource carries it out. For example:
      - Doctors: Visits (VAA); Writing/Moving (NVAA);
      - Nurses: Work on patients (VAA); Writing/moving patients (NVAA);
2. Observe the employees' activities and create a map of the proportion between VAA and NVAA;
3. Quantify the losses due to NVAA and stratify them (per ward per type of employee etc.) and prioritize the areas of intervention;
4. Redesign the structure's activities processes and maybe even organization to increase the level of VAA;
5. Return to point 2.

These 5 steps must first be applied to the most critical wards and then eventually expanded to all other wards. The expansion percentage will be calculated as the ration between 'attacked' wards and total wards.

Indicators' variables (to be measured to obtain the final score):

- depth of application (step reached in the model ward in terms of percentage);
- level of expansion (percentage of wards where the approach has been deployed);

The indicator score is given by the product of the two variables.

$$LP = (\%\ depth\ of\ application) * (\%\ level\ of\ expansion)$$

SCORE	LEAN PROCESS (%)
1	0 < 20
2	20–40
3	40–60
4	60–80
5	80–100

Unit
[%].

Time reference
Quarterly survey.

Initial data availability
Cost per hour of the different types of human resources to be obtained from the finance department.

MANAGERIAL WASTE—built in quality process—only for in-design hospitals

Definition
This indicator evaluates the quality of a hospital's design/planning process by evaluating the level of benchmark activity carried out.

Aim
It aims to encourage a culture where different benchmarks are applied in designing new hospitals. It also wishes to develop a widespread understanding of how the principles behind benchmarks need to be adapted to the scenario in which the building is located with its different opportunities and restrictions especially from the economic point of view.

Description
Scores are assigned based on:

SCORE	BUILT in QUALITY PROCESS
1	The project team (PT) has carried out extensive research on which are the existing European best in class structures as far as different macro-areas are concerned but was not able to apply any best practice to its structure
+1	The PT has understood the principles which characterize the identified best practices and has applied an adapted version of these best practices to at least one macro-area
+1	The PT has applied an adapted version of the identified best practices to at least 50 % of its structure's macro-areas
+1	The PT has applied an adapted version of the identified best practices to at least 100 % of its structure's macro-areas
+1	The PT has developed at least one solution that has been internationally recognized as a new best practice

Unit
[–].

Time reference
Carried out once at the end of the project.

Initial data availability
Final forecasted budget of the hospital building project and actual list of expenses carried out to complete the hospital. Benchmark identification for each hospital macro-area must be considered during the design/planning phase is usually defined on a European level.

MANAGERIAL WASTE—health technology assessment

Definition
The indicator evaluates the Health Technology Assessment (HTA) analysis process and its ability to satisfy the hospital's requirement concerning equipment's safety and risk, effectiveness, flexibility, indication for use, costs, costs/benefits ratio and its social and ethical implications.

Aim
To improve the use of a simple and effective tool, such as HTA, to support decisional processes, in order to reduce healthcare costs according to evidence based medicine and to supply the hospital with appropriate technological equipment according to the population's characteristics and to the social and healthcare standards in the area.

Description
The indicator evaluates the relevance and quality of the activity carried out or planned by a multidisciplinary unit for technology assessment, considering HTA's completeness and consistency with respect to international guidelines.
Scores are assigned through the analysis of the entries enquired by the applied or planned HTA process, according to their significance and spread within the common practice.

SCORE max. +1.5	Clinical evaluation	SCORE max. +0.75	Scientific evaluation
+0.23	Clinical results and benefits	+0.16	Effectiveness efficiency
+0.18	Impact on quality of life (social, work, ect.)	+0.14	Acceptance satisfaction of patients/relatives
+0.23	Potential adverse events	+0.15	Technology's performances
+0.18	Ethical and psychological implications	+0.14	Managerial changes and inertia to change
+0.18	Acceptance and satisfaction of patient's relatives	+0.16	Costs/benefits costs/effectiveness ratio

SCORE max. +1	Technical evaluation	SCORE max. +0.75	Managerial evaluation
+0.2	Indication for use	+0.16	Work flow’s changes
+0.2	Proposal motivation	+0.1	Roles’ and skills’ changes
+0.1	supplier’s reputation	+0.16	Implication on education and organization
+0.1	Future updates	+0.13	Period of transition
+0.2	Alternative technologies	+0.1	Changes in the relationships among departments
+0.1	Institutions which suggest its adoption	+0.1	Changes in the relationships with other hospitals and healthcare structures
+0.1	Department’s priority		

SCORE max. +1	Economic evaluation
+0.15	Initial costs
+0.13	Activity in terms of patients and case-mix
+0.12	Return on image benefits
+0.15	Expected revenues
+0.15	Expected work costs
+0.1	Expected costs for patients/NHS
+0.1	Results variance and sensitivity analysis
+0.1	Adoption typology (purchase, leasing ect.)
+0.5	Systematic results monitoring and feedbacks collection concerning acquired technologies

Unit
[–].

Time reference
Annual survey.

Initial data availability
Ministry’s of Health data; hospital documentation; surveys.

CLINICAL WASTE

Pre-requirements (only for operative hospitals)

- **Risk assessment**: presence of a unit or person in charge for risk management and/or adverse events control and/or hospital acquired infections committee and/or drugs committee which should promote clinical risks reduction and prevention.

Definition
The criterion evaluates the care quality in terms of risk control, which has a strong impact on health outcomes.

Aim
To propose strategies and tools to reduce and prevent clinical risks and adverse events, which damage patients' health and cause additional expenses.

Description
The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Clinical Waste} = \frac{(x \cdot \text{HAI} + y \cdot \text{ADE})}{5}$$

where:
HAI Hospital Acquired Infections
ADE Adverse Drug Events

References
Capolongo 2012; Capolongo et al. 2013a, b; Cinotti and Di Bella 2007; De Vries et al. 2008; Fraser and Spiteri 2011; Garner et al. 1988; Harbarth et al. 2003; Honigman et al. 2001; Nicastri et al. 2003; Pittet et al. 2005; Plowman et al. 2001; V.V.A.A. 2003; Tarasenko and Virone 2011; Trucco and Cavallin 2006; Trucco et al. 2008.

CLINICAL WASTE—hospital acquired infections

Definition
This indicator evaluates the effectiveness of the planned prevention protocols related to Hospital-Acquired Infections (HAI), for in-design hospitals or with respect to existing hospitals the incidence of infections acquired during hospitalization, which were not clinically visible neither in incubation at the admission moment, but occur, generally, at least 48 h after admission, during stay or after discharge.

Aim
To improve the healthcare structure's effectiveness in terms of health, analyzing a frequent typology of adverse events, which cause additional costs and significant complications for the system and the patient, and should therefore be reduced as much as possible.

Description
With respect to existing hospitals, the indicator expresses HAI incidence (defined as the number of new HAIs occurrences over 10,000 days of patient care) in the considered hospital compared to 2009s European average value: 4.8 % (Fraser and Spiteri 2011).

SCORE	HOSPITAL ACQUIRED INFECTIONS (%)
0	HAI > 6
2.5	4 ≤ HAI ≤ 6
5	HAI < 4

Concerning in-design hospitals the indicator evaluates the adequacy and efficacy of the tools chosen to prevent HAI.

SCORE	HOSPITAL ACQUIRED INFECTIONS
+3	Application of innovative technologies, ISO 5 (ISO 2010) operating theatre automatic and continuous air detection system, to enhance hospitals' level of hygiene and sterility
+1	Spread of internal protocols for HAI prevention
+1	Control and motivation to apply the mentioned protocols amongst employees

Unit
[–].

Time reference
Annual survey.

Initial data availability
Ministry's of Health data; hospital documentation; surveys.

CLINICAL WASTE—adverse drug events

Definition
The indicator evaluates strategies for prevention of harms caused by drugs misuse, due to the drug itself (side effects, overdose) or to its assumption (dose reduction discontinuous therapy), which can derive from therapeutic mistakes.

Aim
To promote the adoption of adequate drugs administration systems, including deep controls at each phase of the process, in addition to monitoring of outcomes concerning Adverse Drug Events (ADE) reduction.

Description
The indicator evaluates effectiveness and efficiency of the planned or implemented drug administration process, considering its crucial phases. Scores for **operative hospitals** are given if this requirements are achieved:

SCORE	ADVERSE DRUG EVENTS
Max. +1.5	Creation of a digital integrated-between-drugstore and-department and linked-to-other-entries version of
+0.375	Doctor's drugs prescription, describing dosage, composition, posology and their link to previous clinical analyses

SCORE	ADVERSE DRUG EVENTS
+0.375	Attestation of prescription from doctor in charge of drugstore
+0.375	Attestation from pharmaceutical preparations technician
+0.375	Attestation of occurred administration
+1	Integration between data reading from drugs boxes bar codes and patient's card and hospital information system
+1	Automatic alert system concerning: drugs interactions dose limits patient-specific contraindications
+1	ADE monitoring through analysis of clinical documents
+0.5	ADE monitoring employing software for electronic health record querying

Instead, scores for **in-design hospitals** are given if this requirements are achieved:

SCORE	ADVERSE DRUG EVENTS
+2.5	Presence of a digital, integrated-between-drugstore-and-department and linked-to-other-entries version of doctor's drugs prescription, describing dosage, composition and posology, attestation of prescription from doctor in charge of drugstore, attestation from pharmaceutical preparations technician and attestation of occurred administration
+1.5	Integration between data scanned from drugs boxes bar codes and patient's card in the hospital information system
+1	Automatic alert systems for drugs interactions, dose limits, patient-specific contraindications

Unit
[–].

Time reference
Annual survey.

Initial data availability
Ministry's of Health data; hospital documentation; surveys.

TECHNOLOGICAL WASTE

Pre-requirements

- **Health Technology Assessment**: presence of (or consultancy from) an HTA and/or clinical engineering unit and/or of a technical office able to deal with technical requirements of biomedical technologies and to consider correlated economic and clinical aspects.
- **Information systems**: presence of an information systems area owning the IT skills necessary to allow digital data's delivery and sharing and to promote the development of innovative strategies for communication and information management.

- **Resources management**: presence of a financial resources management area which analyses procurement and renovation issues and properly allocates funds.

Definition
The criterion evaluates the innovativity and appropriateness of the biomedical technologies in an existing hospital or the related evaluation during the design phase, including not only the traditional diagnostic and therapeutic ones, but also advanced information technologies, which can support healthcare services.

Aim
To promote the realization of an up-to-date technological equipment, which is useful and effective for patients and staff, avoiding waste or deficiency, optimizing work flows and improving the service quality.

Description
The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Technological Waste} = \frac{(x \cdot \text{ICT} + y \cdot \text{BTO})}{5}$$

where
ICT Information and Communication Technology
BTO Biomedical Technologies Obsolescence

References
Bakker 2002; Civan et al. 2006; COCIR 2009; Corso and Locatelli 2009; Demiris et al. 2008; Eysenbach 2001; Halamka et al. 2008.

TECHNOLOGICAL WASTE—biomedical technologies obsolescence

Definition
The indicator evaluates the age profile of the available biomedical technologies in an existing hospital or the level of innovation of the ones to be acquired by a newly designed hospital, in addition to the appropriate management of the devices, during their whole life cycle.

Aim
To promote the implementation of proper investments plans for acquisition, maintenance, refurbishment and replacement of biomedical technologies, which should be always safe and sustainably managed.

Description
For existing hospitals, the indicator evaluates the status of diagnostic medical imaging devices in the hospital according to *COCIR Golden Rules* (COCIR 2009) and to proper management criteria.

SCORE	BIOMEDICAL TECHNOLOGIES OBSOLESCENCE
+1	At least 60 % of the equipment is younger than 5 years
+1	Not more than 30 % is between 6–10 years old
+1	Not more than 10 % is older than 10 years
+0.5	Devices are up-dated/refurbished when suitable
+0.5	Replacement before end-of-life is connected to a scientifically proved improvement of cost/effectiveness ratio
+0.5	Devices replacement is correlated to their rate of use
+0.5	When dismissed devices are recycled/reused in different contexts or developing countries

Concerning in-design hospitals, the indicator evaluates the planned acquisition of diagnostic medical imaging devices.

SCORE	BIOMEDICAL TECHNOLOGIES OBSOLESCENCE
+2	At least 40 % of the acquired technologies are old-fashioned
+1	Replacement strategies are implemented
+1	An investment plan is available
+1	A digital queryable technology inventory is implemented

Unit
[–].

Time reference
Annual survey.

Initial data availability
Hospital documentation; technology inventory; surveys.

TECHNOLOGICAL WASTE—information and communication technologies

Definition
This indicator evaluates ICT introduction in the structure, to support care and data management processes.

Aim
To promote the spread of e-health strategies and tools, as means not only of innovation, but also of efficiency increase, costs rationalization and service quality improvement.

Description
The indicator expresses the level of ICT penetration in the considered healthcare structure, scoring the presence or the foreseen implementation of the most significant e-health tools as follows:

SCORE	ICT
+1	Electronic health record (EHR) in some hospital's departments
+1.5	EHR is used in every department
+2.5	Online access to clinical tests' results

Unit
[–].

Time reference
Annual survey.

Initial data availability
Hospital documentation; technology inventory; surveys.

Social Sustainability[2]

Among the three sustainability macro-areas, the *social* one has been the most neglected and underexplored (Partridge 2005); particularly in healthcare structures, where aspects as collaboration and involvement are so important. Notwithstanding the difficulties in defining it thoroughly, there are shared theoretical pillars to be considered. These last ones give the possibility to define *Social Sustainability* in healthcare structures referring to issues as *equity*, *diversity*, *interconnectedness*, *quality of life*, *inclusion*, *access*, *participatory processes*, *future perspective* and *governance* (Partridge 2005). Looking at other emerging issues, like sense of place, culture of health, safety, social cohesion, solidarity, and according to WACOSS definition of Social Sustainability (Colantonio 2009), Social Sustainability is in this context considered as the process of creating an accessible, integrated and equitable community that successfully meets users' needs of health and well-being. This aim is pursued through adequate facilities and people collaboration, in order to create a safe place, a community that, stimulating emotional-physical inclusion, becomes a landmark in its territory, spreading these behaviors among people and institutions, to guarantee them in the future.

According to this definition, it was chosen the minimum number of criteria able to assess most of the issues that characterize social sustainability in hospitals. A common

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thread is represented by a *user-centered vision.* Criteria and indicators were identified looking at people who live hospitals spaces: *staff*, *patients* and *visitors*, for example, taking into account their opinion through the *humanization* criterion, that evaluates the hospital's environment and policies. In an operative hospital this is a very important aspect because it allows to understand the actual hospital performances and its effectiveness, so as perceived by its users (Buffoli 2014a). To evaluate this criterion some pre-requirements must be satisfied; they were chosen looking at those aspects more perceivable by users. The *Comfort* criterion takes into account the hospital environment through quantitative data able to indicate micro-climatic conditions. In fact, in such type of spaces interior ambience quality is a very delicate and tricky issue, because of the multiplicity of factors that affect the hospital particularly during its operating phase. People's psycho-physical status and work environment positivity are also determined by the hospital structure, so the evaluation system evaluates its *distribution* (spaces organization, paths, etc.) in order to take into account its impact on people's well-being.

HUMANIZATION

Pre-requirements

- **Hospital accessibility**: the possibility for all the users, in particular for disabled people, to reach the hospital and to use its spaces and facilities in secure and autonomy conditions.
- **Adequate hygienic conditions**: constant and at least daily cleaning of the most critical areas (hospitalization rooms, operating theatre, etc.) and no contact between clean equipment and dirty one.
- **Adequate safety conditions**: sufficiently good security conditions with respect to regulations. Accessibility, visibility and integrity (according to the hospital typology take in consideration) of all the facilities required to reach the nearest *safe place* (Minister of Interior 1998), of all the safety equipment (signals, fire-extinguishers, emergency doors, etc.) and of the most frequented places (waiting rooms, escape routes, etc.).

Definition
The criterion evaluates the hospital's level of humanization both in its structures and in its services for all its users: patients, staff and visitors.

Aim
To encourage the centrality of the person.

Description
It evaluates users' experience inside the hospital's structure, from a psycho-physical point of view. The importance of a comfortable, collaborative and professional environment has been recognized to bring psycho-physical advantages to all the actors involved in the hospital reality: *patients*, whose psychological well-being helps their therapeutic process; *staff*, whose

motivation and productivity are influenced by a better working environment; *visitors*, who are positively impressed by a clean and functional hospital.
The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Humanization} = \frac{(x \cdot \text{SS} + y \cdot \text{SA} + z \cdot \text{Wb} + w \cdot \text{HP})}{5}$$

where:
SS Safety and Security
SA Social Aspects
Wb Well-being
HP Health Promotion

In the case of operative hospitals (OH) pre-requirements are analyzed looking to the real conditions of the hospital environments and to the real users' perception. Each indicator's score is calculated by a questionnaire which evaluates the different aspects considered; one for the hospital's staff, one for patients/visitors, one for the technical evaluator (for those aspects that require an objective evaluation). Available answers regarding perception (hospital staff and patients/visitors) of the hospital environment are: '*very satisfied*', '*fairly satisfied*', '*not really satisfied*' or '*not satisfied at all*'.
The results for each answer are calculated with the following formula:

$$x/y * 100$$

x total number of respondent which gave a certain answer
y total number of respondents giving valid answer to the question

The score assigned to the different aspects is the following:
- *zero*: <33 % people gave a positive answer;
- *medium score* (*max/*2): 33 % < percentage of people < 66 % gave a positive answer;
- *maximum score*: >66 % people gave a positive answer.

In a positive way are considered the answers '*very satisfied*' and '*fairly satisfied*'. (This specification on how positive is the level of safety perceived by the users gives more credibility to the questionnaire as opposed to a simple 'yes' or 'no').
In the case of in-design hospitals (IDH) pre-requirements are analyzed looking to the correspondence of the hospital environments to the minimum standards considered from regulations.
Each indicator's score is the result of a technical evaluation of hospital's project policies and strategies.

Note: in operative hospital evaluation, when the hospital's staff questions on a certain topic are different from patients/visitors' ones, the final score of the particular aspect of the indicator is obtained by an arithmetical average between the staff's responses and the patients'/visitors' responses. When these particular aspects are also evaluated by the technical evaluator, the final score is then given by the average between the technician's score and the previously calculated users' scores.

References

Alfonsi et al. 2014; Ambiente Italia Istituto di Ricerche 2013; Capolongo et al. 2014; Lindström and Eriksson 2005; Minister of Interior 1998; Office of the Deputy Prime Minister 2005; Spinelli et al. 1994.

HUMANIZATION—safety and security

Definition

The indicator evaluates the level of safety and security of users.

Aim

To encourage adequate safety and security policies. The indicator considers both the existing regulations and the hospital's policies about these aspects, especially users' final perception about them.

Description

Safety is fundamental for the psycho-physical well-being of hospital's users: patients, in a vulnerable condition, and staff, that have to focus only about their work, without other worries.
The total score is given by the sum of the following points (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	SAFETY and SECURITY ASPECTS	
	OH	IDH
+1.5	Perceived security with regards to theft	Policies about theft
+1.5	Trust in hospital services	Policies about patient's trust in hospital services
	Services like: hygiene, surgical operations, chances of contracting infections, etc.	
+1	Perceived personal safety	Policies about personal safety
+1	Presence of security control	Policies about the presence of security control

In the questionnaire for OH the possible answers regarding users' perception of the hospital are: '*very safe*', '*fairly safe*', '*not really safe*' or '*not safe at all*' (similar answers to evaluate perceived security). In a positive way are considered the answers '*very safe*' and '*fairly safe*' (or '*secure*').

Unit

[–].

Time reference

Annual survey.

Initial data availability

Direct questionnaires; valuation of hospital's programs and strategies.

HUMANIZATION—social aspects

Definition
The indicator evaluates the social cohesion inside the hospital.

Aim
To encourage participation and collaboration among all hospital's users (also in the design phase) and to increase the level of attention paid to the hospitals' social policies.

Description
It evaluates the hospital's attention toward social aspects, staff's collaboration and the level of user involvement (according to the hospital typology take in consideration), not only with the medical/therapeutic issues but also with the architectural/environmental ones.
The total score is given by the sum of the following points (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	SOCIAL ASPECTS OH	SCORE	SOCIAL ASPECTS IDH
+1.2	Presence and quality of a mediation, translating and interpreting service	+0.8	Presence of a mediation, translating and interpreting service
+0.9	Level of patient involvement in the therapeutic and design process (for the latter is evaluated also the staff involvement)	+1.5	Level of patient involvement in the therapeutic and design process
+0.7	Structure friendliness towards different cultures (presence of directions in different languages, of spaces that allow people with different cultures to accomplish their own customs, e.g. worship traditions)	+1.5	Structure friendliness towards different cultures (presence of directions in different languages, of spaces that allow people with different cultures to accomplish their own customs, e.g. worship traditions)
+0.6	Presence and use of spaces capable of accommodating meetings between staff and patients	+0.4	Presence of spaces capable of accommodating meetings between staff and patients
+0.4	Presence of spaces to give hospitality to patients' relatives	+0.8	Presence of spaces to give hospitality to patients' relatives
+0.9	Level of collaboration within hospital staff		
+0.3	Discriminatory behavior: all patients and staff are treated with the same care and professionalism regardless of their race, religion, sexual orientation physical and mental handicap, professional specialization		

In the operative hospital, a technician will analyze the presence of aspects 1, 2, 4, 5, 6.
Concerning points 1, 2 (therapeutic process), 5 and 6, the positive answer will yield the maximum score, the negative answer assigns 0 score.

For answers 2 (design process) and 4, scores assigned by the technician are the following:

- *zero*: answer is ‘none’;
- *33 % of total score*: answer is ‘several’;
- *maximum score*: ‘most’ or ‘yes, all’ is the answer.

Unit
[–].

Time reference
Annual survey once during the design phase and every time a major modification (structures/policies) is made.

Initial data availability
Direct questionnaires, direct observation of hospital’s programs and environment, interviews for the operative ones; observation of the hospital’s programs and project, as well as the design process.

HUMANIZATION—well-being

Definition
The indicator evaluates the level of overall well-being with regard to the hospital’s environment and facilities.

Aim
To improve the level of attention paid to the well-being within the hospital, considered as a workplace and a service provider. Aspects as materials, colours and light have a positive effect on the psycho-physical well-being, improving staff performance and helping patient recovery.

Description
Hospital’s structures and policies are evaluated looking to different aspects affecting psycho-physical well-being: colours, material, lighting, leisure activities, green areas, etc.
The total score is given by the sum of the following points (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE OH	SCORE IDH	WELL-BEING ASPECTS
+2	+2	Comfort: colours, materials, artificial and natural lighting, furniture quality
+1.2	+0.9	Good and clear signals and paths within the hospital
+1	+1.5	Presence of activities/facilities for staff and patients/visitors: sport, leisure, culture, bar/restaurant areas, libraries, WI-FI areas, art, exhibitions, etc.
+0.8	+0.6	Quality/presence of green areas and outside views

Unit
[–].

Time reference
Annual survey; once during the design phase and every time a major modification (structures/policies) is made.

Initial data availability
Direct questionnaires; valuation of the project at the different phases of the design (e.g. color, light, material studies, simulation, etc.).

HUMANIZATION—health promotion

Definition
The indicator evaluates the level of health promotion and sustainable lifestyle pursued in the hospital.

Aim
To encourage the attention paid to the promotion of *salutogenic* (Lindström and Eriksson 2005) lifestyle and disease prevention in hospital policies.

Description
It evaluates the level at which the hospital can be an health promoter.
The total score is given by the sum of the following points (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	HEALTH PROMOTION	
	OH	IDH
+2.5	Presence of prevention and promotion campaigns	
+2.5	Presence and use of natural and ecological products and materials, non-toxic, recyclable, with a short supply chain	Presence and variety of natural and ecological products and materials, non-toxic, recyclable, with a short supply chain

The score (based on the technical evaluator questionnaire) is assigned to the different aspects by the following approach:

- *no score*: absence of promotion and prevention campaigns/no use of natural and ecological products and materials;
- *medium score value (max/2)*: presence of promotion or prevention campaigns/presence of natural or ecological products and materials;
- *maximum score value*: presence of both promotion and prevention campaigns/variety of natural and ecological products and materials.

Unit
[–].

Time reference
Annual survey.

Initial data availability
Direct valuation of hospital's strategies and projects; interviews.

COMFORT

Definition
The criterion defines comfort conditions for the indoor environment of a hospital analyzing the quality of air, thermal neutrality, acoustics, natural and artificial lighting.

Aim
To determine sufficient conditions for indoor air quality, visual, acoustical and thermal comfort, and to achieve satisfaction for the occupants of the healthcare facility in order to promote health through comfort in the indoor built environment.

Description
A satisfying quality of the indoor environment (emphasizing the importance of the relationship man-environment-object), must be guaranteed by the hygrothermal comfort, the availability and quality of natural light and view of the outside. All the analyzed aspects can enhance the quality of the indoor environment and can optimize the conditions of space for hospital users. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\mathrm{Comfort} = \frac{(x \cdot \mathrm{Dl} + y \cdot \mathrm{TC} + z \cdot \mathrm{IAQ} + w \cdot \mathrm{Ac})}{5}$$

where
Dl Daylighting
TC Thermal Comfort
IAQ Indoor Air Quality
Ac Acoustic

References
BRE Global Ltd 2010; Buffoli et al. 2007; Capolongo 2001, 2006; CTI 1995, 2008a; ITACA 2011; USGBC 2011a, b; Mardajevic and Nabil 2005; Origgi et al. 2011; Premier of Council Ministers 1997; Spinelli et al. 1994.

COMFORT—daylighting

Definition

Day lighting for human beings, seems to be comfortable (visual, thermal), productivity-enhancing (activity of the medical staff, patients), healthy stimulating (visual and circadian system), psychologically influential (contact with the outside environment is desired).

Aim

To evaluate and improve the of quality level for lighting.

Description

High quality of lighting has its main finality in the physical and psychological wellbeing of medical staff, patients and visitors. Nonetheless it is strongly related to architectural composition, energy costs and consumption by lighting systems. A right approach is inclusive of strategies such as: performance and visual comfort; flexibility in the organization of spaces; maintenance of the luminous flux during the entire day; esthetical value of the environment (intensity and colour of the light); differentiation of the illuminance in relation to the zone or activity (different lighting scenes); stimulation and productivity (circadian rhythms); stress reduction (natural light view of the outside, allows the perception of time passing by, contact with outside events).

The variable which compose the indicator are:

1. Daylight Factor, $DF_m \geq 2$ % for regularly occupied spaces; it can be also calculated with the following formula:

$$FLD_m = \frac{A_f \cdot \tau_l}{(1 - \rho_{lm}) \cdot A_{tot}} \cdot \varepsilon \cdot \gamma [\%]$$

where:

- A_w area of the transparent surface of the window [m^2];
- τ correction factor of the glass [–];
- ε windows factor [–];
- γ retraction coefficient of the plane of the window to the façade;
- ρ_{lm} median coefficient of light reflection of the inner surfaces;
- S area of the internal surfaces that delimit the space [m^2].

2. uniformity ratio, $U = E_{min}/E_{avg} \geq 0.2$ for over 50 % of the floor area, in which E is the illuminance (*E = 1 indicates complete uniformity*);
3. provide a connection to the outdoors through the introduction of daylight for 90 % of regularly occupied spaces;
4. integration of natural and artificial light with control systems in function of the daytime and meteorological conditions (shading for natural daylight and dimmeration for artificial lighting);

5. daylight design with dynamic methods, like Climate-Based Daylight Modeling (CBDM) using parameters *Daylight Autonomy* (DA), *maximum Daylight Autonomy* (D_{Amax}), *continuous Daylight Autonomy* (DA_{con}), Useful Daylight Illuminance (UDI);
6. calculation of UDI achieved ≥ 60 % and calculation of fell-short and exceeded for system integration and to avoid glare;
7. presence of external sun shadings or window integrated blinds, at least 90 % of south façade.

The total score is given by the following:

SCORE	DAYLIGHTING
1	First requirement is achieved
2	First requirement is achieved and one between 2, 3 or 4
3	First requirement is achieved and two between 2, 3 or 4
4	First requirement is achieved two between 2, 3 or 4 and one between 5, 6 or 7
5	First and fourth requirements are achieved and three among the others

Unit
[–].

Time reference
Annual survey.

Initial data availability
Sections, plans, elevations with indications of lighting equipment and use destination of the spaces.

COMFORT—thermal comfort

Definition
The indicator evaluates the individual satisfaction concerning thermo-hygrometric conditions of the environment (subjective definition) and thermal neutrality defined as the state in which the thermal accumulation is none and the organism leaves inactive mechanisms of thermal regulation (objective definition).

Aim
The purpose is to improve thermal comfort in hospital conditions for patients medical staff and visitors. This creates better conditions for general psychological states to work and other activities in the hospital.

Description

Thermal comfort in healthcare facilities is an important objective to be achieved for patients who need the best conditions to get cured for medical staff who spend long hours inside the building and need high comfort for their work and also for visitors. Thermal comfort is function of six parameters:

- 2 individual parameters (related to the user): Energetic metabolism (M) and Thermal resistance of clothing (I_{cl});
- 4 environmental parameters (related to the microclimate): air temperature medium radiant temperature air velocity relative humidity.

Zones such as operating rooms labs and all the zones that require a high air change per hour (higher than 6) are excluded from the application of the indicators. This indicator is suitable for all the zones (e.g. beds consulting rooms offices and so on) which are subject to both temperature and humidity control obtained with the combination of primary-air and hydronic terminals.

The total score is given by the following (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	THERMAL COMFORT
1	$-1 \leq$ Predicted mean vote (PMV) ≤ 1
2	$-0.5 \leq$ PMV ≤ 0.5
+1	Vertical temperature difference under 3 °/m because of predicted percentage of dissatisfied (PPD) < 5 % in hospital blocks
+1	Air velocity: $V_a = 0$–1 m/s
+1	Relative humidity: $\Phi = 30$–70 % for OH
	Relative humidity: $\Phi = 40$–60 % for IDH

Unit

Φ = [Pa]; T = [°C] or [K]; v = [m/s]; M = [met]; I_{cl} = [W/m^2].

Time reference

Annual winter design day, annual summer design day. In the case of in-design hospitals every modification implies the evaluation upgrading.

Initial data availability

Architectural design of the facility and occupancy profile of every environment zone defined within the facility.

COMFORT—indoor air quality

Definition
The indicator evaluates the indoor air quality, in both aspects of security and comfort.

Aim
To improve air quality to reduce infection risks with good air quality and proper ventilation air flow within the hospital.

Description
Indoor air quality in a close environment is considered acceptable when there are not present specific pollutants in harmful concentrations and when at least 80 % of occupants express satisfaction at this regard.
Healthcare facilities require very high air quality for all their occupants patients with health problems medical staff working long hours and visitors under emotional strain. These facilities have corridors and spaces with high flows of people every day emphasis should be put on minimizing the transmission of infections within the environment and good air quality helps people feel well psychologically and physically in these facilities where timing is important for the medical staff moving fast to serve people sometimes crowded and long queues of waiting visitors or patients. There are many variables that influence the quality of the air. The construction materials are subject of emissions people ventilation systems cleaning chemicals, etc. Therefore obtaining good IAQ has three ways of doing so: reduction of sources of air pollution, removal of pollutants at the source and dilution of pollutants by ventilation with external fresh air.
Scores for **operative hospitals** are given if this requirements are achieved:

SCORE	INDOOR AIR QUALITY
+1	Estimation of people flow per every corridor or space which is not regularly occupied and of the hours of occupation to calculate the right air flow for ventilation in all time span to assure good air quality efficiency of ventilation and energy savings for ventilation
+2	Design of ventilation systems (natural and mechanical) with schemes explaining the concept solutions for each case with air in-/outflow indication defining how pollutants are diluted and the right positioning of the air ventilation system so to take into account the position of occupants in the environment
+1	Integration of natural ventilation with mechanical ventilation where possible and integration of passive natural ventilation strategies e.g. stack effect single side ventilation or cross ventilation solutions atrium ventilation solar chimneys wind and stack assisted ventilation fan assisted
+1	Innovative solutions for reduction of pollutants and removal of pollutants (low emission construction), materials cleaning chemicals free of volatile organic compounds (VOC) innovation in ventilation system

Scores for **in-design hospitals** are given if this requirements are achieved:

SCORE	INDOOR AIR QUALITY
1	Calculations according to norm UNI EN 15251 (CTI 2008a) or the Italian reception the UNI 10339 (CTI 1995), has been made and mechanical ventilation systems satisfy the requirements for each environment
2	A correct estimation of persons' flow in space which is not regularly occupied
3	Design of both natural and mechanical ventilation systems, with schemes explaining the concepts solution for each case with air flow in/out indication, how pollutants are diluted and the right positioning of the air ventilation system placed so to take in account the position of occupants in the environment
+2	Innovative solutions for reduction of pollutants and removal of pollutants (low emission construction materials, cleaning chemicals free of VOC)

Unit
[–].

Time reference
Annual survey. In the case of in-design hospital every modification implies an evaluation upgrading.

Initial data availability
Architectural design of the facility and occupancy profile of every area defined within the facility.

COMFORT—acoustic

Definition
The indicator is concerned with the study of sound propagation in the neighboring rooms.

Aim
To provide building occupants with an environment free of intrusive or disturbing noise levels and to separate the interiors that require more privacy from noise sources through a strategic location.

Description
The excessive noise in the spaces caused by continuous reflection of sound waves is an important issue in large areas of the hospital that are often coated with hard and smooth materials, easy to wash, but with a weak sound absorption. The acoustic comfort can be guaranteed with the use of sound insulation or sound-absorbing materials. The indexes (Premier of Council of Ministers 1997) to be monitored are:

- Transmission Loss (TL), R'_w: 55 dB
- Weighted standardized level differences, D_{2mnTw}: 45 dB
- Weighted standardised impact sound pressure, L'_{nw}: 58 dB
- Maximum indoor ambient noise level, L_{Amax}: 35 dB
- Indoor ambient noise level, L_{Aeq}: 25 dB

The total score is given by the sum of the following indications (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	ACOUSTIC
1	Solutions to minimize the noise determined by heating ventilation, air conditioning elevators, plumbing systems are improved
2	Public areas that could generate interference sources, are separated from inpatient rooms to ensure quiet
+1	The value of R'_w is less than 55 dB (OH) or 53 dB (IDH)
+1	The value of D_{2mnTw} is less than 45 dB (OH) or 43 dB (IDH)
+1	The value of L'_{nw} is more than 58 dB (OH) or 60 dB (IDH)

Unit
[dB].

Time reference
Annual survey.

Initial data availability
Direct measurements on-site technical plans of the building.

DISTRIBUTION

Definition
The criterion evaluates the efficiency of paths and access distribution of the spaces.

Aim
To allow users clear movements, in less time and in the best security condition and to optimize resources and staff while working.

Description
It takes into account every characteristic that is related to functional layout and linking among spaces and functions. It esteems a deep study of mobility inside hospital that helps the good organization of paths and spaces for every kind of user.

The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Distribution} = \frac{(x \cdot AP + y \cdot HB + z \cdot SF + w \cdot Dep)}{5}$$

where:

AP Accesses and Paths
HB Hospitalization Blocks
SF Spaces Flexibility
Dep Departments—doctors' offices

References

Buffoli et al. 2012a, b; Capolongo et al. 2012, 2013a, b; USGBC 2011a, b; Velsen 2012; Zevi 2003.

DISTRIBUTION—accesses and paths

Definition

The indicator defines the effectiveness and efficiency of paths and accesses.

Aim

To shorten the distances of paths and to ensure the accessibility of spaces.

Description

The evaluation takes into consideration the following three aspects:

1. corridors' width that allows the passage of the stretcher;
2. separation of all hospital paths (corridor for medical staff and public one) with the exception of hospital blocks;
3. separation of the accesses (emergency room, inpatient/outpatient/diagnostic services).

The total score is given by the following:

SCORE	DEPARTMENTS—DOCTORS' OFFICES
1	Corridors' width less than 2.25 m and some of the accesses and paths are different (<50 % of the surface)
2	Corridors' width more than 2.25 m and some of the accesses and paths are different (<50 % of the surface)
3	Corridors' width more than 2.25 m; accesses are separated and some paths too (<50 % of the surface)
4	Corridors' width more than 2.25 m; accesses are separated and the major of paths too (>50 % of the surface)
5	Corridors' width more than 2.25 m and all the accesses and paths are distinct

Unit
1 = [m]; 2–3 = [–].

Time reference
Calculated in the evaluation phase, remains valid until further modification to the distribution system.

Initial data availability
Construction project.

DISTRIBUTION—hospitalization blocks

Definition
The indicator defines the hospitalization blocks' functionality and flexibility, both from the operational and architectural-functional point of view. It verifies the distances among rooms and control areas, and vertical connections.

Aim
To increase the hospitalization spaces' efficiency and to provide users with small displacements and decrease the risk factor.

Description
The evaluation takes in consideration the following two aspects:

- Hospitalization block typology; the possible typologies are:
  A central corridor and rooms in one of the two sides;
  B central corridor and rooms at the two sides;
  C radial disposition of the rooms and central control zone;
  D quintuple organization of the rooms.
- Maximum distance between the patients rooms and main vertical connections, the distance is measured from the entrance of the room farthest to the vertical connections (block stairs and lifts).

The total score is given by the following:

SCORE	HOSPITALIZATION BLOCKS
1	A-typology with max distance equal or lower than 25 m (between rooms and vertical connections)
2	B-typology with max distance higher than 25 m
3	B-typology with max distance equal or lower than 25 m
4	C/D-typology with max distance higher than 25 m
5	C/D-typology with max distance equal or lower than 25 m

Unit
1 = [–]; 2 = [m].

Time reference
Calculated in the evaluation phase remains valid until further modification to the distribution system.

Initial data availability
Construction project.

DISTRIBUTION—space flexibility

Definition
The indicator evaluates the possibility of spaces to have their function changed with the lowest amount of physical and human resources.

Aim
To increase the hospital space's flexibility to ensure continuous and lasting efficiency and facilitate spaces adaptability over time.

Description
Following characteristics are evaluated:

1. Presence of technical corridors (ceiling or floating floors), for a minimum of 20 % of the total surface, which permit the passage and maintenance of technical systems (electrics, IT, Medical gases, fire systems, etc.);
2. Presence of 'soft spaces', defined as areas with low specific content which can be easily transferred, such as storage rooms or administrative offices (for a minimum of 5 % of the total hospital blocks' surface) located close to those which, according to plausible forecasts, may be spaces that will require future expansion;
3. Presence of future use rooms, (rooms inside the hospital construction, but not completed in the interior) for a surface of 5 % of the total surface, situated where they will be used without disturb or the need of moving other functions (to give the possibility to enter directly from the main paths);
4. The possibility of an horizontal expansion for a minimum of 30 % of the covered surface at the ground (construction footprint), excluding the surface of hospital blocks if they are present. This expansion has to be possible without destroying any existing part, except for the connection spaces that have to be set up in order to be functional. The possibility of a vertical expansion for a minimum of 75 % of the roof surface (not yet occupied by plants or systems in general; in this case plants can cover up to 40 % of the total roof surface). The horizontal or vertical expansion has to be verified not only looking at the real surface availability, but also at the presence of prearranged structures and systems;

5. Possibility to remove 50 % of internal partitions;
6. Presence of modular furniture, for a minimum of 50 % of the total (based on the cost of the total furniture), that can be easily rearranged.

The total score is given by the following:

SCORE	SPACE FLEXIBILITY
1	One strategy among 1-2-3-4 is implemented
2	Two strategies among 1-2-3-4 are implemented
3	Three strategies among 1-2-3-4 are implemented
4	The first four strategies are implemented together with one between the fifth and the sixth
+1	Presence of modular furniture

Unit
1-2-3-4 =[m^2]; 5 = [m]; 6 = [€].

Time reference
Calculated in the evaluation phase, remains valid until further modification to the distribution system.

Initial data availability
Hospital's documents, construction project.

DISTRIBUTION—departments

The indicator defines the departments' functionality and flexibility. It checks the presence and quality of relax areas.

Aim
To improve the research quality and to study spaces and to ensure ease in sharing information and experiences.

Description
The evaluation takes in consideration the following two aspects:

1. Departments' position; the possible typologies are:
   - A many isolated departments, generally linked to hospital blocks;
   - B singular space for departments, with a classical distribution, like offices;
   - C singular place for departments, with an innovative distribution, such as open space, etc.
2. Presence of relax areas.

The total score is given by the following:

SCORE	DEPARTMENTS
1	Typology A, with relax spaces
2	Typology B, without relax spaces
3	Typology B, with relax spaces
4	Typology C, without relax spaces
5	Typology C, with relax spaces

Unit
[–].

Time reference
Calculated in the evaluation phase, remains valid until further modification to the distribution system.

Initial data availability
Construction project.

Environmental Sustainability[3]

It made the philosophy and technical approach to design and operation of healthcare structures inadequate. Moreover the necessity to reduce the impact of human activity on the environment requires the optimization of resource consumption. Nonetheless when the hospital is yet operative, solutions that ensure the highest results at the lowest expenses must be favored.

According to the previous considerations it is easily noticeable how the main topic around the issue is the reduction of consumption, which is more relevant than the improvement of systems to increase efficiency in energy production.

The topics that mainly characterize the macro-area are *energy supply, waste production, water consumption* and *urban planning*.

The energy chain is wholly considered: energy produced by renewable resources is promoted with particular focus on Combined Heat and Power (CHP) plants; the reduction of consumption is focused not only on the efficiency of the system, but also, in the case of the operative hospitals, on awareness and education of hospital staff.

With regard to waste, the hospital's performance is evaluated in terms of quantitative production and are privileged the most favorable solutions of the so-called

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virtuous waste cycle management: minimization, reuse and recycling. Strong attention is given also to the water problematic, sometimes forgotten because of low tariffs and the apparent abundance of resources. The good integration of the hospital in the local community and environment is taken into account by the *urban planning* indicator, that also verifies complex accessibility and connection with transport.

SAVING with EFFICENCY

Pre-requirements

- **E-team**: constitution of an high skilled and multidisciplinary Energy team, to better analyze all the different aspects in which energy is involved.
- **Control and monitor**: the installation of individual lighting and thermal control system at the lowest micro scale, enables staff to reduce waste; moreover it can ensure high comfort, since the optimal hygrothermal and lighting conditions change from a place to another, also in accordance to their occupancy factor.
- **Technical requirement**: observation of a short things-to-do-and-not-do list is advisable:
  - nominal efficiency of heat generator at least of 90 % (referred to Lower Heating Value);
  - no heating must be done directly from power, even though it derives from renewable sources;
  - EER of chillers at least 3 (this value has to be referred to an outdoor air temperature of 30 °C for air cooled chillers or 20 °C for water cooled chillers);
  - decoupled production of fluids at high and low Temperature (both heating and cooling). If this prerequisite is not satisfied, the score for the indicator ‘terminals’ will be zero;
  - obtaining at least 3 points in Envelope Thermal Performance.

Definition
This criterion evaluates the outcomes of the undertaken actions in order to reduce hospital’s energy demand.

Aim
To evaluate the effort and the goals achieved by the Energy team in terms of reducing energy demand: Reducing Energy (RE) demand helps to increase the Renewable sources penetration in consumes definition (for the same RE produced).

Description
The criterion is focused on the technologies and actions that can reduce energy demand. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7).

$$\text{Saving with efficiency} = \frac{(x \cdot EI + y \cdot Li + z \cdot HR + w \cdot Te)}{5}$$

where
Li Lighting
HR Heat Recovery
Te Terminals

References
Brioschi et al. 2010; Buffoli et al. 2012a, b; Incropera et al. 2006; Italian Parliament 1991; Regione Lombardia 2009; Rizzo 2009.

SAVING with EFFICENCY—educinformation—only for operative hospitals

Definition
This indicator evaluates how much the staff is energy responsible and how end users are involved in the hospital's energy efficiency.

Aim
To reward hospitals with an E-team able to train and stimulate hospital's staff toward reducing energy requirement of wards.

Description
The object of evaluation is the level of information and education of the hospital's staff regarding the energy theme.
The total score is given by the sum of the following points:

SCORE	EDUCINFORMATION
+1	Opinions and suggestions are collected to promote energy efficiency and to point out malfunctioning
+1	Presence of an energy-person-in-charge for each ward
+1	Courses were held during the year, for the promotion of energy efficiency
+1	Information campaigns (different from courses) were conducted to promote energy efficiency
+1	Economic incentive to promote energy efficiency (e.g. reward the most sustainable ward)

Unit
[–].

Time reference
Annual survey.

Initial data availability
Interviews are used to evaluate the actions taken by the E-team or the humanization office to form and stimulate hospitals staff to reduce the energy requirement of their ward.

SAVING with EFFICIENCY—lighting

Definition
Correct lighting, both natural and artificial, plays a leading role in hospital daily life, on patient's comfort and on productivity. Promoting synergy between natural and artificial lighting helps in saving costs.

Aim
To minimize power demand through a correct design phase and thanks to the introduction of highly efficient artificial lighting devices.

Description
The indicator considers with the same weight both the efficiency of the artificial lighting system, in terms of power absorption and its integration with natural daylight.

$$\mathrm{Li} = 0.5\mathrm{A} + 0.5\mathrm{B}$$

where:

A accounts for the efficiency of the lighting system and it is defined as:

$$\mathrm{A} = \frac{\text{kW lighting } \geq \text{ A class}}{\text{kW total lighting}}$$

For this parameter the energy class of the lighting bulbs is determined according to the EU energy label.

B is the parameter that accounts for the interaction with natural daylight (referring to **Daylighting indicator** in 'Comfort' criterion) and it is equal to:

$$B = \frac{\textit{Daylighting indicator score}}{5}$$

Scores are assigned according to the following:

SCORE	Li
1	0.15–0.3
2	0.3–0.45
3	0.45–0. 6
4	0.6–0.75
5	>0.75

Unit
A parameter is [kW/kW]; B is [lux].

Time reference
Annual survey.

Initial data availability
Total lighting power can be estimated through technical sheet of lighting design project and data from maintenance report.

SAVING with EFFICIENCY—heat recovery

Definition
The indicator evaluates the technological and design efforts done to recover as much wasted heat as possible.

Aim
To evaluate actions token on design and renovation phase to reduce energy consumption by recovering, where possible, waste heat to pre-heat or heat other work fluids.

Description
Object of the evaluation is the amount of waste energy that is recovered both from air and water/steam. The total amount of recoverable energy can be evaluated by conducting a deep analysis (e.g. pinch analysis), but coupling different fluids must be feasible not only from an energetic point of view but also from economic one. The indicator is defined as:

$$HR = 0.5A + 0.5B$$

where:

A is the parameter that accounts for the heat recovery from fluids (except air) and it is equal to one if any relevant solution is adopted zero otherwise;

B is the parameter that accounts for the energy recovered from air: it is the ratio between the amount of hospital volume on which a heat recovery process has been applied and the total hospital volume served by air-conditioning system. This parameter assumes zero value if the heat recovery devices are not coupled with a control system which ensures heat recovery only when it is convenient.

Scores are assigned according to the following:

SCORE	HR (%)
1	20–35
2	35–50
3	50–65
4	65–80
5	>80

Unit
B parameter in terms of [m^3/m^3].

Time reference
Annual survey.

Initial data availability
Data can be found in technical sheets, operational plant, control room.

SAVING with EFFICIENCY—terminals

Definition
The indicator evaluates the presence of heat exchangers that work with low temperature difference between hot and cold flux.

Aim
To spread diffusion and use of highly efficient terminals working with low different temperatures, ensuring fuel consumption savings.

Description
If there is need of producing heat both at high and low temperature, different equipment should be used for each level of temperature. This is valid for both heating and cooling: terminals are classified as 'low' temperature if they provide heat with transfer fluid temperature between 35 and 45 °C; they are classified as 'high' temperature if they provide cooling with transfer fluid temperature between 10 and 14 °C.

$$T = 0.5H + 0.5C$$

where:
H is the ratio between the floor area heated by low temperature terminals and the total floor area heated by hydronic systems;
C is the ratio between the floor area cooled by high temperature terminals and the total floor area cooled by hydronic systems
It can happen that low temperature (or high one for cooling) terminals, receive energy by a heat exchanger which is coupled to a higher (or lower for cooling) temperature plant loop. This is not energetically convenient. The advantage of using low (and high for cooling) temperature terminals is actually reached if those terminals are fed by devices such as heat pump, solar collector and other equipment which can actually determine an energy saving by working at that level of temperature.

SCORE	Te (%)
1	20–35
2	35–50
3	50–65
4	65–80
5	>80

Unit
[m^2/m^2].

Time reference
Annual survey.

Initial data availability
Data can be found in technical sheets, operational and design plan.

ENVELOPE TECHNOLOGIES

Definition
The criterion considers the technologies designed for the envelope of the building, in particular the envelope thermal performances, the passive and active solution for energy saving, the construction system and the maintenance installations.

Aim
The criterion aims to measure how innovative is a building for what concern modern solutions applicable to the envelope and to value the energy losses through the envelope and the easiness of maintenance.

Description
It focuses its attention on different elements that are relevant to evaluate the degree of innovation, as thermal features of the envelope to waste less energy and the design of an effective and integrated maintenance system. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7):

$$\text{Envelope technologies} = \frac{(x \cdot \text{ETP} + y \cdot \text{MT} + z \cdot \text{CT} + w \cdot \text{PAT})}{5}$$

where
ETP Envelope Thermal Performances
MT Maintenance Technologies
CT Constructive Technology (only for in-design hospitals)
PAT Passive and Active Technologies (only for in-design hospitals)

References
Aste et al. 2011; CENED 2011; CTI 2012, 2008b; European Parliament and the council of the European Union 2002; Italian Parliament 1991; Jørgensen 2004; Minister of Economic Development 2010; Presidency of the Italian Republic 2011.

ENVELOPE TECHNOLOGIES—envelope thermal performances

Definition
The indicator evaluates the thermal performance of the building envelope.

Aim
To measure the global thermal performance of the envelope of the building in order to improve building performances.

Description

To evaluate this indicator the thermal transmittance of envelope components is necessary.

The evaluation of an operative hospitals analyzes the whole thermal performance or the improvement of the dispersing surfaces performances with respect to the original project, through the analysis of the thermal transmittance or its reduction, resulting in an improvement intervention carried out in the hospital. Score is given if the following requisites are achieved:

SCORE	ENVELOPE THERMAL PERFORMANCE
1	If there are selective or dual chamber glasses in windows
1	Presence of a ventilated and isolated roof or a green roof
+1	If the thermal transmittance has decreased more (or equal) than 30 % after the intervention and there is no presence of thermal bridges (they have been solved) or hospital structure realized after 1991 (Italian Parliament 1991)
+2	If the thermal transmittance has decreased more (or equal) than 50 % after the intervention and there is no presence of thermal bridges (they have been solved) or hospital structure realized after Directive 2002/91/CE (European Parliament 2002)
+3	If the thermal transmittance has decreased more (or equal) than 70 % after the intervention and there is no presence of thermal bridges (they have been solved) or thermal performance of the hospital respects the national current regulations

In the case of in-design hospitals, the average thermal transmittance of the principal elements and the avoidance of thermal bridge are the main parameters for the evaluation of the indicator. Considering:

$$U_{average} = \frac{U_1 A_1 + \cdots + U_n A_n}{A_1 + \cdots + A_n}$$

where:

U_1 is the thermal transmittance first component;

A_1 is the area of the first component;

U^* is the maximum thermal transmittance according to MD 26-01-2010 (Minister of Economic Development 2010)

Score is given if the following requisites are achieved:

SCORE	ENVELOPE THERMAL PERFORMANCE
+1	Opaque vertical structures ($U \leq U^*$)
+1	Opaque horizontal structures—roof ($U \leq U^*$)
+1	Opaque horizontal structures—floor ($U \leq U^*$)
+1	Windows ($U \leq U^*$)
+1	Thermal bridges (corrected)

Unit
[W/m^{2}K].

Time reference
Annual survey.

Initial data availability
In general, the stratigraphy of the historical and new intervention envelope. It is necessary knowledge about thickness [m], density [ρ], vapour resistance factor [μ], specific heat [c], thermal conductivity [λ] of each material which constitutes the stratigraphy.

ENVELOPE TECHNOLOGIES—maintenance technologies

Definition
The indicator evaluates the adoption of integrated technologies to realize an efficient, effective and economic maintenance.

Aim
To measure the maintenance technology according to their efficiency, rapidity to reach the scope and their good integration in the envelope.

Description
It focuses its attention on the technologies designed to guarantee a periodical and frequent maintenance of the building envelope. The hospital needs that the façade especially the transparent surfaces is cleaned frequently without an excessive investment.
Scores are assigned according to the following:

SCORE	MAINTENANCE TECHNOLOGIES
1	Life-lines rope access systems
2	Aluminum monorails without platforms, walking, roof car, stairs
3	Aluminum monorails with permanent platforms
+1	Cleaning semi-automated system/easy cleaning properties
+1	Integration of these system in the façade

Unit
[–].

Time reference
Annual survey.

Initial data availability
Project plans building maintenance plans.

ENVELOPE TECHNOLOGIES—constructive technology—only for in-design hospitals

Definition
The indicator looks at the adoption of integrated traditional or innovative construction technologies for providing a system that is fast and cheap.

Aim
The indicator aims to measure the prefabrication degree of the building. Many solutions, if planned in time can save time and money, providing the same performance.

Description
The indicator focuses its attention on the construction system of the hospital. There are traditional techniques, like the ones based on the concrete that requires the presence on the building site of many workers for a long time. There are others instead prefabricated that reduce construction time and can reach better performances. On the other hand they need specialized workers, the products are more expensive and mistakes cannot be corrected on the site. The total result is given by the sum of the following points:

SCORE	CONSTRUCTIVE TECHNOLOGY
+2	Traditional or prefabricated structure: qualitative estimation of the degree of prefabrication of the structural elements
+2	Traditional or prefabricated slabs, roof, internal and external walls: qualitative estimation of the degree of prefabrication of the partitions
+1	Traditional or prefabricate components (bathrooms, etc.): qualitative estimation of the degree of prefabrication of the components

Unit
[–].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Project plans constructor, brochures and documents.

ENVELOPE TECHNOLOGIES—passive and active technologies—only for in-design hospitals

Definition
The indicator looks at the adoption of passive and active technology in the building envelope.

Aim
The indicator aims to measure how is innovative a building for what concern modern solution applicable to the envelope.

Description
The indicator focuses its attention on the technologies to avoid waste of energy or to produce, actively, energy. There are many passive technologies like shadings or different façade solutions or special performing glasses or greenhouses or green roofs, etc. There are also active sources for renewable energy, like photovoltaic panels that can be more or less integrated in the envelope. The total result is given by the sum of the following points:

SCORE	PASSIVE and ACTIVE TECHNOLOGIES
+2	The presence of both external or integrated shadings like shutters, venetian blinds or roller blinds with a value g $\leq$ 0.4, according to UNI EN 13363-1 (CTI 2008b), and selective glasses, low-emissive glasses, etc. with shadings' surface >70 %
+1	The presence of photovoltaic, cells integrated, inorganic or organic ones that cover a surface >30 % of the overall façade surface or >70 % of the overall roof surface
+2	Presence of ventilated façades, double skin façades and natural ventilation systems; or Green houses with a surface >2 % of the net surface; or a surface >30 % of the roof surface for green roofs; or a surface >0.5 % for light openings and solar tubes

Unit
[m^2].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Project plans, constructor brochures and simulation programs.

WATERCARE

Pre-requirements

- **Control and monitor**: to be able to monitor the water consumption water meters have to be installed on water supply of each building. If buildings have major water consumers that correspond to water demand of 10 % of overall building demand (such as swimming pool), separate water sub-meters should be installed before this consumers. If Building Management Systems exist, all sub-meters should be connected to it, to be able to monitor the consumption real time and to intervene if necessary.

Definition
The criterion is used to promote a lower consumption of potable water and to reward the implementation of the solution undertaken to save water.

Aim
To reduce potable water consumption without affecting real needs of the hospital.

Description
The criterion brings into consideration various strategies which are aimed to asses and reduce potable water consumption. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7):

$$\text{Water care} = \frac{(x \cdot WC + y \cdot BE + z \cdot LW + w \cdot WR)}{5}$$

where:
WC Water Consumption (only for operative hospitals)
BE Building Equipment (only for in-designing hospitals)
LW Low Water Use Fittings
WR Water Recycling

References
BRE Global Ltd 2010; ITACA 2011; USGBC 2011a.

WATERCARE—water consumption—only for operative hospitals

Definition
The indicator gives information about potable water consumption in hospitals.

Aim
To give precise information about consumption of potable water in the hospital.

Description
The indicator is calculated from data about yearly consumption and normalized by square meters of the building. Those values consider also the water consumption for laundry services.

Scores are assigned based on the following:

SCORE	WC
1	1500–1250
2	1250–1000
3	1000–750
4	750–500
5	<500

Note: if laundry services are assigned to an external company which provides by itself for water needed for laundry operations range values must be reduced 15 %.

Unit
[(liters/m^2)year].

Time reference
Annual survey.

Initial data availability
Based on potable water flow monitoring and square meters of the hospital.

WATERCARE—building equipment—only for in-design hospitals

Definition
The indicator intends ensure the installation of efficient equipment, to reduce the consumption of potable water in non-potable processes.

Aim
The main purpose of the indicator is to reduce the use of potable water in the non-potable processes.

Description
For each of the following requirements complied one credit has been assigned. Maximal number of credits is 5 and overall score will be the sum of sole requirements complied:

SCORE	BUILDING EQUIPMENT
0	No specific strategies has been anticipated
+1	Large frame X-ray processor and/or 150 mm in length should use film processor water recycling unit, smaller one are excluded from the rule
+2	Water used in heating/cooling processes is technical, non potable water and the process is closed-loop

SCORE	BUILDING EQUIPMENT
+1	When a food waste disposer is used, use cold water, equip systems with load sensing device that regulates the water use to 3.8 L/min in a no-load situation and 11–42 L/min in full load situation and automatic time shutoff that shall have a 10-min time-out with a push button to reactivate
+1	If irrigation is going to be performed using recycled/rainwater (system drop by drop) or the plants are local and dependant only on precipitation (so no need for irrigation)

Unit
[–].

Time reference
Calculated in the design phase remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
In the design stage data should be derived from technical documentation accompanied by manufacturer's equipment specification.

WATERCARE—water recycling

Definition
The indicator represents amount of rainwater and groundwater collected during the year or grey water reused, to cut the use of potable one.

Aim
To reward actions token in order to reduce use of potable water by recovering rainwater, reusing grey water and using groundwater.

Description
Hospital planners has the possibility to choose the strategy to satisfy requirements according to the specific context in which the hospital operates: any ratio between usage of grey and rain water can be freely decided to supply water flushing demand and irrigation. Total predicted flushing demand can be estimated on the basis of following variables:

- number of daily building users;
- effective flush for WCs and urinals;
- estimated number of WC/urinals uses per occupant per day multiplied by the defined period of collection.

Typical values are: 1.3 WC uses per person per day, 2 urinal uses per person per day (assuming that 50 % of occupants will use urinals during a day). Tank size should be estimated according to projected demand: water for

toilet, green areas irrigation, cleaning and different processes. If these requests are met, a certain number of credits will be assigned.
The following formula can be used to calculate the volume of collectable rainwater:

$$\sum(A_{RF} * C * R_{coef} * F_{coef} * D_{col})$$

A_{RF} annual rainfall for site location [mm]—derived from meteorological stations;
C rainwater catchment area;
R_{coef} run-off coefficient;
F_{coef} filter coefficient;
D_{col} defined period of collection: (e.g. 18 days/365 days = 0.05 chosen for assessing purpose).

ROOF TYPE	RUN-OFF COEFFICIENT
Pitched roof tiles	0.75–0.90
Flat roof smooth tiles	0.50
Flat roof with gravel layer	0.40–0.50

Scores are assigned according to:

SCORE	WATER RECYCLING
1	30 % of flushing demand has been achieved
2	45 % of flushing demand has been achieved
3	60 % of flushing demand has been achieved
4	75 % of flushing demand has been achieved
+1	Irrigation and external washing are provided by WR

Note: if the hospital does not present green areas and does not need irrigation. the extra point is given if more than the 90 % of flushing demand is supplied through water recycling.

Unit
[–].

Time reference
Annual survey.

Initial data availability
Fluxes measurement of grey/recycled water has to be provided. Values are compared with flushing demand, calculated previously on the base of the mean number of occupants, average usage of toilets and equipment specifications.

WATERCARE—low water use fittings

Definition
The indicator shows the usage of low water fittings for WCs, showers and taps.

Aim
To show up to which extent strategies for water saving are used inside buildings, considering taps, showers and WCs characteristics.

Description
Strategies for lowering potable water consumption are listed below: scores are obtained if strategies are applied to a significant amount of the hospital, at least 70 % of the total fittings installed.
The total score is given by the sum of the following points:

SCORE	LOW WATER USE FITTNGS
+2	WCs are dual flush, having an effective flush of 4.5 L or less. All urinals have individual presence detectors and work with ultra-low flushes or waterless. Points are also reached if in the indicator 'water recycle' 3 or more points are obtained
+2	Taps have maximum flow rate of 6 L/min for relative water pressure of 0.3 MPa and are equipped with sensors or timed automatic shut-off taps
+1	All showers have a measured flow rate that does not exceed 9 L per minute for a water relative pressure of 0.3 MPa, assuming a delivered water temperature of 37 °C; all baths have a capacity of 100 L to the overflow and each bath is fitted with a device that automatically stops the flow from the taps when the bath's maximum capacity is reached

Unit
[MPa], [1/min], [°C].

Time reference
Annual survey.

Initial data availability
Manufacturer's specifications about the as well as exact locations of installed equipment.

WASTECARE

Pre-requirements

- **Control and monitor**: Data has to be available at any moment: separate data for recyclable waste materials, separate data for hazardous waste and separate data for organic, compostable materials.
- **Waste separation**: separate and dispose the recyclable materials with adequate infrastructure: the collection system has to be well organized, dispersed and managed.

- **Site collection**: Specific collection area has to be dedicated to temporary collection waste collection: the site has to be located at least 20 m from building entrance and easily reachable for lorries. Hospital collection-site needs to be:
  - at least 2 m^2 per 1,000–5,000 m^2 of building net floor area;
  - minimum of 10 m^2 for buildings bigger than 5,000 m^2;
  - an additional 2 m^2 per 1,000 m^2 of net floor area where catering is provided. Recyclable waste compactor must be provided on-site for waste volume reduction to reduce transport costs and waste volume for storage on-site.

Definition
The criterion evaluates the outcomes of the undertaken actions in order to reduce hospital's waste production impact.

Aim
To minimize overall waste generation in hospitals (both general and infective) and to divert compostable, recyclable and hazardous waste from landfills.

Description
It considers the main strategies to reduce the impact of waste produced by the hospital: minimizing waste generation recycling, separating organic fraction, control of hazardous waste. That in accordance with the virtuous waste cycle: minimize, reuse, recycle, energy recovery, landfill. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7):

$$\text{Wastecare} = \frac{(x \cdot WG + y \cdot HW + z \cdot CW + w \cdot WR + k \cdot Co)}{5}$$

where:
WG Waste Generation (only for operative hospitals)
HW Hazardous Waste (only for operative hospitals)
CW Construction Waste (only for in-designing hospitals)
WR Waste Recycling
Co Composting

References
BRE Global Ltd 2010; USGBC 2011a; ITACA 2011; Pruss et al. 1999; Eurostat 2011.

WASTECARE—waste generation—only for operative hospitals

Definition
The indicator evaluates and rewards solutions undertaken by the hospital to reduce its waste generation, through minimization and reuse.

Aim
To minimize overall waste generation in hospitals.

Description
The indicator evaluates the overall amount of waste produced by daily working of the hospital. The main aim in waste production reduction is waste minimization directly at the source, where possible. Overall operational waste generation (non hazardous, hazardous, recyclable, etc.) is computed in terms of kilos of waste produced per day per bed.

$$WG = \frac{\sum \text{yearly operational waste}}{\text{n}^{\circ}\text{bed} * \text{operational days}}$$

Score is assigned according to the waste generation:

SCORE	WG
1	37–42
2	32–37
3	32–27
4	27–21
5	<21

Fluxes are computed at the delivery points after treatment operations (e.g. sterilization, compaction).

Unit
[Kg/(bed*day)].

Time reference
Annual survey.

Initial data availability
Data are to be derived from records of waste fluxes (both for hazardous and non hazardous waste) and normalized by kg/day. Number of beds in the hospital has to be given.

WASTECARE—hazardous waste—only for operative hospitals

Definition
The indicator evaluates the amount of waste treated and disposed as hazardous.

Aim
To reduce the overall generation of hazardous waste in hospitals.

Description
Hospitals produce a certain amount of waste that cannot be treated as common solid waste since it can be infectious it has been in contact with infectious material, or, more generally, requires a specific disposing treatment depending on national regulations. Environmental and economic costs grow with the amount of waste treated as hazardous.
Scores are assigned according to the percentage of total waste produced treated and disposed as hazardous:

$$\mathrm{WG} = \frac{\text{waste treated as hazardous}}{\sum \text{yearly operational waste}}$$

The total score is given by the sum of the following points:

SCORE	HW (%)
1	25–30
2	20–25
3	15–20
4	10–15
5	<10

Unit
Fluxes are in terms of [tons/year] or [m^3/year].

Time reference
Annual survey.

Initial data availability
Data about the amount of hazardous waste produced can be found on specific incinerator reports.

WASTECARE—construction waste—only for in-design hospitals

Definition
Indicator sets the path when dealing with construction waste, ensures adequately defined Site Waste Management Plan (SWMP) and sets certain targets of construction waste generation, which are supposed to be reached.

Aim
The indicator aims to reduce the future waste coming from construction phase, aiming to improve waste management efficiency of construction-site. Long term aim is to assure the reuse of the construction waste and its diversion from landfills.

Description
Construction waste has a great re-use potential in construction industry, but traditionally this waste was mainly put in the landfills. Main objective is to divert construction waste from landfill so operating time of landfills can be increased and economic damage avoided. Credits are assigned based on benchmark chosen (and normalized by the 100 m^2 of gross internal floor area), existence of SWMP. Scores are assigned according to:

SCORE	CONSTRUCTION WASTE
0	No benchmarks chosen and no SWMP prepared
1	Developed SWMP
+1	13.3 m^3/11.1 tones
+2	7.5 m^3/6.5 tones
+3	3.4 m^3/3.2 tones
+1	Waste separation is going to be performed on-site and waste recycling/ reuse where possible

Note: Waste included in the benchmarks is waste from excavation, demolition and waste generated during regular construction works. Presence of SWMP and target for waste generation is important. Waste generated does not have to be necessary used on-site, it can be used on other sites, transported back to supplier or salvaged for further use, but it cannot be sent to landfill otherwise no credits has been assigned.

Unit
[–].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
In the design stage data can be derived from project documentation, which has to prove that SWMP has been designed and benchmarks have been chosen.

WASTECARE—waste recycling

Definition
The indicator evaluates results achieved in separating and collecting recyclable waste.

Aim
To enhance on-site recyclable waste separation and therefore to divert recyclable materials (such as paper, plastic, glass, aluminum, batteries, etc.) from landfills or energy recovery.

Description
The indicator presents two different definitions.
If the structure is already operative, the indicator is defined as the ratio between the amount of separated recyclable materials respect the total mass of non-hazardous hospital waste produced. Organic waste is not computed among the recyclable materials since another indicator is made to consider its specific recovery.

$$WR = \frac{\text{Recycled waste}}{\text{operational non haz. waste}}$$

If the hospital is under design/construction Project team has to be able to demonstrate that the collection system is well designed (as stated in prerequisites) with bins well dispersed labelled and place for storage well designed. Scores are given if this requirements are achieved (OH = Operative Hospitals; IDH = In-Design Hospitals):

SCORE	WR OH (%)	SCORE	WR IDH
1	8–16	0	Required infrastructure is not predicted
2	16–24	+1	Clearly labelled collection bins, in chosen colour has been planned, covering all public areas (outside and inside)
3	24–32	+1	Routes for collection and transportation (from the bins) of recyclable waste to the main storage has been predicted
4	32–40	+2	Temporary storage has been defined according to prerequisites described in the main page of the indicator waste
5	>40	+1	Compacter has been planned on the temporary storage site

Unit
Fluxes in terms of [Tons/year] or [m^3/year].

Time reference
Annual survey.

Initial data availability
Waste fluxes records.

WASTECARE—composting

Definition
This indicator evaluates efforts done to collect and separate organic waste.

Aim
To divert from landfills all organic non-hazardous compostable material (food, waste, garden waste, etc.), which is normally coming from hospital operation, employing composting.

Description
Organic waste is mainly produced by kitchen and gardening maintenance. Even though data varies from structure to structure, food waste is one of the main voice in hospital waste composition. Typically hospital canteen is managed by an external company, but it may happen that its waste disposal is made with others waste produced by the hospital.
Credits are assigned based on:

SCORE	COMPOSTING
+4	Organic waste produced by the kitchen is collected in separated way and disposed in a different way (composted in internal plant or in an external one) OR the external company to which is committed the canteen and the disposal of its waste certifies the different collection of organic waste produced
+1	Green waste derived by gardening maintenance is collected and treated differently with respect to non hazardous waste produced by the hospital (composted in internal plant or in an external one)

Note: if no green areas are present in the hospital scores available for different disposal of organic waste from kitchen are 5.

Unit
[–].

Time reference
Annual survey.

Initial data availability
Data are to be derived from waste management, agreements with external companies private or public utilities.

COMBINED HEAT and POWER

Pre-requirements

- **Exergetic convenience**: CHP is compared with separated generation of heat and power. Given a certain output, the higher is the exergetic efficiency of CHP compared to separate production, the better it is. Once the plant is working, the constraint

$$(\eta_{exCHP} - \eta_{exsep})/\eta_{exCHP} = \text{PES (Primary Energy Saving)} > 10\,\%$$

Has to be satisfied over a year. To define the $\eta_{ex,sep}$ the average efficiency of the national power system production and the thermal average national efficiency for industrial use are to be considered.

Definition
The criterion evaluates the convenience of CHP technology and the amount of energy produced through cogeneration.

Aim
To reward hospitals which exploit as much as possible a convenient CHP plant in order to supply the contemporaneous needs for electricity and thermal energy.

Description
CHP produces both electricity and energy for thermal needs at different temperatures. If trigeneration is present also the hot fluxes for absorption chillers must be accounted.
To better compare different fluxes the indicator is defined as the ratio between the exergy need supplied by CHP and the exergy related to the above mentioned fluxes.

$$CHP = \frac{(Ee + \sum Et * \theta)_{CHP}}{(Ee + \sum Et * \theta)_{tot}}$$

where:
Ee electric energy;
Et*θ thermal energy multiplied by Carnot factor to turn it into exergy form in order to make a fair comparison with electric energy. The Carnot factor must be referenced to sizing temperature T_{winter} and T_{summer} for hot and cold production respectively.
Scores are assigned according to:

Score	CHP (%)
1	>15
2	30–45
3	45–60
4	60–75
5	>75

References
European Parliament and the council of the European Union 2004; Galliani 2008; Midwest CHP Application Center 2007.

MATERIALS and RESOURCES—only for in-design hospitals

Definition

Assessment of the quality and the reduction of used resources during construction phase. The aim is to cut the global impact due to the realization of the building, thorough the selection of short chain materials, resulting from recycling processes, not-toxic materials, characterized by a predefined recovery destination.

Aim

The indicator try to minimize the problem linked with the consumption of resources, it is mainly due to materials used in the construction phase of the building. It is not just considered the specific problem due to the construction, but also the future problems due to the disposal phase with the problem of materials disposal. Is incentivized the recycling and the recyclability or the possibility to reuse some components to decrease the overall use of resources.
The TVOC indicator is finalized to sensitize to the design of buildings which are not illness generative is so considered the phase of material selection particularly for the finishing materials.

Description

It considers different problems connected with technological choices, using an optic from cradle to cradle. The use of sustainable politics in production building phase ere incentivized, besides an assessment of possible future scenarios is considered, therefore are favoured politics which don't neglect the rooms healthiness. The indicator evaluate with a percentage score from 0 (insufficient) to 100 % (excellent) the effectiveness of the material selection phase (refer to the values reported in Fig. 4.7):

$$M\&R = \frac{(x \cdot 0\,\text{km} + y \cdot \text{Re} + z \cdot \text{RC} + w \cdot \text{TVOC})}{5}$$

where

0 km	0 km materials
Re	Recyclability
RC	Recycled Components
TVOC	VOC and Materials toxicity

References

BRE Global 2010; ITACA 2011; USGBC 2011a.

MATERIALS and RESOURCES—0 km materials—only for in-design hospitals

Definition
Evaluation on the origin of materials used, is believed that the closest is the place of extraction or production to the construction yard more sustainable is the overall building process.

Aim
The indicator aim to foster the use of local material to reduce the environmental impact of transports, minimizing energetic costs and also promote local economy (through the promotion of companies which favourite the recycling and the reduction of the production of waste).

Description
The indicator assess with a score from 0 (insufficient) to 5 (excellent) the presence of '0 km materials' evaluating the percentage of material (assessed in kg) coming from a distance of 350 or 150 km (between production site to building site).
Scores are assigned according to:

SCORE	0 km MATERIALS
0	0 % of materials coming from a distance of 350 km
1	10 % (or more) of materials coming from a distance of 350 km
2	20 % (or more) of materials coming from a distance of 350 km
3	30 % (or more) of materials coming from a distance of 350 km
4	10 % (or more) of materials coming from a distance of 150 km
5	20 % (or more) of materials coming from a distance of 150 km

Unit
[km].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Bills of materials to evaluate de distances, bill of quantities to assess the quantity of materials.

MATERIALS and RESOURCES—recyclability—only for in-design hospitals

Definition
Assessment of recyclable components among building materials: is believed that the selection of recyclable materials with up cycling outcomes (conversion of the material in product with the same quality of the initial one) gives additional value to the sustainability of the project.

Aim
To reduce the use of row materials, thorough the use of recycled materials, easily separable materials and building procedures that allow selective demolitions. Reducing wastes generated by demolition.

Description
The indicator assess with a score from 0 (insufficient) to 5 (Excellent) the percentage of materials used in the construction which are recyclable thorough simple procedures, meaning disassembly of dry works, stratigraphy composed by a limited number of layers, easy removal of mortars and glues or crush of indivisible materials.
Scores are assigned according to:

SCORE	RECYCLABLE MATERIALS
0	No use of any recyclable material
1	Up to 10 % weigh in the total weigh of the building
2	Up to 20 % of weigh in the total weigh of the building
3	Up to 40 % of weigh in the total weigh of the building
4	Up to 60 % of weigh in the total weigh of the building
5	More than 60 % of weighs in the total weigh of the building

Unit
[kg].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Contract performance of building materials, technical specifications building phase specifications to evaluate the recyclability of each stratigraphy. Bill of quantities to assess the quantity of materials.

MATERIALS and RESOURCES—recycled components—only for in-design hospitals

Definition
The indicator assess the presence of recycled material used in the building phase, it incentivizes a design that is directed toward a decreasing use of not renewable resources. The use of recycled materials takes to a decrease of wastes produced in dismantling process, also the overall decreasing in energy consumption is achieved, energy considered as embodied energy due to productive processes of materials. The assessment takes into account the presence of percentage of recycled material because is difficult for many type of materials to have the whole producing process based on recovered row materials.

Aim
Sensitize to a design that incentivize a sustainable selection of finishing materials, is rewarded the selection of materials with less organic materials that can disperse VOC, as timber or natural derived materials.

Description
The indicator assess the percentage of materials used in the construction which are characterised by the presence (for a part or the whole) of content derived by recycling processes. Score is assigned according to:

SCORE	RECYCLED COMPONENTS
0	0 % of materials characterized by content derived (for a part or the whole) by recycling process
1	5 % of materials derived by recycling process
2	10 % of materials derived by recycling process
3	15 % of materials derived by recycling process
4	20 % of materials derived by recycling process
5	25 % of materials derived by recycling process

Unit
[kg].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Contract performance of building materials technical specifications to evaluate the recyclability of each stratigraphy. Bills of quantities to assess the quantity of materials.

MATERIALS and RESOURCES—tvoc and materials toxicity—only for in-design hospitals

Definition
The indicator analyses the problem created by the presence of compounds or elements in the indoor air which can create discomfort or problems on the health of room users. Concentration analysis is used, to compare values to threshold given by laws; the material selection must be oriented toward sustainability not just to achieve benchmarks but also the improvement of the performance by this point of view.

Aim
Sensitize to a design that take into account a sustainable selection of finishing materials, the incentive is related to the selection of materials with low presence of organic materials that could disperse VOC, for example timber or natural derived materials.

Description
The indicator evaluates the presence of materials that in operative phase do not release into the indoor environment Total Volatile Organic Compound (TVOC). The assessment evaluates the indoor directly measurable concentration after 28 days of installation of the material.
Scores are assigned according to:

SCORE	TVOC and MATERIALS TOXICITY
+1	Using of materials for **floors** that take into account a reduction of TVOC for at least 70 % of the total surfaces
+1	Using of materials for **walls** with a reduction of TVOC for at least 70 % of the total surfaces
+1	Using of materials for **ceilings** that guarantee a reduction of TVOC for at least 70 % of the total surfaces
+1	Using **furnitures** and **appliances** that guarantee a reduction of TVOC for at least 70 % of the total surfaces
+1	Specific studies about pollutants during the design phase

Unit
[$\mu g/m^3$].

Time reference
Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Technical specifications, bill of quantities for the finishing materials.

UNCONVENTIONAL SOURCE SUPPLY

Pre-requirements

- **E-team**: going beyond art. 19, Ministerial directive 10/91 (Italian Parliament 1991) must be constituted an high skilled and multidisciplinary Energy team to better analyze all the different aspects in which energy is involved.
- **Feasibility study**: the main feature of renewable technologies is the dependence on intermittent sources. This is why the different solutions are not equivalent since they depend on the boundary conditions of the hospital's site. Before deciding which solution is the best one for the hospital the Energy Team must conduct an Energy/Economic analysis to determine which is the most efficient way to supply hospital's needs.
- **Compliance to Legislative decree n. 28**, for buildings under construction from 05/2012, (Presidency of the Italian Republic 2011): hospitals must cover 30 % of cooling heating and hot water need by using renewable energy sources (over a year). Moreover 60 % of hot water must be produced by renewable energy sources.

Definition
The criterion evaluates the percentage of the energy need covered by renewable energy sources.

Definition
To promote the exploitation of renewable energy sources for thermal and electric needs and to stimulate the adoption of innovative technologies.

Description
This criterion is focused on technologies which can exploit Renewable Energy Sources (RES). The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7):

$$\text{USS} = \frac{(x \cdot \text{DHW} + y \cdot \text{HC} + z \cdot \text{El})}{5}$$

where
DHW Domestic Hot Water
HC Heating and Cooling
El Electricity

References
Italian Parliament 1991; Presidency of the Italian Republic 2011.

UNCONVENTIONAL SOURCE SUPPLY—domestic hot water

Definition
The indicator evaluates the fraction of Domestic Hot Water (DHW) need covered by renewable energy sources.

Aim
To reward hospitals which exploit Renewable Energy Sources (RES) to supply DHW needs as much as possible and to stimulate energy production from renewable sources.

Description
The object of evaluation is the amount of energy need covered exploiting RES over the total energy need for DHW.

$$f = f_{district\ Heating} + f_{heat\ pumps} + f_{Biomass} + f_{solar\ collector}$$

The parameter f is the sum of all the energy fractions corresponding to the different technologies exploited to satisfy thermal needs. Each fraction is defined as the ratio between the amount of DHW produced by the specific technology and the total amount of DHW.
If CHP plant is present and its Primary Energy Saving (PES) is higher than 10 % (see **CHP indicator**), the part supplied by the CHP must be deducted from the DHW need.
The term 'heat pump', includes all the different technologies (air/air, water/air, water/water, geothermal absorption, etc.) which can be used to produce DHW. If the score of **Electricity indicators** is lower than 5, the thermal flux considered as produced from renewable source is the one extracted from the source (ground water, air). Otherwise is the heat introduced in the DHW flux. Scores are obtained according to the following:

SCORE	f (%)
1	<10
2	10–20
3	20–30
4	30–40
5	>50

Note: for buildings under construction from May of 2012 a value of 0 has to be assigned to hospitals that reach a value of *f* lower than 4.

Unit
All the *f* fractions are in terms of [(kWh/kWh)/year].

Time reference
Annual survey.

Initial data availability
Data on meters and counters of boilers and other systems (or estimation).

UNCONVENTIONAL SOURCE SUPPLY—heating and cooling

Definition
The indicator evaluates the fraction of heating need covered by renewable energy sources and it considers the possibility to exploit innovative solutions also for cooling needs.

Aim
To reward hospitals which exploit Renewable Energy Sources (RES) for heating and cooling as much as possible and to stimulate energy production from renewable sources.

Description
The object of evaluation is the amount of energy produced exploiting RES over the total amount of energy needed for heating and cooling.

$$f = f_{district\ Heating} + f_{heat\ pumps} + f_{Biomass} + f_{solar\ collector}$$

The parameter f is the sum of all the energy fractions exploited to satisfy thermal needs each one corresponding to a different technology. Each fraction is defined as the ratio between the amount of heat produced by the specific technology and the total amount of heat required by the structure.
If a CHP plant is present and its Primary Energy Saving (PES) is higher than 10 % (see **CHP indicator**) the part supplied by the CHP must be deducted from the heating/cooling needs.
The term ‘heat pump’, includes all the different technologies (air/air, water/air, water/water, geothermal absorption, etc.) which can be used to grant heating/cooling. This technology is able to exploit renewable energy sources both for heating and cooling. If the score of **Electricity indicator** is lower than 5, RE produced by heat pumps is the one extracted by the source (ground water, air). Otherwise heating/cooling flux produced from RE is the one introduced in the conditioned space.
Scores are assigned according to:

SCORE	H/C (%)
1	5–10
2	10–15
3	15–20
4	20–25
5	>25

Unit
[kWh/kWh].

Time reference
Annual survey.

Initial data availability
Data on meters and counters of boilers and other systems (or estimation).

UNCONVENTIONAL SOURCE SUPPLY—electricity

Definition
The indicator evaluates the fraction of electric need covered by renewable energy sources.

Aim
To reward hospitals which exploits Renewable Energy Sources (RES) for electric needs as much as possible and to stimulate energy production from renewable sources.

Description
The object of evaluation is the amount of energy produced by exploiting RES over the total amount of electric energy needed.

$$f = f_{PV} + f_{external\ Agreement}$$

The parameter f is the sum of the fractions of total power supplied by PV plants and by external agreements that certify energy used by the hospital as produced from renewable sources. If other renewable sources are used to produce electricity, they can be computed as external agreements since this indicator evaluates only the energy output of any solution.
If CHP plant is present and its Primary Energy Saving (PES) is higher than 10 % (see **CHP criterion**) the fraction supplied by the CHP must be deducted from the total electric needs.
Scores are assigned according to:

SCORE	El (%)
1	<15
2	15–20
3	20–25
4	25–30
5	>35

Unit
All the f fractions are in terms of [(kWh/kWh)/year].

Time reference
Annual survey.

Initial data availability
Data can be collected from meters of PV plants and external providers reports.

URBAN PLANNING

Definition

The criterion evaluates the localization of the hospital, dealing with quality and environmental impact, site accessibility and landscaping.

Aim

To analyze the context and the site where the hospital is located the transport system and the connection to the city, the accessibility of the building and the possible introduction of vehicles with unconventional fuels or car sharing for patient transport.

Description

The criterion needs the observation and analysis of the context in which the hospital is built; it is necessary to identify the exogenous pressure elements that influence the hospital activities. Moreover impact due to the insertion of a new structure in a preexisting context is considered. The final credit is the result of a weighted average of the scores obtained in each indicator (refer to the values reported in Figs. 4.6 and 4.7):

$$\text{Urban planning} = \frac{(x \cdot TA + y \cdot ELI + z \cdot Ri + k \cdot SP)}{5}$$

where:

TA Transport and Accessibility
ELI Environmental and Landscape Impact
Ri Risks (only for in-designing hospitals)
SP Site Physics (only for in-designing hospitals)

References

BRE 2010; Capolongo et al. 2011; ITACA 2011; USGBC 2011a, b; Minister of Public Works 1968; Rossi Prodi and Stocchetti 1990.

URBAN PLANNING—transport and accessibility

Definition

Is assessed the effectiveness of paths to accede to the hospital.

Aim

To verify the presence of a good connection of the transports with the city, cycling routes, use of vehicles with eco-fuels or car sharing methods.

Description

It evaluates the accessibility to the hospital for workers patients and visitors considering different transports (car, bus, bicycle, ambulance) and the quality of paths; it also verifies the easiness to reach the hospital. The indicator assess also the quantity of parkings and the differentiation between the workers and visitors ones. Score is given for:

SCORE	TRANSPORT and ACCESSIBILITY
+1	Localization of the building within a distance (from a main entrance) of 1,000 m by foot, from a railway station a helicopter landing field, port or a light subway existing or planned
+1	Localization of the building within a distance (from a main entrance), of 250 m from one or more public transport stop or a shuttle system provided by the hospital. The point is scored only if the regulations on accessibility for disabled are guaranteed
+1	Presence of cycle routes to reach the hospital and of covered spaces and security systems to store bicycles for at least 10 % of users
+1	Car sharing service for the hospital users equipped with low emission vehicles or with vehicles provided with unconventional fuels
+1	Parking capacity sized in respect to one of these two methods • Parkings for not less than one s.m. every ten cubic meters; • Ponter study (Rossi Prodi 1990), parking spaces (p.s.): – p.s. for visitors: 1 p.s. every 3-5 patients; – p.s. for patients: 5 p.s. every doctor; – p.s. for nurses: 1 p.s. every 3 nurses; – p.s. for doctors: 1 p.s. every 1.5 doctor; – p.s. for emergency: 10 p.s.

Unit

[m].

Time reference

Annual survey.

Initial data availability

Cycle paths, public transports routes; external hospital plan.

URBAN PLANNING—environmental and landscape impact

Definition

The indicator evaluates the quality of the master plan part which focuses on the outdoor area of the hospital.

Aim

To minimize the impacts of the building and to analyze the environmental quality of the hospital and its surroundings.

Description

It defines the footprint of the building the presence of accessible green areas and integration of the hospital in the context.

Scores are assigned according to:

SCORE	ENVIRONMENTAL and LANDSCAPE IMPACT
1	The ecological footprint is not changed by the action
2	The ecological footprint is decreased by the action
+1	The operation increases the accessibility conditions to green areas for users (increased surface of green areas such as gardens and parks or increasing of existing green presence thorough ponds, rocky gardens, etc.)
+1	The operation increases the volume of the building and this addition is architectonically integrated or the operation improves the external quality of the building
+1	Measures that aim to minimize the soil waterproofing through the minimization of asphalted surfaces, or the use of semi permeable surfaces or green roofs are taken

Unit

[–].

Time reference

Annual survey.

Initial data availability

Direct assessment in site.

URBAN PLANNING—risks—only for in-design hospitals

Definition

The indicator defines the best site choice, allowing the minimisation of some risks due to context site by an environmental and urban optics.

Aim

To avoid possible discomfort for patients and workers due to errors in the site choice. Good score means a design oriented on these issues.

Description

The risk absence is necessary in the hospital designing process, very often risks may come directly from the context where the building is situated. Contextual risks can be sometimes minimised through the right localization choice, putting the building in less hazardous areas. In other cases hazardous conditions are developed in a broad territorial area, so the indicator should assess how much are effective the contrast solutions adopted in the designing process. The evaluation method is characterized by a score structure considering the attribution of points due to the achievement of benchmarks. Scores are assigned according to:

SCORE	RISKS
1	If the building is between 150 and 230 m to an electromagnetic pollution creator such as a high voltage electric line or a communication antenna
2	If the building is farther than 230 m to an electromagnetic pollution creator
+1	Where are adopted proceedings finalized to minimize the hydro geological risk
+1	If are adopted innovative systems to avoid seismic problems
+1	If the industrial plants hazardous for the kind of production present in the contextual areas have adopted procedures to minimize risks more restrictive than what imposed by law

Unit
[–].

Time reference
Calculated in the design phase remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability
Direct measurements, statistical values, thematic cartography.

URBAN PLANNING—site physics—only for in-design hospitals

Definition
Quantitative physical performances due to master plan choices.

Aim
The indicator aim is to assess the choices on building localization, materials of external finishing and discomfort issues mitigation.

Description
The indicator assesses the designing choices at master plan level, it gives threshold linked to the performances on thermal pollution caused by the excessive overbuilding, material choice, acoustic insulation regarding contextual noises and evaluate the daylight availability.

Scores are assigned according to:

SCORE	SITE PHYSICS
0	If the average energetic reflection factor (rm) xf external area surfaces is higher than 70 %
1	If the average energetic reflection factor (rm) of external area surfaces is between 50 and 70 %
2	If the average energetic reflection factor (rm) of external area surfaces is lower than 50 %
+1	If the intake level calculated near the façade (L_{2eq}) is lower than 45 dB $A_{diurnal}$—35 dB A during night
+1	If the percentage of glazed surfaces exposed, during winter to direct solar radiation are between 30 and 15 %
+1	If the percentage of glazed surfaces exposed, during winter to direct solar radiation are higher than 30 %

Unit

[–].

Time reference

Calculated in the design phase, remains valid until further modifications. Every modification implies the evaluation upgrading.

Initial data availability

Direct assessment and evaluation in the designing phase.

References

Alfonsi E, Capolongo S, Buffoli M (2014) Evidence based design and healthcare: an unconventional approach to hospital design. Annali di Igiene 26(2):137–143. doi:10.7416/ai.2014.1968

Ambiente Italia Istituto di Ricerche (2003) Indicatori Comuni Europei. Verso un profilo di sostenibilità locale, 2003. Ambiente Italia. http://www.a21italy.it/medias/696-rapportofinaledef.pdf. Accessed 16 Dec 2011

Aste N, Adhikari RS, Del Pero C (2011) Photovoltaic technology for renewable electricity production: towards net zero energy buildings. Paper presented at 3rd international conference on clean electrical power: renewable energy resources impact, ICCEP 2011, pp 446–450

Azienda Provinciale per i Servizi Sanitari di Trento (2006) Carta di Trento sulla valutazione delle tecnologie sanitarie in Italia. Provincia Autonoma di Trento, Trento

Bakker A (2002) Health care and ICT: partnership is a must. Int J Med Informatics 66(1–3):51–57. doi:10.1016/S1386-5056(02)00036-9

BRE Global Ltd. (2010) Breeam Healthcare. BRE, Watford

Brioschi A, Capolongo S, Buffoli M (2010) Energy and environmental in hospital: evaluation of consumptions and impacts of health facilities in region Lombardia. Ann Ig 22(6):563–573 (PubMed PMID: 21425653)

Bottero M (2011) Indicators assessment systems. In: Cassatella C and Peano A (eds) Landscape Indicators Springer Berlin, pp 15–29

Buffoli M, Capolongo S, Cattaneo M, Signorelli C (2007) Project, natural lighting and comfort indoor. Ann Ig 19(5):429–441 (PMID: 18210773)

Buffoli M, Capolongo S, Loconte V, Signorelli C (2012a) Thermovalorization: new technologies, impacts and mitigation strategies. Annali di Igiene 24(2):167–178 (PubMed PMID: 22755503)

Buffoli M, Nachiero D, Capolongo S (2012b) Flexible healthcare structures: analysis and evaluation of possible strategies and technologies. Ann Ig 24(6):543–552 (PubMed PMID: 23234192)

Buffoli M, Capolongo S, Bottero M, Cavagliato E, Speranza S, Volpatti L (2013) Sustainable healthcare: how to assess and improve healthcare structures' sustainability. Ann Ig 25(5):411–418

Buffoli M, Bellini E, Bellagarda A, di Noia M, Nicholova M, Capolongo S (2014a) Listening to people to cure people: the LpCp-tool, an instrument to evaluate hospital humanitazion. Ann Ig 25(5):447–455 (PMID: 25405376)

Buffoli M, Gola M, Rostagno M, Capolongo S, Nacchiero D (2014b) Making hospitals healthier: how to improve sustainability in healthcare facilities. Ann Ig 26(5):418–425 (PMID: 25405372)

Capolongo S (2001) Un nuovo modello progettuale. Proposta progettuale di Renzo Piano. Tecnica Ospedaliera 10(5):38–45

Capolongo S (2006) Edilizia ospedaliera. Approcci metodologici e progettuali, Hoepli, Milan

Capolongo S (2012) Architecture for flexibility in healthcare. Franco Angeli, Milan

Capolongo S, Adiansi M, Buffoli M, Signorelli C (2001) Experimental evaluation of natural air exchange in different indoor environments. Ann Ig 13(1 Suppl 1):21–31 (PubMed PMID: 11305176)

Capolongo S, Battistella A, Buffoli M, Oppio A (2011) Healthy design for sustainable communities. Ann Ig 23(1):43–53 (PubMed PMID: 21736006)

Capolongo S, Buffoli M, Riva MG, Tognolo C, Oppio A (2012) Hygiene and emergency: considerations and proposals for improving hygiene and health features of advanced medical post. Ann Ig 24(5):389–396 (PubMed PMID: 23193895)

Capolongo S, Buffoli M, Oppio A, Nachiero D, Barletta MG (2013a) Healthy indoor environments: how to assess health performances of construction projects. Environ Eng Manag J 12(S11):209–212

Capolongo S, Buffoli M, Oppio A, Rizzitiello S (2013b) Measuring hygiene and health performance of buildings: a multidimensional approach. Ann Ig 25(2):151–157. doi:10.7416/ai.2013.1917

Capolongo S, Bellini E, Nachiero D, Rebecchi A, Buffoli M (2014) Soft qualities in healthcare method and tools for soft qualities design in hospitals' built environments. Ann Ig 26(4):391–399. doi:10.7416/ai.2014.1998

CENED (2011) Manuale del Software CENED+. CENED. http://www.cened.it/manuale_sw_cenedpiu. Accessed 20 Sept 2012

Cinotti R, Di Denia P (2007) Gestione del rischio in Emilia-Romagna 1999–2007. Regione Emilia-Romagna, Bologna

Civan A, Skeels M, Stolyar A, Pratt W (2006) Personal health information management: consumers' perspectives. In: Proceedings of AMIA annual symposium, pp 156–160 (PMCID: PMC1839450)

COCIR (2009) Good refurbishment practice for medical imaging equipment, 2nd edn. COCIR. http://www.cocir.org/index.php?mode=0. Accessed 20 Mar 2012

Colantonio A (2009) Social sustainability: linking research to policy and practice. dissertation, sustainable development—a challenge for European research, Brussels

CTI (Comitato Tecnico Italiano) (1995) Norm UNI 10339: Impianti aeraulici al fini di benessere. Generalità, classificazione e requisiti. Regole per la richiesta d offerta, l offerta, l ordine e la fornitura. UNI, Rome

CTI (Comitato Tecnico Italiano) (2008a) Norm UNI EN 15251: Criteri per la progettazione dell'ambiente interno e per la valutazione della prestazione energetica degli edifici, in relazione alla qualità dell'aria interna, all'ambiente termico, all'illuminazione e all'acustica. UNI, Rome

CTI (Comitato Tecnico Italiano) (2008b) Norm UNI EN 13363-1: Dispositivi di protezione solare in combinazione con vetrate - Calcolo della trasmittanza solare e luminosa. UNI, Rome
CTI (Comitato Termotecnico Italiano) (2012) Norm UNITS 113000. Certificazione energetica degli edifici. CTI. http://11300.cti2000.it/. Accessed 10 Oct 2012
Corso M, Locatelli P (2009) La cartella clinica elettronica: verso un supporto integrato ai processi clinici. Politecnico di Milano, Osservatorio ICT in Sanità, Milan
De Vries E, Ramrattan M, Smorenburg S, Gouma D, Boermeester M (2008) The incidence and nature of in-hospital adverse events: a systematic review. Qual Saf Health Care 17:216–223. doi:10.1136/qshc.2007.023622
Demiris G, Afrin L, Speedie S, Courtney K, Sondhi M, Vimarlund V, Lovis C, Goossen W, Lynch C (2008) Patient-centered applications: use of information technology to promote disease management and wellness. A white paper by the AMIA knowledge in motion working group. J Am Med Inf Assoc 15(1):8–13. doi:10.1197/jamia.M2492
Dente B (2011) Le decisioni di policy. Come si prendono, come si studiano. Il Mulino, Bologna
Doran G (1981) There's a S.M.A.R.T. way to write management's goals and objectives. Manag Rev 70(11):35–36
Ente Nazionale Italiano di Unificazione (2003) UNI 11097:2003. Quality management—quality indicators and quality management synoptical tables—general guidelines. UNI, Rome
European Parliament and the Council of the European Union (2002) Directive 2002/91/CE sul rendimento energetico nell'edilizia. European Parliament, Brussels
European Parliament and the Council of the European Union (2004) Directive 2004/8/CE: on the promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42/EEC. European Commission, Brusseles
Eurostat (2011) The development of waste indicators at European union level: some recent Eurostat experiences. Eurostat. www.unece.org/stats/documents/2001/10/env/wp.29.e.pdf. Accessed 10 Apr 2012
Eysenbach G (2001) What is e-health? J Med Internet Res 3(20). doi:10.2196/jmir.3.2.e20
Fraser G, Spiteri G (2011) Annual epidemiological report 2011. Reporting on 2009 surveillance data and 2010 epidemic intelligence data. ECDC, Stockholm
Galliani A, Pedrocchi E (2008) Analisi exergetica. Polipress, Milan
Garner J, Jarvis W, Emori T, Horan T, Hughes J (1988) CDC definitions for nosocomial infections. Am J Infect Control 16(3):128–140. doi:10.1016/0196-6553(88)90053-3
Goodman C (2004) HTA 101: introduction to health technology assessment. NICHSR of the National Library of Medicine, Virginia
Graban M (2012) Lean hospitals. improving quality patient safety, and employee engagement, 2nd edn. CRC Press, Boca Raton
Hailey D (2003) Elements of effectiveness for health technology assessment programs. AHFMR, Edmonton
Halamka J, Mandl K, Tang P (2008) Early experiences with personal health records. J Am Med Inf Assoc 15:1–7. doi:10.1197/jamia.M2562
Harbarth S, Sax H, Gastmeier P (2003) The preventable proportion of nosocomial infections: an overview of published reports. J Hosp Infect 54(4):258–266. doi:10.1016/S0195-6701(03)00150-6
Honigman B, Lee J, Rothschild J, Light P, Pulling R, Yu T, Bates D (2001) Using computerized data to identify adverse drug events in outpatients. J Am Med Inf Assoc 8:254–266. doi:10.1136/jamia.2001.0080254
Incropera F, Dewitt D, Bergman T, Lavine A (2006) Fundamentals of heat and mass transfer, 6th edn. Wiley, New York
I.T.A.C.A (2011) Protocollo Itaca per la valutazione della qualità energetica ed ambientale di un edificio. ITACA, Rome
Italian Parliament (1991) Regulation n. 10: Norme per l'attuazione del Piano energetico nazionale in materia di uso razionale dell'energia, di risparmio energetico e di sviluppo delle fonti rinnovabili di energia. Italian Parliament, Rome
JCI (Joint Commission International) (2010) Accreditation standard for hospitals, standards lists version, 4th edn. Joint Commission International, Illinois

Jørgensen OB (2004) Energy efficient European hospitals and health care building. Case studies from Denmark, Germany, Italy, The Netherlands and Poland. Dissertation, CleanMed Europe

Kristensen F, Sigmund H (2007) Health technology assessment handbook. Danish Centre for Health Technology Assessment, National Board of Health, Copenhagen

Lettieri E (2009) Uncertainty inclusion in budgeting technology adoption at a hospital level: evidence from a multiple case study. Health Policy 93(2):128–136. doi:10.1016/j.healthpol.2009.07.002

Lettieri E, Masella C (2007) Spesa sanitaria e valutazione delle tecnologie sanitarie. Giornale Italiano di Nefrologia 40:22–36

Lettieri E, Masella C (2009) Priority setting for technology adoption at a hospital level: relevant issues from the literature. Health Policy 90(1):81–88. doi:10.1016/j.healthpol.2008.07.007

Lettieri E, Masella C, Nocco U (2008) Budgeting and health technology assessment: first evidence obtained from proposal forms used to submit the adoption of new technology. Int J Technol Assess Health Care 24(4):502–510. doi:10.1017/S0266462308080665

Lindström B, Eriksson M (2005) Salutogenesis. J Epidemiol Community Health 59(6):440–442. doi:10.1136/jech.2005.034777

Mardajevic J, Nabil A (2005) Useful daylight illuminance: a new paradigm for assessing daylight in buildings. Lighting Res Technol 37:41–57. doi:10.1191/1365782805li128oa

Midwest CHP Application Center (2007) Combined heat and power, resource guide for hospital applications. CHP Center. http://www.chpcentermw.org/pdfs/USHospitalGuidebook_111907.pdf. Accessed 15 Apr 2012

Minister of Economic Development (2010) Ministerial directive n. 35. Aggiornamento del decreto 11 marzo 2008 in materia di riqualificazione energetica degli edifici. Ministry of Economic Development, Rome

Minister of Interior (1998) Ministerial directive 10/03/1998, III: Criteri generali di sicurezza antincendio e per la gestione dell'emergenza nei luoghi di lavoro. Ministry of Interior, Rome

Minister of Public Works (1968) Ministerial directive n. 1444: Limiti inderogabili di densità edilizia, di altezza, di distanza fra i fabbricati e rapporti massimi tra spazi destinati agli insediamenti residenziali e produttivi e spazi pubblici o riservati alle attività collettive, al verde pubblico o a parcheggi. Ministry of Public Works, Rome

Ministry of Health (2009) Piano Sanitario Nazionale 2006–2008. Ministero della Salute. http://www.salute.gov.it/portale/documentazione/p6_2_2_1.jsp?id=1205. Accessed 3 June 2012

Nicastri E, Petrosillo N, Martini L, Larosa M, Gesu GP, Ippolito G (2003) Prevalence of nosocomial infections in 15 Italian hospitals: first point prevalence study for the INF-NOS project. Infection 31(2):10–15 (PubMed PMID: 15018467)

Office of the Deputy Prime Minister, Audit Commission, Department of Environment, Food and Rural Affairs, Local Quality of Life Indicators (2005) Supporting local communities to become Sustainable. A guide to local monitoring to complement the indicators in the UK Government Sustainable Development Strategy. Audit Commission. http://www.audit-commision.gov.uk/SiteCollectionDocuments/AuditCommissionReports/NationalStudies/QofL2005.pdf. Accessed 16 Dec 2011

Origgi L, Buffoli M, Capolongo S, Signorelli C (2011) Light wellbeing in hospital: research, development and indications. Ann Ig 23(1):55–62 (PubMed PMID: 21736007)

Partridge E (2005) Social sustainability: a useful theoretical framework? Dissertation, Australasian Political Science Association annual conference

Pittet D, Allegranzi B, Storr J, Donaldson L (2005) Clean care is safer care: the global patient safety challenge 2005–2006. WHO, Geneva

Plowman R, Graves N, Grin M, Roberts J, Swan A, Cookson B, Taylor L (2001) The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed. J Hosp Infect 47:198–209. doi:10.1053/jhin.2000.0881

Premier of Council of Ministers (1997) Legislative decree n. 297: Determinazione dei requisiti acustici passivi degli edifici. Council of Ministers, Rome

Presidency of the Italian Republic (2011) Legislative decree n. 28: Attuazione della direttiva 2009/28/CE sulla promozione delluso dellenergia da fonti rinnovabili. Italian Parliament, Rome
Pruss A, Girolut E, Rushbrook P (1999) Safe management of wastes from healthcare activities. WHO, Genève
Regione Lombardia (2009) Piano strategico delle tecnologie per la sostenibilità energetica in Lombardia. Sistema Informativo Regionale Energia Ambiente. http://sirena.cestec.eu/sirena/download/Piano_Strategico_Tecnologie.pdf. Accessed 20 June 2012
Ricciardi W, Agostinelli A, La Torre G, Cicchetti A, Derrico P, Patarnello F (2010) Primo Libro Bianco sull'HTA in Italia. ViHTA, Rome
Rizzo G (2009) Analisi dello stato dell'arte nazionale ed internazionale dei sistemi integrati di illuminazione naturale/artificiale in relazione all'involucro edilizio nel caso di edifici del terziario e abitativi, ai fini di un loro impiego nell'ambito della certificazione energetica degli edifici. ENEA. http://www.enea.it/it/Ricerca_sviluppo/ricerca-di-sistema-elettrico/Risparmio-energia-elettrica/risparmio-di-energia-elettrica-nel-settore-civile/report. Accessed 25 Apr 2012
Rossi Prodi F, Stocchetti A (1990) L' architettura dell'ospedale. Alinea editrice, Florence
Saaty T (2005) Theory and applications of the analytic network process. RWS Publications, Pittsburgh
Saaty T, Ozdemir M (2008) The encyclicon. RWS Publications, Pittsburgh
Spinelli F, Bellini E, Bocci P, Fossati R (1994) Lo spazio terapeutico. Un metodo per il progetto di umanizzazione degli spazi ospedalieri. Alinea Editrice, Florence
Tarasenko N, Virone M (2011) Patient engagement in reducing safety risks in health care. WHO Regional Office for Europe, Copenhagen
Toussaint J, Gerard R, Adams E (2010) On the Mend: revolutionizing healthcare to save lives and transform the industry. Lean Enterprise Institute, Cambridge
Trucco P, Cavallin M (2006) A quantitative approach to clinical risk assessment: the CREA method. Saf Sci 44(6):491–513
Trucco P, Cavallin M, Lorenzi F, Chiarelli P (2008) Error and risk antecedent monitoring in healthcare. HEPS. http://www.timeoutintensiva.it/archivio/8%20Lorenzi.pdf. Accessed 25 Apr 2012
USGBC (2009) LEED for new construction and major renovations. USGBC, Washington
USGBC (2011a) LEED for healthcare. USGBC, Washington
USGBC (2011b) LEED for existing buildings operations and maintenance rating system with alternative compliance paths for projects outside the U.S. USGBC, Washington
Velasco-Garrido M, Busse R (2005) Health technology assessment: an introduction to objectives, role of evidence, and structure in Europe. WHO Regional Office for Europe, Copenhagen
Velsen K (2012) Restorative space. World Health Des 5(1):18–20
V.V.A.A. (2003) Progetto di ricerca finalizzata: Principi guida tecnici, organizzativi e gestionali per la realizzazione e gestione di ospedali ad alta tecnologia e assistenza. Supplementi di Monitor (6), ASSR Editore, Rome
Wright P et al. (2012) Monitoring for forest management unit scale sustainability: the LUCID test. U.S Department of Agriculture, Washington
Young D, Ballarin D (2006) Strategic decision-making in healthcare organizations: it is time to get serious. Int J Health Plann Manag 21(3):173–191. doi:10.1002/hpm.844
Zevi B (2003) Nuovissimo Manuale dell'Architetto, Mancosu Ed., Rome