ANNEX

The Sustainability Assessment of Buildings and Urban Space: Multicriteria Assessment and Rating

Sustainability Assessment:

Review of Literature & Market Analysis

Malta Chamber of Commerce | HSBC PROJECT

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Table of Contents

1 INTRODUCTION

This report refers to a review of literature with respect to the sustainability of buildings and urban space.

1.1 The Context of the HSBC Research Project

The context pf the project refers to a building scale and a cluster of buildings / spaces which refer to urban sustainability scale. This report refers to the Building and urban scale in addressing Sustainability assessment. Further the report refers to issues indicators to help define the sustainability framework for the intended application, which however are contextualised to the Mediterranean and local case and validated with respect to case studies. Such a framework with indicators and KPIs informs the Sustainability assessment method adopted.

1.2 Objective of the Report

The objective is to analyse Methods and tools which are used for the assessment of buildings and urban spaces / neighbourhoods (cluster of buildings and surrounding spaces), assess indicators used and their relevance, in particular in the Mediterranean context and assess case study applications and the outcome of such assessments. This approach is adopted to enable the extraction of the key issues – indicators which define sustainability at the building and the urban scale, therefore supporting the approach for sustainable interventions, both with respect to retrofit and refurbishment interventions and also strategic planning at the building and urban scale.

1.3 Method

In order to address these objectives, the report has been devised with reference to:

A background on Sustainability, Energy Efficiency, European frameworks and rating tools; A Detailed assessment of existing sustainability assessment tools at building and urban scale; the detailed assessment of a representative framework which is used to define issues and indicators of relevance in a Mediterranean context; the application through case studies in different Mediterranean regions, of such tools, to define urban and building assessment and the validation of such indicators in practice; the review of Key performance indicators and their applicability, in a local context (based on case study analysis); review of the application of the assessment at building and urban scale to wider case study examples which showcase best practice.

1.4 Report Structure and Content

To report focuses on key areas:

1. Background on Sustainability in the Built Environment
2. The context of the Energy performance of buildings including gaps in the Maltese context.
3. Sustainability assessment based on key Performance indicators, with a focus on a Mediterranean context.
4. Review of Tools for Sustainability Assessment
5. Examples in Sustainability Assessment Building and Urban Scale
6. Best Practice Examples: A Neighbourhood award was launched, based on the Sustainability assessment through KPIs. This report draws directly from this activity.

Premise: the report also draws directly from and refers directly also to documents prepared by the author and partners in the CESBA Med project (Sustainable Mediterranean Cities – Interreg Med Programme of the European Union), including the University of Malta as Key Partner. The examples refer to the Mediterranean region and are therefore, in great part contextual and relevant to the local Mediterranean context of Malta. Other examples (including examples in Austria) are also presented in view of their relevance.

This review leads to the identification of key issues including gaps and opportunities which may be exploited in a local context when referring to the Sustainability of new build and also retrofit of buildings and clusters of buildings / urban areas.

Note that further detailed reference to the Key Performance Indicators and Gaps with a view to the Maltese context is given in a future deliverable in the HSBC Green Building Project.

2 Background: Buildings and Sustainability

The European buildings sector represents 41.7% of the total annual final energy in the European Union Member States (EU-28) or 442 million tonnes of oil equivalent (Mtoe) in 2017 (Figure 1), and is responsible for ~30% of the total carbon dioxide emissions [Eurostat, 2019]. During their life cycle, buildings also use half of all raw material extraction and a third of all water consumption [Dodd, 2015]. Furthermore, the waste stream from the construction of buildings and civil infrastructure, demolition, road planning and maintenance (i.e., construction and demolition waste—CDW) is one of the heaviest and most voluminous waste streams that accounts for 25% to 30% of all waste generated in the EU-28 [EC - CDW, 2019].[1]

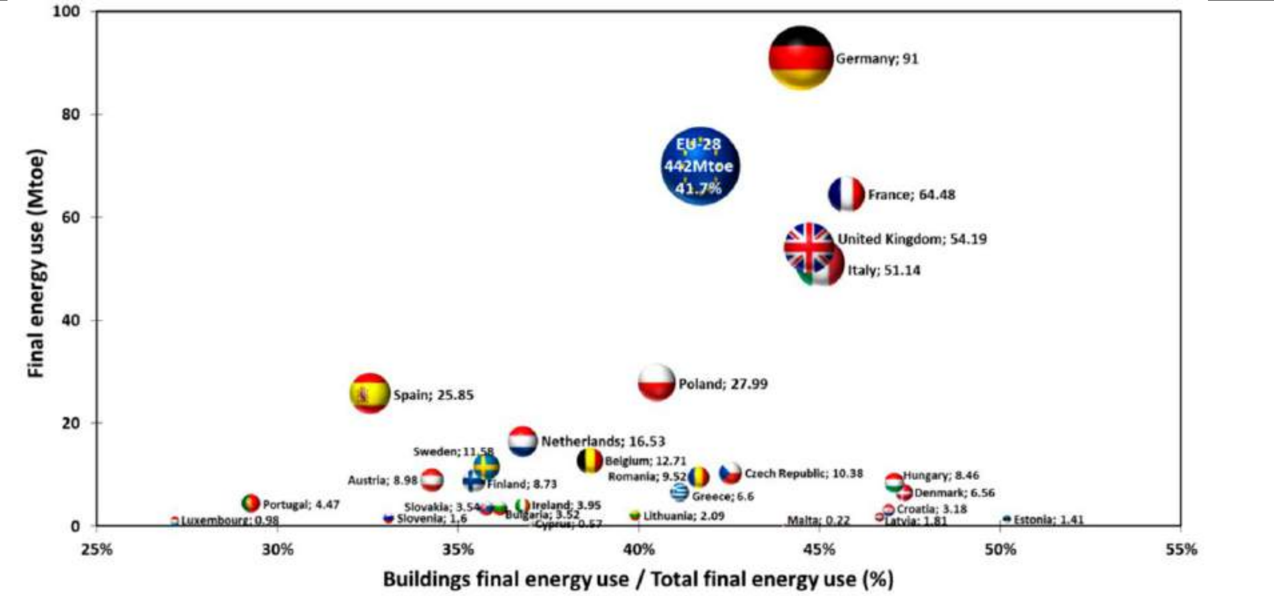


Figure 1: Final energy use (million tonnes of oil equivalent—Mtoe) in European buildings and ratio (%) of the buildings' final energy consumption to the total. The bubble size represents the total final energy use in each country; for EU-28, the value is not to scale. Data source: Eurostat (Ref. to Balaras et al 2019 & CESBA Med project – U.Malta 2019))

According to the European Commission's urban development network, the European urban areas are home to over two-thirds of the EU's population and account for about 80% of the final energy use [EC – Regional Policy, 2019]. These urban areas are the engines of the European economy, but they are also places where persistent problems, such as unemployment, segregation and poverty, are most evident. Urban development is central to the EU's Regional Policy, which addresses the environmental, economic, social and cultural dimensions. An integrated approach is necessary in order to achieve sustainable urban renewals or new developments by incorporating environmental protection, education,

[1] The background section draws also on detailed literature analysis conducted within the framework of the CESBA Med Sustainable Mediterranean Cities Research Project) (Ref. to Balaras et al 2019, Borg R.P. et al, 2019 & CESBA Med project – U.Malta 2019))

economic development, social inclusion through strong partnerships between local citizens, civil society, industry and various levels of government.

Recognizing the importance of buildings and the built environment, the EU has initiated ambitious efforts to minimize the use of energy and natural resources in buildings, with radical resource effciency and circular material flows in its Circular Economy Action Plan [EC – Circular Economy, 2019] to alleviate their environmental impacts. The 2030 EU climate and energy framework includes binding targets and policy objectives for reducing the greenhouse gas (GHG) emissions by at least 40% from 1990 levels, for increasing the share of renewables by at least 32% of final energy consumption, and for improving energy effciency by at least 32.5% [EC – 2030, Climate & Energy, 2019]. Member States are also obliged to adopt integrated National Climate and Energy Plans (NECPs) for the period 2021–2030 and develop national long-term strategies to ensure consistency with NECPs. One of the main instruments for addressing these challenges and the energy use in buildings is the Energy Performance of Buildings Directive (EPBD), recently amended by EU 2018/844 that entered into force on 9 July 2018, an integral part of the "Clean Energy for All Europeans" package [EC – Clean Energy, 2019].

2.1 EPBD

EPBD encourages energy effciency and promoting cost-effective building renovations, with the vision of a decarbonised building stock by 2050. As we move into the new era of nearly-zero-energy buildings (nZEB) as of January 2021, the next big challenge is the renovation of national building stocks. These large-scale efforts could best be served by addressing groups of buildings in urban neighbourhoods, considering synergies and energy interactions between individual buildings and the broader energy system at local level, towards the concept of zero-energy districts [Saheb, 2019]. Although the evolution towards energy and spatial planning is challenging, good practices promoting bottom-up initiatives are emerging, focusing on neighbourhood scale oriented urban projects, using decentralised energy systems, local energy communities, energy districts, etc. [De Pascale, 2019].

2.2 Sustainable Development Goals (SDGs)

The EU was also instrumental in shaping the Global 2030 Agenda and the United Nations Sustainable Development Goals (SDGs) [UN, 2019] and is a frontrunner for the long-term implementation of the SDGs that are further enhanced with EU's policies and integrated into all the Commission's priorities [COM 739, 2016]. The 17 SDGs are the blueprint to achieve a better and more sustainable future for all, addressing the global challenges we face, including those related to energy, climate and environmental degradation in buildings and cities. The 2030 Agenda integrates in a balanced manner the three pillars of sustainable development—economic, social and environmental.

At the centre stage of the work related to the built environment is SDG-11 aiming to make cities inclusive, safe, resilient and sustainable, targeting sustainable urbanization and transport systems, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, reducing adverse environmental impacts, safeguarding the cultural and natural heritage, and providing green and public spaces. In this context, the supporting goals in the areas of energy and climate include: SDG-7 to ensure access to affordable, reliable, sustainable and modern energy for all, by focusing on increased energy efficiency and the use of renewables for creating more sustainable and inclusive communities and resilience to environmental issues like climate change; SDG-13 to take urgent action to combat climate change and its impacts. Additional goals that are an integral part of sustainable development include: SDG-3 to ensure healthy lives and promote well-being for all by providing and facilitating access to health systems, reducing ambient pollution; SDG-6 to preserve clean water as a natural resource and combat chronic or recurring shortages of fresh water; SDG-8 to promote inclusive and sustainable economic growth, employment and decent work for all; SDG-9 to build resilient infrastructure, promote sustainable industrialization and foster innovation, including transportation, energy and information and communication technology; SDG-10 to reduce inequality by paying attention to the needs of disadvantaged and marginalized populations; SDG-12 to ensure sustainable consumption and production patterns, by promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life; SDG-15 to combat desertification, halt and reverse land degradation, halt biodiversity loss in relation to urban growth; SDG-16 to promote just, peaceful and inclusive societies for sustainable development in an urban context; SDG-17 to facilitate inclusive partnerships between governments, the private sector and civil society, built upon principles and values, a shared vision, and shared goals that place people at the centre, at the global, regional, national and local level.

The Urban Agenda for the EU was launched in May 2016 with the Pact of Amsterdam as a new multi-level working method promoting cooperation between Member States, cities, the European Commission and other stakeholders in order to stimulate growth, liveability and innovation in the European cities and to identify and successfully tackle social challenges [Urban Agenda, 2019]. According to the first-ever SDG index and dashboards report for European cities that was recently released, no European capital city or large metropolitan area has yet fully achieved the SDGs [Lafortune, 2019]. As illustrated in Figure 2 below (https://euro-cities.sdgindex.org) major challenges lie ahead. The SDG agenda may not be fully achieved without the involvement of cities. Addressing unsustainable patterns of consumption and production, and climate change and environmental degradation, extreme poverty, unemployment and socio-economic disparities, mandates the engagement of regional and local authorities. Overall, cities in Europe perform best on SDG-3 (Health and Well-Being), SDG-6 (Clean Water and Sanitation), SDG-8 (Decent Work and Economic Growth) and SDG-9 (Industry, Innovation and Infrastructure). By contrast, performance is lowest on SDG-12 (Responsible Consumption and Production), SDG-13 (Climate Action) and SDG-15 (Life on Land). As expected, the definition of territorial levels and metropolitan areas and standardize subnational data and indicators, revealed major gaps in available information in order to monitor all the SDGs.

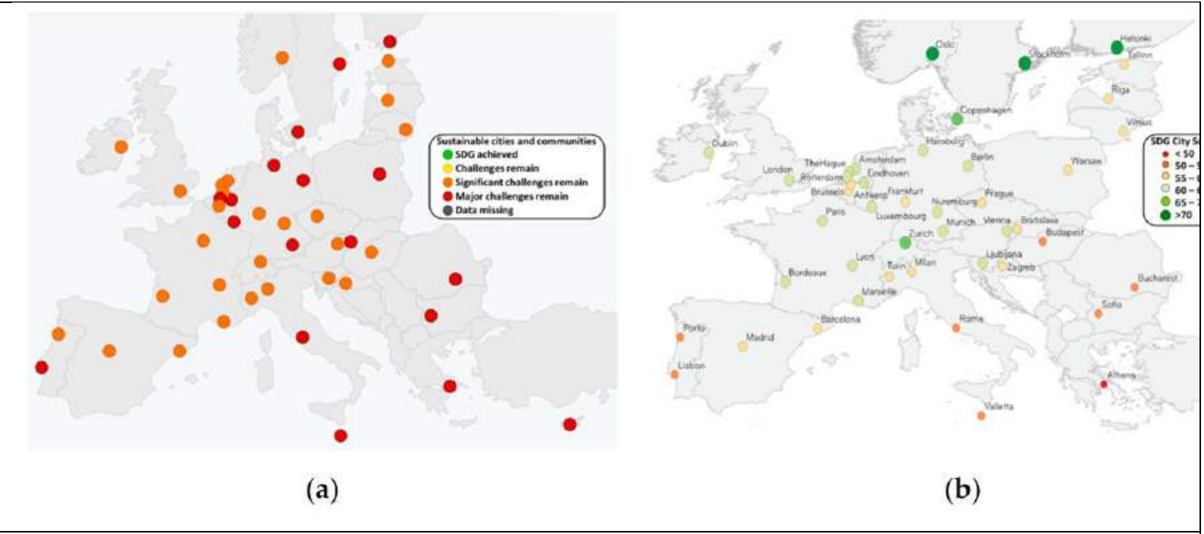


Figure 2. (**a**) European cities Sustainable Development Goals (SDGs) index for sustainable cities and communities (SDG-11); (**b**) overall SDG city scores. Source: https://euro-cities.sdgindex.org.

The various aspects of sustainable development in an urban context include energy, environment, transportation, infrastructure and services, land use, natural resources, and social wellbeing among others, as well as mandating specific actions and significant efforts. The SDGs are further enhanced through national action plans, with regional level and finally local level priorities and goals. More than ever, a local push is needed to improve sustainability efforts following a bottom-up approach of local actions that will effectively drive the processes to meet the SDGs in the spirit of the concept "Think Globally, Act Locally". However, developing, monitoring and assessing local, regional and national plans towards sustainable development at building and neighbourhood scale, considering the plethora of SDGs and sustainability issues, are complex undertakings. These efforts can be overwhelming for local and regional authorities that may not have the expertise and personnel. Accordingly, there is a need to facilitate local authorities and municipalities to act quickly and accelerate progress.

2.3 Existing Systems for Rating and Labelling

Energy and environmental audits in industry, tourism, commerce and the buildings sector have been used to collect the appropriate data that is essential for a systematic analysis in order to identify, quantify and report on the opportunities for improved performance. There are several available schemes for building energy audits that depend on the project intent and procedure (e.g., energy performance assessment, rating, certification or labelling), the specific operating conditions, the building type, among other factors [Balaras, 2018]. The use of the term "energy audit" can be subjective and can vary from country to country since they are conducted in varying degrees or levels of technical detail, accuracy and complexity based on the purpose they serve. In some cases, this is done intentionally to reflect certain attributes, levels of complexity or stand-out in the market as a tailored process to a specific scheme and thus differentiate from other competing processes. Sometimes, it may also be an unintentional result in an effort to directly link required processes to different legal acts and relevant regulations that may apply. Some examples include survey, screening, diagnosis, inspection, review, preliminary (detailed) audit or preliminary (detailed) assessment, or as it relates to financial assessments like an investment-grade audit or feasibility study.

Practically all schemes include some common stages: preliminary contacts (e.g., client interview to define project intent, collect preliminary information), intake (e.g., collect available data like drawings, energy bills or metered data, perform an on-site visit, collect field data, complete checklists, audit forms and protocols, verify estimates and default values, perform in-situ measurements), analysis (e.g., rating, benchmarking, perform calculations or simulations, define a baseline to investigate energy conservation measures and assess scenarios, determine a list of cost-effective recommendations with quantified savings), and results (e.g., meet and present results to the client, generate reports and other deliverables).

Some schemes may have distinct characteristics (e.g., use specific calculation tools that will determine the input data, or deliver distinct results like an energy performance certificate or prepare documents and specifications for tenders). Sustainability audits in an urban context are more elaborate since they involve various issues and themes that need to be addressed [Barbano, 2016].

Sustainability is also being adopted into building codes at different levels of government and with varying motivations. The approach taken reflects local societal perceptions, political priorities, national policies and economic factors [Lawrence, 2016]. The creation of standards or codes that define a level of performance for sustainable buildings has emerged as a need within the industry. However, there are different approaches due to wide variations in economic, social, political and technological conditions and priorities in different countries and jurisdictions around the world. Rating systems provide a method that one can voluntarily adopt and comply with various sustainability measures that meet a pre-defined set of requirements. Standards are also being developed as a collection of criteria for meeting the acceptable requirements at a high level of performance. They may be adopted in building codes or simply used as a level of performance that a project may comply by. For example, the ASHRAE Standard 189.1 that is recognized as a leading green standard around the world and forms the technical basis for the International Green Construction Code (IgCC), includes mandatory criteria in several sustainability issues and themes, site, construction, materials, energy, indoor environmental quality, water, etc. [ASHRAE, 2017].

2.4 Building Scale Assessment

At building scale, various voluntary sustainability rating systems and labelling schemes have been developed, e.g.,

- BREEAM (https://www.breeam.com/),

- CASBEE (http://cabee.eu/),
- Green Star (https://new.gbca.org.au/green-star/), LEED (https://new.usgbc.org/leed) and
- Protocollo ITACA (http://itaca.org/),

to facilitate the process for reducing energy use and environmental impacts during construction, management and operational phases [Mattoni, 2018]. The systems include different performance indicators that are used as metrics with fixed weighting and scoring systems to determine how well the sustainability objectives are achieved, facilitate the decision-making process, assess specific project requirements or ensure compliance with regulations and norms [Chethana, 2017; He, 2018; Sicignano, 2019]. The indicators quantify what one is trying to achieve, and depending on specific project needs and priorities one may need to use several of them at different stages of the work or process. The indicators can be expressed as numerical values (e.g., building's energy use intensity in order to assess different performances or compare against other benchmarks; water consumption per building occupant, etc.), or ratios and percentages (e.g., percent of renewables that cover power or heat demand; percent of recycled waste, etc.).

2.4.1 LEVEL(s)

A voluntary reference framework known as LEVEL(s) is also being developed for the European Commission [JRC, Level(s), 2019] providing a common European framework of common indicators to measure the sustainability performance of buildings across their whole life cycle, focusing on GHG emissions, resource efficiency, water use, health and comfort, resilience and adaptation to climate change, cost and value. Each indicator links the building's individual characteristics (currently referring to only residential and office buildings) and impacts to sustainability priorities, facilitating users to consider key concepts and building-scale indicators, following specific guidelines and standardized calculations for each indicator.

Note: The European platform Level(s) provides a common language for assessing and reporting on the sustainability performance of buildings. It is a simple entry point for applying circular economy principles in our built environment. Level(s) offers an extensively tested system for measuring and supporting improvements, from design to end of life. It can be applied to residential buildings or offices. Level(s) uses core sustainability indicators to measure carbon, materials, water, health, comfort and climate change impacts throughout a building's full life cycle. It is a flexible solution for identifying sustainability hotspots and for future-proofing your project or portfolio. By using Level(s) you are contributing to EU policy goals to strengthen the sustainability of Europe's buildings, which are responsible for:

- 1/2 of all extracted materials
- 1/2 of total energy consumption
- 1/3 of water consumption
- 1/3 of waste generation.

2.5 Urban Scale Assessment

2.5.1 The Urban Scale

Several systems have also been extended to urban scale, e.g., BREEAM Communities, CASBEE for Urban Development, LEED for Neighbourhoods and Protocollo ITACA Urban Scale. The main aspects for sustainable cities address similar performance indicators like the ones for building scale, and include more categories, for example, urban transport, supply and distribution networks, social factors, etc. [Martos, 2016].

2.5.2 CESBA Med: The Common European Sustainable Built Environment Assessment for Mediterranean Cities

A new European multicriteria assessment method has been developed that enhances existing knowhow in a holistic system for accessing urban sustainability of the built environment at neighbourhood scale. This complements the existing public approaches at building and city scales, so that it is more suitable and manageable to handle by municipalities.

This report outlines the main structure of the method and tools for addressing the sustainability issues for buildings and urban neighbourhoods, the generic framework with an emphasis on the energy and environmental indicators, the key performance indicators, the results from nine European pilots, providing details for the application in Greece, and the training system that includes educational material developed and managed by the University of Malta, for decision-makers and technical professionals.[2]

2.6 Published Sustainability Assessment Projects and Methods

2.6.1 Sustainability Assessment Methods

This report refers and reviews different assessment methods and projects which have been developed. These are outlined below. The available sets of indicators across countries and regions intended for the assessment of the sustainability of buildings and urban areas, which have been developed within the frame of the different international / trans-national projects and also the public assessment systems, are analysed. The review presents a comprehensive overview of the available indicators and methods, which is exploited to derive a generic list of indicators based on the level of relevance, operability and affordability of the available indicators, for a Mediterranean context. This approach is applied for the development of the CESBA Med Framework for the Assessment of Buildings and Urban Areas.

2.6.2 Transnational Projects:

- CABEE - Capitalizing Alpine Building Evaluation Experiences (ASP ALPINE Space Programme, European Territorial Cooperation, 2013-15) http://www.cabee.eu

[2] University of Malta – CESBA Med Project: https://cesba-med.research.um.edu.mt/

- CAT MED - Platform for Sustainable Urban Models (Interreg MED,2013-15) http://www.catmed.eu
- CEC5 - Demonstration of Energy Efficiency and utilization of renewable energy sources trough public buildings (Interreg Central Europe, 2010-12) http://wiki.cesba.eu/wiki/CEC5
- CLUE - Climatic Neutral Urban Districts in Europe (Interreg IVC, 2011-14) http://www.clue-project.eu
- ENERBUILD - Energy Efficiency and Renewable Energies in the Building sector (ASP ALPINE Space Programme, European Territorial Cooperation, 2010-12) http://www.enerbuild.eu
- EPISCOPE - Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks (IEE, 2012-14) http://www.episcope.eu
- FASUDIR - Friendly and affordable sustainable urban districts retrofitting (FP7, 2014-16) http://fasudir.eu
- IRH-MED - Innovative Residential Housing MED (Interreg MED, 2010-12) http://wiki.cesba.eu/wiki/IRH_med
- NewTREND - New integrated methodology and tools for retrofit design towards a next generation of energy efficient and sustainable buildings and districts (H2020, 2015-18) http://newtrend-project.eu
- OpenHouse - Benchmarking and mainstreaming building sustainability in the EU based on transparency and openness (open source and availability) from model to implementation (FP7, 2010-12) http://www.openhouse-fp7.eu
- SuPerBuildings - Sustainability and Performance Assessment and Benchmarking of Buildings (FP7, 2010-12) http://cic.vtt.fi/superbuildings

Public Assessment Systems (P.A.S.)

- Eco-Quartier - French Label Eco Quartier (Eco-District) http://www.eco-quartiers.fr
- Protocollo ITACA- Environmental label (Federal Association of the Italian Regions, with the scientific support of iiSBE and ITC-CNR) http://wiki.cesba.eu/wiki/Protocollo_Itaca
- QDM- Quartiers Durables Méditerranéens (Sustainable Mediterranean Neighbourhoods) http://www.envirobatbdm.eu/baroque

3 EPB: The Energy Performance of Buildings

3.1 Energy performance certificate Requirements.

The following is an overview of the energy performance certificate requirements:

1. Member States shall lay down the necessary measures to establish a system of certification of the energy performance of buildings. The energy performance certificate shall include the energy performance of a building and reference values such as minimum energy performance requirements in order to make it possible for owners or tenants of the building or building unit to compare and assess its energy performance.

The energy performance certificate may include additional information such as the annual energy consumption for non-residential buildings and the percentage of energy from renewable sources in the total energy consumption.

2. The energy performance certificate shall include recommendations for the cost-optimal or cost-effective improvement of the energy performance of a building or building unit, unless there is no reasonable potential for such improvement compared to the energy performance requirements in force. The recommendations included in the energy performance certificate shall cover:

(a) measures carried out in connection with a major renovation of the building envelope or technical building system(s); and

(b) measures for individual building elements independent of a major renovation of the building envelope or technical building system(s).

3. The recommendations included in the energy performance certificate shall be technically feasible for the specific building and may provide an estimate for the range of payback periods or cost-benefits over its economic lifecycle.

4. The energy performance certificate shall provide an indication as to where the owner or tenant can receive more detailed information, including as regards the cost-effectiveness of the recommendations made in the energy performance certificate. The evaluation of cost effectiveness shall be based on a set of standard conditions, such as the assessment of energy savings and underlying energy prices and a preliminary cost forecast. In addition, it shall contain information on the steps to be taken to implement the recommendations. Other information on related topics, such as energy audits or incentives of a financial or other nature and financing possibilities may also be provided to the owner or tenant.

5. Subject to national rules, Member States shall encourage public authorities to take into account the leading role which they should play in the field of energy performance of buildings, inter alia, by implementing the recommendations included in the energy performance certificate issued for buildings owned by them within its validity period.

6. Certification for building units may be based:

(a) on a common certification of the whole building; or

(b) on the assessment of another representative building unit with the same energy-relevant characteristics in the same building.

7. Certification for single-family houses may be based on the assessment of another representative building of similar design and size with a similar actual energy performance quality if such correspondence can be guaranteed by the expert issuing the energy performance certificate.

8. The validity of the energy performance certificate shall not exceed 10 years.

9. The Commission shall, by 2011, in consultation with the relevant sectors, adopt a voluntary common European Union certification scheme for the energy performance of non-residential buildings. That measure shall be adopted in accordance with the advisory procedure referred to in Article 26(2). Member States are encouraged to recognise or use the scheme, or use part thereof by adapting it to national circumstances."

3.2 EPBD: The application of EPC in Europe.

The following is a summary / review of the current situation in Europe in relation to the use of EPCs. "The European Union has established clear legislative frameworks to reduce energy demand from buildings. The directives on the Energy Performance of Buildings (EPBD, 2018/844/EU) and on Energy Efficiency (EED, 2018/2002/EU) are being implemented by the EU Member States to this end. Under the EPBD, EU member States have established energy performance certification systems with independent mechanisms for implementing and controlling national pathways towards improving the energy efficiency of buildings.

In this context, Energy Performance Certificates (EPCs) are an instrument that contributes to the improvement of the overall buildings' performance in a transparent and comparable way across Europe. EPCs were first introduced under the EPBD in 2002, and in 2010 the recast EPBD added a set of new requirements to improve the quality, usability and public acceptance of EPCs. Not to be confused with Energy Performance Contracting (which is also commonly abbreviated as EPC), the purpose of an Energy Performance Certificate is to provide information on a building's energy performance rating and to make recommendations about cost-effective improvements. Energy certification can also be a means for informing consumers and can influence the building's property value. The report by the European Commission's Joint Research Centre supports 'de-risking' activities by evaluating existing literature about the impact of energy efficiency improvements on the value of property through the impact on operational costs. The contribution of EPCs to so-called green premiums and brown discounts are also analysed. EPCs may also include information on non-energy parameters, such as comfort. A 2018 report by BPIE puts a spotlight on Indoor Environmental Quality (IEQ) parameters. It presents national cases and initiatives and provides recommendations on how to integrate IEQ in national and EU policies.

The European Commission supports Concerted Actions that assist Member States to implement EU sustainable energy legislation effectively. The EPBD Concerted Action facilitates the sharing of experiences between national authorities responsible for implementing the EPBD. One of its Core Teams focuses on EPCs, including issues of compliance, use of databases, and training of inspectors. These topics are developed around the idea of feeding into three major pillars linked to EPCs:

1. Quality (inputs, outputs, data, methodologies, experts),

2. Visibility (awareness, communication, image, perception of EPCs, range, how EPCs call to action, advertising),

3. Usability (information, how triggers lead to action, choices made, interoperability).

The EPBD Concerted Action published a report on the status of certification, control systems and quality across the EU's Member States plus Norway, in 2018. The report discusses the procedural steps to carry out certification and inspections in buildings, as well as measures the countries are taking to ensure the public's acceptance and awareness of EPCs. Some countries have designed their EPCs to take account the possibility of carrying out step-by-step renovations to improve energy performance in stages over time. The Concerted Action also publishes factsheets, including one on Member States' experiences in changing EPC scales and layouts, and another on the EPCs impact on property value."

3.3 The EPB standards

The European Commission has established a set of standards and accompanying technical reports to support the energy performance of buildings directive (EPBD). These standards are called the energy performance of buildings standards or "*set of EPB standards*" [1][2].

A revised version of the EPBD was published in 2018 (Directive (EU) 2018/844) [3] and this revised version defined a stronger role to the EPB standards as follows (Annex 1, point 1):

"Member States shall describe their national calculation methodology following the national annexes of the overarching standards, namely ISO 52000-1, 52003-1, 52010-1, 52016-1, and 52018-1, developed under mandate M/480 given to the European Committee for Standardisation (CEN). This provision shall not constitute a legal codification of those standards."

The modular, transparent, unambiguous, but flexible set of EPB standards is a critical instrument in the proper implementation of the EPBD and to support the EU green deal by:

- Defining Nearly Zero Energy Buildings (NZEB) in a consistent, methodological, and transparent manner.
- Enhancing and reinforcing energy performance certification and consistency

- Enhancing transparency/consistency of the EP assessment procedures whilst allowing flexibility.
- Supporting the decarbonization of the building stock by 2050 considering the local climate, the national legal framework, the building tradition, the building use, and the energy infrastructure and critically maintaining or improving health, comfort, and Indoor Air Quality standard (refer to EN 16798-1[4]).
- Establishing and defining overall and partial energy performance indicators in ISO 52000-1[5] and ISO 52018-1[6]. These indicators aim to promote optimal comfort, indoor air quality (IAQ), energy efficiency first principle, use of renewable energy and systematically treat on-site/off-site renewables whilst supporting self-consumption which is important for grid stability and energy security. To enable this, a multi-indicator
- Promote transparency/consistency on the use of primary energy factors (PEF) and CO_2 emission factors (refer to standard EN 17423[7]).

While more than 50 standards comprise the full list of EPB standards, only a small number of standards, specifically 5 standards, termed "*overcharging standards*" are defined in the 2018 EPBD and these standards cover the core assessment of the energy performance of buildings, while the other standards cover specific applications.

These five 'overarching' EPB standards have in common that each of them describes an important step in the assessment of the energy performance of building. The five so called 'overarching' standards referred to in the 2018 EPBD are the following:

1. EN ISO 52000-1[5]: Energy performance of buildings — Overarching EPB assessment Part 1: General framework and procedures

2. EN ISO 52003-1 [8]: Energy performance of buildings — Indicators, requirements, ratings, and certificates — Part 1: General aspects and application to the overall energy performance

3. EN ISO 52010-1[9]: Energy performance of buildings — External climatic conditions — Part 1: Conversion of climatic data for energy calculations

4. EN ISO 52016-1 [10]: Energy performance of buildings — Energy needs for heating and cooling, internal temperatures, and sensible and latent heat loads — Part 1: Calculation procedures

5. EN ISO 52018-1[11]: Energy performance of buildings — Indicators for partial EPB requirements related to thermal energy balance and fabric features — Part 1: Overview of options

Most relevant info re metrics and indicators from the overarching EPB standards.

The multi-indicator assessment approach (ISO 52000-1)

It is recommended that buildings are assessed using the multi-indicator assessment approach provided in Annex H of the standard. A detailed explanation and example of how this concept can be applied is given in Gatt et al. [12]

For the building to have a qualified NZEB status, each of the NZEB "*requirements*" are to be met. The following are the requirements stipulated in the ISO standard:

(1) First requirement: "*The building Fabric* (*Energy needs*)" accounting for the building envelope quality in terms of both insulation and thermal inertia, bioclimatic design, building zoning and the need to guarantee adequate environmental indoor conditions.

(2) Second requirement: "*The total primary energy use*" reflecting the performance of the technical building systems including active space heat and cooling systems, DHW and artificial lighting. This is expressed as primary energy excluding any renewable energy contributions.

(3) Third requirement: "*Non-renewable primary energy use without compensation between energy carriers*" directly reflects the use of non-primary energy given that both the energy exported to the grid and the compensation between different energy carriers (example between gas and on-site PV production) are not accounted.

(4) Final NZEB rating: "*Numerical indicator of non-renewable primary energy use with compensation*" accounts for both the compensation between energy carriers and the effect of exported energy.

The standards ISO 52003-1 and ISO 52018 recommend a list of partial indicators to be defined.[3]

3.4 EPBD: European Research Projects

3.4.1 The ALDREN Project

The core of the ALDREN project is to answer EPBD- Article 11 [3] EPBD — Article 11(9): "The Commission shall (...) adopt a voluntary common European Union certification scheme for the energy performance of non-residential buildings."

[3] Reference: https://u-certproject.eu/media/filer_public/26/cf/26cf5f47-787d-42de-b01c-3790a504c70a/ucert-d32_v11.pdf

To develop this voluntary common European Union certification scheme, ALDREN applies a methodological framework to propose and develop an ALDREN European common certificate (ALDREN EVC) that supports decision-making and investment in deep energy renovation of non-residential buildings. It is voluntary and provides consistent sustainability metrics to improve certification of energy and IEQ performance. ALDREN could be used as a whole, but also in a modular approach by each stakeholder of the renovation implementation chain. It is built to ensure consistent information sharing between stakeholders depending on their needs.

ALDREN's framework is holistic, harmonized, and modular: it is based on a set of procedures (modules) that consist in implementing step-by-step operational protocols to assess the energy performance, Indoor Environmental Quality (IEQ, related to health & well-being) and financial value of buildings before and after energy renovation.

ALDREN protocols rely on simulations and measurements based on best practice and the consistent use of CEN and ISO standards to ensure transparency and quality. ALDREN is also the first integrated common framework for deep renovation that is based on these standards.

ALDREN is a methodological framework that implements the EVCS, with 4 standalone modules and 2 reporting tools.

The 4 stand-alone modules are the following:

1. Energy Rating and target
2. Energy Verification
3. Comfort and well-being
4. Cost Value Risk

The aim of each four modules are summarized below.

1. ALDREN energy rating and targets: A consistent, harmonized, unique European energy performance rating, based on ISO/CEN standards, offering comparability and transparency across the EU to provide a common metrics and highlight the quality for financial instruments connected with renovation. A rating scale with classes from A-G has been defined to compare and identify in priority the buildings fitting best for deep renovation and to evaluate the impact of renovation actions on energy performance.

2. Energy Verification: An energy performance verification framework allowing actual (measured) performance to be compared with simulated (predicted) performance. It encompasses a "Design for Performance" protocol that sets out and tracks the actions required during the deep renovation process. It also includes a "*Performance*

Verification Tool" (PVT) to compare predicted and actual performance at different levels of granularity.

3. A health and well-being assessment protocol: It is based on an index called ALDREN-TAIL to rate the Indoor Environment Quality (IEQ) of buildings undergoing deep renovation, focusing on 4 key components:
   - Thermal environment (T),
   - Acoustic environment (A),
   - Indoor air quality (I),
   - Luminous environment (L).

   TAIL ratings can and should be evaluated before and after renovation.

4. Cost, Value, and Risk: A protocol to evaluate impacts of energy and non-energy benefits associated with deep renovation on the financial value and risks of office and hotel buildings. The information and sustainability metrics provided by the 3 previous modules and the Renovation Roadmap of the ALDREN BRP is shared with financial valuation experts who compare the financial impacts – costs, risks, and value – associated with different renovation scenarios.

3.4.2 The U-Cert Project

Building performance indicators based on measured data for holistic EPCs are provided through the U-Cert project.[4] U-Cert Projects supporting details[5]

[4] Reference U-Cert Project: (https://www.rehva.eu/fileadmin/user_upload/U-CERT_D2.4.pdf)
[5] Reference: https://www.e3sconferences.org/articles/e3sconf/abs/2021/22/e3sconf_hvac2021_13003/e3sconf_hvac2021_13003.html

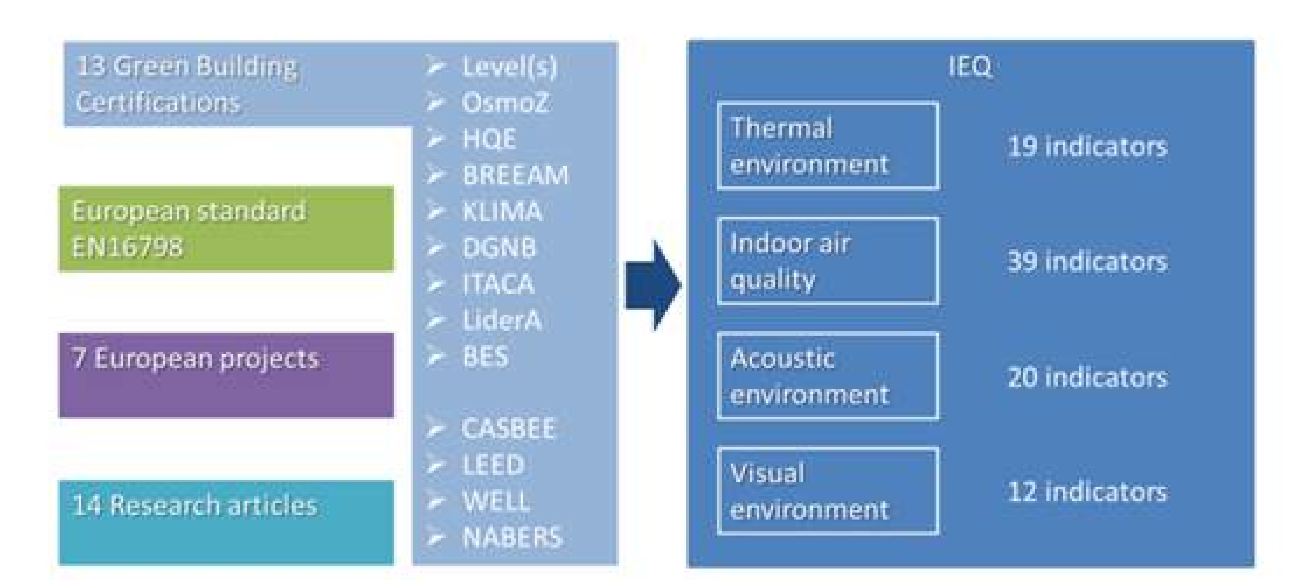


Figure 3: U-Cert project structure

3.4.3 The X-Tendo project

The X-Tendo project is developing a framework of ten "*next-generation EPC features*", aiming to improve compliance, usability and reliability of the EPC. The features explored in the project fall into two broad categories:

Category 1: New technical features used within EPC assessment processes and enabling the inclusion of new indicators on EPCs:

- FEATURE 1: SMART READINESS INDICATOR
- FEATURE 2: COMFORT INDICATOR
- FEATURE 3: OUTDOOR AIR POLLUTION INDICATOR
- FEATURE 4: REAL ENERGY CONSUMPTION DATA
- FEATURE 5: DISTRICT ENERGY SYSTEMS

Category 2: Innovative approaches to handle EPC data and maximise their value for building owners and other end-users:

- FEATURE 6: EPC DATABASES
- FEATURE 7: BUILDING LOGBOOKS
- FEATURE 8: TAILORED RECOMMENDATIONS
- FEATURE 9: FINANCING OPTIONS
- FEATURE 10: ONE-STOP-SHOPS FOR DEEP ENERGY RETROFITS

A full list of indicators for X-Tendo is available for the X-Tendo Project.[6]

[6] Reference: X-Tendo: https://www.bpie.eu/wp-content/uploads/2020/08/D3.1-Exploring-innovative-indicators-for-the-next-generation-EPC-features.pdf

Figure 4: The X-Tendo project

4 SUSTAINABILITY ASSESSMENT TOOLS

4.1 A Contextualised Building Assessment Tool and its Critical Assessment: HEART[7]

A contextualised Building assessment tool was developed at a first level for application in Malta based on a methodological framework intended to focus on a local Maltese context.

4.1.1 Methodology

In accordance with the European resource efficiency and sustainable development aims there is a need to develop a framework based on a set of basic indicators going along with a recommended assessment method and a European marking model for the local context. It has to have a ground breaking approach covering all features along the building life cycle from planning and design, to construction and commissioning and to operations and maintenance. For the aims and principles a local assessment to be developed the following had to be kept in mind:

1. *The User* - First and foremost it had to focus on the user first. The commitment becomes to design, construct, operate and maintain buildings to meet the users' practical and well-being needs.
2. *Sustainability* - the assessment had to cover all sustainability aspects that is environmental, economic and social dimensions.
3. *Local Contextualization* - Building assessment systems had to embrace the local exclusive priorities, behaviours, traditions, and construction practices. This implied embracing local standards and regulations suitable to the local climate and accounting for the available natural resources and cultural design features. Each criterion had to be assigned a relative weight and a reference target adequate to the local conditions. The Rating Results value shrinks when systems are used outside their original contexts.
4. *Comparability* – The performance results had to be comparable thanks to a points/target system.
5. *Simple to use* - The system had to find the adequate balance between the straightforwardness to use and the scientific/technical value. It had to be correct, clear and observable. A system requiring complex computations or inaccessible data would request too much time and effort to be widely used.
6. *Stakeholders* - the system had to be adopted and used by different building sector stakeholders for different purposes namely

[7] Sant, R., & Borg, R. P. (2016). A review of green building rating tools and their application in Malta. CESB 2016, Central Europe towards sustainable building ; innovations for sustainable future, Prague. 1460-1467.

- As a design tool by establishing design priorities and objectives
- As a guidance in developing appropriate design strategies
- As a benchmark for the sustainable design guidance and decision making processes
- As a project management tool to organise and structure environmental matters during the building development delivery.

Further it can be used by construction related SME's and workers, contractors and Building Developers for the formulation of business strategies. The tool can be an aid to students, at Universities and research Institutions, sustainable building experts and Energy Institutes and Energy Providers. Finally it can be used for policy formation by Public administration at National level dealing with incentives systems and technical aspects of sustainable buildings. This research will contribute to a better grasp of the GBRT concept and its role for achieving sustainable building development. In addition the objectives are:

1. To achieve sustainable development through the development of an effective green building rating tool for buildings in the Maltese Islands in dimensions terms used by existing global assessment tools but weighted according to the local context.
2. To provide a comparison of the various existing rating tools used over the world such as LEED, CASBEE, BREEAM, Green Star, PBRS, DNGB, SBtool and others.
3. Define the most appropriate tool based on the terms and criteria most applicable to the local context to be used throughout the whole development cycle.

Stakeholders: Key Questions Asked

1. Is the local profession familiar with the GBRT assessments? Are GBRT ratings applicable to the Maltese Islands? Do such systems apply to the whole development process? Should they be made voluntary or mandatory assessments?

2. What type of assessment should be developed? What measurements should be made? What criteria are the most applicable to the local context? What weight should these be given?

3. Are ratings a prerequisite to achieving national targets/market goals? Are such targets aligned to goals within the local market? Can our market meet and exceed such targets? What policies are needed to back up the GBRT implementation in the local market? What are the challenges, benefits and barriers to driving future GB growth on the Island?

4.1.2 Research Design

The aim of the research was to identify and weight the most important criteria considered for the development of a GBRT system for Malta to be used by local building Professionals. It adopted a multidimensional design strategy that involved a variety of approaches both qualitative and quantitative. The research was divided into five different stages to deliver the aim as follows

1. *Literature Review* - A critical literature review to completely understand different existing global Green Building Rating tools and assessment methods.

2. *Comparison of Assessment Tools* – Sixteen global tools were also briefly compared for their economic and process aspects (Figure 5).

   The tools analysed are the following: BREEAM (UK), SBtool (Canada), LBC (USA), LEED (USA) GREEN GLOBES (USA), BEAM (Hong Kong), GREEN STAR SA (South Africa), CASBEE (Japan), HQE (France), GREEN STAR (Australia), GRIHA (India), GREEN MARK SCHEME (Singapore), 3 STAR (China),VERDE (Spain), ESTIDAMA PBRS (UAE) and DNGB (Germany) were chosen and are listed in Table 3.3. These were also compared to the EU Framework for sustainability Assessment of Buildings namely EN 15643 parts 1 to 4. The comprehensive list was short listed to five main tools – one from each continent namely BREEAM (UK-Europe), LEED (United States of America), CASBEE (Japan- Asia), GREEN STAR (Australia) and ESTIDAMA PBRS (UAE). DNGB (Germany) and CESBA SBtool (Austria)

3. *Case Study* - Smart City Phase 1B LEED Silver Certified Case Study Results were used to show how certification was achieved.

4. *Data Collection* - Twenty In-depth Interviews with ‘Experts’ and a Web survey were conducted among local building professionals architects, civil engineers and building services engineers to establish the importance of the selected Main Criteria and their respective final weighting. One hundred and eighteen professionals participated in the Web Survey.

5. *Data Analysis* – The lack of experts on the Island made analysis by the AHP method (pairwise comparison) impossible. SPSS package was used to analyse the collected data. The *SAW* and *COPRAS* methods were used for the comparative multi criteria data analysis to weight and develop HEEART – the High Environment Efficient Assessment Rating Tool for the Maltese Islands.

Table 3.3 Multi Criteria Comparison		GREEN BUILDING RATING SYSTEMS															
		BREEAM	SBTOOL	LIVING BUILDING CHALLENGE	LEED	GREEN GLOBES	BEAM	GREENSTAR	GREEN STAR SA	CASBEE	HQE	GRIHA	GREEN MARK SCHEME	3 STAR	VERDE	PBRS	DNGB
Country		UK EU	CANADA	USA	USA	USA CANADA	HONG KONG	AUSTRALIA	SOUTH AFRICA	JAPAN	FRANCE	INDIA	SINGAPORE	CHINA	SPAIN	ESTIDAMA ABU DHABI	GERMANY
Developed in		1990	1996	1996	1998	1999	2002	2003	2003	2004	2004	2005	2005	2006	2006	2010	2009
Multi Criteria Based		Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi	Multi
	INTEGRATED DEVELOPMENT PROCESS																
PROCESS	MANAGEMENT	X (10)						X (14)									
	Service Quality		X (20-10-2)														
	Integrated Development Process				X (1)											X(13)	X (10)
	Project Management					X (120)			X (9)					X 0.10			
	Innovation in Design	X (10)			X (6)		X	X (10)	X		X	X (4)	X (7)			X	
	Operations Management													X 0.10			
	Process Quality																
	ENERGY																
ENVIRONMENTAL	Energy Efficiency and Atmosphere			X	X (33)	X (395)	X (35)		X (25)	X	X	X (35)	X (116)	X	X	X (44)	
	Energy and Resource Consumption	X(15)	X (10-8-4)					X (22)						(0.35/0.25)			
	WATER																
	Water Efficiency	X (7)	X	X	X (11)	X (110)	X (12)	X (12)	X (14)		X	X (17)	X (17)	X (0.10/0.15)	X	X (43)	
	POLLUTION																
	POLLUTION	X (10)						X (5)									X (22.5)
	EMISSIONS		X			X (50)			X (8)		X				X		
	WASTE	X (8.5)									X	X(13)					
	MATERIALS & RESOURCES																
	MATERIALS	X (13.5)	X	X	X (13)	X (125)	X (8)	X(14)	X (13)	X		X (12)	X(8)	X (0.2/0.15)	X	X (28)	
	Equity			X													
	Beauty			X													
	Technical Quality																
	INDOOR ENVIRONMENTAL QUALITY																
SOCIAL	HEALTH & WELL BEING	X (15)		X													
	IEQ		X (18-10-2)		X(16)	X (150)	X (20)	X(17)	X (15)	X	X	X(4)	X (8)	X (0.2/0.15)	X	X (23)	X (22.5)
	Health & Safety					X											
	Awareness & education				X												
	Sociocultural and Functional Quality																
	ECONOMIC QUALITY CRITERION																
ECONOMIC QUALITY	Cost Benefit Analysis																
	Life cycle costs										X						
	Operational Costs																X(22.5)
	Cost & Economic Aspects		X (4-3-1)														
	End of Life Costs																
	Economic Performance																
	Economic Quality																
	SITE CRITERION																
SITE	LAND USE AND ECOLOGY	X (10)						X(6)									
	Sustainable sites		X (22-12_2)	X	X (10)	X (120)	X (25)					X (22)					
	Local environment									X							
	Land use & Ecology		X						X (7)				X		X		
	Environmental protection															X (12)	X (extra)
	Land efficiency		X											X (0.15/0.10)			
	TRANSPORT	X (10)	X					X (10)	X (9)				X(4)				
	Locations and linkages				X(16)												
	Outdoor environment													X		X (13)	
Version		NC 2014	Sbtool 2012	NA	NC v.4 BD + C	NC 2015	Beam + V 1.2	D & B v1.1	Office V1.1	NA	NA	2008	NRB/4.1	2010	NA	2010	NO 2014

Figure 5: Sustainability Assessment Tools - Comparison

4.1.3 Results

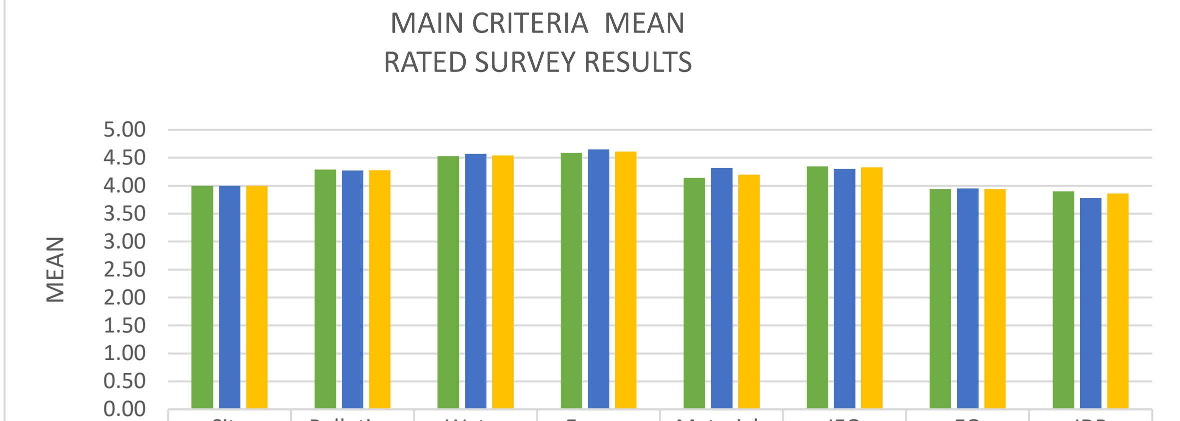
The Criteria Weighting system is a fundamental stage for the development of Green Building assessment tools (Ali & Nsairat 2009). SAW and COPRAS Method Table 3.1 were used to compute the multi criteria weighting on the Rank Order Results. Criteria data was collected on a Likert scale 1 (highly unimportant) to 5 (highly important) (maximising) Figure 6 - and a Rank order scale from 1(highest) to 8(lowest Ranking) (minimizing) Figure 7.

Hypothesis

H_0 *There is no difference in the mean rating scores, for the criteria are comparable and all criteria are of equal importance.*

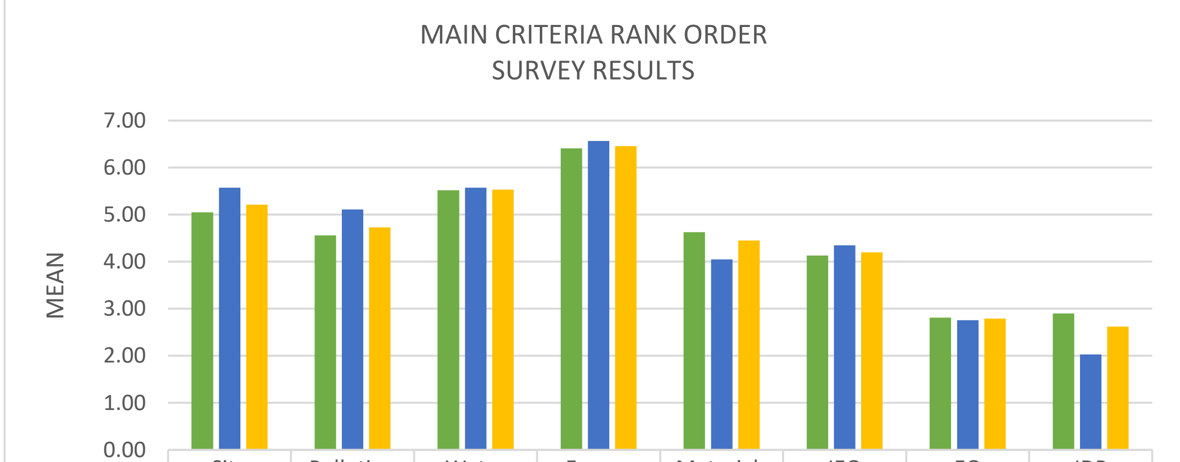
H_1 *there is a significant difference in the mean rating scores, for the criteria are not comparable and some criteria are of higher importance than others.*

Both rated and ranked data Friedman test result exhibit a *p*value less than the 0.05 criterion thus hypothesis H_1 is accepted. Therefore it can be generalised that the criteria are not comparable and some criteria are of higher importance than others.



	Site	Pollution	Water	Energy	Materials	IEQ	EQ	IDP
A. & C.E.	4.00	4.29	4.53	4.59	4.14	4.35	3.94	3.90
M. & E.	4.00	4.27	4.57	4.65	4.32	4.30	3.95	3.78
Total	4.00	4.28	4.54	4.61	4.20	4.33	3.94	3.86

Figure 6: Main criteria mean rated survey results



	Site	Pollution	Water	Energy	Materials	IEQ	EQ	IDP
A. & C.E.	5.05	4.56	5.52	6.41	4.63	4.13	2.81	2.90
M. & E.	5.57	5.11	5.57	6.57	4.05	4.35	2.76	2.03
Total	5.21	4.73	5.53	6.46	4.45	4.20	2.79	2.62

Figure 7: Main criteria rank order survey results

4.1.4 Weighting Criteria and the HEEART Model Development

The Rank order means scores were used to investigate the comparative importance among the criteria. Weighting factors were computed using the SAW and COPRAS methods. Both methods are based on the Criterion main score result expressed as a proportion of the Total Mean Rank Scores using the highlighted formulas in Table 1.

Table 1: SAW and COPRAS Methods Formulas

mSAW METHOD	COPRAS METHOD
$$Sj\% = \frac{\text{Sj}}{\sum_{j=1}^{n}(\text{Sj})}$$	$Z_j = Z_{+j} + Z_{-j}$ and $Z_{+j} = S_{+j}$ $$Zj = S\text{+j} + \frac{\sum_{j=1}^{n}(S\text{-j})}{S\text{-j}\sum_{j=1}^{n}\frac{1}{(S\text{-j})}}$$
Simple Additive Weighting is the oldest most widely known and practically used method. Suitable for maximising criteria. All minimising criteria needs transformation before analysis can take place.	Complex Proportional Assessment used for multicriteria evaluation of both maximizing and minimizing criteria values Zavadskas, Kaklauskas 1996

Table 2: Main Criteria Weighting Results for the Maltese Assessment System.

MAIN CRITERIA	S+j	S-j	Zj	SAW Sj		COPRAS Zj		HEEART	
				WF	%	**WF**	%	WF	%
Site	5.216	3.780	10.160	**0.1449**	14.49	**0.1412**	14.12	**0.1411**	**14.0**
Pollution	4.733	4.270	9.109	**0.1315**	13.15	**0.1265**	12.65	**0.1265**	**12.5**
Water	5.535	3.470	10.920	**0.1537**	15.37	**0.1516**	15.16	**0.1517**	**15.5**
Energy	6.457	2.540	13.815	**0.1794**	17.94	**0.1919**	19.19	**0.1919**	**19.0**
Materials	4.448	4.550	8.556	**0.1236**	12.36	**0.1188**	11.88	**0.1188**	**12.0**
IEQ	4.198	4.802	8.090	**0.1166**	11.66	**0.1124**	11.24	**0.1124**	**11.5**
ECQ	2.793	6.210	5.803	**0.0776**	7.76	**0.0805**	8.05	**0.0806**	**8.0**
IDP	2.621	6.380	5.550	**0.0728**	7.28	**0.0771**	7.71	**0.0771**	**7.5**
	36.000	36.002	72.002						100

An Assessment Score of 100 points was used to compute the Credit point scores for the relevant criteria using the resulting weight factors. Weighting Factors were calculated on the RO means results as these defined the criteria importance much better than the rated mean scores. Further response errors for this question were remote as the rank once defined for a criteria could not be chosen for another. Finally computed results were closer to the results found in the existing GBRT models. The HEEART assessment model is made up of 8 main criteria with fixed number of points according to the weighting factor computed in the analysis. Maximum points achievable are 100.

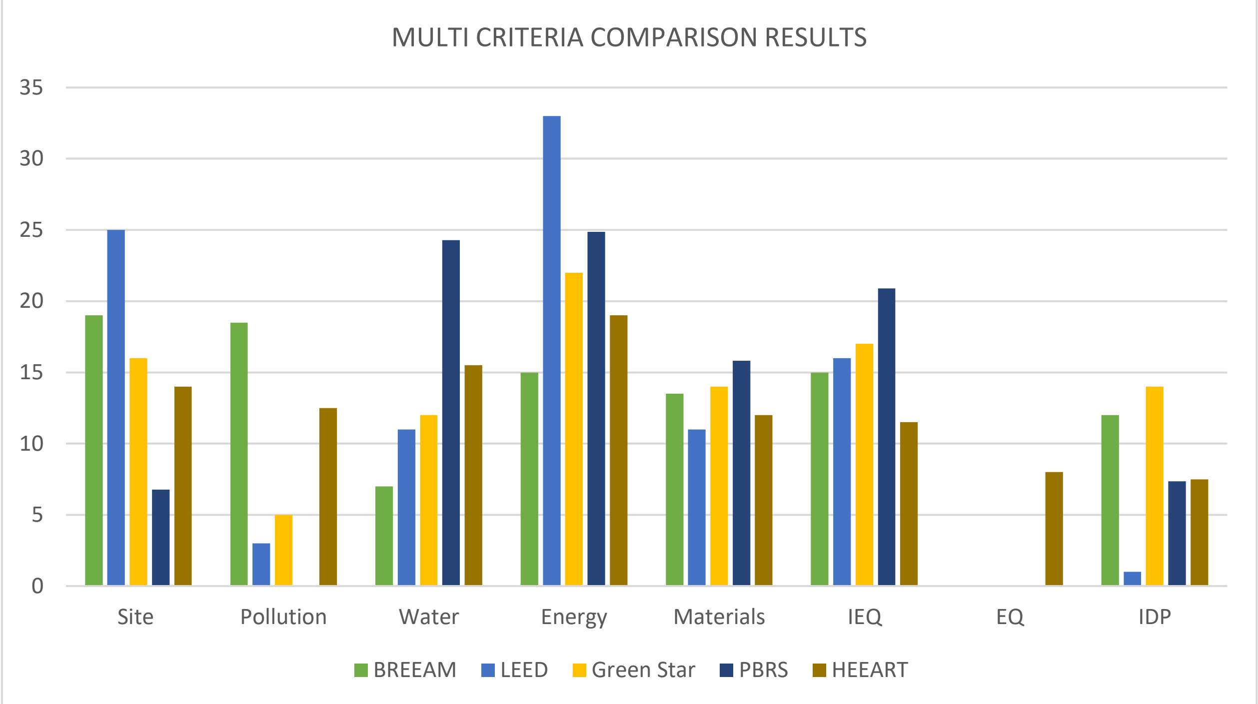


Figure 8: shows results obtained for the Maltese GBRT system in comparison with the main GBRT systems.

4.1.5 Conclusions

The Maltese HEEART System is classified as a multi criteria-based tool that defines a system of assessing point values to a selected number of criteria/indicators. The scope of this system mainly targets the non-residential projects and their surrounding environment. This system as proposed commences with a precertification assessment and develops into a three-stage assessment that is

- At the Design Stage
- At the Construction and Commissioning Stage (Completion/Handing over Stage)
- At the Operation stage (one to two years of operation)

The end of life has to be catered for at the design stage by including an End of life Plan for the building's maintenance, dismantling, demolition and disposal. The system Figure 9 defined the ENVIRONMENTAL, ECONOMICAL and the SOCIAL aspects as well as gave importance to the SITE and the INTEGRATED DEVELOPMENT PROCESS. The Assessment is presented in three Hierarchy Levels:

Category Level: - Environmental, Social, Economic, Site and Integrated development Process

Criteria Level: - Energy, Water, Pollution, Materials, Economic Quality, Indoor Environment Quality, Site and Integrated Development Process are the eight criteria proposed for the local system. These were the main scope of this study. The relevant criteria for the Maltese Assessment System were identified and their respective weights developed. This mainly depended on the Criteria's importance ranking.

Indicators Level: - Although discussed briefly and their analysis was based on interview results, no conclusions can be made on the indicators as this was not within the scope of this study. However further studies are needed to conclude the relevant number and their relative weights to be included in the local system. Further investigation is needed to decide which prerequisite items have to be included in the system.

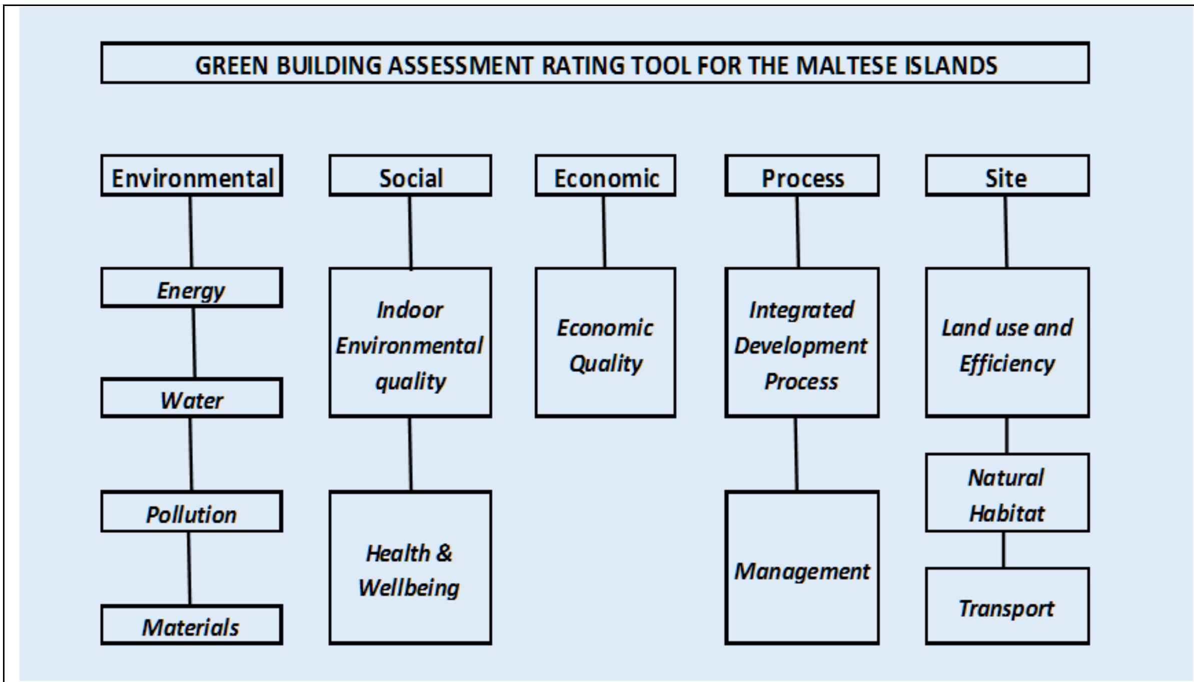


Figure 9: The GBRT for the Maltese Islands

A Green Building Assessment Tool is important for Malta. It is a prerequisite for the Islands to meet the 2020 targets and beyond - that is for the Maltese present and future generations to 'live well within the limits of our Islands' - 2050 Vision. The time has arrived for the Maltese Building Industry to adopt such GBRT systems. New Large Developments have to be subject to mandatory rigorous assessment evaluations not only to minimise impacts on the surrounding environments but to deliver the best value for all stakeholders involved.

This approach can produce significant benefits which are not likely to result from standard practice. It is a holistic approach incorporating all sustainability development aspects and not just concentrating on minimizing the environmental impacts. By taking decisions at the concept and design stage to meet the sustainability objectives and targets, most negative outcomes can be prevented. By integrating Criteria from different assessment methodological frameworks, this research built on the strengths of each and provided a more holistic assessment approach with careful adaptation to the local context. The outcome is a GBRT system for Malta based on scientific research and technical knowledge, shared multi stakeholders' knowledge and experiences in a mutual process. In addition the assessment framework suits Malta's local context; its culture, issues, resources, priorities, practices and institutions. By experiencing the use of the LEED and BREEAM assessment certifications in Malta, some irrelevant criteria and indicators were suggested, others were prioritised for their importance in the local context. In fact the Transport criteria was amalgamated within the SITE Criteria whilst the Waste was included under the POLLUTION Criteria. Category levels are similar to those adopted in Europe such as the DNGB and CESBA, however the analysis has resulted in differences in the weighting of each category. Energy has dominated the Performance assessment. Water has been ranked as the second highest important Criterion for the local assessment. The latter result justifies this natural resource scarcity on the Island. Being the EU's member state with the highest built up area, the Site has been ranked as the third important Criterion for the Maltese GBRT assessment. This was followed by the Pollution, Materials and Indoor Environmental Quality. These results are rational for Malta when considering the lack of natural resources, the land and water scarcity and the high level of air pollution (PM_{10} levels) present.

The new tool, adapted to the local Maltese context, is intended to support industry stakeholders and professionals in the delivery of Green Buildings in Malta.

4.2 A Review of Existing Sustainability Assessment methods & Indicators for Buildings and Urban Areas

4.2.1 General

The aim of this section is to identify the method and the set of KPIs that are more suitable in energy and sustainability plans for public buildings, in order to increase their impact and effectiveness. This section of the report draws on existing methods and their analysis and review with respect to the definition of trans-national indicators and assessment methods for buildings and urban areas (CESBA MED - Sustainable Med Cities)[8]

The review is based on available sets of indicators across countrimes and regions, intended for the assessment of the sustainability of buildings and urban areas, which have been developed within the frame of different international / trans-national projects and also public assessment systems. The review presents a comprehensive overview of the available indicators and methods which is exploited to derive a generic list of indicators based on the level of relevance, operability and affordability of the available indicators, for a Mediterranean context.

- A: available performance indicators under main issues and categories.
- B: presents a detailed overview of the existing performance indicators that have been developed within different European projects and public assessment systems for the sustainability assessment of buildings and urban areas.
- C: outlines the results from the classification of the existing performance indicators to then define two sets of indicators at [1] building and [2] urban scale, as a catalogue. It also includes a description of the revised SBTool multi-criteria assessment methodology for the urban scale in the Mediterranean context.

4.2.2 Background[9]

Buildings are the leading energy consuming sector, representing about 40% of the final energy consumption in Europe, and have a major impact on the natural environment. Energy efficiency improvement is a key European strategy to reduce the environmental impact of buildings. However, common energy efficiency plans do not fully exploit the potential for synergies that groups of buildings may offer (at the urban scale). The implementation of large scale energy efficiency measures at the urban level: city, district, neighbourhood or block level (e.g. district heating and cooling, photovoltaics and solar thermal installations) have clearly demonstrated that a building scale is not an optimal approach for reaching significant and

[8] CESBA MED Project and reference to other Sustainability Assessment methods based on Indicators, as presented in this section.
[9] CESBA Med Project Report D3.1.1. (2017)

cost-effective solutions. On the other hand, decision making processes for the design and assessment of interventions are more complex at larger scales due to the number of the various sustainability themes that need to be addressed.

Indicators are metrics that can be used to determine how well the sustainability objectives are achieved. They can be expressed as:

- numerical values (e.g. how much energy is used normalized per unit floor area of the building, so that it is possible to compare different buildings or against other benchmarks; how much water is consumed per building occupant or building occupant) or
- ratios and percentages (e.g. what is the percentage of renewables that cover power or heat demand; what percentage of waste is recycled).

Various performance indicators are available for benchmarking different building and urban attributes or characteristics, facilitating decision making, assessing specific project requirements, or ensuring compliance with regulations and norms. These indicators quantify what one is trying to achieve and thus may need to select and use several of them at different stages of their work or process.

Opinions vary as to which one is the most important since they all depend on the user or the intent. Apparently, different indicators can support the diverse needs of stakeholders and their priorities, to support decision making. For example, in routine building design practice, the first step is to calculate peak power demand (loads) or energy demand, in an effort to minimize system sizing and thus meet building code requirements or minimize first cost. Depending on the opportunities for a given project, efforts may focus on building architecture, selection of different thermal envelope materials and components and then electromechanical (E/M) systems. Other indicators may also be used for the assessment of indoor environmental quality and occupant the well-being. This usually includes indoor thermal comfort conditions under free floating conditions (e.g. minimum and maximum indoor temperature), indoor visual comfort conditions (e.g. daylight) and indoor air quality (e.g. different air flow rates and minimum fresh outdoor requirements).

Simple numeric metrics may be easily associated with a building's energy performance (i.e. lower or higher energy use) as a result of the building's characteristics, design, equipment selection and overall operation. This way, one can compare different design scenarios in order to optimize building construction, operation or assess energy refurbishment scenarios and alternatives, and use these indicators to quantify and substantiate selections to the different stakeholders.

Indicators can be considered at different scales, e.g. Building or District scale. In some cases they share some common indicators, with building scale values contributing to a larger scale, e.g. a neighbourhood or a district scale (Figure 12).

	Number	Name
Environment	B.1	*Energy*
	B.1.1	Operational Primary Energy Demand
	B.1.2	Delivered Energy Demand
	B.1.3	Renewable Energy on Site
	B.2	*Impacts*
	B.2.1	Global Warming Potential
Society	B.5	*Air Quality*
	B.5.1	Indoor Air Quality
	B.6	*Thermal Comfort*
	B.6.1	Summer Comfort without Cooling
	B.6.2	Thermal Comfort in the Heating Season
	B.6.3	Thermal Comfort in the Cooling Season
	B.8	*Acoustic Comfort*
	B.8.1	Acoustic Comfort
Economy	B.10	*Operational Costs*
	B.10.1	Operational Energy Costs

	Number	Name
Environment	D.1	*Energy*
	D.1.1	Operational Primary Energy Demand
	D.1.2	Delivered Energy Demand
	D.1.3	Renewable Energy on Site
	D.2	*Impacts*
	D.2.1	Global Warming Potential
Society	D.8	*Acoustic Comfort*
	D.8.1	Acoustic Environment
Economy	D.10	*Operational Costs*
	D.10.1	Operational Energy Costs

Figure 12: Breakdown examples of Building (left) and District (right) indicators [Barbano et al. 2016].

Selected indicators may also be targeted for evaluating the district energy status or neighbourhood central systems for small scale areas (e.g. up to 12 buildings). They can be suitable for energy networks analysis [Barbano et al. 2016] and for example may include:

- Evaluation of district energy status, e.g. percentage of energy demand to be covered by renewables, surplus of electricity from renewables, available storage capacity
- Evaluation of neighbourhood readiness for central systems, e.g. central heating, central cooling and smart grids.

One of the most important industry-led initiatives to harmonise environmental performance indicators is that of the Sustainable Building Alliance (SBA http://www.sballiance.org). SBA assembled various representatives from major building assessment schemes (e.g. BREEAM, HQE, DGNB, SB Tool, LEED) and developed a harmonised framework of common metrics that focus on four life cycle analysis indicators:

- non-renewable primary energy consumption,
- CO2 equivalents,
- drinking water consumption and waste production, as well as measures of
- thermal comfort and indoor air quality.

The Common European Sustainable Built Environment Assessment (CESBA http://wiki.cesba.eu) has been working to respond to the perceived confusion caused by the proliferation of various building assessment schemes, by bringing together various projects and platforms led by public authorities. A set of KPIs that form the basis for the CESBA 'building signature', include:

- primary energy use,
- CO2 emissions,
- reused/recycled materials,
- water consumption,

- solid waste,
- building life cycle costs,
- health and wellbeing factors (IAQ and thermal comfort),
- monitoring/optimisation in operation.

Over the past few years, the European Commission has recognized the importance developing a common EU framework of core indicators for the environmental performance of buildings and released the Communication on Resource Efficiency Opportunities in the Building Sector - COM(2014)445. This Communication identified the need for a common European approach to assess the environmental performance of buildings throughout their lifecycle, taking into account the use of resources such as energy, materials and water. The six macro objectives that will be translated into indicators include:

- Greenhouse gases from life cycle energy use
- Resource efficient material life cycles
- Efficient use of water resources
- Healthy and comfortable spaces
- Resilience to climate change
- Optimised life cycle cost and value.

The CESBA MED work focuses on identifying the most suitable transnational sets of indicators for the integrated assessment of public buildings and urban areas in the Mediterranean context, addressing the main dimensions of sustainability.

4.2.3 Issues & Indicators

The emphasis of CESBA MED is on the energy use of public buildings in the context of their surrounding urban area. This work considers various indicators for three major issues (*in alphabetical order*):

- Economic
- Environmental
- Social

and numerous categories of various commonly used indicators that are briefly discussed in the following subsections.

Economic Issues

Most decision-making processes are influenced to a great extent by the project's economic aspects. Improving the building's energy performance has a direct impact on first and operational costs. For example, starting with the efforts to minimize loads one can reduce the size of equipment and thus minimize first cost, which includes materials, labour, overhead, VAT etc. Some design options and materials may last for the life time of the building, while others will extend over the life time of the components that may run over several years or decades. For high performance buildings, construction costs average 3 to 10% higher than standard alternatives, but using energy efficient equipment or exploiting renewables will reduce operational costs by up to 40-50% lower than for conventional buildings, with proper operation and maintenance.

Different economic indicators are used for appraising the benefits and financial attractiveness of different design options and scenarios. For example, the simple payback period (PBP) that is commonly used and easily understood in the market. More accurate but more demanding methods are sometimes considered, e.g. accounting rate of return (ROR) or average annual rate of return on investment (RRI) discounted cash flow (e.g. the net present value (NPV) and internal rate of return (IRR) methods). Life cycle costing (LCC) and analysis (LCCA) methodologies can be used to reach cost optimal levels. However, they are not easy to

implement since they require information on energy prices, different material/equipment costs, and a number of relevant rates (e.g. variables and cash flow components) that may be difficult to realistically define in uncertain financial times.

Different indicators can be used in order to assess the benefits and financial attractiveness of different design options for new buildings and renovation scenarios for existing buildings. Starting from the simple payback period (PBP) that is commonly used and easily understood in the market, to more accurate but more demanding calculation methods like accounting rate of return (ROR) or average annual rate of return on investment (RRI) discounted cash flow (e.g. net present value (NPV) and internal rate of return (IRR) methods). Progressively the focus is placed on life cycle costing (LCC) and analysis (LCCA) methodologies that can be used to reach cost optimal levels for the entire lifetime of the building. However, these methods are not easy to implement since they require information on energy prices, different material/equipment costs, and a number of relevant rates (e.g. variables and cash flow components) that may be difficult to realistically define in uncertain financial times.

Environmental Issues

Environmental issues that relate to new and existing buildings involve the use of natural resources, various gaseous emissions (that are directly related to greenhouse gases and linked to global warming), waste etc. They can impact the air, land (use, preservation, open available green areas), and water (consumption, pollution, waste). The rational use of fresh water resources, the exploitation of rain water and waste water treatment, are some major environmental priorities, especially in the Mediterranean basin. The area also has a sensitive and significant biodiversity, with numerous indigenous plants that are suitable for landscaping and also have reduced water needs.

The emphasis of CESBA MED is on building energy use. Most commonly used energy related indicators, which quantify a building’s energy performance, include the normalized final (site) energy breakdown of different fuels (e.g. renewables, electricity, heating oil, natural gas) and primary (source) energy consumption that facilitates the assessment of environmental impact (e.g. emissions). Although different time steps may be used (e.g. hourly, monthly), the most common is on an annual basis (e.g. annual energy consumption or annual emissions). In addition, indicators can be used for evaluating different scenarios for equipment and system selection that can lower the total building's energy consumption, specific end-use energy consumption, e.g. related to HVAC equipment, lighting, service hot water, major office equipment, appliances and other plug loads, vertical transportation etc. Emissions are then directly related to the specific energy carriers. Environmental emissions are usually expressed in CO2 emissions (or equivalent) in kg per unit floor area of a building or aggregated as total quantities.

Social Issues

For the social aspects, the indoor environmental quality (IEQ) and well-being of occupants inside the buildings, involves, thermal, visual and acoustical comfort, and proper indoor air quality. Temperature and humidity levels provide helpful insight on the prevailing conditions that effect thermal comfort. Detailed simulation results and monitoring data can be used to assess prevailing conditions and for example, identify overheating conditions in summer (implying thermal discomfort) or even in winter that means energy waste beyond discomfort. The minimum indoor temperature in winter and the maximum indoor temperature in summer can be used as indicators for checking compliance with the desirable indoor conditions and preliminary assessment of peak sensible loads. Similarly, indoor humidity can reveal relevant priorities for humidification in winter or dehumidification in summer and support the preliminary assessment of peak latent loads. On an annual basis, spaces should have no more than 1% of the annual occupied hours over/under the desirable set point temperature. The predictive mean vote (PMV) and percentage people dissatisfied (PPD) are common thermal comfort indicators in order to quantify indoor thermal conditions and further assess the impact on occupancy.

Visual comfort is an integral part of proper IEQ and a critical design parameter in commercial buildings, since it improves productivity and overall functions. In terms of energy consumption, for some building categories, lighting may constitute a major final end-use and may also contribute to internal heat loads.

Another relevant indicator is the indoor air velocity that impacts thermal comfort conditions. Computational fluid dynamics (CFD) simulations can handle the complex phenomena and provide the necessary information in order to optimize the architectural and system design. CFD data visualization of spaces allows users to easily follow path lines and flow mixing resulting from mechanical or natural ventilation in order to evaluate the effectiveness of natural or mechanical ventilation systems. CFD may also be used to assess indoor air quality, outdoor pollution and concentrations of contaminants, which are compared against standards and health regulations.

Air ventilation and circulation plays a dominant role in achieving comfort conditions and securing the necessary amount of fresh (outdoor) air by natural, mechanical and/or hybrid ventilation. Minimum air flow rate of fresh outdoor air is a commonly used indicator, which depends on the building end-use, the number of occupants and the generation of indoor pollutants. Minimum requirements per person (m3/h/person), according to the maximum occupancy (person/m2 net occupiable floor area) to ensure proper indoor air quality are set by standards and technical regulations.

On an urban scale, transportation infrastructures, including public transport, availability of safe bicycle routes, suitable pedestrian streets etc, are major elements for sustainable urban development. Public safety and security are also important social aspects that influence the well-being of residents and working visitors. Accessibility to public spaces (e.g. community centres and services, parks) and other services (e.g. broadband networks) are also very important social criteria.

4.2.4 CESBA Med Assessment System

Several European projects and other public or commercial programs and initiatives have addressed these issues and have proposed different methods, tools and indicators. Accordingly, there is an abundance of available knowhow but on the other hand there is a need to collectively look at these outcomes in order to establish a common basis of a methodology and tool set that is suitable for the refurbishment of public buildings in the urban context of the MED area.

CESBA MED exploits available information from 14 transnational projects and public assessment systems. They are critically reviewed in order to develop a generic list of CESBA MED set of indicators at building and urban scale that will allow the sustainability assessment of public buildings and areas in the context of the Mediterranean area.

CESBA MED will produce an assessment system composed by a generic framework (CESBA MED SN Generic Framework) and the locally contextualized assessment tools (CESBA MED SNTools). The reference assessment methodology adopted by CESBA is the SBTool of iiSBE that gives the possibility of a total contextualization of tools to local conditions. The SBTool assessment methodology, originally developed for the building scale, is adapted for the application at urban scale. Finally, an integrated multicriteria CEBA MED assessment methodology is developed to connect the assessments at building and urban scale.

4.2.5 Transnational Methods & Indicators

The starting point of CESBA MED are the available information and main results from 14 transnational projects and public assessment systems (P.A.S.) dealing with energy efficiency at building and urban scale. They all define and use several indicators in their methods in order to assess sustainability of buildings at different scales. The main projects and P.A.S. considered in this work are outlined next in alphabetical order and they are elaborated in detail in CESBA Med Report D3.1.1.

Overview of projects & associated indicators

1 - CABEE
2 - CAT-MED
3 - CEC5
4 - CLUE
5 - ENERBUILD
6 - EPISCOPE
7 - FASUDIR
8 - IRH-MED
9 - NewTREND
10 - OPEN HOUSE
11 - SuPerBuildings
12 - Eco-Quartier m
13 - Protocollo ITACA
14 – QDM

A review of the transnational projects

- **CABEE** - Capitalizing Alpine Building Evaluation Experiences (ASP ALPINE Space Programme, European Territorial Cooperation, 2013-15) http://www.cabee.eu

A rating tool at cluster scale that contains criteria based on quantitative and qualitative criteria dealing with environmental, social and economic issues.

- **CAT MED** - Platform for Sustainable Urban Models (Interreg MED,2013-15) http://www.catmed.eu

A common system of urban sustainability indicators to track the evolution of urban systems in time. Different indicators are organized around four main axes: territorial management & urban design, mobility & transport, natural resources management and social and economic cohesion.

- **CEC5** - Demonstration of Energy Efficiency and utilization of renewable energy sources trough public buildings (Interreg Central Europe, 2010-12) http://wiki.cesba.eu/wiki/CEC5

CESBA Tool is a transnational sustainability assessment tool at building scale based on common indicators dealing with process, environmental, social and economic issues.

- **CLUE** - Climatic Neutral Urban Districts in Europe (Interreg IVC, 2011-14) http://www.clue-project.eu

A set of 50 criteria and indicators for sustainability assessment at cluster and neighborhood scale. The indicators are all quantitative and performance based. Similar indicators with ITACA.

- **ENERBUILD** - Energy Efficiency and Renewable Energies in the Building sector (ASP ALPINE Space Programme, European Territorial Cooperation, 2010-12) http://www.enerbuild.eu

A transnational sustainability assessment tool at building scale based on common indicators dealing with process, environmental, social and economic issues.

- **EPISCOPE** - Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks (IEE, 2012-14) http://www.episcope.eu

A scheme of energy performance indicators to access national actions for tracking and assessing refurbishment plans for improving the energy performance of building stocks.

- **FASUDIR** - Friendly and affordable sustainable urban districts retrofitting (FP7, 2014-16) http://fasudir.eu

A set of indicators at building and district level for assessing the three issues of sustainability: environmental, economic and social aspects. Calculation methods and benchmarks of KPIs are defined.

- **IRH-MED** - Innovative Residential Housing MED (Interreg MED, 2010-12) http://wiki.cesba.eu/wiki/IRH_med

A common framework for residential building sustainability assessment in MED areas that can be used as a basis for the implementation of future regional initiatives.

- **NewTREND** - New integrated methodology and tools for retrofit design towards a next generation of energy efficient and sustainable buildings and districts (H2020, 2015-18) http://newtrend-project.eu

An efficient collaborative design platform that accounts for current best practices in the design process for energy efficient refurbishment of buildings.

- **OpenHouse** - Benchmarking and mainstreaming building sustainability in the EU based on transparency and openness (open source and availability) from model to implementation (FP7, 2010-12) http://www.openhouse-fp7.eu

A common European methodology to assess the sustainability of buildings based on the existing certification schemes and European standards, using a transnational set of indicators.

- **SuPerBuildings** - Sustainability and Performance Assessment and Benchmarking of Buildings (FP7, 2010-12) http://cic.vtt.fi/superbuildings

A set of sustainability indicators for buildings and methods for the assessment and benchmarking considering the output of the standardization processes, focusing on the validity of indicators, comparability of assessment results, benchmarking criteria. I

Public Assessment Systems (P.A.S.)

- **Eco-Quartier** - French Label Eco Quartier (Eco-District) http://www.eco-quartiers.fr

A French label to formalize sustainable development of districts and assess Eco-districts. The approach is compatible with the Reference Framework for Sustainable Cities (http://rfsc.eu). The approach considers 20 commitments of a common charter, covering life quality and users practices; territorial development; environment and climate.

- **Protocollo ITACA**- Environmental label (Federal Association of the Italian Regions, with the scientific support of iiSBE and ITC-CNR) http://wiki.cesba.eu/wiki/Protocollo_Itaca

A voluntary environmental label promoted by the Italian Regions based on the international assessment methodology SBMethod of iiSBE and it has been contextualized at local level by several regions to support specific policies in promoting sustainable buildings. A national version is also under development to create a point of reference for the market stakeholders. Similar indicators with CLUE.

- **QDM**- Quartiers Durables Méditerranéens (Sustainable Mediterranean Neighbourhoods) http://www.envirobatbdm.eu/baroque

A local and contextualised approach to sustainability in neighbourhood planning for local authorities. It is based on a bottom up and participative approach, using 8 themes, 31 criteria and 240 indicators.

The available indicators are clustered into three (3) major sustainability Issues and nineteen (19) main Categories, illustrated in Figure 13. The various categories are listed in alphabetical order, not in terms of their importance.

In order to facilitate the organization of the available information and easy cross reference, a common letter coding is introduced as follows:

- Each issue is denoted by a three letter code (the three first letters of the issue’s name)
- Each category is denoted by a two letter code: the first letter (in caps) and the second letter of the category’s name, in case of category with a single-word name, OR the first letter (in caps) of the first word and the first letter (in caps) of the last word of the category’s name, in case of category with a more than one word name.

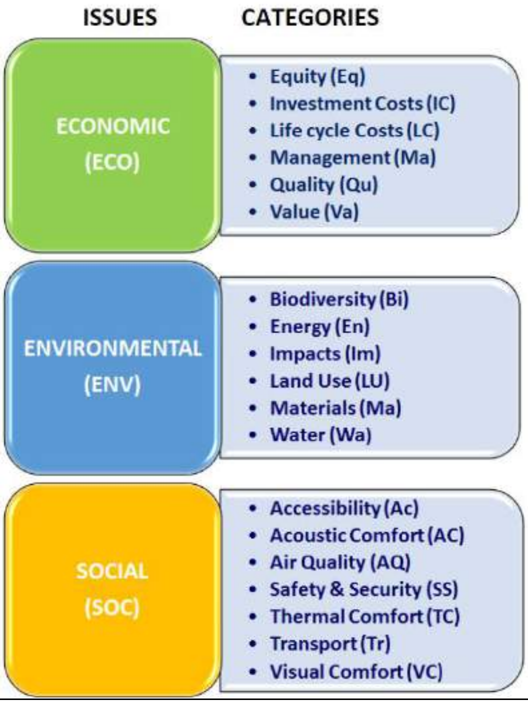


Figure 13: Issues and corresponding Categories (listed in alphabetical order) of indicators.

A complete list of the corresponding indicators for each category and criterion are summarized in Table 3. They are listed in alphabetical order, not in terms of their importance.

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

ECONOMIC (ECO) ISSUE						
Category	**Criterion**	**Indicator (units)**		Building (B) and Neighbourhood (N) scale		
				B	**N**	**B&N**
Equity	**Housing value**	1	Affordability of housing property (m^2)		◆	
		2	Affordability of housing rental (%)		◆	
	Local economy	3	Support to local economy (%)		◆	
	Prevention of prejudice	4	Prevention of prejudice		◆	
	Social & Economic cohesion	5	Future evolution and modularity		◆	
		6	Gentrification index (-)		◆	
		7	Labor force participation (%)		◆	
		8	Potential Employment (%)		◆	
		9	Social housing ratio (%)		◆	
		10	Social mixing and solidarity based economy		◆	
		11	Unemployment rate (%)		◆	
Investment Costs	**Capital cost**	1	Additional costs for energy efficiency and sustainability (€)			◆
		2	Investment costs (€/m^2)			◆
		3	Investment costs aggregated (€)		◆	
		4	Participation of local authority in the total investment cost (%)		◆	
	Performance	5	Return on investment (%)			◆
Life cycle Costs	**Benchmarking & Targeting**	1	Verifiable sustainable targets			◆
	Cost benefit	2	Cost benefit analysis focused on sustainability			◆
	Energy cost	3	Operational energy costs (€/m^2)			◆
		4	Operational energy costs aggregated (€)			◆
	Non- Energy cost	5	Operational non-energy costs aggregated (€)		◆	
	Total cost	6	Cost in operational phase (€)			◆
		7 8	Life cycle costs (-) (€)	◆		
		9	Life cycle costs aggregated (€)		◆	
Management	**Building operation**	1	Communication and information management (%)			◆
		2	Information and participation of users			◆
		3	Synergy management (-)		◆	
		4	User information (-)	◆		
	Social & Economic cohesion	5	Environmental activities in primary school (%)		◆	

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

ECONOMIC (ECO) ISSUE						
Category	Criterion	Indicator (units)		Building (B) and Neighbourhood (N) scale		
Quality	Architectural	1	Aesthetic quality (-)		◆	
		2	Enhance architectural, cultural and landscape patrimony (yes/no)		◆	
	Benchmarking & Targeting	3	Setting verifiable environmental targets (-)	◆		
	Building energy performance	4	Energy optimization during planning (-)	◆		
	Cultural heritage	5	Monument or monumental value / Historical value (-)			◆
	Process & Planning	6	Building works quality control	◆		
		7	Community management (yes/no)		◆	
		8	Community planning (yes/no)		◆	
		9	Finalising the design phase (yes/no)		◆	
		10	Integrated design in the planning process (-)		◆	
		11	Plus 6 (+6) project management (yes/no)		◆	
		12	Process and planning quality (-)			◆
		13	Project management (yes/no)		◆	
		14	Working with skilled professionals (yes/no)		◆	
	Risk management	15	Long term stability of value (€)			◆
		16	Risk management (-)		◆	
	Territorial management & Urban design	17	Urban complexity, Shannon-Wiener index (-)		◆	
Value	Flexibility & Adaptability	1	Flexibility and adaptability, during the life of the project (yes/no)		◆	
		2	Flexibility and adaptability, programming (yes/no)		◆	
	Process & Planning	3	Assessing the current situation (yes/no)		◆	
		4	Competent professional team		◆	
		5	Economic advantage of cluster in comparison to single buildings (-)		◆	
		6	Equipment and services pooling		◆	
	Social & Economic cohesion	7	Tourist frequency trends, seasonality overnight stays (%)		◆	
		8	Tourist frequency trends, seasonality tourists (%)		◆	

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

ENVIRONMENTAL (ENV) ISSUE						
Category	**Criterion**	**Indicator (units)**		Building (B) and Neighbourhood (N) scale: **B**	**N**	**B&N**
Biodiversity	Building site	1	Ecological quality of the building site (-)	◆		
Biodiversity	Land preservation	2	During programming, design and before the beginning of the works; the land is maintained through mowings, prunings, maintenance of canals and hedges (yes/no)		◆	
Biodiversity	Public spaces	3	Change in ecological value of the site, species(-)			◆
Biodiversity	Public spaces	4	Connectivity of green spaces (%)		◆	
Biodiversity	Public spaces	5	Diversity (yes/no)		◆	
Biodiversity	Public spaces	6	Ecological corridors and continuity (yes/no)		◆	
Biodiversity	Public spaces	7	Use of local plants (%)		◆	
Biodiversity	Public spaces	8	Vegetal areas (%)		◆	
Energy	Building vertical transportation	1	Escalators and moving walks design and efficiency (-)	◆		
Energy	Building vertical transportation	2	Lift design and efficiency (-)	◆		
Energy	Building vertical transportation	3	Stairs and ramps planning (-)	◆		
Energy	Embodied energy	4	Embodied energy demand (kWh/m^2)	◆		
Energy	Final energy	5	Annual heat generation for space heating and DHW (kWh/m^2)			◆
Energy	Final energy	6	Cooling demand (kWh/m^2)	◆		
Energy	Final energy	7	Delivered energy demand (kWh/m^2)			◆
Energy	Final energy	8	Energy consumption (Toe/inhabitant)		◆	
Energy	Final energy	9	Heating demand (kWh/m^2)	◆		
Energy	Final energy	10	Peak energy demand			◆
Energy	Primary energy	11	Abiotic Depletion Potential (kWh/m^2)	◆		
Energy	Primary energy	12	Consumption of non-renewable primary energy (kWh/m^2)			◆
Energy	Primary energy	13	Operational primary energy (kWh/m^2)			◆
Energy	Primary energy	14	Primary energy for cooling (%)		◆	
Energy	Primary energy	15	Primary energy for heating (%)		◆	
Energy	Primary energy	16	Primary energy for public lighting (%)		◆	
Energy	Primary energy	17	Primary energy for public lighting (kWh/yr)		◆	
Energy	Primary energy	18	Total primary energy demand (kWh/m^2)			◆
Energy	Renewables	19	Renewable electricity production (%)		◆	
Energy	Renewables	20	Renewable energy on site (%)			◆
Energy	Renewables	21	Share of renewable primary energy in total primary energy demand (kWh/m^2)	◆		
Energy	Renewables	22	PV-power plant (kWh/a)	◆		
Energy	Virtual power systems	23	Electric energy and Virtual power systems		◆	

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

ENVIRONMENTAL (ENV) ISSUE						
Category	Criterion	Indicator (units)		Building (B) and Neighbourhood (N) scale		
				B	N	B&N
Impacts	Eco-mobility	1	Eco-mobility potential of a building in its context (km/unit)			◆
	Effects on surrounding buildings	2	Impacts on surrounding buildings (%)		◆	
	Emissions	3	Acidification potential ($kgSO_2$-eq/m^2)			◆
		4	Acidifying emissions, Intensity (%)		◆	
		5	Annual CO2 emissions ($kgCO_2/m^2$)			◆
		6	CO2 emission factor heat supply (kg/kWh)			◆
		7	CO2 emissions (tonnes CO_2-eq/yr)		◆	
		8	Eutrophication potential ($kgPO_4$-eq/m^2yr)			◆
		9	Global Warming Potential ($kgCO_2$-eq/m^2 yr)			◆
		10	Global Warming Potential (-)		◆	
		11	Global Warming Potential ($kgCO_2$-eq/m^2 yr)			◆
		12	Intensity of GHG emissions (%)		◆	
		13	Ozone depletion potential (kgR11-eq/m^2yr)			◆
		14	Photochemical Ozone creation potential (kgC_2H_4-eq/m^2yr)			◆
		15	Photo-oxidants emissions, Intensity (%)		◆	
	Light pollution	16	Light on properties (lx)		◆	
		17 18	Light pollution (-) (%)		◆	
		19	Luminaire intensity (cd)		◆	
		20	Luminance (cd/m^2)		◆	
		21	Upward Light		◆	
	Outdoor conditions	22	Monitoring of air quality (%)		◆	
		23	Thermal comfort of outdoor areas (%)		◆	
	Raw materials	24	Abiotic Depletion Potential elements (kgSB-eq/m^2yr)			◆
	Solid waste management	25	Accessibility to differentiated waste collection (%)		◆	
		26	Accessibility to waste sorting facilities (%)			◆
		27	Composting (-)	◆		
		28	Construction and demolition waste generation (kg/m^2)			◆
		29	Recyclable waste storage (m^2)	◆		
	Water pollution	30	Water pollution due to material leaching (mg/m^2 yr)			◆

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

ENVIRONMENTAL (ENV) ISSUE						
Category	Criterion	Indicator (units)		Building (B) and Neighbourhood (N) scale		
				B	N	B&N
Land Use	Preservation	1	Conservation of built environment (%)		◆	
		2	Preservation of land (%)			◆
	Quality	3	Site quality (-)		◆	
	Soil sealing	4	Permeability of site / land (%)			◆
	Spatial planning	5	Change of land use (-)		◆	
		6	Imperviousness change, Imperviousness coefficient (-)		◆	
	Urban design	7	Green zones & recreation areas (m^2/inhabitant)		◆	
		8	Green zones & recreation areas density (%)		◆	
		9	Green zones & recreation areas proximity (%)		◆	
		10	Outdoor space (-)		◆	
		11	Population density (inhabitants/ha)		◆	
		12 13	Urban compactness (dwelling/m^2) (m^3/m^2)		◆	
		14	Urban context (-)		◆	
		15	Urban conversion (%)		◆	
Materials	ECO materials	1	Low-pollutant and low-emission materials (-)	◆		
	Emissions	2	Building materials and construction, OI3 index (-)			◆
Water	Embodied water	1	Embodied water use (m^3/m^2)			◆
	Freshwater	2	Intensity of water treatment (%)		◆	
		3	Operational water use (m^3)			◆
		4	Water consumption (l/inhabitant day)		◆	
	Rainwater	5	Dedicated network (yes/no)		◆	
		6	Intensity of rainwater usage (%)		◆	
		7	Landscaped and accessible retention ponds and ditches (yes/no)		◆	
		8	Rainwater collection from roofs (%)		◆	
		9	Respecting streaming continuity (yes/no)		◆	
	Total water use	10	Operational water use and waste water (m^3)			◆
	Wastewater	11	Intensity of wastewater treatment (%)		◆	
		12 13	Waste management & removal (l/inhabitant day) (%)		◆	
		14	Wastewater management (%)		◆	
		15	Wastewater management (m^3/m^2)			◆
		16	Water consumption & use of rainwater (-)	◆		

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

SOCIAL (SOC) ISSUE						
Category	**Criterion**	**Indicator (units)**		Building (B) and Neighbourhood (N) scale		
				B	**N**	**B&N**
Accessibility	**Broadband communication network**	1	Access to a broadband communication network, areas (%)		◆	
		2	Access to a broadband communication network, population (%)		◆	
	Flexibility	3	Flexibility of residential buildings (%)			◆
		4	Flexibility use (%)		◆	
	Public space planning	5	Access to parks and open spaces (-)		◆	
		6	Adaptation to users practices (yes/no)		◆	
		7 8	Availability of green spaces (%) (m^2/inhabitant)		◆	
		9	Barrier-Free accessibility of the district (%)		◆	
		10	Community gardens (yes/no)		◆	
		11	Parks and vegetated spaces network (yes/no)		◆	
		12	Public space quality (yes/no)		◆	
		13	Shared community spaces (yes/no)		◆	
	Services & Leisure facilities	14	Access to services and facilities (%)		◆	
		15	Collective facilities and outsourcing of services (%)		◆	
		16	Community support (yes/no)		◆	
		17	Proximity to leisure facilities (%)		◆	
		18	Proximity to services (%)		◆	
		19	Proximity to services and leisure facilities (%)		◆	
		20	Social gatherings and common cluster activities (-)		◆	
	Street network	21	Cyclomatic complexity of the street network (-)		◆	
	Urban planning	22	Development and integration of land parcels (%)		◆	
		23	Homogeneity of the urban fabric (%)		◆	
		24	Mixing functions (yes/no)		◆	
Acoustic Comfort	**Noise - Indoor**	1	Indoor A-weighted sound pressure level (dBA)			◆
		2	Weighted sound pressure from ventilation (dBA)	◆		
	Noise - Outdoor	3	Building area over noise limit (%)		◆	
		4	Noise pollution, silence quality – day (%)		◆	
		5	Noise pollution, silence quality – night (%)		◆	
	Noise pollution management	6	Accoustics studies (yes/no)		◆	
Air Quality	**Indoor air quality**	1	Concentration of pollutants (μg/m^3)			◆
	Outdoor air quality	2	Number of days with bad air quality (days/yr)		◆	

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

SOCIAL (SOC) ISSUE						
Category	Criterion	Indicator (units)		Building (B) and Neighbourhood (N) scale		
				B	N	B&N
Safety & Security	Energy & Management systems	1	Objective/subjective safety measures (-)		◆	
	Green production	2	Local production of food (m²/inhabitant)		◆	
	Mobility	3	Pedestrian safety paths (%)		◆	
Thermal Comfort	Indoor conditions	1	Predicted Mean Vote (-)			◆
		2	Predicted Percentage Dissatisfied (%)			◆
		3	Thermal comfort in summer (-)	◆		
	Outdoor conditions	4	Exploitation of local resources: sun, daylight, wind (-)		◆	
		5 6	Heat island effect (-) (yes/no)		◆	
		7	Microclimate Index I (-)		◆	
Transport	Mobility & Alternative transportation	1	Availability of safe bicycle routes (m)		◆	
		2	Bicycle and pedestrian network quality (-)		◆	
		3	Bicycle facilities (-)		◆	
		4	Car sharing pool/station (yes/no)		◆	
		5	Contiguity of bicycle and car routes (%)		◆	
		6	Pedestrian streets and walkways, area (%)		◆	
		7	Pedestrian streets and walkways, length (%)		◆	
		8	Proximity to bicycle lanes and paths (%)		◆	
		9	Shared mobility (%)			◆
	Parking facilities	10	Parking facilities (number/dwelling)		◆	
		11	Parking facilities, Off-street parking spaces (%)		◆	
		12	Parking places with innovative features (%)		◆	
		13	Bicycle Parking (%)	◆		
	Public transportation	14	Access to public transport nodes, areas (%)		◆	
		15	Access to public transport nodes, population (%)		◆	
		16	Access to public transport, District Accessibility Index (-)		◆	
		17	Accessibility of public transport, stops and frequency (-)	◆		
		18	Accessibility to public transport, Lense index (-)			◆
		19	Dwellings with access to public transport (%)		◆	
	Street network	20	Connectivity of the street network (number/m²)		◆	
		21	Cul-de-sac roads and path ratio (%)		◆	

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

SOCIAL (SOC) ISSUE						
Category	Criterion	Indicator (units)		Building (B) and Neighbourhood (N) scale		
				B	N	B&N
		22	Scale of the street network (m)		◆	
		23	Traffic modal split (%)		◆	
Visual Comfort	Artificial lighting	1	Illuminance (lx)			◆
	Daylighting	2	Daylight factor (%)			◆

Table 3. Indicators and Criteria under the main Issues & Categories (listed in alphabetical order). The spatial coverage is based on the building scale and/or neighbourhood scale.

Depending on the amount of information required for the definition of the indicators they can also be grouped into three categories, depending on the level and complexity of their calculation:

- Basic (B): using simple parametric calculations, values from literature, benchmark averages,
- Standard (S): using standards, simple tool calculations, simple measurements or utility bills,
- Advanced (A): using advanced software for dynamic simulations

and in some cases based on a combination of calculation approaches, for example, Basic and Advanced (B&A). Furthermore, the available indicators can be categorized according to their spatial coverage (Table 3) based on the scale of their application at:

- Building Scale (B)
- Neighbourhood Scale (N)
- Both (B&N)

The CESBA MED set of indicators at building scale will allow the sustainability assessment of public buildings with different end-uses (e.g. school, offices, residential). At urban scale the CESBA MED set of indicators will allow the sustainability assessment of areas at different scales and physical boundaries.

- A small urban scale area (Neighbourhood scale, e.g. block/cluster of buildings) includes 5 – 15 buildings with a traditional composition, e.g. few buildings (adjacent or separated) with an internal courtyard.
- A large urban scale (e.g. neighbourhood) covers an area of 200-400 m in size that can be crossed in 10-15 min walk and incorporates 200-1500 inhabitants. The CESBA MED set of indicators will also consider different time scales to facilitate the sustainability assessment of existing urban areas

The CESBA MED set of indicators at urban scale will allow the sustainability assessment of an area concerning:

Existing urban areas

- actual performance assessment in order to take snap shot of the urban area and to identify the sustainability critical issues;
- potential performance related to retrofit scenarios in order to identify the most cost effective sustainable retrofit scenario;
- monitoring of urban retrofit actions in order to evaluate the effectiveness of urban retrofit actions and the achievement of the sustainability performance targets.

New urban developments

- potential performance of alternative planning options in order to identify the most cost effective sustainable development option;
- monitoring of new urban developments in order to monitor new urban development and the achievement of the performance targets.

The two CESBA MED sets of indicators at:

- Building scale and
- Neighbourhood (Urban) scale

These are composed by indicators selected from existing sets developed by the previous EU projects and P.A.S. The available indicators are presented in detail for each project and P.A.S. in CESBA Med Report D3.1.1. (CESAB – Med, 2017)[10]. These information include:

- Short description of the project and its objectives
- Short list of indicators used in the specific project
- Detailed presentation of the indicators (e.g. name, units, categorization using the abbreviated codes for issue/category/level/scale, a brief description, the calculation method, and reference sources for more information).

The code name for each indicator follows the abbreviated notation from the Table as: “*Issue.Category.Number*”. For example, “Energy consumption” is denoted as “*ENV.En.8*”.
An overview of the available indicators and their association with all the projects and P.A.S. considered in this work are summarized in CESBA Med report D3.1.1. (Project List of Indicators_Overview.xlsx). Over 210 indicators have been identified. As illustrated in the part presented in Figure 14, each indicator is identified in terms of the issues (ECO, ENV, SOC), categories, descriptive name and units, the calculation complexity (B, S, A), the spatial coverage (B, N), linked to the specific projects and P.A.S. considered in this work. The counter column indicates the number of times that the specific indicator has been used. The last

[10] CESBA Med Report D3.1.1. (CESAB – Med, 2017) Transnational Indicators and Assessment Methods for Buildings and Urban areas.

column is used for supplementary notes to provide clarity on specific processes or approaches.

					level			scale		projects											public a.s.				
ISSUE	CATEGORY	CRITERION	INDICATOR	UNITS	basic	standard	advanced	building	neighbourhood	CLUE	FASUDIR	CABEE	CAT-MED	EPBCOPE	ENERBUILD	CECS	OPEN HOUSE	IRH-MED	SuPerBuildings	NewTREND	Protocollo ITACA	QDM	Eco-Quartier BDM	count	notes
ECO	equity	Housing value	Affordability of housing property	m2			X		X	A											A			2	
ECO	equity	Housing value	Affordability of housing rental	%			X		X	A											A			2	
ECO	equity	Local economy	Support to local economy	%		X			X													S		1	
ECO	equity	Prevention of prejudice	Prevention of prejudice	???	X				X									B						1	
ECO	equity	Social & Economic cohesion	Future evolution and modularity	???	X				X									B						1	
ECO	equity	Social & Economic cohesion	Gentrification index	-			X		X		A													1	requires a lot of historical economical data in the area
ECO	equity	Social & Economic cohesion	Labor force participation	%		X			X				S											1	
ECO	equity	Social & Economic cohesion	Potential Employment	%			X		X	A											A			2	
ECO	equity	Social & Economic cohesion	Social housing ratio	%		X			X				S											1	
ECO	equity	Social & Economic cohesion	Social mixing and solidarity based economy	???	X				X									B						1	
ECO	equity	Social & Economic cohesion	Unemployment rate	%		X			X				S											1	
ECO	investment costs	Capital cost	Additional costs for energy efficiency and sustainability	€		X		X	X										S					1	comparison with average costs
ECO	investment costs	Capital cost	Investment costs	€/m2		X		X	X											S				1	
ECO	investment costs	Capital cost	Investment costs aggregated	€			X		X		A													1	
ECO	investment costs	Capital cost	Participation of local authority in the total investment cost	%		X			X														S	1	
ECO	investment costs	Performance	Return on investment	%		X	X	X	X		A									S				2	assumptions required on 20-30 yrs financial outlook
ECO	life cycle costs	Benchmarking & Targeting	Verifiable sustainable targets	???	X			X	X									B						1	
ECO	life cycle costs	Cost benefit	Cost benefit analysis focused on sustainability	???	X			X	X									B						1	
ECO	life cycle costs	Energy cost	Operational energy costs	€/m2		X		X	X											S				1	in SB, absolute value
ECO	life cycle costs	Energy cost	Operational energy costs aggregated	€		X	X	X	X		A								S					2	in SB, absolute value
ECO	life cycle costs	Non- Energy cost	Operational non-energy costs aggregated	€			X		X		A													1	includes all maintenance, subsitution, removal; in SB, absolute value
ECO	life cycle costs	Total cost	Cost in operational phase	€		X		X	X										S					1	in SB, absolute value
ECO	life cycle costs	Total cost	Life cycle costs	-			X	X							A	A								2	does not require simulation, but a lot data and assumptions on 50 yrs
ECO	life cycle costs	Total cost	Life cycle costs	€		X		X											S					1	does not require simulation, but a lot data and assumptions on 50 yrs
ECO	life cycle costs	Total cost	Life cycle costs aggregated	€			X		X		A													1	does not require simulation, but a lot data and assumptions on 50 yrs
ECO	management	Building operation	Communication and information management	%		X		X	X			S												1	
ECO	management	Building operation	Information and participation of users	???	X			X	X									B						1	
ECO	management	Building operation	Synergy management	-		X			X			S												1	
ECO	management	Building operation	User information	-		X		X							S	S								2	
ECO	management	Social & Economic cohesion	Environmental activities in primary school	%		X			X				S											1	
ECO	quality	Architectural	Aesthetic quality	-		X			X										S					1	panel-based assessment
ECO	quality	Architectural	Enhance architectural, cultural and landscape patrimony	yes / no	X				X													B		1	
ECO	quality	Benchmarking & Targeting	Setting verifiable environmental targets	-		X		X							S	S								2	specific to ENERBUILD/CESBA tool usage
ECO	quality	Building energy performance	Energy optimization during planning	-		X		X							S	S								2	
ECO	quality	Cultural heritage	Monument or monumental value / Historical value	-		X		X	X										S					1	panel-based assessment
ECO	quality	Process & Planning	Building works quality control	???	X			X										B						1	
ECO	quality	Process & Planning	Community management	yes / no	X				X													B		1	
ECO	quality	Process & Planning	Community planning	yes / no	X				X													B		1	
ECO	quality	Process & Planning	Finalising the design phase	yes / no	X				X													B		1	
ECO	quality	Process & Planning	Integrated design in the planning process	-		X			X										S					1	
ECO	quality	Process & Planning	Internal project management	yes / no	X				X													B		1	
ECO	quality	Process & Planning	Process and planning quality	-		X		X	X			S			S	S								3	CABEE Document with planned quantitative and qualitative objectives

Figure 14. Part of the overview of available indicators and frequencies in transnational projects and PAS.

4.2.6 Analysis

The analysis of the available information provides some useful insight with regard to the most relevant indicators. The goal of the following analysis is to identify from the generic list of indicators used in the transnational projects consider in this work, the ones that are most commonly used under each of the main issues (ECO, ENV, SOC) and specific categories, while at the same time identify common trends, for example, the commonly used calculation approaches. The analysis considers both Building & Neighbourhood (Urban) scales. The outcome of this analysis provides the appropriate CESBA MED set of indicators that will then be coupled with a multi-criteria assessment methodology in order to derive the specific CESBA MED key and core performance indicators.

Generic Indicators

The generic list of indicators from the EU projects and P.A.S. considered in this work include a total of 216 indicators (Table 3). Some of the indicators are expressed with different units. The breakdown of the indicators based on their spatial coverage (Figure 15) is as follows:

- 24 indicators (11% of the total) at Building Scale (only)
- 142 indicators (66% of the total) at Neighbourhood (urban) Scale (only)
- 50 indicators (23% of the total) are common and apply at both B&N scale.

Considering that some indicators are common and used at both building and neighbourhood scales, their breakdown is as follows:

- 74 indicators (34%) at Building Scale
- 192 indicators (89%) at Neighbourhood (urban) Scale

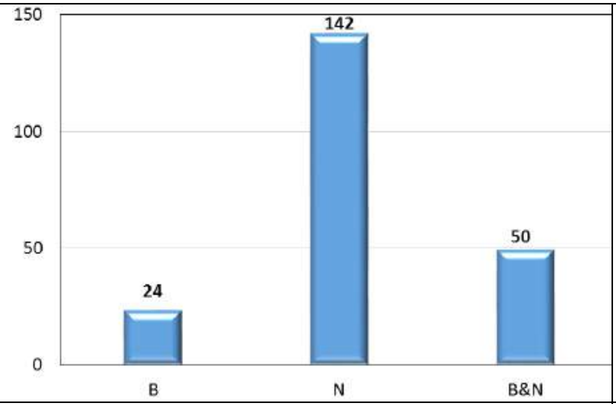


Figure 15: Number of indicators at building (B) scale, neighbourhood (N) scale, and both B&N scale.

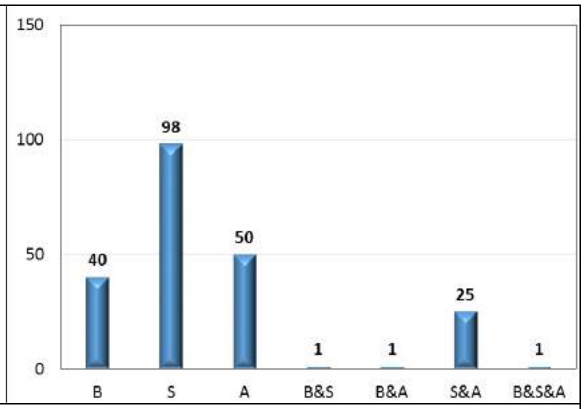


Figure 16: Number of indicators with different levels of calculation complexity (B: Basic, S: Standard, A: Advanced) and their combinations thereafter.

In terms of the level and complexity of their calculation, the majority of the indicators are derived using standard calculations (Figure 16). A total of 98 indicators or 45% are based on standard calculations, followed by advanced (50 indicators or 23%), basic (40 indicators or 19%) and their combinations thereafter (i.e. S&A for 25 indicators or 12%, and only one for B&S, B&A and B&S&A).

Specifically, for the indicators that use Basic calculations, 21 of them are included in the ECO issue, 13 in ENV issue and 9 in SOC issue (Figure 17a). Of the ones using Standard calculations, 28 indicators are included in the ECO pillar, 63 in ENV pillar and 34 in SOC pillar (Figure 17b), while for the ones that use Advanced calculations, 11 are included in the ECO issue, 35 in ENV issue, 31 and in SOC issue (Figure 17c).

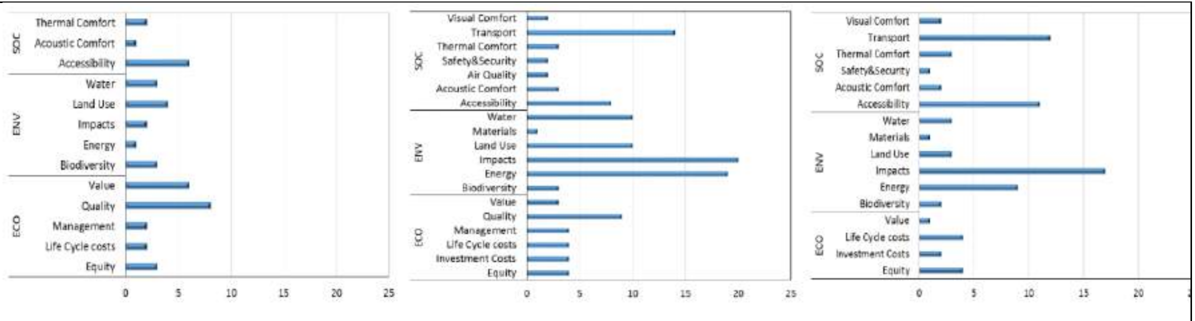


Figure 17 (a,b,c). Number of indicators that use a-Basic, b-Standard and c-Advanced level calculations for the main sustainability issues and categories.

The following sections elaborate the most popular indicators under the three main issues.

ECONOMIC

A total of 55 indicators (addressed 66 times in total) are assigned under Economic (ECO) issue. The two most popular categories under the specific issue are Quality (Qu) and Equity (Eq).

ECO - Quality (ECO.Qu)

A total of 17 indicators are assigned under «ECO.Qu» amongst the various projects and P.A.S. considered during this work. Specifically, 3 of them address the neighbourhood scale (N), 3 the building scale (B) and 11 both scales (B&N). These indicators have been addressed 21 times in total, following different calculation methodologies. The majority use a "Standard" level calculation approach (53%), followed by "Basic" level approach (47%).

ECO - Equity (ECO.Eq)

A total of 11 indicators are assigned under «ECO.Eq» amongst the various projects and P.A.S. and all of them address the neighbourhood scale (N). These indicators have been addressed 14 times in total, following different calculation methodologies. The majority use a "Standard" level calculation approach (36%), followed by "Advanced" level approach (36%) and 28% use a "Basic" level approach.

ENVIRONMENTAL

A total of 93 indicators (addressed 133 times in total) are assigned under Environmental (ENV) issue. The two most popular categories under the specific issue are Impacts (Im) and Energy (En).

ENV – Impacts (ENV.Im)

A total of 30 indicators are assigned under «ENV-Im» amongst the various projects and P.A.S. considered during this work. Specifically, 15 of them address the neighbourhood scale, 13 both B&N scales and 2 indicators the building scale. These indicators have been addressed 46 times in total, following different calculation methodologies. The majority use a “Standard” level calculation approach (37%), followed by 30% that use both “Standard” and “Advanced” level approaches, 27% that use an “Advanced” level approach and only 6% use a “Basic” level approach.

ENV – Energy (ENV-En)

The emphasis of CESBA MED is on building energy use. A total of 23 indicators are assigned under «ENV-En» amongst the various projects and P.A.S. considered during this work. Specifically, 9 of them address the building scale, 7 both B&N scales and 7 the neighbourhood scale. These indicators have been addressed 33 times in total, following different calculation methodologies. The majority use a “Standard” calculation approach (57%), 26% use both “Standard” and “Advanced” level approach, 13% use “Advanced” level approaches and only 4% use a “Basic” level approach.

SOCIAL

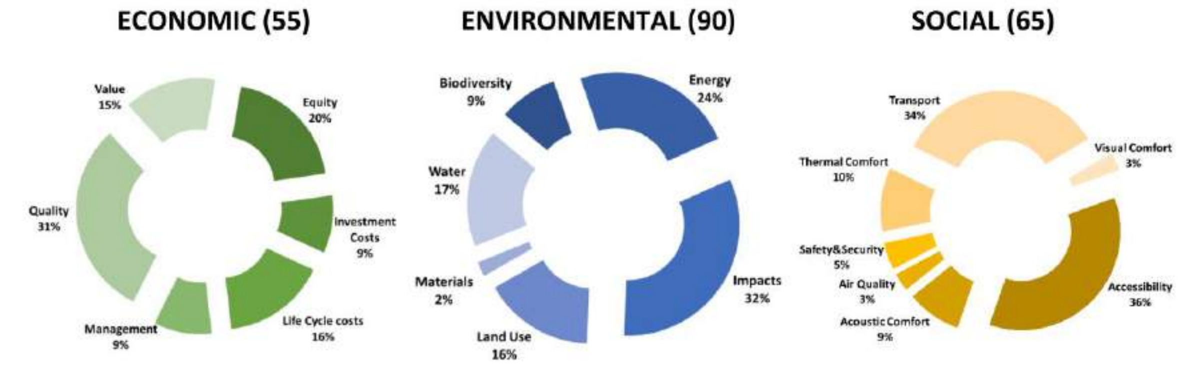
A total of 67 indicators (addressed 94 times in total) are assigned under Social (SOC) issue. The two most popular categories under the specific issue are Accessibility (Ac) and Transport (Tr).

SOC - Accessibility (SOC.Ac)

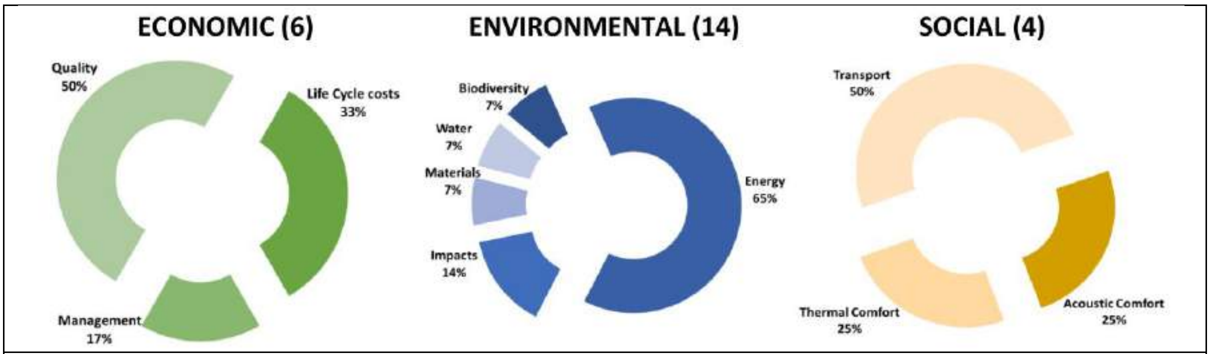
A total of 24 indicators are assigned under «SOC.Ac» amongst the various projects and P.A.S. considered during this work. Specifically, 23 of them address the neighbourhood (N) scale and only 1 both B&N scales. These indicators have been addressed 33 times in total, following different calculation methodologies. The majority use an “Advanced” level calculation approach (42%), followed by “Standard” level approach (29%), “Basic” level approach (25%) , while only 4% use both “Standard” and “Advanced” level approaches.

SOC - Transport (SOC.Tr)

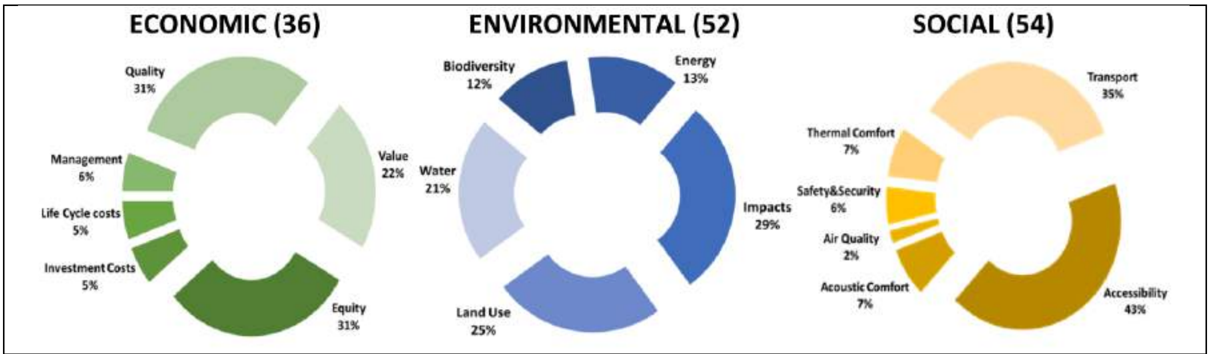
A total of 23 indicators are assigned under «SOC.Tr» amongst the various projects and P.A.S. considered during this work. Specifically, 19 of them address the neighbourhood (N) scale, 2 the building (B) scale, and 2 both B&N scales. These indicators have been addressed 35 times in total following different calculation methodologies. The majority use a “Standard” calculation approach (48%), followed by “Advanced” level approach (39%) and 13% use both “Standard” and “Advanced” level approaches.



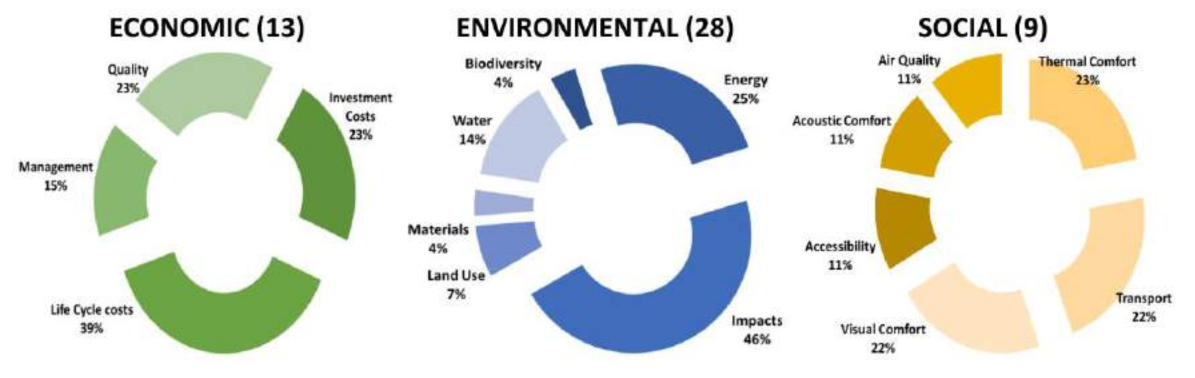
Total: 215 Indicators



Building Scale: 24 Indicators



Neighbourhood Scale: 142 indicators



Building and neighbourhood Scale: 52 indicators

Figure 18: The Indicators Reviewed

4.2.7 CESBA MED Set of Indicators

The practical issues one needs to consider in order to identify a manageable number of indicators should address some general aspects (e.g. stakeholders, clarity and accuracy) and specific items related to energy and environmental aspects (e.g. energy demand and consumption, emissions).

Stakeholders

Different indicators can support the diverse needs and priorities of public authorities, policy makers and other public and private technical stakeholders (e.g. urban planners, investors, SMEs, grant managers, owners, construction companies, solutions providers, users), in their efforts to assess and improve the overall environmental, social and economic performance of buildings. The clarity of the indicators is critical, in order to properly support the decision making process of specific stakeholders, without demanding elaborate training for using them and being able to readily adopt them.

Clarity & Accuracy

Effective indicators should be based on scientifically and robust calculations that provide clear results that can be easily communicated and understood by the stakeholders. Simplicity and reproducibility should not conflict with accuracy. Input uncertainties that may result from increased complexity to determine the necessary data from which they are derived, require time consuming data collection processes or very complicated simulations, will impose unnecessary burdens and may limit the applicability of the indicators.

Primary vs Final Energy Consumption & Emissions

The primary energy, i.e. the source energy that has not been subjected to any conversion or transformation process (e.g. power plant), is used to produce the energy delivered to the building (e.g. electrical energy). Most European and national approaches consider primary (source) instead of final (site) energy consumption. For natural gas and oil, the multiplier to obtain the primary energy is about 5% and 10% higher, respectively. However, for electricity generated from conventional power plants, depending on the MED area this may be about three times higher. From a resource depletion point of view, it is necessary to evaluate the primary energy. However, from an occupant's or owner's perspective, the final energy use is directly related to the operating costs of the building. Final energy consumption is usually retrieved from energy bills and utilities for existing buildings or estimated using appropriate calculation tools.

Energy consumption may be normalized, for example, per unit floor area, unit volume or weather conditions (e.g. using heating- or cooling-degree days) and may even be expressed for different end-uses at either the building scale and/or neighbourhood scale (e.g. for heating or cooling). The definition of the reference floor area (e.g. gross floor area, heated floor area, useful floor area) using internal or external dimensions, should be carefully specified. Energy use per inhabitant is commonly used for comparison at large (national) level.

The use of primary energy is necessary for calculating the environmental impact and CO2 emissions. Environmental emissions are expressed in CO2 emissions (or equivalent) in kg per unit floor area of the building and depend on the specific primary fuel. National or even regional conversion factors for calculating the primary energy consumption from calculated or measured final energy consumption depends on the fuel and the fuel mix for generating electricity. Comparing CO2 emissions one may optimize the selection of different equipment that use different fuels.

Total vs Specific end-uses Energy Consumption

Due to the climate characteristics of the Mediterranean region, cooling energy is of special interest for the scope of CESBA MED. Lighting and plug loads can also be of significant importance in commercial and public buildings. Depending on the specific end-uses (e.g. heating, cooling, ventilation, lighting, etc) and the use of different energy carriers, it is important to consider both total and the breakdown of specific energy use.

Embodied energy (EE) in building materials, equipment and systems, is attracting more attention as buildings' energy consumption continues to decrease as a result of strict regulations, codes, building practices and market advances. It is important for new building constructions or other public works to select materials and equipment with low EE. For building refurbishments one needs to also account for the EE of any materials or equipment that are removed, in addition to the new ones. However, there are several obstacles to consider in order to easily handle this type of analysis, given that there is limited availability of local (national) tools and databases.

The CESBA MED indicators cover the following:

- All issues (Economic, Environmental, Social) and main sustainability aspects, with an emphasis on environmental-energy related issues
- Both scales: Building (B) and Neighbourhood (N)
- Different stakeholders

They taking into account the following:

- Frequency of use in the existing projects considered during this work (i.e. how frequently used are the indicators)

They comply with the following requirements

- Operational: calculate the indicators on the basis of easily accessible open data and information from existing databases;
- Affordable: calculate the indicator through a cost and time effective process;
- Practical: support decision making processes for the sustainability improvement of public buildings and urban areas;
- Suitable: support certification processes at building and urban scale;
- Relevant: for the Mediterranean context.

The two sets of CESBA MED indicators at Building Scale & Neighbourhood (urban) Scale are defined with the intent to be used in assessment activities for the:

- Evaluation of the actual level of sustainability of urban areas and public buildings;
- Identification of the most cost-effective retrofit scenario for sustainable urban areas and public buildings;
- Evaluation of alternative design options for new sustainable urban developments and public buildings;
- Development of target-based action plans for sustainable public buildings;
- Sustainability certification of public buildings and urban areas.

Eventually one needs to consider a realistic number of indicators. This is critical in order to secure the practical aspects during implementation, e.g. time constraints, complexity and relevant accuracy for collecting the main input data, etc. This is the trend and current practice within several projects, e.g. ENERBUILD includes 16 KPIs, similar with NewTREND that includes 16 core KPIs, while FADUSIR includes 20 KPIs for building and district level.

Building Scale Indicators

(listed in alphabetical order)

ENVIRONMENTAL (ENV) ISSUE			
Category	Criterion	Indicator (units)	
Biodiversity	Building site	1	Ecological quality of the building site (-)
	Public spaces	3	Change in ecological value of the site, species (-)
Energy	Building vertical transportation	1	Escalators and moving walks design and efficiency (-)
		2	Lift design and efficiency (-)
		3	Stairs and ramps planning (-)
	Embodied energy	4	Embodied energy demand (kWh/m²)
	Final energy	5	Annual heat generation for space heating and DHW (kWh/m²)
		6	Cooling demand (kWh/m²)
		7	Delivered energy demand (kWh/m²)
		9	Heating demand (kWh/m²)
		10	Peak energy demand
	Primary energy	11	Abiotic Depletion Potential (kWh/m²)
		12	Consumption of non-renewable primary energy (kWh/m²)
		13	Operational primary energy (kWh/m²)
		18	Total primary energy demand (kWh/m²)
	Renewables	20	Renewable energy on site (%)
		21	Share of renewable primary energy in total primary energy demand (kWh/m²)
		22	PV-power plant (kWh/a)
Impacts	Eco-mobility	1	Eco-mobility potential of a building in its context (km/unit)
	Emissions	3	Acidification potential ($kgSO_2$-eq/m²)
		5	Annual CO2 emissions ($kgCO_2$/m²)
		6	CO2 emission factor heat supply (kg/kWh)
		8	Eutrophication potential ($kgPO_4$-eq/m²yr)
		9 11	Global Warming Potential ($kgCO_2$-eq/m² yr) (kWh/m²)
		13	Ozone depletion potential (kgR11-eq/m²yr)
		14	Photochemical Ozone creation potential (kgC_2H_4-eq/m²yr)
	Raw materials	24	Abiotic Depletion Potential elements (kgSB-eq/m²yr)
	Solid waste management	26	Accessibility to waste sorting facilities (%)
		27	Composting (-)
		28	Construction and demolition waste generation (kg/m²)
		29	Recyclable waste storage (m²)
	Water pollution	30	Water pollution due to material leaching (mg/m² yr)
Land Use	Preservation	2	Preservation of land (%)
	Soil sealing	4	Permeability of site / land (%)
Materials	ECO materials	1	Low-pollutant and low-emission materials (-)
	Emissions	2	Building materials and construction, OI3 index (-)
Water	Embodied water	1	Embodied water use (m³/m²)
	Freshwater	3	Operational water use (m³)
	Total water use	10	Operational water use and waste water (m³)
	Wastewater	15	Wastewater management (m³/m²)
		16	Water consumption & use of rainwater (-)

ECONOMIC (ECO) ISSUE			
Category	Criterion	Indicator (units)	
Investment Costs	Capital cost	1	Additional costs for energy efficiency and sustainability (€)
		2	Investment costs (€/m²)
	Performance	5	Return on investment (%)
Life cycle Costs	Benchmarking & Targeting	1	Verifiable sustainable targets
	Cost benefit	2	Cost benefit analysis focused on sustainability
	Energy cost	3	Operational energy costs (€/m²)
		4	Operational energy costs aggregated (€)
	Total cost	6	Cost in operational phase (€)
		7 8	Life cycle costs (-) (€)
Management	Building operation	1	Communication and information management (%)
		2	Information and participation of users
		4	User information (-)
Quality	Benchmarking & Targeting	3	Setting verifiable environmental targets (-)
	Building energy performance	4	Energy optimization during planning (-)
	Cultural heritage	5	Monument or monumental value / Historical value (-)
	Process & Planning	6	Building works quality control
		12	Process and planning quality (-)
	Risk management	15	Long term stability of value (€)

SOCIAL (SOC) ISSUE			
Category	Criterion	Indicator (units)	
Accessibility	Flexibility	3	Flexibility of residential buildings (%)
Acoustic Comfort	Noise - Indoor	1	Indoor A-weighted sound pressure level (dBA)
		2	Weighted sound pressure from ventilation (dBA)
Air Quality	Indoor air quality	1	Concentration of pollutants (μg/m³)
Thermal Comfort	Indoor conditions	1	Predicted Mean Vote (-)
		2	Predicted Percentage Dissatisfied (%)
		3	Thermal comfort in summer (-)
	Outdoor conditions	7	Microclimate Index I (-)
Transport	Mobility & Alternative transportation	9	Shared mobility (%)
	Parking facilities	13	Bicycle Parking (%)
	Public transportation	17	Accessibility of public transport, stops and frequency (-)
		18	Accessibility to public transport, Lense index (-)
Visual Comfort	Artificial lighting	1	Illuminance (lx)
	Daylighting	2	Daylight factor (%)

Figure 19: Building Scale Indicators

Neighbourhood (urban) Scale Indicators

(listed in alphabetical order)

ECONOMIC (ECO) ISSUE

Category	Criterion		Indicator (units)
Equity	Housing value	1	Affordability of housing property (m^2)
		2	Affordability of housing rental (%)
	Local economy	3	Support to local economy (%)
	Prevention of prejudice	4	Prevention of prejudice
	Social & Economic cohesion	5	Future evolution and modularity
		6	Gentrification index (-)
		7	Labor force participation (%)
		8	Potential Employment (%)
		9	Social housing ratio (%)
		10	Social mixing and solidarity based economy
		11	Unemployment rate (%)
Investment Costs	Capital cost	1	Additional costs for energy efficiency and sustainability (€)
		2	Investment costs (€/m^2)
		3	Investment costs aggregated (€)
		4	Participation of local authority in the total investment cost (%)
	Performance	5	Return on investment (%)
Life cycle Costs	Benchmarking & Targeting	1	Verifiable sustainable targets
	Cost benefit	2	Cost benefit analysis focused on sustainability
	Energy cost	3	Operational energy costs (€/m^2)
		4	Operational energy costs aggregated (€)
	Non- Energy cost	5	Operational non-energy costs aggregated (€)
	Total cost	6	Cost in operational phase (€)
		9	Life cycle costs aggregated (€)
Management	Building operation	1	Communication and information management (%)
		2	Information and participation of users
		3	Synergy management (-)
	Social & Economic cohesion	5	Environmental activities in primary school (%)
Quality	Architectural	1	Aesthetic quality (-)
		2	Enhance architectural, cultural and landscape patrimony (yes/no)
	Cultural heritage	5	Monument or monumental value / Historical value (-)
	Process & Planning	7	Community management (yes/no)
		8	Community planning (yes/no)
		9	Finalising the design phase (yes/no)
		10	Integrated design in the planning process (-)
		11	Internal project management (yes/no)
		12	Process and planning quality (-)
		13	Project management (yes/no)
		14	Working with skilled professionals (yes/no)
	Risk management	15	Long term stability of value (€)
		16	Risk management (-)
	Territorial management & Urban design	17	Urban complexity, Shannon-Wiener index (-)
Value	Flexibility & Adaptability	1	Flexibility and adaptability, during the life of the project (yes/no)
		2	Flexibility and adaptability, programming (yes/no)
	Process & Planning	3	Assessing the current situation (yes/no)
		4	Competent professional team
		5	Economic advantage of cluster in comparison to single buildings (-)
		6	Equipment and services pooling
	Social & Economic cohesion	7	Tourist frequency trends, seasonality overnight stays (%)
		8	Tourist frequency trends, seasonality tourists (%)

ENVIRONMENTAL (ENV) ISSUE

Category	Criterion		Indicator (units)
Biodiversity	Land preservation	2	During programming, design and before the beginning of the works, the land is maintained through mowings, prunings, maintenance of canals and hedges (yes/no)
	Public spaces	3	Change in ecological value of the site, species (-)
		4	Connectivity of green spaces (%)
		5	Diversity (yes/no)
		6	Ecological corridors and continuity (yes/no)
		7	Use of local plants (%)
		8	Vegetal areas (%)
Energy	Embodied energy Final energy	6	Annual heat generation for space heating and DHW (kWh/m^2)
		7	Delivered energy demand (kWh/m^2)
		8	Energy consumption (Toe/inhabitant)
		10	Peak energy demand
	Primary energy	12	Consumption of non-renewable primary energy (kWh/m^2)
		13	Operational primary energy (kWh/m^2)
		14	Primary energy for cooling (%)
		15	Primary energy for heating (%)
		16	Primary energy for public lighting (%)
		17	Total primary energy demand
	Renewables	18	Renewable electricity production (%)
		19	Renewable energy on site (%)
Impacts	Eco-mobility	1	Eco-mobility potential of a building in its context (km/unit)
	Effects on surrounding buildings	2	Impacts on surrounding buildings (%)
	Emissions	3	Acidification potential ($kgSO_2$-eq/m^2)
		4	Acidifying emissions, intensity (%)
		5	Annual CO2 emissions ($kgCO_2/m^2$)
		6	CO2 emission factor heat supply (kg/kWh)
		7	CO2 emissions (tonnes CO_2-eq/yr)
		8	Eutrophication potential ($kgPO_4$-eq/m^2yr)
		9 10 11	Global Warming Potential ($kgCO_2$-eq/m^2 yr) (-) (kWh/m^2)
		12	Intensity of GHG emissions (%)
		13	Ozone depletion potential (kgR11-eq/m^2yr)
		14	Photochemical Ozone creation potential (kgC_2H_4-eq/m^2yr)
		15	Photo-oxidants emissions, intensity (%)
	Light pollution	16	Light on properties (lx)
		17 18	Light pollution (-, %)
		19	Luminaire intensity (cd)
		20	Luminance (cd/m^2)
		21	Upward Light
	Outdoor conditions	22	Monitoring of air quality (%)
		23	Thermal comfort of outdoor areas (%)
	Raw materials	24	Abiotic Depletion Potential elements (kgSB-eq/m^2yr)
	Solid waste management	25	Accessibility to differentiated waste collection (%)
		26	Accessibility to waste sorting facilities (%)
		28	Construction and demolition waste generation (kg/m^2)
	Water pollution	30	Water pollution due to material leaching (mg/m^2 yr)
Land Use	Preservation	1	Conservation of built environment (%)
		2	Preservation of land (%)
	Quality	3	Site quality (-)
	Soil sealing	4	Permeability of site / land (%)
	Spatial planning	5	Change of land use (-)
		6	Imperviousness change, imperviousness coefficient (-)
	Urban design	7	Green zones & recreation areas (m^2/inhabitant)
		8	Green zones & recreation areas density (%)
		9	Green zones & recreation areas proximity (%)
		10	Outdoor space (-)
		11	Population density (inhabitants/ha)
		12 13	Urban compactness (dwelling/m^2) (m^2/m^2)
		14	Urban context (-)
		15	Urban conversion (%)
Materials	Emissions	2	Building materials and construction, OI3 index (-)
Water	Embodied water	1	Embodied water use (m^3/m^2)
	Freshwater	2	Intensity of water treatment (%)
		3	Operational water use (m^3)
		4	Water consumption (l/inhabitant day)
	Rainwater	5	Dedicated network (yes/no)
		6	Intensity of rainwater usage (%)
		7	Landscaped and accessible retention ponds and ditches (yes/no)
		8	Rainwater collection from roofs (%)
		9	Respecting streaming continuity (yes/no)
	Total water use	10	Operational water use and waste water (m^3)
	Wastewater	11	Intensity of wastewater treatment (%)
		12 13	Waste management & removal (l/inhabitant day) (%)
		14 15	Wastewater management (%) (m^3/m^2)

SOCIAL (SOC) ISSUE

Category	Criterion		Indicator (units)
Accessibility	Broadband communication network	1	Access to a broadband communication network, areas (%)
		2	Access to a broadband communication network, population (%)
	Flexibility	3	Flexibility of residential buildings (%)
		4	Flexibility use (%)
	Public space planning	5	Access to parks and open spaces (-)
		6	Adaptation to users practices (yes/no)
		7 8	Availability of green spaces (%, m^2/inhabitant)
		9	Barrier-Free accessibility of the district (-)
		10	Community gardens (yes/no)
		11	Parks and vegetated spaces network (yes/no)
		12	Public space quality (yes/no)
		13	Shared community spaces (yes/no)
	Services & Leisure facilities	14	Access to services and facilities (%)
		15	Collective facilities and outsourcing of services (%)
		16	Community support (yes/no)
		17	Proximity to leisure facilities (%)
		18	Proximity to services (%)
		19	Proximity to services and leisure facilities (%)
		20	Social gatherings and common cluster activities (-)
	Street network	21	Cyclomatic complexity of the street network (-)
	Urban planning	22	Development and integration of land parcels (%)
		23	Homogeneity of the urban fabric (%)
Acoustic Comfort	Noise - Indoor	1	Indoor A-weighted sound pressure level (dBA)
	Noise - Outdoor	3	Building area over noise limit (%)
		4	Noise pollution, silence quality – day (%)
		5	Noise pollution, silence quality – night (%)
	Noise pollution management	6	Acoustics studies (yes/no)
Air Quality	Indoor air quality	1	Concentration of pollutants (μg/m^3)
	Outdoor air quality	2	Number of days with bad air quality (days/yr)
Safety & Security	Energy & Management systems	1	Objective/subjective safety measures (-)
	Green production	2	Local production of food (m^2/inhabitant)
	Mobility	3	Pedestrian safety paths (%)
Thermal Comfort	Indoor conditions	1	Predicted Mean Vote (-)
		2	Predicted Percentage Dissatisfied (%)
	Outdoor conditions	4	Exploitation of local resources: sun, daylight, wind (-)
		5 6	Heat island effect (-) (yes/no)
		7	Microclimate Index I (-)
Transport	Mobility & Alternative transportation	1	Availability of safe bicycle routes (m)
		2	Bicycle and pedestrian network quality (-)
		3	Bicycle facilities (-)
		4	Car sharing pool/station (yes/no)
		5	Contiguity of bicycle and car routes (%)
		6	Pedestrian streets and walkways, area (%)
		7	Pedestrian streets and walkways, length (%)
		8	Proximity to bicycle lanes and paths (%)
		9	Shared mobility (%)
	Parking facilities	10	Parking facilities (number/dwelling)
		11	Parking facilities, Off-street parking spaces (%)
		12	Parking places with innovative features (%)
	Public transportation	14	Access to public transport nodes, areas (%)
		15	Access to public transport nodes, population (%)
		16	Access to public transport, District Accessibility Index (-)
		18	Accessibility to public transport, Lense index (-)
		19	Dwellings with access to public transport (%)
	Street network	20	Connectivity of the street network (number/m^2)
		21	Cul-de-sac roads and path ratio (%)
		22	Scale of the street network (m)
		23	Traffic modal split (%)
Visual Comfort	Artificial lighting	1	Illuminance (lx)
	Daylighting	2	Daylight factor (%)

Figure 20: Neighbourhood (Urban) scale inidcators.

4.2.8 SBTool Multi-Criteria Assessment

The CESBA MED Generic Framework for Sustainable Neighborhoods is based on the "SBEMethod" (Sustainable Built Environment Method) developed by iiSBE (international initiative for a Sustainable Built Environment). The SBEMethod is a generic multi-criteria analysis methodology for assessing the sustainability of the built environment. Starting from a set of assessment entries (criteria), the SBEMethod provides a final concise score about a building, urban area or territory overall performance. The SBEMethod [Moro 2017] constitutes the reference assessment methodology for the CESBA MED SN Generic Framework.

The SBEMethod [Moro, 2017] is organized in:

- Issues (describe general themes for sustainability assessment)
- Categories (address particular aspects of issues)
- Criteria (detail specific aspects of categories).

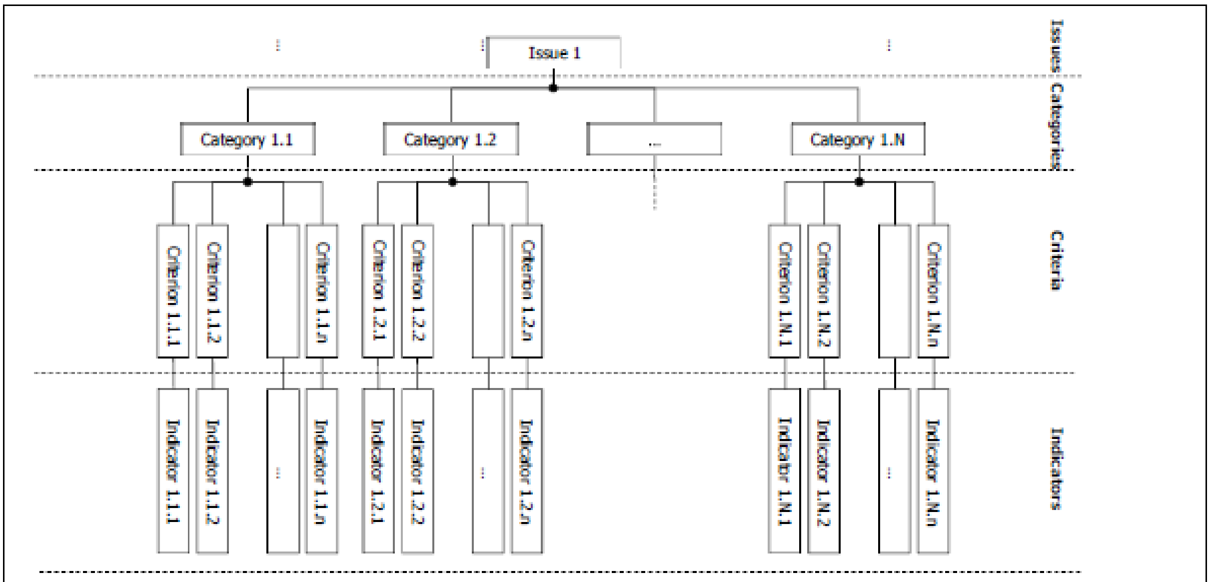


Figure 21: CESBA MED Tool: Issues, Categories, Criteria – Indictaors.

Each issue includes a different number of categories, each one of them describing a specific aspect of the issue that it belongs to. Categories include different criteria, each of them describing a particular aspect of the corresponding category. Criteria represent the basic assessment entries used to characterize an urban area from the very beginning of the assessment process. The indicators quantify the performance with respect to each criterion. In principle, several indicators can be associated with the same criterion, since one can define multiple strategies to quantify the urban area performance with regard to a specific criterion.

However, in most cases, each criterion is generally associated with a single indicator. A final concise score summarizes the overall performance of an urban area with respect to all criteria. The score is computed starting from indicator values following an assessment procedure that is based on three main steps, i.e. characterization, normalization and aggregation step. The relevant procedures are detailed in this report [Moro A; 2017].

5 CESBA Med Assessment Method

The Common European Sustainable Built Environment Assessment for Mediterranean cities (CESBA MED) was a collaborative effort of several European organizations from seven countries. The work is structured around the UN 17 SDGs, aiming to support users and their efforts towards a sustainable future. The initial concept of the assessment method and tool was a reference decision-making process that was originally developed for the building scale[11] [iiSBE, 2019] and then extended at neighbourhood scale. The following sections outline and briefly discuss the process for converging on the number and type of sustainability indicators that are considered in the method, the normalization and scoring process, the development of the generic framework, and the national tools.[12]

5.1 Sustainability Indicators and Key Performance Indicators (KPIs)

The approach taken in this work was to first develop a generic framework that includes an "exhaustive" list of sustainability indicators that cover all relevant themes, given that there is still no consensus on a specific number or types of indicators. This way one can have access to a comprehensive database that includes different performance indicators from which to select the ones that meet local priorities and needs, or best fit the project intent. A minimum number of key performance indicators are defined and used in order to ensure that the core sustainability issues can be addressed in a satisfactory manner.

Accordingly, the first step was to critically review 14 transnational European projects and public assessment systems, in order to derive a representative list of indicators at building and neighbourhood scales that address the main sustainability pillars [Balaras, 2017]. A total of 216 indicators were identified, critically reviewed and finally grouped under the main sustainability issues. (*Refer to Sections 2.6 and 4.2 of this report*)

The structure of the method organizes the information in Issues, Categories and Criteria-Indicators [Moro, 2017].

The "Issues" identify the general themes that are essential for assessing the sustainability at building and neighbourhood (urban) scales. The sustainability Issues for the building scale include: A-Site and infrastructures, B-Energy and resources, C-Environment, D-Indoor Environmental Quality (IEQ), E-Service quality, F-Social, cultural and perceptual aspects and G-Economy. The seven sustainability Issues for the neighbourhood scale include: A-Urban systems, B-Economy, C-Energy, D-Emissions, E-Natural resources, F-Environment and G-Social aspects.

The "Categories" under each Issue describe its specific aspects that group relevant Criteria and Indicators. Each Issue includes a different number of Categories. The building scale includes 25 Categories. For example, under the issue "IEQ" there are four categories: Indoor

[11] www.iisbe.org

[12] CESBA Med Sustainable Mediterranean Cities; https://cesba-med.interreg-med.eu/

air quality and ventilation, Air temperature and relevant humidity, Daylight and illumination and Noise and acoustics. The neighbourhood scale includes 23 Categories. For example, the issue “Energy” includes two categories: Non-renewable energy sources, and Renewable and clean energy sources. The “Criteria” detail the specific aspects of a Category and represent the main assessment entries used to characterize a building or an urban area. The “Indicators” quantify the performance with respect to each criterion. In principle, several indicators can be associated with the same criterion, since one can define multiple strategies to quantify the building or urban area performance with regard to a specific criterion. For example, building energy use intensity (EUI) can be expressed as kWh/m2 or kWh/m3 and in some cases energy use per employee (e.g., for an office building) or energy per bed (for hotels), depending on the characteristic functions of a building. For simplicity in this work, only one indicator is associated with each criterion. The metrics are used to quantify the performance and determine how well the sustainability objectives are achieved. The tools is therefore based on sustainability Issues, Categories and Indicators for building scale [Moro, 2019] and neighbourhood scale [Moro, 2019]. Different numbers of criteria-indicators are included under a given category, each one of them describing a particular aspect of the corresponding category. For example, at the neighbourhood scale, Category ‘C.2 Renewable and clean energy’ includes fourteen Indicators, e.g., share of on-site renewables on total final or primary energy consumption for residential or non-residential buildings, share of electricity production from renewables on public or private property, total electricity from renewables that is exported from the area, total electricity from renewables used in or exported from the area, share of thermal energy from renewables on public or private property, etc. Some indicators may appear under both scales (e.g., energy use at the building scale and for all buildings in the area at the neighbourhood scale). For example, at the building scale under the Issue ‘B. Energy and Resources’, the Category ‘B.1 Life Cycle Non-Renewable Energy’ includes the Criterion ‘B.1.2 Final Thermal Energy Use’ and ‘B.1.3 Final Electrical Energy Use’.

Aggregating the relevant information for all the buildings in the area, one can derive the equivalent indicators at the neighbourhood scale (i.e., B.1.1 for each building and C.1.1 for all buildings in the area). Sometimes qualitative criteria are used instead of quantitative ones. In this case, the expert’s assessment is based on the prescribed reference descriptions in order to assess and score the specific performance. For example, at the building scale under Issue ‘F. Social, Cultural, Perceptual’, Category ‘F.2 Culture and Heritage’ that includes Criterion ‘F.2.1 Compatibility of urban design with local cultural values’ is qualitatively assessed with an indicator of whether the architectural design features related to the urban design are incompatible, marginally- or fully-compatible. Similarly, at the neighbourhood scale, under Issue ‘G. Social Aspects’, Category ‘G.6 Management and Community Involvement’ the Criterion ‘G.6.3 Community involvement in urban planning activities’ is qualitatively assessed with an indicator that reflects different levels of citizens’ engagement in the planning process, from a non-participatory process (to reflect performance below standard) to full co-decision with delegated citizen power (to reflect an ideal performance).

A limited number of key performance indicators (KPIs) were selected from the various indicators as mandatory minimum requirements in order to be able to address the main sustainability issues, which are also identified in the Tool. For example, one commonly accepted metric to measure a building’s energy use performance is the energy use intensity

(EUI in kWh/m2), which can be used to benchmark against similar buildings or with best-practices and assess energy efficiency measures within buildings. The KPIs are defined and calculated following common standardized procedures. This work considered most of the LEVEL(s) indicators in the process of selecting the KPIs for the building scale. The results from the normative KPI calculations can then be used as a passport for comparing different buildings, areas, regions or countries, on a common basis. The organization of the sustainability issues, the selection of the most applicable criteria, performance indicators and KPIs followed an iterative process at various stages of the work. The first step was to review, analyse and organize the knowhow generated from 14 EU projects and systems [Balaras, 2017] and the work in the new LEVEL(s) indicators [Dodd, 2017]. Each national team of the CESBA MED partnership including the University of Malta team engaged and collaborated with local committee experts in six EU countries to elaborate the issues and indicators, in order to ensure that they are representative and cover national needs and priorities in local context.

In order to reach a wider consensus, the work progress on the performance indicators and the proposed KPIs were also reviewed and elaborated with other European experts and project representatives during two sprint workshops organised in Austria and in Gozo, Malta[13]. The final list of the KPIs for building and neighbourhood scale was fixed following the nine national pilot tests performed by the partners in six EU countries. As a result, some KPIs were excluded due to the limited availability of the input data, e.g., quantities of building construction materials and recyclable content that have been used for existing buildings or other public works in the area, thus ensuring the applicability of the approach and the use of the indicators in the field.

5.2 Normalization and Scoring

All sustainability assessment and rating systems use a normalization process in order to convert the indicator values into a common basis (scale). The various indicators are diverse in nature, have numerical values with different orders of magnitude and correspond to physical quantities with different units or in some cases include qualitative scores. The normalized scores of the individual indicator values are then aggregated using different weights to calculate a score for the correspondingcategories and issues, and finally a total sustainability score for a building or a neighbourhood.

5.2.1 Indicator Scores

Each indicator value is a dimensionalized and rescaled value (Figure 3) in an interval from −1 (performance below standard) to 5 (advanced performance) [Moro, 2017], following a similar concept with Protocollo ITACA [ITACA, 2019]. For example, the score value at "0" corresponds to the minimum acceptable performance of an indicator in compliance with minimum standard regulation mandates defined by law (e.g., an EUI for new buildings or the percentage

[13] 5th CESBA Sprint Workshop, Gozo Malta 2018: https://www.youtube.com/watch?v=xAh3nUCAR6Y

use of renewables), or the value of current practice in case of no regulations of employment, length of pedestrian and bicycle paths). The score value at “+5” corresponds to excellence or ideal performance (e.g., an EUI for a nearly zero energy building, or very-high employment rate for the residents in a neighbourhood). Values of indicators below minimum standards or current practice are assigned to a score of “-1”. indicator values are then aggregated using different weights to calculate a score for the corresponding categories and issues, and finally a total sustainability score for a building or a neighbourhood.

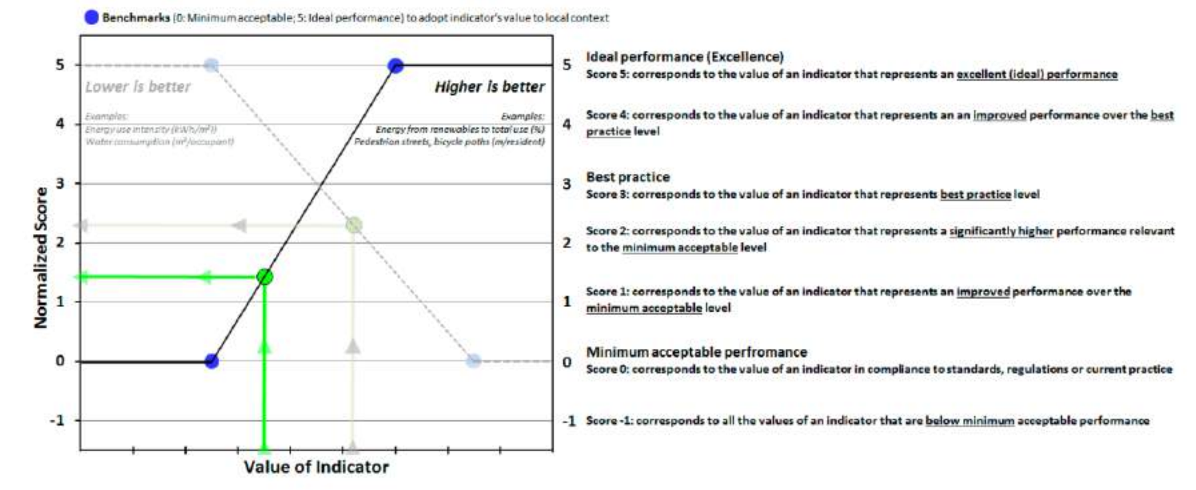


Figure 22: Normalizing and scoring process. For an indicator following the principle “higher is better,” the linear correlation is illustrated with the black solid line, while the principle “lower is better” is illustrated with the grey dashed line.

For simplicity, individual scores are defined by linear interpolation between the two limits (i.e., “0” and “+5”). For each indicator, the numerical values at the two limits are adapted to the local context by using appropriate national, regional or local benchmarks. For some indicators, higher performance corresponds to a higher normalized score, following the principle that “higher is better”, thus the slope of the linear correlation (from 0 to +5) is positive (e.g., the percentage use of renewables, the length of pedestrian and bicycle paths in a neighbourhood). In this case, a higher value of the indicator corresponds to higher performance and thus it receives a higher normalized score. For others, the normalized score follows the principle that “lower is better” (e.g., a low EUI for buildings or low water consumption), thus the linear correlation (from 0 to +5) has a negative slope. In this case, a lower value of the indicator corresponds to higher performance and thus it receives a higher normalized score. The national and local benchmarks for each indicator have been predefined at the appropriate values for (ideal) excellent practice (corresponding to “+5” in the normalized score), the minimum acceptable performance (corresponding to “0”) and below standard (corresponding to “1”). These values are already included in the national and local versions of the method (see Section 3.1). If necessary, the user can adjust them according to the local characteristics (e.g., energy use intensities for the local buildings, water consumption in the area, etc.).

5.2.2 Sustainability Score

The calculations for the sustainability score are weighted in terms of the regional, local or project priorities. The weighting factors are properly estimated values that reflect the relative importance of characteristics compared to others. This way, the user has an opportunity to place the desirable emphasis on specific sustainability issues and performance indicators, to reflect regional variations and add local context. The weighted score of each Indicator is calculated by using different multiplicative factors to adapt its normalized score (see Section 5.2.1 above) as illustrated in Figure 23a. The following discussion reviews the various weighting factors that are taken into account, at different stages of the calculations, starting at the overarching level of the sustainability Issues and then at the more detailed level for addressing the characteristics of each indicator.

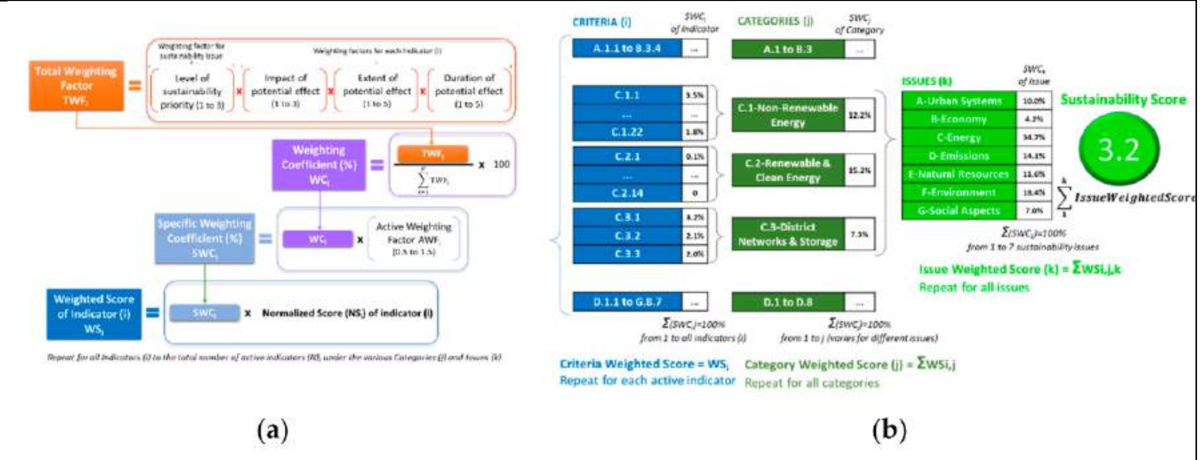


Figure 23: Overview of the calculation processes at the neighbourhood scale for the: (a) Indicator's (i) weighted score; (b) weighting allocation and aggregation of scores for Criteria, Categories, Issues and sustainability score. For illustration purposes, the active indicators are identified with a numerical value, while for the inactive indicators (not selected), the specific weighting coefficients are shown as 0.

For each one of the seven sustainability Issues, it is possible to define its level of priority on a scale from 1 (less important) to 3 (most important or more relevant). For example, the level of sustainability priority for the energy issue may be set at 2 (i.e., considered of average importance if the buildings have an average energy performance and good exploitation of renewables), while the issue of emissions in an area with major environmental problems the assigned priority may be set at level 3 (i.e., considered a major issue). Beyond the mandatory KPIs, one can select an appropriate number of active indicators that best fit the local needs and project-specific priorities under each Category and Issue. As a default, the weighting factors are equally distributed among the active indicators so that the weightings equal 100%. These coefficients may then be adjusted to place more emphasis on a specific indicator.

The total weighting factor (TWFi) for each indicator (Figure 23a) is calculated as the product of the following weighting factors that account for the:

- Level of sustainability priority for the Issue that includes the specific indicator, which is rated using a 1 to 3 points scale described above, and for each Indicator the:

- Impact of potential effect, rated using a 1 to 3 points scale, i.e., 1-minor, 2-moderate, 3-major),
- Extent of potential effect, rated using a 1 to 5 points scale depending on the spatial coverage, i.e., 1-block, 2-neighborhood, 3-district, 4-urban/region, 5-global),
- Duration of potential effect, rated using a 1 to 5 points scale, i.e., 1 for 1 to 3 years, 2 for 3 to 10 years, 3 for 10 to 30 years, 4 for 30 to 75 years, 5 for greater than 75 years).

For example, based on the above, the global warming potential indicator (C.1.3 at building scale) the Issue (C-Environment) can be weighted with 3 (i.e., the environment is considered a major issue), and assigning for the indicator a weighting factor of 3 (major impact), 5 (global potential effect) and 5 (duration >75 years). The on-site use of renewables in buildings (C.2.1 at neighbourhood scale), the Issue (C-Energy) can be weighted with 2 (i.e., energy is considered an average issue in an area where all buildings use solar collectors), and assigning for the indicator a weighting factor of 3 (major impact), 2 (neighbourhood potential effect) and 3 (duration 10 to 30 years). Since the specification of these weighting factors is not a trivial process, the national versions of the method include national default values, although a user can always adjust them. The weighting coefficient (WCi) that accounts for the relative importance of an indicator among the selected ones is calculated as a percentage of the ratio of the individual TWFi to the total for all active indicators (Figure 23). To further fine-tune the weighting coefficients, the values may be adjusted using another multiplicative factor to account for the possible importance of an indicator in the context of a specific project or its potential impact on more than one criterion, categories or even under different issues. The active weighting factor (AWF) is set at 0.5 (i.e., lowering the Indicator's weight by half) or 1.5 (i.e., increasing its weight by half). For example, the AWF for C.1.20 Energy use for public lighting can be set to 1.5 (i.e., 50% more important) because of its importance in a project not only in terms of energy savings, but also in relation to the perceived safety of public areas (G.8.3) and even aesthetics (G.8.7). Finally, the normalized score of each indicator is multiplied by the specific weighting coffcient (SWC) to obtain the weighted score (WS) of each indicator.

Overall, the process provides the ability to use different weights for adjusting each indicator (criterion), category and issue, according to local environmental, social and economic priorities and scenarios under assessment. Although altering the weighting system may be perceived as a manipulation of the results in order to improve the overall scores, the intent is to allow sufficient user flexibility for adapting the method to the local and project-specific priorities. Alternatively, to safeguard the process, the default weights can be reviewed, agreed upon and then locked by the decision-makers, before allowing third party interaction. The normalized scores associated with all active indicators (criteria) in the same category, e.g., are aggregated to produce a single weighted score for each category. For example, the criteria weighted scores for C.1.1 up to potentially C.1.22, C.2.1 up to C.2.14 and C.3.1 to C.3.3 at neighbourhood scale are used to obtain the category weighted scores for C.1, C.2 and C.3, shown in Figure 23b. Then, the scores for all categories in the same issue are further aggregated to produce a single weighted score for each issue (e.g., C-Energy in Figure 23b). Finally, the results from all seven issues are aggregated to produce a concise total sustainability score for the project.

5.2.3 The Generic Framework

The CESBA MED Generic Framework (GF) is the general, all-inclusive starting version of the tool that supports the assessment method with all seven issues, categories and indicators available for the building and neighbourhood scales. The total number of indicators in the GF that one can potentially select from and use is 153 for the building scale [Moro, 2019] and 178 for the neighbourhood scale [Moro, 2019]. This “exhaustive” list of performance indicators is an excellent starting point for developing national and local tools by selecting and using only the ones that are relevant according to national, local sustainability priorities and project intent. For practical purposes, one should select a manageable number of indicators from the complete list under the various issues and categories that for a given project best match the local sustainability issues, priorities and strategic policies. During the development of the national tools, this exercise was elaborated for adapting the GF Tools in six national versions and then to local context during the specific pilot projects. Always, the minimum number of indicators are the key performance indicators that were determined as a result of the iterative process for developing the CESBA MED GF that finally reached 13 KPIs for the building scale [Moro (3.4.3a), 2019], including most of the LEVEL(s) indicators, and 16 KPIs for the neighbourhood scale [Moro, (3.4.3b), 2019]. The KPIs are collected and stored in a “Passport” that constitutes a depository of common and comparable data. The two-page CESBA Passport provides some general information on the project and details the KPI values. These results enable a consistent comparison of the key information on the sustainability performance of buildings and neighbourhoods for exchanging and sharing information and good practices between different areas, cities, regions and countries. A single page CESBA Certificate is a concise single-page information sheet that captures the scores for each of the seven sustainability issues and can be used to display and communicate the overall performance.

5.2.4 The General Framework (GF) Tools

All the indicators are analytically presented in the building and neighbourhood scale GF tools. The presentation of each indicator (Figure 24) includes background information, an overview of relevant calculation steps that one must follow for KPIs (according to standards) and for others based on recommended good practices that may be adapted according to national or local practices. Supporting references and other resources are also included and the user may also write-in other relevant notes. The input is the calculated value for the corresponding indicator (e.g., the energy use intensity in kWh/m2) for the specific project. Under the assessment criteria, the tool automatically transfers the default benchmark values that correspond to the scale (-1, 0, 3, 5).

These values may be further adjusted, if necessary, in order to accommodate for some specific characteristics for a given project (e.g., adjust the energy use intensity benchmarks for historic buildings that may not strictly comply with conventional high-performance standards). Entering the numerical value of the indicator, the tool estimates a weighted score. The user may also include a target performance value for reference and comparative assessment. As an option, there is also a place holder for a third-party score that can be used during verification.

The final results (Figure 24b) summarize the performance assessment for the building or the urban area, along with insights on the importance of the different issues in the final score, number of active indicators and detailed overview of the KPIs. The specific scores for each one of the seven sustainability issues are listed and are also illustrated in a spider chart to easily understand and by identifying the sustainability issues with strong performance (scores close to 5) or the weaker ones (scores close to 0) and the total sustainability score for the project. A detailed presentation of the results for each one of the KPIs includes the corresponding target and actual value.

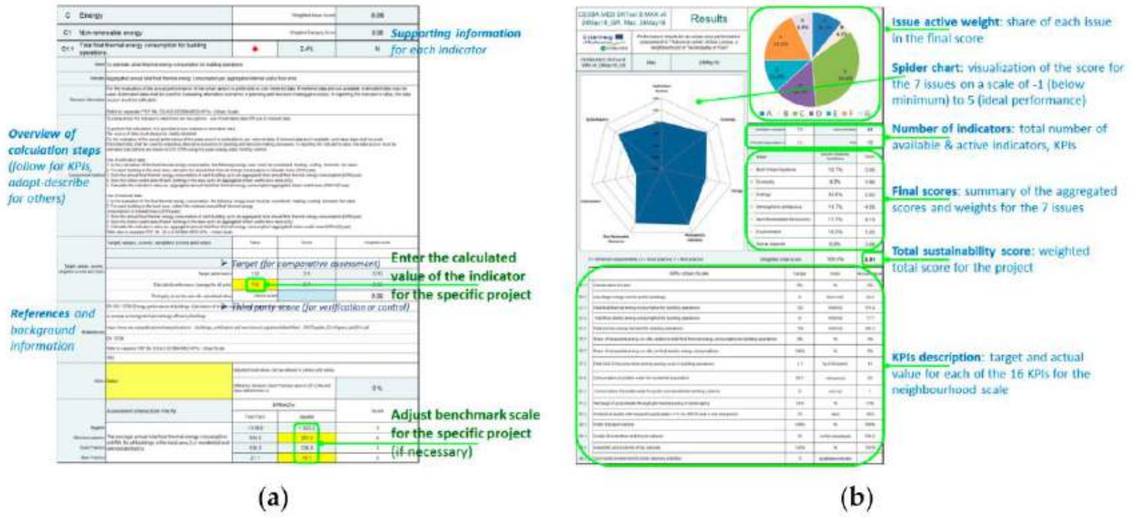


Figure 24: Excerpts from the Generic Framework (GF) tool: (a) Presentation an indicator and interface for benchmarking and scoring; (b) overview of the main final results.

5.3 The Decision-Making Process in the CESBA_Med Tool

The CESBA MED Tools are intended to support decision-makers and managers of public and municipal building stocks in the implementation of more sustainable renovation plans or the new developments, combining the building and the neighbourhood scales [Moro, 3.3.2, 2019]. The process should consider the buildings in their urban environment and look for synergies between groups of buildings in the area in order to optimize energy planning in the context of a sustainability performance assessment. The CESBA MED method and tools (Figure 6) can support all project phases. Instrumental in the whole process is the engagement of the people. Urban developments affect a wider community of citizens, workers, commuters, visitors, etc. Therefore, it is essential that all affected parties, including residents and businesses, are actively involved in all stages of the process, from the early diagnosis, for shaping the developments that affect them. Empowering local communities through regular and meaningful consultations and engagement, improves transparency through more open governance and greater public participation of citizens and other local stakeholders and helps reach greater public acceptance through a sense of ownership. Assessing the actual performance at the current state takes a snapshot of the existing condition and characteristics, and identifies the critical sustainability issues. Accordingly, one can assess the potential performance resulting from the implementation of different renovation scenarios in order to identify the most cost-effective and sustainable one. Similarly, for new developments, it is possible to assess the potential performance of alternative planning options in order to identify the most cost-effective sustainable development scenario. In both cases, after implementation, it is possible to monitor and evaluate the progress at different stages, the effectiveness of implemented actions and the achievement of the sustainability performance targets.

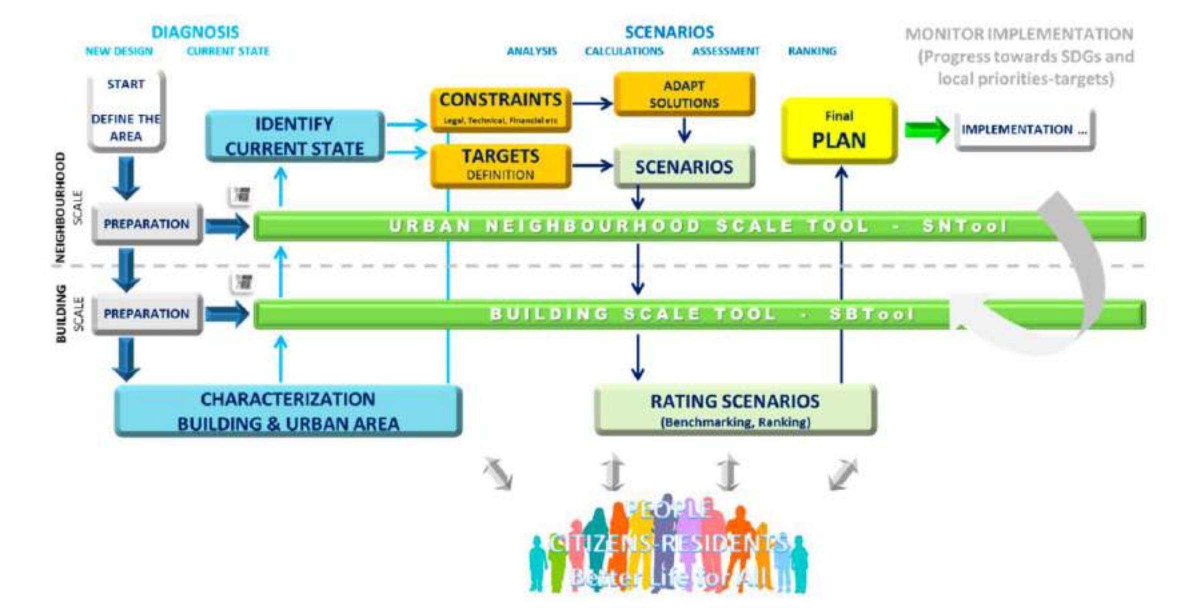


Figure 25: Schematic of the main stages and overall decision-making process

5.3.1 Assessing the Tool

The first step is to define the physical boundaries and decide which of the surrounding infrastructures are relevant. The physical boundaries of the urban area may be derived considering the spatial coverage along with the legal and administrative lines, the property ownership status and land use, the social and economic characteristics of the area, the period of building construction and the energy supply infrastructure, etc. The neighbourhood of a small urban scale area (e.g., block/cluster of buildings) may include 5–15 buildings with a traditional composition extending over 200–400 m in size that can be crossed in 10–15 min walk, with 200–1500 inhabitants. During the preparation phase, the appropriate input data is collected in order to create a sufficient knowledge basis. Like in every audit process [14] it is essential to collect good quality data is essential, since this will have a direct impact on the overall quality of the process and it is critical for securing accurate and realistic final results for quantifying the respective indicators. Sometimes specific characteristics cannot be determined or measured in a practical way with an acceptable cost, at least for routine audits, while even the perception of building or neighbourhood characteristics can deviate significantly from one assessor to the other. Accordingly, it is crucial to find the right level of simplification so that the audit and data processing is time-efficient while obtaining results that are close to the most detailed analysis as possible. Accessibility to reliable data and information is indispensable to adequately assess the sustainability performance of the urban environment. This will allow the adoption of good monitoring practices, resulting in better policy formulation and implementation. In general, data acquisition may be time-consuming.

Information may be scattered among different administrative bodies of the municipalities and other organizations (e.g., building authorities, cadastral office, land surveying office) and other resources like census data, municipality and regional reports (e.g., operational programs), existing energy performance certificates, energy supply companies, along with publicly accessible resources (e.g., Google Earth, Open Street Map), etc. In all cases, a site visit will be necessary in order to perform field inspections of the buildings and the neighbourhood and to collect missing data or verify and extend available information.

Educated assumptions or use of default values may be needed for quantifying some indicators. However, one must consider the trade-offs between the effort involved to measure specific data; what accuracy can be reached, how much effort will be involved, how much time will be required and what is the relevance or impact on the results. With the exception of the calculations for the KPIs that follow specific normative procedures according to standards, the final decision depends on the relevant expertise and past experience of the user/assessor. In any case, one needs to be aware of the uncertainties or inaccuracies involved in a given process as a result of the assumptions that will be made or imposed by specific calculation procedures and the ways to interpret and use the results.

5.3.2 Scenarios Analysis

As a first step, the information collected during the tool assessment as outlined in Section 5.3.1 is used for a SWOT analysis. This way one can prepare more applicable scenarios that will exploit the area’s main strengths and opportunities in terms of sustainability and take corrective measures that are responsive to its weaknesses, while accounting for legal–technical–financial–environmental constraints that may limit the range of possible retrofit strategies. Legal constraints may result from building codes, mandates for improving the energy performance of buildings, and cultural heritage protection regulations. Technical constraints may limit the use of some technologies in building renovations, e.g., space availability for on-site installation of renewables on building rooftops or facades or near-by areas. Financial constraints are often the largest obstacles in renovation projects. Available funding sources must be secured early in the planning phase, taking advantage of different financing instruments.

For building renovations, one needs to consider the financial status of the building owners, as well as the tenants, in order to avoid negative social impacts like gentrification. Environmental constraints are usually related to the local climatic conditions which may not favour some technologies or the exposure of building roofs and facades to solar radiation for the proper exploitation of thermal solar or photovoltaics.

Early in the process, one must define clear and measurable targets that should be achieved by the project, covering all main aspects of sustainability, e.g., environment-energy, economy and social. The targets must be SMART, i.e., Specific (clearly defined), Measurable (quantifiable), Attainable (realistic and achievable), Relevant (for energy retrofitting of urban districts) and Time-bound (with a specific time plan of when they can be achieved). Environmental targets should consider the means to improve energy performance, reduce GHG emissions, increase the share of renewables, prioritize the use of sustainable materials, reduce soil sealing and increase open natural areas. Targets related to the economy should consider means to improve return on investment, exploit the use of different instruments for financing, maintain affordable property and value of land, secure resources to strengthen economic feasibility and secure sustainable growth and enhance local labour force participation. Social targets should avoid gentrification that may result from energy renovations, improve district surroundings (e.g., open spaces, accessibility, heat island), improve transport infrastructure and mobility, encourage community involvement and citizen's engagement in near- and long-term planning, strengthen public services and improve safety and security. The scenarios for improving the performance of a neighbourhood should consider all the buildings in the area and seek synergies and opportunities to increase energy performance by prioritizing central energy supplies and district energy systems versus individual solutions, use environmentally friendly materials, enhance open green public spaces, improve public transport and mobility and improve public infrastructures. At the building scale, the priority is to improve energy performance of public buildings, reduce energy use and emissions from non-renewables, integrate renewables (e.g., consider thermal solar for domestic hot water or combi systems, use photovoltaics with appropriate energy storage and/or smart grids), expand central energy supply (e.g., natural gas network) and increase energy efficiency by prioritizing central energy networks over individual solutions. Engaging the citizens and building occupants in the process can provide valuable input to the experts and technical teams.

Different scenarios are evaluated along the following lines:

(a) Selecting and optimizing energy renovations at a building and neighbourhood scale (i.e., reducing energy demand, increasing energy performance by prioritizing central energy supplies versus individual solutions, integrating renewables with appropriate energy storage and/or smart grids);

(b) considering other interventions for improving public transportation and mobility, enhancing green spaces, and other public infrastructures;

(c) exploiting different business models and financing instruments; and finally

(d) identifying the desirable scenario that will address the municipality's objectives and priorities.

Considering the final sustainability score for each scenario, one can select the best one that meets expectations and plans of the municipality or the public authority having jurisdiction, in-line with the local sustainability objectives and priorities, or the owner's intent (e.g., an authority that manages public buildings). The results can be easily communicated to the decision-makers to document the current state, summarise the proposed strategies of the final plan and illustrate the anticipated improved sustainability performance. Once a decision is taken to proceed with implementation, the concept will have to be elaborated in more detail including a cost–benefit analysis, exploit different business models and financing instruments, issue tenders and conclude with a contract. Following implementation, the local tools are ready to be used to assess whether the goals and objectives have been met, document actual progress for improving sustainability and monitor progress towards the performance targets. The results should be properly publicized and communicated so that they gain visibility and acceptance.

6 Results and Discussion: The Testing of the CESBA Med Tool on Pilot Projects

6.1 Sustainability Assessment of Buildings and Spaces – Urban area

In the Market research section reference is made to a new approach, whereby the building scale and urban scale are both analysed through sustainability assessment tool; a tool which are based on key performance indicators and Indicators organised in groups, a tool which is sensitive to the Mediterranean context. CESBA stands for Common European Sustainable Building Assessment and has the objective of creating a common platform with common attributes presented through KPIs which enable comparison and understanding in principle across territories.

6.1.1 CESBA MED – For Sustainable MED Cities

CESBA is a collective European bottom-up initiative that provides knowledge on harmonised built environment assessment. CESBA‘s mission is to facilitate diffusion and adoption of sustainable built environment principles through the use of harmonized assessment systems in the whole life cycle of the built environment. Therefore CESBA wants to be Europe's leading organization for the harmonization of existing and future built environment assessment systems.

The 9 CESBA principles:

- The User First!
- Sustainability
- Regional Contextualizaion
- Comparability
- Mass-oriented
- Simple to use
- Open source
- Co-creaion
- Transparency

CESBA MED promotes a neighbourhood level approach to develop synergies in energy efficiency. CESBA MED: 3.2 Mio Euro total project budget, 36 month project duration, Nov 2016 - Oct 2019, 2.7 Mio Euro ERDF co-financing rate.

6.1.2 Project summary

Energy efficiency improvement is a key strategy to reduce the environmental impact of public buildings. Energy efficient measures and their implementation at neighbourhood level (i.e. district heating, PV installations, etc.) are showing clearly that a building scale approach is not optimal in reaching significant and cost-effective improvements. Groups of buildings offer remarkable potentials for synergies. However, at neighbourhood scale, decision making processes and the design of the intervention are more complex. CESBA MED intends to ind the most affordable and operational solutions for the development of energy efficiency plans at neighbourhood scale.

6.1.3 Testing the pilots:

The project tested 10 previous EU projects supporting the development of energy efficiency plans for public buildings in the context of their surrounding neighbourhoods. The objevice of the test is to identify the most affordable, operational and suitable assessment criteria and method for the MED region at building and neighbourhood scale. One of the Test areas was the University of Malta - Msida Campus which was analysed using the tool based on indicators. Further to the Urban area, building s on campus were also analysed using the Building assessment tool.

The 10 previous EU projects are: CLUE (Interreg IVC), CAT MED (Interreg MED), CABEE (ASP), ASUDIR (FP7), EPISCOPE (IEE), ENERBUILD (ASP), CEC5 (Central Europe), IRH MED (Interreg MED), Open-House (FP7) and Superbuildings (FP7).

6.1.4 CESBA MED Passport:

The project develops a CESBA MED Passport for public buildings. The CESBA MED Passport will allow
comparing in absolute terms the sustainability performance of neighbourhoods in the MED area.

6.1.5 Transferring Knowledge:

- The project transfers the test results to target groups with the support of CESBA Local Project Committees (CPCs).
- A CESBA SN Toolkit (SN = Sustainable Neighbourhoods) to support the transferring activities will be prepared in 6 languages (Croatian, English, French, Greek, Italian, Spanish) and locally disseminated.
- A CESBA SN Training System and specific training programs for different users will be developed. The system will include training materials (manual, slides) and an e-learning platform. The e learning platform was developed by the University of Malta Research team.

6.1.6 EU-Project partners included the following:

- City of Torino (lead partner)
- CESBA - Common European Sustainable Built Environment Assessment (main organizer CESBA Neighborhood Award)
- Government of Catalonia (co-organizer CESBA Neighborhood Award)
- EnvirobatBDM (co-organizer CESBA Neighborhood Award)

- iiSBE ItaliaR&D srl
- Municipality of Udine
- Auvergne-Rhône-Alpes Énergie Environnement
- Municipality Sant Cugat del Vallès
- University of Malta
- Naional Observervatory Athens
- Energy Insitute Hrvoje Požar
- Urban Community of Marseille Metropolitan Province cesba-med.interreg-med.eu

6.2 CESBA Med Pilot Project - Case Studies

The CESBA MED system was used in the field during nine pilot studies in six countries (Table A3) to demonstrate its applicability in diverse applications at different building uses and urban areas (e.g., social housing, 19th century historic buildings), scales (e.g., a building block, a university campus and different size urban neighbourhoods) and project intents (e.g., renovations or new developments). In some cases, different renovation scenarios were also assessed. The pilots served two main purposes. First, working together with local experts and municipalities, the goal was to develop the national versions of the tools, by selecting a suitable number of indicators, translating the tools and incorporating representative national weights for the different sustainability issues and benchmarks for normalizing the indicator values. This way, the existing default values in the national versions of the tools are ready to be fine-tuned, to better match the local characteristics (e.g., energy use intensities for the local buildings, water consumption in the area, etc.). Second, they were used as a final test phase for verifying that the selected KPIs can be realistically used in the field.

The goal was to ensure that the input data are commonly available during the building and urban audits, so that the KPIs can be consistently calculated. The national pilots also revealed some interesting information on the most popular sustainability indicators that were selected by each national team, illustrating the emphasis and the priorities given by the participating municipalities.

6.2.1 National Tools

The GF Tools are available in English, while the nationally contextualized assessment tools are available in different languages (i.e., Catalan, Croatian, French, Greek, Italian and Spanish). The national tools include the same KPIs, but use a different number of categories, criteria and indicators (Table 4) that best fit in the national and local context and their sustainability priorities.

Table 4: Overview of the sustainability issues, categories and criteria-indicators used in the generic framework (GF) and the national framework tools.

	GF	Italy (A)	Italy (B)	France (A)	France (B)	Spain (A)	Spain (B)	Malta	Greece	Croatia	Average
Building Scale											
Issues	7	7	7	7	7	7	7	7	7	7	7
Categories	25	15	18	8	8	19	21	11	16	15	15
Indicators	153	16	31	16	19	38	40	36	31	27	28
KPIs	13	13	13	13	13	13	13	13	13	13	13
Neighbourhood Scale											
Issues	7	7	7	7	7	7	7	7	7	7	7
Categories	23	14	20	11	13	16	20	20	16	20	17
Indicators	178	34	46	16	19	33	59	66	44	38	39
KPIs	16	16	16	16	16	16	16	16	16	16	16

Each team selected from the pool of indicators included in the Generic Framework the ones that are most relevant according to their national sustainability priorities and are commonly encountered at regional-local issues. For example, the generic framework for the neighbourhood scale includes a total of 23 categories and 178 criteria-indicators, while the national tool in Greece uses a total of 16 categories and 44 criteria-indicators. The only core set of criteria that is mandatory and included in all national tools, are the KPIs that represent internationally recognized priorities for sustainability assessment. According to the pilot test results, the selected number of sustainability criteria averaged 28 indicators at building scale and 39 indicators at neighbourhood scale (Table 4). The sustainability issue that has attracted more emphasis based on the number of selected indicators (Figure 26) was "B-Energy and Resources" with 32% of the total number indicators used at building scale and "G-Social Aspects" with 26% of the total at neighbourhood scale.

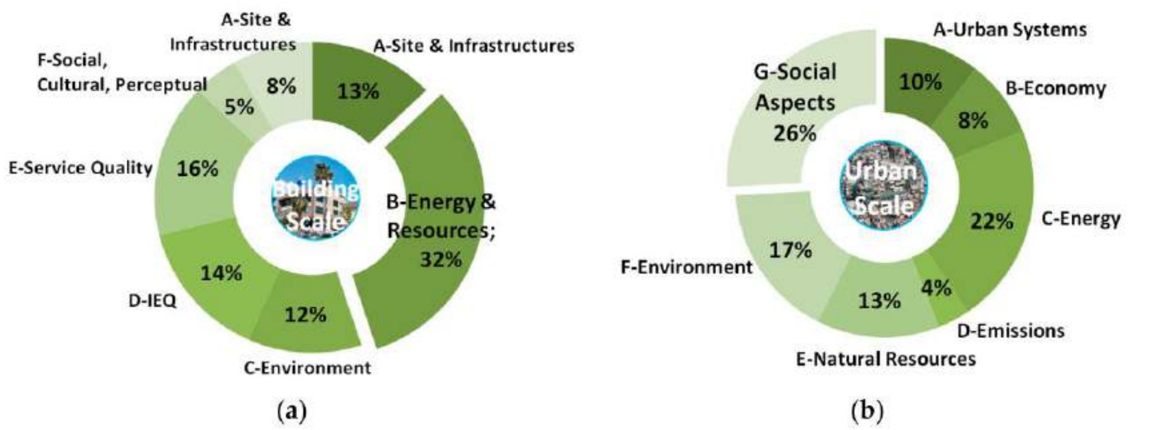


Figure 26:. Overview of the average breakdown of the selected criteria-indicators used in the national tools for the seven sustainability issues for (a) the building scale; (b) the neighbourhood scale

For each one of the selected indicators, the national teams in collaboration with local committee experts specified the local benchmarks, i.e., the values that correspond to the appropriate local excellent practice (corresponding to "+5" in the normalized score), the minimum acceptable performance (corresponding to "0" in the normalized score) and below minimum standard (corresponding to "−1" in the normalized score). This information was used to benchmark the values for each indicator and normalize them on the -1 to 5 points scale. The benchmarks for the KPIs from the different regions are summarized in Table 2. The values can provide initial guidance during future developments and adaptations of similar tools in other regions. The empty cells in Table 5 (i.e., B.1.10 for embodied energy, C.3.2 for recycled solid waste, D.1.9 for ventilation rates) refer to cases with missing information.

Code	Key Performance Indicators (KPIs)	Units	Value	Italy (A)	Italy (B)	France (A)	France (B)	Spain (A)	Spain (B)	Malta	Greece	Croatia	Average
			BUILDING SCALE										
B.1.1	Primary energy use	$kWh/m^2/y$	Minimum	80	140	48	140	225	292		310.6	90	165.7
			Best	30	23	0	0	70	58		87.6	55	40.5
B.1.2	Final thermal energy use	$kWh/m^2/y$	Minimum	70	80	40	130	22	75		69.1	50	67.0
			Best	20	10	0	30	12	20		11.5	10	14.2
B.1.3	Final electrical energy use	$kWh/m^2/y$	Minimum	30	23	40	140	75	70		99.4	30	63.4
			Best	20	5	0	0	20	30		29.1	0	13.0
B.1.5	Renewables in final thermal energy use	%	Minimum	30	25	25	10	30	30		16	20	23.3
			Best	100	50	100	100	100	100		80	90	90.0
B.1.6	Renewables in final electrical energy use	%	Minimum	40	35	10	10	40	40		20	5	25.0
			Best	100	75	200	100	100	100		100	90	108.1
B.1.10	Embodied non-renewable primary energy	MJ/m^2	Minimum	2500		180	900				6230	14	1964.8
			Best	1000		90	504				3000	3	919.4
B.4.5	Water consumption for indoor uses	m^3/occupant/y	Minimum	40	47	40	90	100	11		6	5.5	34.2
			Best	25	23	20	20	20	5		1.5	2	13.8
C.1.3	Global warming potential	kg CO_2 eq./m^2/y	Minimum	30	28	20	80	30	96.31		7.5	40	43.1
			Best	0	5	5	5	10	19.26		2	5	5.9
C.3.2	Solid waste categories recycled	%	Minimum	50	14	0.4	0.4	15			57	28	23.5
			Best	80	100	1	1	100			100	100	68.9
D.1.9	Ventilation rate	$Lt/s/m^2$	Minimum	10	0.35	0.5		6			0.29	2.77	3.3
			Best	20	0.49	0.9		12			0.83	6	6.7
D.2.2	Thermal comfort index	%	Minimum	10	10	10	10	25	10		25	25	15.6
			Best	0	6	5	0	5	0		5	5	3.3
G.1.4	Operational energy cost	€/m^2/y	Minimum	20	10.7	15	15	60	35		18.9	7.5	22.8
			Best	10	1.75	5	5	40	10		4.7	1.5	9.7
G.1.5	Operational water cost	€/m^2/y	Minimum	5	1.55	10	13		5		0.59	0.5	5.1
			Best	1	0.7	3	2.3		1		0.15	0.2	1.2
			NEIGHBOURHOOD SCALE										
A.1.7	Land conservation	%	Minimum	0.5	7	15	10	4	10	10	10	2	7.6
			Best	2	42	30	20	15	20	28	20	10	20.8
B.3.3	Operational energy cost for public buildings	€/m^2/yr	Minimum	7.4	10	14	14	20	13.56	100	17.7	100	33.0
			Best	4	3	3.5	3.5	10	3.33	0	4.1	0	3.5
C.1.1	Total final thermal energy consumption for buildings	$kWh/m^2/yr$	Minimum	70	80	40	50	75	76.23	50	314	100	95.0
			Best	30	10	0	0	20	33.8	0	21.1	50	18.3
C.1.4	Total final electric energy consumption for buildings	$kWh/m^2/yr$	Minimum	50	23	12	55	70	29.85	25	64.2	75	44.9
			Best	20	5	0	5	20	10.88	5	7.9	50	13.8
C.1.7	Total primary energy consumption for buildings	$kWh/m^2/yr$	Minimum	322	72	40	140	225	152	50	461.9	100	173.7
			Best	242	50	0	0	70	15	15	38.2	70	55.6
C.2.1	On-site renewables in total final thermal energy consumption	%	Minimum	20	25	25	30	25	25	25	4	5	20.4
			Best	100	50	100	100	90	90	90	14	30	73.8
C.2.7	On-site renewables in total final electrical energy consumption	%	Minimum	20	35	25	35	15	15	35	1	20	22.3
			Best	100	75	200	75	75	75	75	47	35	84.1
D.1.2	Total GHG Emissions from energy use in buildings	kg CO_2 eq./m^2/yr	Minimum	22.5	13	20	30	30	30	80	46	22	32.6
			Best	0	11	5	10	10	10	30	5	15	10.7
E.1.6	Water consumption in residential buildings	m^3/occupant/yr	Minimum	65	47.45	40	68	150	150	15	62.1	250	94.2
			Best	61	23.7	20	30	40	60	5	18.6	100	39.8
E.1.7	Water consumption in public buildings	m^3/m^2	Minimum	1	1.3	5	1.1	15	15		0.65	5	5.5
			Best	0.5	0.6	2	0.4	5	5		0.33	3	2.1
F.1.3	Recharge of groundwater through permeable paving/landscaping	%	Minimum	20	40	20	20	20	20	20	15	20	21.7
			Best	40	60	70	100	70	70	100	80	80	74.4
F.2.3	Ambient air quality (PM10) above acceptable limits	days/yr	Minimum	35	35	30	30	15	15		35	20	26.9
			Best	25	0	11	11	11	11		0	15	10.5
G.2.1	Proximity of residents to public transport	%	Minimum	70	60	50	0	30	30	30	50	5	36.1
			Best	100	100	100	100	100	100	100	100	40	93.3
G.2.4	Pedestrian & bicycle network	m/100 inhabitants	Minimum	14	43	15	200	20	5	5	2	0	33.8
			Best	42	129	40	50	80	40	40	20	500	104.6
G.4.2	Proximity of residents to key services	%	Minimum	80	30	30	30	30	50	50	50	20	41.1
			Best	100	80	100	100	80	100	100	90	70	91.1
G.6.3	Community involvement in urban planning (qualitative score)	level (score)	Minimum	0	3	0	0	0	0	0	0	0	0.3
			Best	5	5	5	5	5	5	5	5	3	4.8

Table 5: Summary of the key performance indicators (KPIs) benchmarks (minimum and best values) used in the national framework tools for the building and
neighbourhood scales.

The weights used for each one of the seven sustainability issues from 1 (less important) to 3 (most important or more relevant) defined in the national versions of the tools reflect the local priorities, policies or project intent. As summarized in Table 6, for the building scale, the sustainability issue "B-Energy and Resources" stands out as the strongest priority. Along with "C-Environment" are the two most prominent issues, averaging together ~80%. For the neighbourhood scale, lower weights were consistently used for "B-Economy" illustrating that once there is a commitment for sustainable development, the economic criteria have a lower priority.

The sustainability issue related to "C-Energy" stands out by averaging 26.6% among all the pilots, although different regions have other priorities in terms of where they focus their efforts by allocating higher weights.

Sustainability Issues	Italy (A)	Italy (B)	France (A)	France (B)	Spain (A)	Spain (B)	Malta	Greece	Croatia	Average
Building Scale										
A-Site and Infrastructures	0.0%	0.0%	0.0%	0.0%	4.9%	11.6%	7.0%	6.5%	7.6%	4.2%
B-Energy and Resources	58.0%	69.8%	72.0%	72.0%	62.9%	54.9%	31.6%	28.5%	51.2%	55.7%
C-Environment	23.0%	24.3%	25.0%	25.0%	19.5%	20.4%	23.6%	36.6%	19.5%	24.1%
D-IEQ	11.0%	4.2%	2.0%	2.0%	2.1%	1.5%	2.0%	0.5%	8.0%	3.7%
E-Service Quality	0.0%	0.0%	0.0%	0.0%	7.9%	8.1%	20.7%	12.6%	3.2%	5.8%
F-Social, Cultural, Perceptual	0.0%	0.0%	0.0%	0.0%	1.9%	2.7%	12.0%	4.3%	5.1%	2.9%
G-Economy	8.0%	1.8%	2.0%	2.0%	0.8%	0.8%	3.1%	11.0%	5.5%	3.9%
Neighbourhood Scale										
A-Urban Systems	11.6%	10.4%	18.9%	0.0%	6.5%	10.2%	13.5%	10.8%	12.2%	10.4%
B-Economy	1.7%	6.6%	5.0%	1.8%	9.1%	3.6%	1.8%	4.2%	4.6%	4.3%
C-Energy	41.1%	18.4%	30.5%	28.2%	26.7%	25.9%	16.2%	33.7%	21.5%	26.9%
D-Emissions	6.9%	14.3%	23.6%	33.9%	7.3%	12.7%	5.8%	14.7%	13.3%	14.7%
E-Natural resources	6.9%	14.1%	3.4%	8.7%	7.3%	10.1%	11.7%	11.5%	14.3%	9.8%
F-Environment	18.3%	15.7%	9.4%	9.9%	31.3%	23.8%	28.7%	18.2%	9.0%	18.3%
G-Social Aspects	13.4%	20.5%	9.1%	17.4%	15.4%	13.6%	22.3%	6.9%	25.0%	15.9%

Note: Cells a green highlight identify the Issues with the Highest Weight in each national tool

Table 6: Summary of the weights on different sustainability issues used in the national framework tools for the building and the neighbourhood scales.

6.3 Discussion: The CESBA Med Tool and its Application to Building and Urban Areas.

In their efforts to achieve local-regional-national and international Sustainable Development Goals (SDGs), municipalities and public authorities need flexible and easy to use methods and tools to facilitate their efforts and overcome the burdens of addressing the complexities of the issues involved. CESBA MED is a new open and flexible multicriteria assessment system structured around the UN and EU SDGs that can be used to quantify and include sustainability issues in the decision-making process. It supports users throughout the process in order to initiate, organize, adapt, evaluate and identify the best sustainable renovation strategies for buildings or neighbourhoods, and monitor progress towards achieving sustainability targets.
Compared to other sustainability audit and rating systems, CESBA MED offers an open-source assessment system for measuring the sustainability at building and neighbourhood scale in a harmonized approach. Cities can easily adapt it to local context by selecting and using the most suitable indicators, incorporating weighting factors that reflect local targets, priorities and policies, and have their own tailored system, which strengthens a sense of local ownership. The assessment results are comparable among cities at national and transnational levels. At building scale, CESBA MED addresses seven sustainability issues, including: A-Site and infrastructures, B-Energy and resources, C-Environment, D-Indoor environmental quality, E-Service quality, F-Social, cultural and perceptual aspects and G-Economy, which are described and quantified with 153 sustainability criteria/indicators. Among them, 13 KPIs have been selected as mandatory indicators, which represent the priority sustainability

transnational issues. At the neighbourhood scale, seven sustainability issues are addressed, including: A-Urban systems, B-Economy, C-Energy, D-Emissions, E-Natural resources, F-Environment and G-Social aspects, which are described and quantified with 178 sustainability criteria/indicators, including 16 KPIs.

The generic framework and common tools are available in English and different languages, while the assessment and rating approach have been contextualized to national (local) context for Croatia, France, Greece, Italy, Malta and Spain.

Nine pilots performed in six Mediterranean countries demonstrated the applicability and adaptability of the CESBA MED system in practice for diverse applications at different scales, and verified the practical use of the KPIs in the field. The assessment system can be used to carry out a sustainability diagnosis of buildings and neighbourhoods, to set up performance targets and to assess suitable retrofit or new development scenarios, in order to integrate sustainability in urban planning efforts. At this stage, CESBA MED does not include specific cost-related information for the various scenarios. Future work will consider the integration of relevant information since this will add practical value and facilitate the cost/benefit analysis for implementation. Furthermore, although the pilots provided sufficient confidence in the use of the overall method in the field, additional work will be necessary in order to test all the indicators included in the generic framework. In some cases, it may be necessary to reconsider some indicators. For example, A.2.4 Extent and connectivity of bicycle paths are expressed in km/1000 residents. Apparently, an area with a very low number of inhabitants will result in very high value for A.2.4, even for a small bicycle route. Although this will not be an issue in a densely populated urban area, it may be more appropriate to consider an indicator expressed as km/resident. With the exception of KPIs, in cases that a specific indicator may not be appropriate in local context, one can adapt the existing indicator to a more suitable one, provided that the benchmarks are also adjusted accordingly, along with the weighting factors, if necessary. In other cases, one may wish to use alternative indicators to quantify a criterion. For example, there are several indicators to evaluate environmental impacts (e.g., using the quantities of GHG emissions or the global warming potential), energy consumption (e.g., expressing the energy use intensity per unit area or per unit volume at building scale or per capita at neighbourhood scale), or thermal comfort conditions (e.g., using the standard effective temperature—SET or the predicted mean vote—PMV), etc. In principle, a method that includes several alternative indicators for some or all of the criteria may appear more flexible and advantageous. However, this is not the case for local authorities targeted by CESBA MED that need a straight forward and easy to implement tool, taking into account their limited human resources and expertise to fully understand the pros and cons of selecting and using different indicators and alternative paths.

In this direction and to facilitate implementation, the CESBA MED system is also supported by an electronic training system that provides open access to educational material in different languages for different target groups (e.g., engineers, technical staff, decision and policymakers). The material can be used for self and in-house education, training and professional development to improve the knowledge base and understanding of the various sustainability issues and indicators, strengthen the capacity of local stakeholders to develop efficient policies and implement integrated local action plans for sustainable urban development.

The results from this work motivated the development of eight clear, actionable recommendations targeted to policymakers for promoting a new culture of the built environment in Europe [Torrent, 2019]. Some notable good practices are already in place, illustrating the potential applicability of CESBA MED.

For example, Protocollo ITACA [ITACA, 2019] that is an environmental label promoted by the Italian regions for the evaluation and classification of buildings, is based on the transnational building scale tool [iiSBE, 2019], the reference assessment methodology adopted by CESBA MED. Since 2004, it was accepted by the Conference of Presidents of the Italian Regions and has been contextualised and used at local level by several Italian regions. Since 2015, Protocollo ITACA is the Italian national standard for the assessment of the sustainability of buildings and it is legally binding. Similar statutory audit obligations and regulatory actions for buildings may be adopted in other countries to help implement the European initiative level(s), and extended for neighbourhoods, cities and regions. Along these lines, the City Council of Sant Cugat del Vallès in Spain is using the CESBA MED method in the sustainable development of new buildings and urban areas. For example, during the design phase of new urban areas, developers are required to provide the appropriate data to calculate the CESBA MED indicators, in order to assess their proposals.

Future work will focus on extending the CESBA MED approach to regions and possibly national scales (In Malta the CESBA md tool is developed for University Campuses and University Buildings, School buildings and Church complexes, by the University of Malta Faculty for the Built Environment team / Committee for Sustainability at UM and SBE Malta). The ambition is to facilitate and improve the effectiveness and impact of action plans and policies, towards a sustainable future for all.

7 eLearning Training System (University of Malta – CESBA Med)

To further facilitate the process, users are also supported by a comprehensive electronic CESBA MED Training System for self and in-house education, training and professional development on sustainability. The developed material facilitates the proper use of the method and tools, improves the knowledge base and enhances the understanding of the various sustainability issues by different target groups and stakeholders (e.g., engineers, technical sta_, decision and policymakers) to set up and implement high quality and sustainable urban plans, and supports continuous learning [Borgaro, 2018]. The training material is organized in different modules [Borg, 2019], including the GF concept and the multicriteria assessment methodology, the decision-making process, case studies, the assessment criteria of the contextualized tool at building and neighbourhood scale with a detailed presentation of the KPIs along with calculation examples. The electronic training material is accessible through an open e-learning platform (https://cesba-med.research.um.edu.mt) and is available in different languages, e.g., Catalan, Croatian, English, French, Greek, Italian and Spanish. The educational material was successfully used during 17 national pilot training courses that were held in the participating countries with about 275 participants.[14]

[14] University of Malta: https://cesba-med.research.um.edu.mt

8 CESBA Med – International Mediterranean Best Practice Case Studies.

8.1 Background

It is argued that sustainability of a neighbourhood is achieved when citizens and users take over responsibility for the development of their spaces or when potential users involve themselves in the planning process. Key Performance Indicators help considering and communicating basic values among all stakeholders. The CESBA Neighbourhood Award shows best practices of good neighbourhood developments. The 1st CESBA Neighbourhood Award launched by the CESBA Med Project of which the University of Malta was a key partner and promoter through the Sustainable Construction, Materials Engineering and Structural Monitoring Research Group at the Faculty for the Built Environment, laid the foundations for further discussions on the quality of the built environment.

8.2 Case Studies in Building & Urban Area Sustainability

This section of the report draws on the outcomes of the Neighbourhood Award for Sustainability, created within the framework of the CESBA MED project funded through the INTERREG MED programme in which the University of Malta was a key partner. Reference to the award and its submissions enables us to refer to key developments in Sustainable Building but also in Sustainable Spaces and urban areas, therefore effectively addressing the aims of the literature review / market research in Sustainable Buildings, planned for this Phase of the project.

The objectives of the CESBA Neighbourhood Award were the following:

- Improve the quality of life for inhabitants and minimise negative impacts on climate and resources
- Collect knowledge on urban development
- Give visibility and share knowledge
- Contribute to the global SBE Urban Challenge
- Geographical coverage

The CESBA Neighborhood Award, launched in 2019 was open to different urban areas (cities, districts, neighborhoods, etc.) throughout the Europe territory (EU members countries and non-EU members countries). Applications were open for all those who could submit a project including Municipalities in European Cities, NGOs, Professionals and Consultants and also Students.

The Categories for participation were organised as follows:

By population:

- Urban areas in cities under 10.000 inhabitants
- Urban areas in cities between 10.001 and 50.000 inhabitants
- Urban areas in cities over 50.001 inhabitants

By sort of project:

- New developments: New urban areas, where the implementation works are nearly finished
- Existing areas: Existing areas, where the refurbishment works are nearly finished
- Areas under planning or in implementation phase
- Geographical coverage

A neighborhood was defined as having at least three of the following criteria: 40.000 m^2 up to 160.000 m^2 ground area (200 m to 400 m); can be crossed in 10-15 min walk; cluster of 5 - 15 buildings; 200-1.500 Inhabitants. This context provides key Sustainable Building excellence across Europe, which is not only confined to the single building but extends to a group of buildings and the spaces surrounding these buildings and constituting an urban area. This is an important consideration which is an important next step beyond the sustainability assessment of single building blocks with the latter experiencing limitations effectively addressed through an assessment of areas. The neighbourhood initiative allows us to get access to a variety of projects of excellence across Europe.

8.3 Best Practice Examples:

A number of Best practice examples are identified to define successful projects in delivering Sustainability in the Built Environment through Key Performance indicators.

8.3.1 Zac Castellane

(Award Winner in the category: New developments, areas in cities under 10.000 inhabitants)

Extension of the existing city

The ZAC Castellane was created for the realization of an extension of the existing city center on an area of approximately 12 ha. ZAC Castellane aims to strengthen the centrality to accommodate a new population, by providing the town with new equipment and services. This district has been operational since 2010 and will by 2021 (11 years) accommodate around 800 households (1500 new inhabitants).

Challenging tasks

The challenge of doubling a municipality is to ensure the harmonious development through qualitative public spaces: public park, quality facilities, rainwater harvesting system, wood heat network but also by ensuring the provision of services and resources necessary for the new population through a new supply of businesses, services and equipment. The major challenge for the Castellane district, was to densify the city center in order to stop the urban sprawl, to move from the single-family house to a city made up of small buildings. ZAC Castellane and more generally the project of conversion of the former military camp of Sathonay-Camp carries the ambition of a sustainable urbanism, in the sense that a sustainable urbanism favours the renewal to the urban extension. This operation was carried out with clear intentions on each of the three pillars of sustainable development (social and societal pillar, economic pillar, environmental pillar).

Buildings designed around people

The works that are undertaken are those of a new district where the human and the nature meet in all harmony: an environmental dimension that respects and enhances the site by its green spaces and amenities; an architectural dimension where the building is designed around the human: accessibility, habitability, thermal and acoustic comfort are the rule; an urban dimension: new buildings are an essential anchor point in the city; they ensure an ideal transition between today‘s Sathonay-Camp and tomorrow‘s Sathonay-Camp. Creaion of approximately 68,000 square meters of floor area (SDP) distributed: 650 housing units; shops 6200 m²; tertiary activities (medical center) 1800 m² and public facilities (tracks and networks).
Key Performance Indicators

Ecological value of land:	**15 %**
Use stage energy cost for public buildings:	**115 €/m^2/year**
Share of renewable energy on total final thermal energy consumption:	**68,5 %**
Total GHG Emissions from energy used:	**99,79 kg CO2 eq./m^2/year**
Consumption of water for residential population:	**20 m^3/occupant/year**
Quality of pedestrian and bicycle network:	**280 m/100 inhabitants**
Community involvement in urban planning activities:	**Level 3**

8.3.2 El Cabanyal

Award Winner in the category: Areas under a planned or project phase retrofitting, areas in cities under 10.000 inhabitants.

Characterisics of El Cabanyal

El Cabanyal has a small, but diverse, subdivision, grouped into narrow and elongated blocks, in which the buildings acquire an individual prominence with respect to the street. The richness of the plot allows a great typological variety in dwellings capable of housing different family nuclei. Damage through center splitting El Cabanyal suffered a damage caused by a municipal project that had planned to cross it through its center, splitting it in two and demolishing 25% of its buildings. Therefore El Cabanyal implemented an integrated urban regeneration process that revitalizes the urban area in an advanced state of deterioration through a comprehensive program. Encompassing actions of rehabilitation, remodelling, renovation or improvement, without being limited particularly to any of them. It does not only refer to the physical, but to the economic and social, and all this supporting and consolidating the identity traits. From the energetic point of view, very defined characteristics can be found: location contiguous to the coast, defined plot and parallel to the sea, regular height of construction, abundant access to the sun and access to sea breezes, and finally the use of small building types and little varied materials. Environmental studies carried out in El Cabanyal allow to affirm that, due to the climatic conditions of its geographical location, the geometry of its urban plot and the typologies that compose it, suitable conditions are presented for the use of passive bioclimatic strategies in order to obtain situations of comfort in the interior of buildings without any contribution of external energy more than that provided by solar radiation and natural ventilation.

Citizens participation

One of the key aspects in the development of the neighbourhood is the citizen participation by establishing effecive mechanisms to strengthen the role of citizens and local agents in the design and
development of the strategy, as well as throughout all phases of its development and application. The instruments of participation legally regulated so far, have not been effecive for citizens, causing some frustration and the emergence of numerous social movements that have tried to alleviate this deficit.

Future Developments

Based on the diagnosis of the area, and taking into account the results of the citizen participation process carried out the following future scenarios have been suggested for the neighbourhood:

- A neighbourhood for living, of residential character
- A diverse district in buildings and people, formal and social diversity
- An inclusive and safe district, a neighbourhood that integrates and empowers socially, educationally and occupationally those neighbours who live at risk of exclusion
- A balanced and healthy neighborhood with sustainable dynamics
- A neighborhood that continues being different and remaking itself
- A neighbourhood that is the marine front of the city
- A neighbourhood that improves its relationship with the rest of the maritime towns

Key Performance Indicators

Ecological value of land:	**0%**
Use stage energy cost for public buildings:	**4,42 €/m²/year**
Share of renewable energy on total final thermal energy consumption:	**0,13 %**
Total GHG Emissions from energy used:	**17,71 kg CO^2 eq./m²/year**
Consumption of water for residential population:	**43,56 m^3/occupant/year**
Quality of pedestrian and bicycle network:	**150,91 m/100 inhabitants**
Community involvement in urban planning activities:	**Level 3**

8.3.3 Schnifis

Award - Winner in the category: Areas under a planned or project phase retrofitting, areas in ciies under 10.000 inhabitants

Intensificaion of the use of existing buildings

The planning area includes the center of Schniis with the relevant public insituions: municipal office, bank, ire station and club house, event hall, church, cemetery, local supply infrastructure, mail service staion, restaurant, bank and grocery store as well as the identity-forming “Abbrandhäuser”, which are used as residential buildings as well as possible central development areas. The more intensive use of the existing building structure and thus the development of the village center of Schnifis are becoming more and more important. It is important to make the best possible use of the available resources for the citizens and to ensure the sustainable development of the municipality.

Preservation of existing building Structure

Of high importance as part of the neighbourhood development of the center of Schnifis is the preservation of the existing building structure and the landscape of the village, the renovation of buildings and securing the re-use of the buildings, the revitalization of large, partly underused buildings, the development of the “empty” key development areas as well as the offer of apartments and shared flats for municipal citizens as an alternative to single family houses. There is currently no official commitment to active real estate policy in the municipality. The “Abbrandhäuser” are an essential spatial feature in the municipality of Schnifis and therefore find special regard in the spatial development of Schnifis.

Involvement of inhabitants

The basic approach of the neighbourhood development is the development together with the inhabitants of the village and the residents of the buildings (about 20 buildings). Impulses among the owners for the refurbishment of the buildings are set as well as proposals for the design of the buildings. An analysis of the construction by the municipality and by experts together with the owners and development of a proposal for a solution is made. Owners receive an offer about the sale of a building to the municipality or to building contractors as well as discussion with owners take place. A legal framework for parking spaces within the building is developed. Public green and recreations areas nearby (300m) are planned. A planning process to clarify development opportunities with experts and residents, development of action plans and proposals for action and the creation of legal frameworks were started.

Spatial development concept - village centre

In 2011 and in 2019 a survey of residents was conducted, in 2012-2015 a spatial development concept with special reference to the village centre and suggestions for development was created. Further private development iniiaives in the planning area were initiated. Moreover in a public assembly „living space in Schniis“ on September 21th, 2017 with the participaion of over 10% of the population a rough concept on the topics of land and building use was developed and deepened as part of the conference of the municipal representatives in November 4th ,2017. The result of the conference was the development of the present project outline „Neighborhood development centre of Schnifis,“ which was further deepened in the spatial planning committee of the municipality on January 22nd, 2018. Although the development of the neighbourhood center of Schnifis is sill in a planning phase the project will contribute to the development of economic and cultural sustainable solutions, the adaptation to the latest technological and environmental standards, the preservation of the identity of the village as well as towards strengthening exchange between centre and periphery.

Key Performance Indicators

Ecological value of land:	**26 %**
Use stage energy cost for public buildings:	**7,99 €/m^2/year**
Share of renewable energy on total final thermal energy consumption:	**29,2 %**
Total GHG Emissions from energy used:	**28,7 kg CO^2 eq./m^2/year**
Consumption of water for residential population:	**50,2 m^3/occupant/year**
Quality of pedestrian and bicycle network:	**1.491 m/100 inhabitants**
Community involvement in urban planning activities:	**Level 3**

8.3.4 Strubergasse

Award - Winner in the category: Existing retrofitted area, areas in cities over 50.001 inhabitants

First sustainable and holisic neighbourhood development of Salzburg

The area of "Strubergasse" is situated in the city part "Lehen" in Salzburg / Austria. It is a very central city part with a rather high density of inhabitants. Next to the area, an industrial wasteland was located, where between 2009 and 2016 a new urban area ("Stadtwerk Lehen") was built. With 300 new social housing units, shops, commercial areas, offices and an educaion and science cluster, the district was transformed significantly. It was the first time in the federal state Salzburg, that the development of a whole neighbourhood was planned in a sustainable and holistic way. From 2009-2010, a working group was set up and an implementation study for the Strubergasse was developed, where following aspects were checked: building condition, barrier freeness, urban planning aspects for a modern city part, energy efficiency, social mixture of inhabitants, infrastructure, energy supply, traffic, bike infrastructure, economical aspects and finance.

Vision of „Strubergasse"

The vision for the project "Strubergasse" is to increase the living and building quality and reach a modern standard, improve the ecology and the quality of the green areas, reduce the energy costs and CO2 emissions and to reach a better image and identification for the inhabitants of this city part.

Challenges

The biggest challenges to get over were motivating the politicians for such a long-term process and to inform tenants to go with this solution and offer participation opportunities. Especially the traffic and heating situation in this district were not sustainable and had to be redeveloped in general. For overcoming the challenges information evenings and a questionnaire have been made. Politicians have been motivated by providing solid and transparent preparation of the facts by experts including all involved partners.

Objectives achieved

The area of Strubergasse has become a modern living area with a very high living quality. A better age mix of the residents was achieved by the new building structure. The improvement is a result of better building standards, new green areas, better traffic solutions and the comprehensive development of the city part Lehen. Inhabitants now have a lot of new infrastructure (supermarket, shops, medical services, social infrastructure) in direct proximity. The whole process lasted about 12 years and a lot of people were involved. The project “Strubergasse” will now serve as best practice example for other districts refurbishments.

Ecological value of land:	**62 %**
Use stage energy cost for public buildings:	**5,09 €/m²/year**
Share of renewable energy on total final thermal energy consumption:	**25 %**
Total GHG Emissions from energy used:	**5,48 kg CO2 eq./m²/year**
Consumption of water for residential population:	**40 m³/occupant/year**
Quality of pedestrian and bicycle network:	**265 m/100 inhabitants**
Community involvement in urban planning activities:	**Level 2**

8.3.5 Msida Campus - University of Malta

Description: University of Malta Campus (UM) centrally located on the island composed by 14 faculties, 8 institutes, 12 centres, 3 schools and a sports complex Vision: to provide educational facilities in a safe environment; attaining sustainability at building scale and at urban neighbourhood scale; wellbeing for the community on campus; serving as a hub with various facilities including office spaces, accommodation, library, etc.

Unique specific situation: it is Malta`s only university and students come from all over the island; university is composed of a mixture of buildings constructed from 1960s-to date using different systems and construction methodologies; campus includes refurbished buildings and is a dynamic space with new buildings and faculty buildings; abundance of open space and piazzas

Challenges: The neighborhood is publicly funded; high population density puts pressure on infrastructure (communication, waste, water, energy); difficulties in adapting and modifying the older buildings to meet current trends and requirements since buildings are always in use

Solutions: rooftops fitted with solar panels to reduce electrical energy consumption; state of the art VRF systems (Variable Refrigerant Flow) on newer buildings to fine tune the thermal comfort of the buildings

Lessons learned: how to improve transport systems; improvement in the management of green public areas; gaps in the benchmark were addressed with reference to urban areas in similar climatic zones

Efforts: installation of solar panels on all roofs led to a shift towards saving in energy and improved energy managing; various buildings on campus are zero energy buildings; public transport was improved and upgraded; reduced demand for parking on campus and reduced traffic congestion; campaigns to promote waste separation; sustainable management of space; new buildings on campus designed with sustainability principles

Target group: students, administration, technical staff, academics

Financing: estimated invested budget of the local community for the neighbourhood 1.2 Mio Euro

Success: during the sustainable audit and the use of the Sustainable Neighbourhood (SN) tool knowledge and data about water resources, energy consumption, waste management, transport data, economic data and social data were gathered; tool highlights the challenges the neighbourhood is facing;

Future perspective / Recommendations: by conducting the sustainable audit on the UM campus, certain challenges were highlighted by the tool; improving waste management systems and transport across UM; promoting carpooling and use of public transport; better use of water resources, etc; sustainable committee C-SUM was set up in 2018;

Ecological value of land:	13 %	**State:**	Malta
Use stage energy cost for public buildings:	no data	**Region:**	Malta
Share of renewable energy on total final thermal energy consumption:	93,1 %	**City:**	Msida
Total GHG Emissions from energy used:	76,5 kg CO_2 eq./m^2/year	**Size:**	27 ha
Consumption of water for residential population:	2,14 m^3/occupant/year	**Inhabitants:**	14.000 inhabitants
Ambient (outdoor) air quality with respect to particulates:	52 days/year	**Project by population:**	Area in cities between 10.001 and 50.000 inhabitants
Quality of pedestrian and bicycle network:	2,29 m/100 inhabitants	**Sort of project:**	Existing retrofitted areas
Community involvement in urban planning activities:	Level 1		

9 Low Carbon Built environment – Case Studies across Europe

A European Carbon Atlas was developed and published as part of a European project C23: 'Strategies for a Low Carbon Urban Built Environments (LCUBE)' which took place over the period 2004 to 2009. The main objective of the project was to investigate, through a network of nineteen countries across Europe, how carbon reductions can be achieved through appropriate design and management of the urban built environment. This involved investigating the built environment at building and urban scale, focusing on minimising energy use and associated carbon dioxide emissions. In this regard, the project investigated how nineteen EU member states were active in reducing carbon dioxide levels in the built environment, not only in line with buildings meeting the requirements of the Energy Performance of Buildings Directive (EPBD), but also in taking standards further and looking at how national and regional planning initiatives are being developed to reduce the energy use of urban areas. The publication includes a collection of case studies which include public buildings of relevance, compiled to illustrate the development and implementation of low carbon strategies at urban and building scales. The European Carbon Atlas[15] though not a recent publication, does present the challenges in achieving low carbon buildings through best practice examples, and serves as a reference in defining key actions in relation to the particular counties and regions including the Mediterranean context.

[15] Euro Carbon Atlas: https://vbn.aau.dk/ws/portalfiles/portal/75302209/C23_European_Carbon_Atlas.pdf

10 Building Energy Modelling

A reduction in building energy consumption can be achieved by improving energy efficiency and utilizing new technologies in the built environment. This shall lead to a more sustainable built environment given at the energy consumption in buildings accounts for a significant portion of primary energy.

Energy models for reference buildings represent fairly realistic buildings and typical construction practices and can support energy efficiency studies. The definition of the methodology to create a building model to refer to is an important key step. methodology for the creation of reference buildings is illustrated. The building modelling and definition of parameters is conducted using established tools such as EnergyPlus. The model can then serve as the basis for additional and subsequent research on the building energy efficiency assessment, building energy consumption, impact factors analysis, urban building energy consumption prediction and related action.

11 Conclusions

The Market Research is based on a review of assessment methods to measure sustainability at the building and urban scale. The review also refers to practical case study examples which allows us to set the scene for the Sustainability assessment of buildings and spaces / urban areas in Malta, in a Mediterranean context. It allows for the assessment of new build and retrofit projects. The review highlights the importance of key performance indicators and other indicators which are used to define sustainability, based on a quantitative assessment. The assessment highlights the importance of a rigorous approach which requires data and information gathered and its assessment using recognised methodologies to ensure an adequate comparison and review. The public and stakeholder participation in the process is key.

12 Bibliography

The CESBA Neighbourhood Award 2019, (Publication CESBA Med project), CESBA Med Interreg Med Project, Sustainable Mediterranean Cities, 2019.

Borg Ruben Paul, Luzkendorf T, 2021, The EPC framework, Unpublished Report, Malta

Borg, Ruben Paul, 2019, The University of Malta Campus – Sustainability Assessment, CESBA Med, 2019.

European Commission, Directorate-General for Environment, The Level(s) Calculation and Assessment Tool (CAT), 2022, https://data.europa.eu/doi/10.2779/109620

Level(s) https://ec.europa.eu/environment/topics/circular-economy/levels_en (Accessed 2nd April 2022)

CESBA Med Sustainable Mediterranean Cities, https://www.um.edu.mt/newspoint/news/features/2018/03/cesbamedsustainablemedcities (Accessed 5th May 2022)

Barbano G., N. Eßig, P. Mittermeier, M. Orova, P. Beagon, L. Claudi, J.F. Gómez-Salcedo, F. Kiedaisch (2016). Definition of sustainable Key Performance Indicators, NEWTREND Project, H2020 Program, European Commission. http://newtrend-project.eu/wp-content/uploads/2015/11/NewTREND_WP2_D2.2_KPI_GB04_V5.2.pdf

Moro A. (2017). CESBA MED D3.3.1 Testing Protocol, CESBA MED Consortium, Marseille.

CABEE http://www.cabee.eu

CAT MED http://www.catmed.eu

CEC5 http://wiki.cesba.eu/wiki/CEC5

CLUE http://www.clue-project.eu

ENERBUILD http://www.enerbuild.eu

EPISCOPE http://www.episcope.eu

FASUDIR http://fasudir.eu

IRH-MED http://wiki.cesba.eu/wiki/IRH_med

NewTREND http://newtrend-project.eu

OpenHouse http://www.openhouse-fp7.eu

SuPerBuildings http://cic.vtt.fi/superbuildings

Eco-Quartier http://www.eco-quartiers.fr

Protocollo ITACA http://wiki.cesba.eu/wiki/Protocollo_Itaca

QDM http://www.envirobatbdm.eu/baroque

Eurostat. Energy Statistical Country Datasheets; European Commission, DG Energy, Unit A4: Brussels, Belgium, 2019; Available online: https://ec.europa.eu/eurostat/web/energy/data/energy-balances (accessed on 10 July 2019).

Dodd, N.; Donatello, S.; Garbarino, E.; Gama-Caldas, M. Identifying Macro-Objectives for the Life Cycle Environmental Performance and Resource Efficiency of EU Buildings; Joint Research Centre, European Commission: Seville, Spain, 2015; 116p, Available online: https://www.construction-products.eu/application/files/1615/2466/0561/151222_Resource_E_cient_Buildings_Macro_objectives_WP_Final_version.pdf (accessed on 10 July 2019).

Construction and Demolition Waste (CDW);Waste streams, Environment, European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/environment/waste/construction_demolition.htm (accessed on 10 July 2019).

Regional Policy; Urban Development; European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/regional_policy/en/policy/themes/urban-development/ (accessed on 15 October 2019).

Circular Economy Action Plan; Environment, European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/environment/circular-economy/index_en.htm (accessed on 7 October 2019).

2030 Climate & Energy Framework; Climate Strategies & Targets; European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/clima/policies/strategies/2030_en (accessed on 8 October 2019).

Clean Energy for all Europeans Package; Energy; European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans (accessed on 7 October 2019).

Saheb, Y.; Shnapps, S.; Paci, D. From Nearly-Zero Energy Buildings to Net-Zero Energy Districts; EUR 29734 EN; Publications O_ce of the European Union: Luxembourg, Luxembourg, 2019.

De Pascali, P.; Bagaini, A. Energy Transition and Urban Planning for Local Development. A Critical Review of the Evolution of Integrated Spatial and Energy Planning. Energies 2019, 12, 35. [CrossRef]

UN Sustainable Development Goals; United Nations: New York, NY, USA, 2019; Available online: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed on 10 July 2019).

COM. 739 Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions; European Commission: Strasbourg, France, 22 November 2016; Available online: https://eur-lex.europa.eu/legal content/EN/TXT/PDF/?uri=CELEX:52016DC0739&from=EN (accessed on 7 October 2019).

Urban Agenda for the EU; European Commission: Brussels, Belgium; Available online: https://ec.europa.eu/futurium/en/urban-agenda (accessed on 5 October 2019).

Lafortune, G.; Zoeteman, K.; Fuller, G.; Mulder, R.; Dagevos, J.; Schmidt-Traub, G. The 2019 SDG Index and Dashboards Report for European Cities (prototype version). Sustainable Development

Solutions Network (SDSN) and the Brabant Center for Sustainable Development (Telos), 2019. Available online: https://www.sustainabledevelopment.report/news/first-ever-sdg-index-and-dashboards-report-foreuropean-cities/ (accessed on 16 October 2019).

Balaras, C.A.; Dascalaki, E.G. Chapter 9.1—Energy Audits of Existing Buildings. In Handbook of Energy Efficiency in Buildings, 1st ed.; Asdrubali, F., Desideri, U., Eds.; Butterworth-Heinemann Elsevier: Oxford, UK, 2018; pp. 677–713.

Barbano, G.; Eßig, N.; Mittermeier, P.; Orova, M.; Beagon, P.; Claudi, L.; Gómez-Salcedo, J.F.; Kiedaisch, F. Definition of Sustainable Key Performance Indicators; NEWTREND Project, H2020 Program; European Commission: Brussels, Belgium, 2016; Available online: http://newtrend-project.eu/wp-content/uploads/2015/11/NewTREND_WP2_D2.2_KPI_GB04_V5.2.pdf (accessed on 16 October 2019).

Lawrence, T.; Balaras, C.A.; Means, J.K. A Comparison of How Sustainability and Green Building Standards are Being Adopted into Building Construction Codes within the United States and the EU. In Proceedings of the International Conference on Sustainable Built Environment SBE 16—Strategies—Stakeholders—Success

Factors, Hamburg, Germany, 8–11 March 2016; pp. 42–51. Available online: https://pure.tugraz.at/ws/portalfiles/portal/3050178/SBE16Hamburg_ConferenceProceedings.pdf (accessed on 8 October 2019).

ANSI/ASHRAE/USGBC/IES Standard 189.1—Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings; ASHRAE: Atlanta, GA, USA, 2017; Available online: https://www.ashrae.org/standards-research--technology/standards--guidelines (accessed on 8 October 2019).

BREEAM (https://www.breeam.com/),

CASBEE (http://cabee.eu/),

Green Star (https://new.gbca.org.au/green-star/), LEED (https://new.usgbc.org/leed) and

Protocollo ITACA (http://itaca.org/),

Mattoni, B.; Guattari, C.; Evangelisti, L.; Bisegna, F.; Gori, P.; Asdrubali, F. Critical review and methodological approach to evaluate the differences among international green building rating tools. Renew. Sustain. Energy Rev. 2018, 82, 950–960. [CrossRef]

Chethana, I.M.; Illankoon, S.; Tam, V.W.Y.; Le, K.N.; Shen, L. Key credit criteria among international green building rating tools. J. Clean. Prod. 2017, 164, 209–220. [CrossRef]

He, Y.; Kvan, T.; Liu, M.; Li, B. How green building rating systems a_ect designing green. Build. Environ. 2018, 133, 19–31. [CrossRef]

Sicignano, E.; Di Ruocco, G.; Stabile, A. Quali—A Quantitative Environmental Assessment Method According to Italian CAM, for the Sustainable Design of Urban Neighbourhoods in Mediterranean Climatic Regions. Sustainability 2019, 11, 4603. [CrossRef]

Level(s)—Taking Action on the Total Impact of the Construction Sector, Joint Research Centre (JRC); Publications Office of the European Union: Luxembourg, Luxembourg, 2019; Available online: https://ec.europa.eu/environment/eussd/pdf/LEVELS_REPORT_en.pdf (accessed on 7 October 2019).

Martos, A.; Pacheco-Torres, R.; Ordóñez, J.; Jadraque-Gago, E. Towards successful environmental performance of sustainable cities: Intervening sectors. A review. Renew. Sustain. Energy Rev. 2016, 57, 479–495. [CrossRef]

EPBD, Energy Performance of Buildings Directive, EPBD, 2018/844/EU)

EED, Energy Efficiency Directive (EED, 2018/2002/EU

CESBA Med, 2018, University of Malta – CESBA Med Project: https://cesba-med.research.um.edu.mt/

CABEE - Capitalizing Alpine Building Evaluation Experiences (ASP ALPINE Space Programme, European Territorial Cooperation, 2013-15) http://www.cabee.eu

CAT MED - Platform for Sustainable Urban Models (Interreg MED,2013-15) http://www.catmed.eu

CEC5 - Demonstration of Energy Efficiency and utilization of renewable energy sources trough public buildings (Interreg Central Europe, 2010-12) http://wiki.cesba.eu/wiki/CEC5

CLUE - Climatic Neutral Urban Districts in Europe (Interreg IVC, 2011-14) http://www.clue-project.eu

ENERBUILD - Energy Efficiency and Renewable Energies in the Building sector (ASP ALPINE Space Programme, European Territorial Cooperation, 2010-12) http://www.enerbuild.eu

EPISCOPE - Energy Performance Indicator Tracking Schemes for the Continuous Optimisation of Refurbishment Processes in European Housing Stocks (IEE, 2012-14) http://www.episcope.eu

FASUDIR - Friendly and affordable sustainable urban districts retrofitting (FP7, 2014-16) http://fasudir.eu

IRH-MED - Innovative Residential Housing MED (Interreg MED, 2010-12) http://wiki.cesba.eu/wiki/IRH_med

NewTREND - New integrated methodology and tools for retrofit design towards a next generation of energy efficient and sustainable buildings and districts (H2020, 2015-18) http://newtrend-project.eu

OpenHouse - Benchmarking and mainstreaming building sustainability in the EU based on transparency and openness (open source and availability) from model to implementation (FP7, 2010-12) http://www.openhouse-fp7.eu

SuPerBuildings - Sustainability and Performance Assessment and Benchmarking of Buildings (FP7, 2010-12) http://cic.vtt.fi/superbuildings

Eco-Quartier - French Label Eco Quartier (Eco-District) http://www.eco-quartiers.fr

Protocollo ITACA- Environmental label (Federal Association of the Italian Regions, with the scientific support of iiSBE and ITC-CNR) http://wiki.cesba.eu/wiki/Protocollo_Itaca

QDM- Quartiers Durables Méditerranéens (Sustainable Mediterranean Neighbourhoods) http://www.envirobatbdm.eu/baroque

Sant, R., & Borg, R. P. (2016). A review of green building rating tools and their application in Malta. CESB 2016, Central Europe towards sustainable building ; innovations for sustainable future, Prague. 1460-1467.

iiSBE. International Initiative for a Sustainable Built Environment; Ottawa, ON, Canada, 2007; Available online: www.iisbe.org (accessed on 8 October 2019).

Balaras, C.A.; Dascalaki, E.G.; Droutsa, K.G.;Moro, A.; Barbano, G.; Chanussot, L.; Cazas, J.; Zidar,M.; Baˇcan, I.; et al.D3.1.1 Transnational Indicators and AssessmentMethods for Buildings andUrban Areas; CESBAMEDConsortium:

Marseille, France, 2017; 409p, Available online: https://cesba-med.interreg-med.eu/fileadmin/user_upload/Sites/Efficient_Buildings/Projects/CESBA_MED/D3.1.1_Indicators_CESBA_MED_Final-V1.5_June_2017.pdf (accessed on 8 October 2019).

Moro, A. D3.3.1 Testing Protocol—Assessment Methodology; CESBAMED Consortium: Marseille, France, 2017; 100p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

Moro, A. D3.4.1—CESBA MED SBT Building Generic Framework; CESBA MED Consortium: Marseille, France, 2019; 78p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

Moro, A. D3.4.2—CESBAMEDSNTUrbanGeneric Framework; CESBAMEDConsortium: Marseille, France, 2019; 83p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

Dodd, N.; Cordella, M.; Traverso, M.; Donatello, S. Level(s)—A common EU Framework of Core Sustainability Indicators for Office and Residential Buildings, Part 3: How to Make Performance Assessments Using Level(s);

Joint Research Centre, European Commission: Seville, Spain, 2017; 211p, Available online: - https://susproc.jrc.ec.europa.eu/E_cient_Buildings/docs/170816_Levels_EU_framework_of_building_indicators.pdf (accessed on October 2019).

ITACA. Istituto per l0Innovazione e Trasparenza Degli Appalti e la Compatibilità Ambientale; Institute for Transparency of Contracts and Environmental Compatibility: Rome, Italy; Available online: http://www.itaca.org (accessed on 7 October 2019).

Moro, A. D3.4.3a CESBA MED KPIs—Building Scale; CESBA MED Consortium: Marseille, France, 2019; 30p, Available online: https://cesba-med.interreg-med.eu/results/deliverables (accessed on 16 October 2019).

Moro, A. D3.4.3b CESBA MED KPIs—Urban Scale; CESBA MED Consortium: Marseille, France, 2019; 28p, Available online: https://cesba-med.interreg-med.eu/results/deliverables (accessed on 16 October 2019).

Moro, A. D3.3.2 v.1.1 Model of Decision Making Process for Sustainable Urban Areas and Public Buildings; CESBA MED Consortium: Marseille, France, 2018; 15p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

Borgaro, P. D4.2.2 v.1.4 Training System Framework; CESBA MED Consortium: Marseille, France, 2018; 26p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

Borg, R.P. D5.2.1—elearning Courses; CESBA MED Consortium: Marseille, France, 2019; 19p, Available online: https://cesba-med.interreg-med.eu/results/deliverables/ (accessed on 16 October 2019).

STRAT-Board: Territorial and Urban Strategies Dashboard; Greece Country Fact Sheet; European Commission: Brussels, Belgium; Available online: https://urban.jrc.ec.europa.eu/strat-board/#/factsheetcountry?id=EL&name=Greece&fullscreen=yes (accessed on 15 October 2019).

Droutsa, K.G.; Balaras, C.A.; Dascalaki, E.G.; Kontoyiannidis, S. D3.3.2-GR Pilot Test in Greece, Assessment Report—Hellenic Pilot Test Results; CESBA MED Consortium: Marseille, France, 2019; 15p, Available online: https://cesba-med.interreg-med.eu/results/deliverables (accessed on 16 October 2019).

Torrent, L.; Wadel, G.; Sagrera, A. D5.3.1 CESBA MED Policy Paper; CESBA MED Consortium: Marseille, France, 2019; 15p, Available online: https://cesba-med.interreg-med.eu/results/deliverables (accessed on 16 October 2019).

EN 15643-1., E. (2010). Sustainability of Construction works. Part 1; General framework.

EN15643-2., E. (2011). Sustainability of construction works-Assessmant of buildings. Part 2: Framework for the assessment of environmental performance.

EN15643-3., E. (2012). Sustainability of construction works-Assessment of buildings. Part 3: Framework for the assessment of social performance.

EN15644., E. (2012). Sustainability of construction works - Assessment of buildings. Part 4: Framework for the assessment of economic performance.

ALI, H and AL NSAIRAT, S (2009) Developing a Green Building Assessment tool for developing countries – case of Jordan. Building and Environment, 44(5), 1053-1064.

BREEAM UK New construction. (2015, January - August Several). Retrieved from BREEAM: http://www.breeam.org/page.jsp?id=369

CESBA, (2015, June)Iniatitive Policy Paper(2014)"Towards a Common Sustainable Building Assessment for Europe", http://cesba.eu

COLE, R. (2005). Building environmental assessment methods: redefining intentions and roles. Build Research Information 2005, 455-467

DIACONO, J.S. and CARUANA, A. (2012), Environment and Climate Change Law Malta, International comparative legal Guide,ICLG, Chapter 25, 195-205. http://www ICLG.co.uk

DING, G.K.C. (2008). Sustainable construction - the Role of Environmental Assessment tools, Journal of environmental Management, 86, 451-464.

EC. (L 354/176 - 2013). Living Well in the Future 7th EAP -2050 Vision. Brussels: European Union.

EC. (445 final - 2014). On Resource efficiency opportunities in the Building Sector, Brussels: European Union.

EC. (433 final - 2012). Strategy for the sustainable competitiveness of the construction sector and its enterprises. Brussels, European Union.

EC. (COM 571 final - 2011), RoadMap to a Resource Efficient Europe, Brussels, European Union.

ELKINGTON J., (1997) Cannabals with Forks: The Triple bottom Line of the 21st Century business, Capstone, Oxford.

GREEN STAR. (2015, January - August Several). Retrieved from green building council australia: http://www.gbca.org.au/green-star

LEED v4. (2015, June 1). Retrieved from LEED: http://www.usgbc.org/leed#v4

PBRS v1 2010. (2015, June) Retrieved from ESTIDAMA: http://estidama.upc.gov.ae/template/estidama/docs/PBRS%20Version%201.0.pdf

REED, R, BILOS, A, WILKINSON, S and SCHULTE, K (2009) International Comparison of Sustainable Rating Tools. JOSRE, 1(1), 1 - 22. Washington, United States of America: National Academy Press.

RODRIGUEZ, S.I., ROMAN, M.S., STURHAHN, S.C. & TERRY, E.H.. *Sustainability Assessment and reporting for the University of Michigan's Ann Arbor Campus,* Report No CC02-04, Michigan 2002.

Valentinas, P. (2011). The comparitive analysis of MCDA Methods SAW and COPRAS. Engineering Economics, 134-136

Sant, R., & Borg, R. P. (2016). A review of green building rating tools and their application in Malta. CESB 2016, Central Europe towards sustainable building ; innovations for sustainable future, Prague. 1460-1467.

U-Cert Project: (https://www.rehva.eu/fileadmin/user_upload/U-CERT_D2.4.pdf)

X-Tendo: https://www.bpie.eu/wp-content/uploads/2020/08/D3.1-Exploring-innovative-indicators-for-the-next-generation-EPC-features.pdf

Euro Carbon Atlas: Low Carbon Urban Built Environment, European Carbon Atlas, Editors: Phil Jones, Paulo Pinho, Jo Patterson, Chris Tweed; accessed online: January 2023: https://vbn.aau.dk/ws/portalfiles/portal/75302209/C23_European_Carbon_Atlas.pdf

Weipeng Guo, Zhi Zhuang, Jiawei Yao & Philip F. Yuan, 2019, Building Energy Modeling: A Case Study for Green Office Buildings in Shanghai, Conference paper First Online: 05 July 2019

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