COST Action CA16114 RESTORE: REthinking Sustainability TOwards a Regenerative Economy,
Working Group Three Publication: REGENERATIVE CONSTRUCTION AND OPERATION

RESTORE
REthinking Sustainability TOwards a Regenerative Economy

Regenerative Construction and Operation

Bridging the gap between design and construction, following a Life Cycle Approach consisting of practical approaches for procurement, construction, operation and future life.

EDITORS
Giulia Peretti, Carsten K. Druhmann

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RESTORE Working Group Three Report: Regenerative Construction and Operation

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CONTENT

1. INTRODUCTION

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CONTENTS

Bridging the gap between design and construction following a life cycle approach consisting of practical approaches for procurement, construction, use & operation and future life

This publication is the main summary of COST Action RESTORE Working Group 3. It starts with a short introduction to the topic of Working Group 3 "Regenerative CONSTRUCTION AND OPERATION" its organisation and activities. The main part of the publication consists of the reports of the four sub-working groups "Procurement", "Construction", "Use & Operation" and "Second Life". These four reports contain a state-of-the-art analysis and analysis for the respective sub-theme, the identified gaps and give an outlook. The report is supplemented by the abstracts of some presentations given by the speakers at the Training School 3 (TS3) in Bolzano (IT) in March 2019 followed by articles from selected trainees of the Training School. The booklet concludes with the result from the Training School 3 challenge.

The main question Working Group Three faced, is how a building can be built, operated and maintained in a regenerative manner. The easiest answer is that this can be achieved through integration of restorative and regenerative principles into the construction and operation process. However, the current state of the art in construction and operation do not include, or only includes partially sustainable or regenerative values.

In regard to Regenerative Construction and Operation, and developing further the theoretical regenerative concepts of Working Group 1 and the design approaches of Working Group 2, a number of gaps, difficulties and opportunities become evident. Barriers can undercut a paradigm shift from the “business as usual” to a regenerative economy, making the realisation of regenerative projects difficult. The need for robust strategies to guide a transition from traditional construction process towards one which incorporates regenerative values is very clear. This publication collates the thoughts developed by the participants of Working Group Three, investigating and proposing robust approaches helping the paradigm shift, from the procurement to the operation and maintenance phases. The main aspects, questions and analysis investigated by the subgroups can be summarised as:

Theory vs. Practice:

Investigation of the process to allow a smooth and effective implementation of theoretical concepts and design into practice. Do we need special instruments, from tools up regulations, which support the realization of regenerative concepts?

Implementation of regenerative concepts and aspects needed throughout the whole process:

The basis of a successful realisation for a regenerative building are set in procurement and tendering of activities related with the building (design, site, maintenance). Further a regenerative building does not end with commissioning, as its operation as well as what happens after its primary use can be even more important.

Urban scale vs. building scale

It is not only buildings that can be regenerative. The regenerative principles must be applied and integrated at the urban scale, from place, landscape and infrastructure to the city level.

Regulation and Standards

The awareness of policy makers is crucial for the successful and wide implementation of regenerative targets. In the actual scenarios, are there legislative and certification frameworks that yet support the realisation or regenerative projects?

Existing Buildings or New Construction

When approaching a traditional End of Life, existing buildings need to be refurbished or retrofitted in order to assure a better second and future life. Further, an approach that allows the regeneration (recycling, reuse, and disassembly) of buildings needs to be integrated into the design and construction phases.

Regenerative Economy

Moving towards a Regenerative Economy is a key factor in the purpose of buildings. How, for example can buildings lead to a regenerative economy for all stakeholders involved in the construction and operational process and for those who work, live, play and use our buildings?.

Stakeholders

Who is involved in the construction and operation process? From the designer to the investor, from the construction company up to the municipality, a shift is urgently needed from a “consumer” approach up to a “prosumer” one. Currently, we use buildings, as building users (until they are used up) We don’t look after buildings as prosumers or as inhabitants. Here we need to think more about regeneration of resources, and of the environment.

1.1 LIFE CYCLE APPROACH

The Working Group One publication "Sustainability, Restorative to Regenerative" summarised the understanding of regenerative sustainability. WG3 focuses on the sustainable regeneration of the construction sector for buildings, landscape and infrastructure across the spectrum of sustainability values along the real estate life cycle. All relevant interests and interest groups must be integrated in a balanced manner. This makes the task a complex one, especially in terms of practical implementation. The concept of real estate as a life cycle is not new; the international standard, ISO 15686, has been in existence since 2000. It names the life cycle phases Planning, Design, Construction, Maintenance & Operation and Disposal. WG3 is based on these phases, and in accordance with our mission of regenerative sustainability. In the last decades many studies[1] on green building has been published, especially regarding their definition and scope, the quantification of their benefits and various approaches to the design of sustainable buildings[2]. However, there is often a lack of implementation at procurement, as covered by SG1 in Chapter 03 Procurement. During the implementation phase, a lot can be achieved for regenerative sustainability, and construction, covered by SG2 in Chapter 04 Construction. An area that is still in its infancy is the regenerative use and operation of buildings, as covered by SG3 in Chapter 05 "Operation & Maintenance". Defining the final life cycle phase of real estate merely as deconstruction does not go far enough. SG4 covered the "future life" of buildings in Chapter 06.

Summary of key Chapters

- **03 Procurement** (considering what follows design stage and proceeds construction phase, including bidding, tendering, procurement),
- **04 Construction** (from the preparation of the site up to the management of the construction site, including materials and technologies used during the construction process),
- **05 Operation** (starting from the commissioning and going through the operation and maintenance of the building), [2]
- **06 Future life** (considering what is happening to the building after its preliminary life, including refurbishment, retrofitting, reuse, adaptation, and in the worst case, demolition and dismantling).

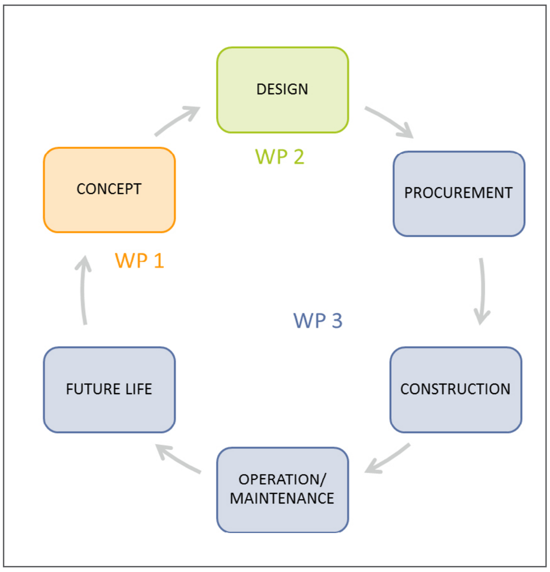

Figure 1.1 - Structure of WG3 in relation with the previous working groups

1.2 RESTORE CONTEXT - CONTINUITY FROM WG1 AND WG2

The RESTORE action commenced with re-thinking sustainability and the consideration of regenerative sustainability and a new language for sustainability. The identification of the key topics and the triggers for Regenerative Sustainability provided from Working Group 1 set the basis of the regenerative thinking which aims "to achieve the goal that we have to embrace a different vision, one in which our sustainable well-being emerges from our love for the planet" and allow the transition to a Regenerative Economy, where the process of living systems define the economic system as well.

[1] Zuo, J. and Zhao, Z., 2013. Green building research-current status and future agenda: A review. Elsevier Ldt.
[2] Please refer to the known publication platforms e.g. www.researchgate.net, www.elsevier.com

The resulting action is to think about methods and processes to get closer to the application of those concepts in real projects. Therefore, in Working Group 2, specific Pillars of the Regenerative Design in the practice have been investigated. Regenerative design is the now unavoidable challenge for designers and engineers, therefore the practical guidance for interdisciplinary design processes investigated in the working group are an essential step toward new design approaches. It tests old and new guidelines, tools, analogue and computational, which support regenerative, creative and innovative solutions.

Moving from a concept, as the definition of a common language for regenerative design of WG1, and design-oriented task, for the design and simulation tools investigated in WG2, the goal of WG3 was to move deeper into practice, bridging the gap between design concepts and construction. Inadequate construction or operation, will under-mine efforts done by the design team.

Through investigating the processes, methods, obstacles and changes of procurement, construction and operation of regenerative building, this working group aimed to bridge the gap between design and practice, providing guidance for those involved in the process, ensuring that no contradictions arise (e.g. cost and efficiency vs. responsibility and environmental effects). As this approach is valid in both new and existing building are considered, as well as different scales of the build environment, building as well as urban level.

1.3 WORKING GROUP 3 ORGANISATION & ACTIVITIES

The main activities of the WG3 began in June 2018 with 26 active participants. Prior to the initial workshop in Koper (SLO), the work plan and planned publications were agreed. In addition, a common developed “Manifesto” was developed at Koper, which set the common vision, mission, priorities, language, goals and action plan of the group and was used as a basis for the regenerative construction activities of WG3.

The mission of transforming the building life cycle by integrating regenerative principles bases on six priorities, which influenced the approach of each activity of the working groups:

- Address the human perspective
- Create output which can be used in practice
- Consider new and existing buildings
- Consider different scales of the built environment (building and urban level)
- Pay attention that no contradiction arises
- Consider regenerative goals in each stage of the process

This last point - the consideration of regenerative aspects in each stage of the process was identified as a base layer aspect, hence participants worked in four subgroups on the development of outputs for each life stage of the building,

The investigation of practical consequences for a regenerative was the priority, with the aim to bridge the gap between current construction practice and a new sustainable construction process.

Workshops/Meetings
Working Group 3 organized a number of physical and digital workshops and meetings. In addition to the workshop in Koper, further meetings took place in Stuttgart and Brussels. The most frequent exchange, however, took place online. For example, there were short zoom meetings every two weeks at which all participants of the subgroups exchanged information.

Short Term Scientific Missions (STSMs)
STSMs are 5- to 90-day research visits funded by COST Actions. They provide an opportunity for a visiting researcher or practitioner to access expert knowledge, research equipment, new demographics for social research, and experience the opportunities mobility in research provides. All STSMs should result in a scientific publication and should contribute to the goals of RESTORE.
At the time of going to press, several STSMs were advertised[3] and candidates were in the application process. We hope to successfully complete several STSMs by the end of the RESTORE funding period.

Training School 3
The Training School 3 (TS3) was one of the most powerful instruments for the development and dissemination of the content investigated in COST Restore and in particular in WG3. It brought together professional and academics from across Europe and beyond, focusing on implementation of regenerative approaches in construction and facilities management practice.

With the title “regenerative construction and operation – make the concept reality” 24 trainees with input from ten international speakers and five RESTORE trainers worked over four days on the paradigm shift to the realise of a regenerative building. TS3 was organized in accordance to the four main stages and subgroups plus a focus on circular economy principles and examples, mixing seminars with presentations and round tables, workshops with trainers, visit of case study and teamwork.

For each of the four phases defined in WG3, international experts gave input presentations to the trainees. This ensured that the trainees could be brought up to speed in a short period of time on the respective topic area, whilst providing a motivating boost for the group work. Abstracts of selected presentations can be found at the end of this chapter.

The challenge for the trainees was to develop a tool to support the process of construction and operation of regenerative building, from their procurement up to their destiny after their primary life. Chapter 07 of this report details the scope of work for the TS and the tools developed by the six teams. In addition, the trainees were required to write a short (1000 word) article regarding one of the life stages matched to one of the key topics introduced in WG 1. This exercise gives the opportunity to investigate more conceptual topics including Wellbeing, Equity and Resources, from the sound perspectives of procurement, construction, operation and second life.

1.4 DISSEMINATION

Communicating and disseminating outcomes of this working group is an essential step towards the RESTORE paradigm shift. Therefore, traditional media in additional to social media has been used for the spread of the activities and results. The most used communication media is the webpage of RESTORE with linked social media, In addition conferences and publication of papers[4] allowed the spread of technical and academic contents, increase the awareness and knowledge regarding regenerative construction and operation and the overall message of RESTORE.

[3] For details please see: http://www.eurestore.eu/short-term-scientific-missions-stsm/hosting/
[4] http://www.eurestore.eu/deliverables/

1.5 LOOKING FORWARD TO WORKING GROUP 4

After the 14 months of intensive work on procurement, construction, operation and future life, the work passes over to future working groups (4 & 5) dealing with the technologies to be used to impact, influence and create a regenerative building sector.

Working Group 4 is a technical and practical working group to further the work of WG3, including monitoring, communication technologies, information management and nanotechnologies.

Working Group 3 will continue to support the goals of COST RESTORE, e.g. by providing STSMs, creating publications and we will continue with the dissemination of the results with presentations and conferences.

1.6 SELECTED ABSTRACTS FROM TRAINING SCHOOL 2019 SPEAKERS

SUSTAINABLE BUILDING OPERATION - OVERVIEW OF EXISTING APPROACHES

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Today, with regards to sustainable buildings and infrastructure, the focus is on design and construction with the main goal being energy conservation. Almost 10 years ago, the Swiss Green Building Council[5] was founded by individuals from the Institute of Facility Management (IFM)[6] of the Zurich University of Applied Sciences (ZHAW). Together with the IFM, it researches issues relating to the sustainable use and operation of facilities in line with the Real Estate Life Cycle concept.

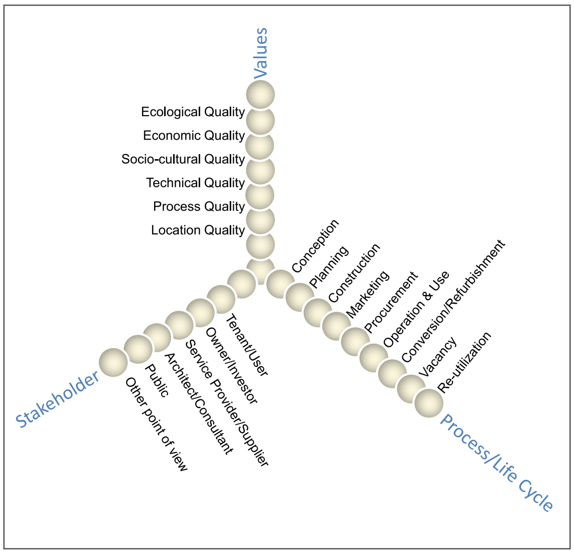

Figure 1.2 - IFM Real Estate LIfe Cycle Approach, Bernegger/IFM (2015)

It is important to include the three main stakeholder groups “user - operator - owner” in sustainability considerations and to balance their demands on sustainable building operation. We must also consider the social, ecological, economic, technical and procedural aspects.

With the support of the Swiss Federal Office of Energy (SFOE), IFM has carried out a preliminary project for a “Standard/Bevertungssystem Nachhaltiges Betreiben Schweiz” (Standard/Evaluation System Sustainable Operation Switzerland). The aim was to extend the standard for sustainable construction in Switzerland (SNBS) in line with the market in order to ensure that the use and operation phases were integrated.

In the first step, a comparison of international/national standards was carried out. A key finding emerged, that no existing standard covers all concerns nor a full life cycle approach. Subsequently,

5 www.zhaw.ch/de/lsfm/institute-zentren/ifm/
6 www.sgni.ch

a catalogue of criteria was synthesised from this comparison, which covers the above-mentioned stakeholders and aspects, taking into account the Swiss process and performance model (ProLemo)[7], The next step is to develop an easy-to-use evaluation tool.
In another application-oriented development project, a sustainability rating system is being developed for the real estate portfolio of a large Swiss city. The focus will be on conversion possibilities depending on future space requirements. During the pilot phase, it quickly became apparent that a better information situation regarding the properties is necessary in order to be able to carry out more complex analyses and optimization of performance during operation. In addition, in the future, it will no longer be necessary to look at properties individually, but rather networked, in order to achieve the high goals of regenerative sustainability in the real estate industry.
Now it is about acting actively and not hesitating. This requires more passion from everyone involved. Above all, this includes moving away from the only motivation in management being to achieve cost reductions through FM. FM can achieve much more. It requires different contract forms and durations between client and provider. One goal must be more transparency about the true performance of the buildings in order to work together for regenerative sustainability in building operation.

REDUCTION OF RESOURCES, WASTE, DELAYS AND COST OVERRUNS: OPTIMISATION OF THE CONSTRUCTION PROCESS THROUGH CONTINUOUS SITE MONITORING FOLLOWING A LEAN APPROACH AND DIGITAL BIM-BASED TOOL

Camilla Follini
Fraunhofer Innovation Engineering Center, Bolzano/Bozen, Italy

The high unpredictability of construction sites, characterised by unforeseen circumstances and subject to uncontrollable external factors, and the ever-increasing complexity of buildings are among the reasons that make construction management difficult, especially at the early stages.
These factors generally lead to the waste of resources, delays, and cost overruns, which may be considerably reduced by increasing the industrialisation of the construction process.

The ERDF funded project COCkPiT (Collaborative Construction Project Management) aims at facilitating the optimisation of the construction process through the development of a methodology and intuitive IT tools, to maximise the use of resources and reduce the overall waste. To this end, an approach based on lean management and new IT technologies, including BIM, was developed. The approach is composed of three main "modules", modelling, monitoring, and scheduling, which are cyclically optimized and connected to a BIM model to store and visualize data (see Figure 1.3). The overall methodology makes use of a normalised workload approach, based on the lean management concept of "pitch", that is the normalization of workloads to a certain time interval, in order to establish uniform scheduling and measurement of each construction task. The pitch can be applied to any kind of work, and it is used to establish a connection between the three variables that influence any task:

the quantity of the job to perform in a specific area,
the number of people working on it, and
the time needed to complete it.

The aim of the monitoring module is to provide means to systematically register the progress on-site, independently from the task-specific measurement unit. It, therefore, has a strong role in waste reduction and can be considered a trigger to a continuous improvement of operations of construction companies. The latter is due to the regular notation of data concerning delays, quality and management issues, which in time can provide reliable statistical information highlighting possible bottlenecks in the company processes.

[7] www.ifma.ch/de/produkte-standards/prolemo

In the COCkPiT approach, monitoring is strictly connected to short-term detail scheduling. By continuously monitoring the actual work performed on-site, the value of the pitch for all tasks is iteratively optimised, thus granting increasingly realistic scheduling based on effective construction operation. The monitoring module can be a digital extension of the site diary, which in practice is already registered daily on site.

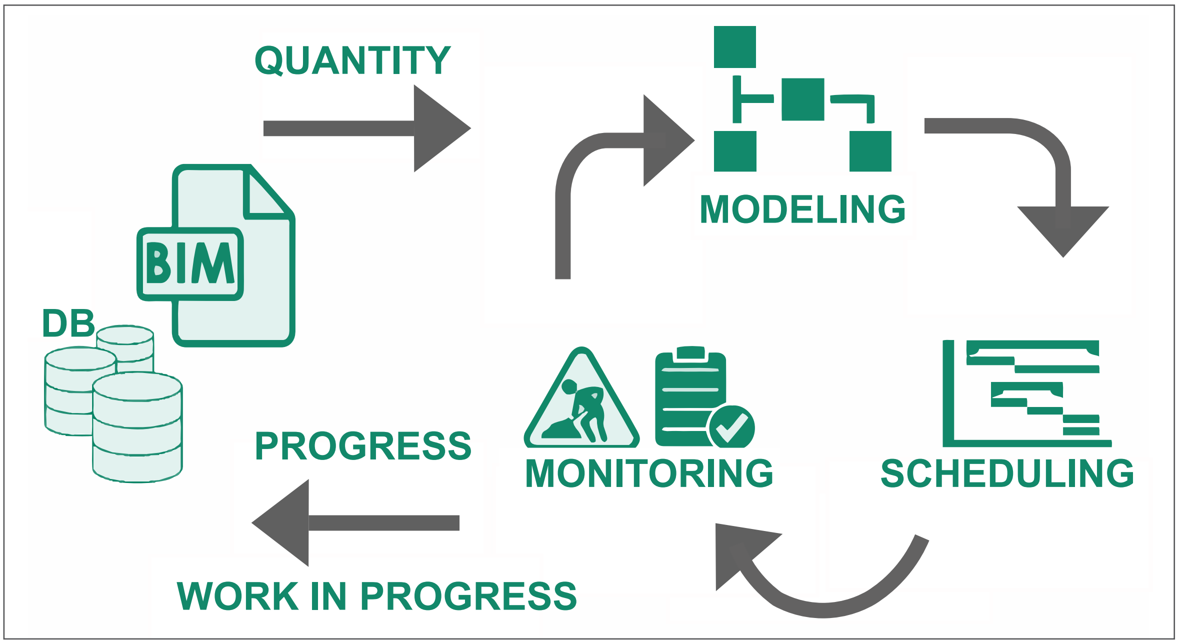

Figure 1.3 - The COCkPiT project approach

Although still at a development stage, the monitoring module has been tested on two construction sites for validation. The module consisted of the methodology built on a BIM-based tool. The first case study involved the installation of façade panels, and the second the mounting of HVAC components, based on multiple construction units and non-repetitive tasks. In both examples, the monitoring tool was generated making use of a BIM authoring tool, which provided quantities and object-specific properties. The monitoring was then fed back, to store the data tracked and visualize the progress directly in the BIM model. According to the companies' feedback, the methodology has the potential of providing early warning signals during the construction process, thus enabling the possibility of counteracting delays and waste on time.

OPERATIONAL TOOLS AND BUSINESS MODEL FOR ENERGY REFURBISHMENT - THE KLIMAKIT MODEL

Paola Penna [a] with **A. Schweigkofler** [a], **R.Brozzi** [a], **C.Marcher**[a,b], **D.Matt**[a,b]
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[b] *Free University of Bozen-Bolzano*

Despite a widely acknowledged need of retrofitting existing building stock, accessibility of a number of energy efficient technologies, financial products and public incentives, both building owners and public sector struggle to invest in energy refurbishment. High costs and uncertainty of the investment payback time are cited as the main reasons for a low rate of energy renovation in the European building stock.
Within the KlimaKit project, specific operational tools and a business model have been developed to support the refurbishment process of buildings owned by the Provincial Institute of Social Housing (IPES[8]) of

[8] Istituto Provinciale di Edilizia Sociale della Provincia Autonoma di Bolzano

the Autonomous Province of Bolzano-South Tyrol. The following operational tools have been defined on the base the analysis of the main challenges along the entire value chain of a refurbishment project:

1. An **analysis tool** assisting decision makers in the choice of the most suitable Energy Efficiency Measures (EEMs). The tool provides several items of data such as expected energy savings, CO_2 equivalent emissions, retrofit costs for the envelope and for the technical system as well as an estimation of the payback time of the intervention;
2. The **definition of soft criteria** to be implemented into public tenders supporting the selection of reliable partners, assuring compliance of required energy performance and architectural quality standards;
3. The use of **Building Information Modelling** for creating a database with all the data related to the retrofit project and for managing the building during the operational phase;
4. Guidelines defining the **main structure of the contracts** regulating the relationship between the stakeholders involved in the retrofit process.

The operational tools aim to support application of the business model, developed to increase the residential retrofitting rates in South Tyrol.

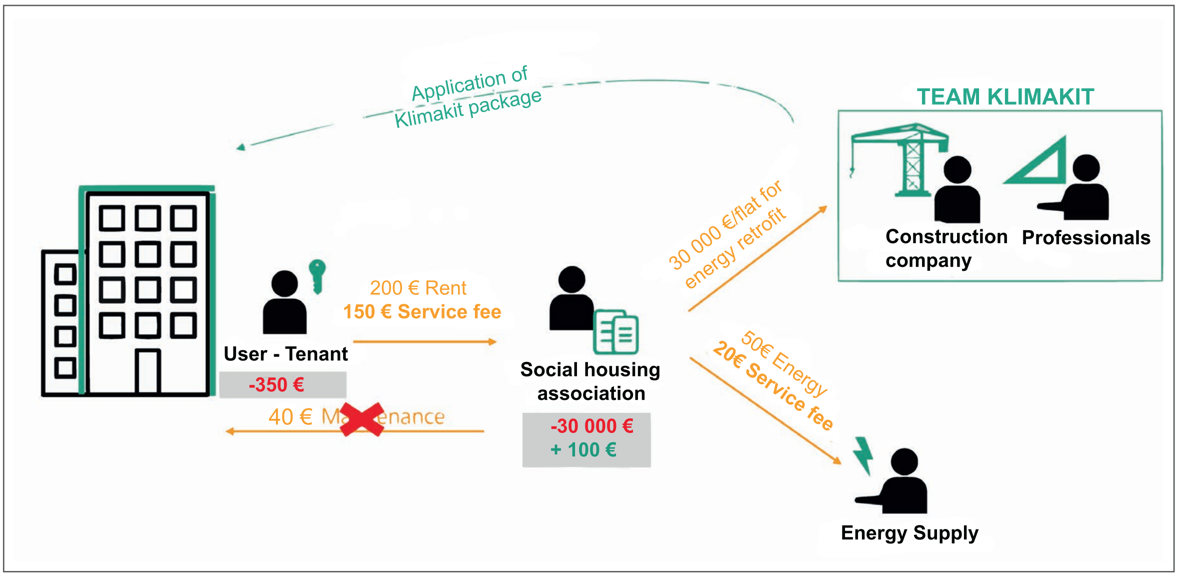

Figure 1.4 – The proposed KlimaKit Business Model

The purpose of the business model is the integration of the individual energy bills of the tenants into an energy plan for the payback of the retrofit costs. This allows IPES to recover part of the investment cost by means of the achieved energy savings. Figure 1.1 summarizes the proposed business model. After the refurbishment, the tenants pay a fixed service fee in addition to the rent. These costs are equal to the sum of the rent and the energy bills paid before the retrofit. This fee guarantees an energy service bundle e.g. thermal energy supply (heating and domestic hot water) and electricity, securing the tenants to future energy price fluctuations. In the case where the threshold foreseen in the specific consumption bundle is exceeded by the tenants, the additional energy consumptions are accordingly charged. This allows IPES to recover part of the investment, thanks to the reduced energy costs due to the energy retrofit intervention. Equipping the dwellings with a monitoring system plays a crucial role to provide information to tenants about their energy consumption. At the same time, IPES pays a service fee to the energy supplier, for the supply of energy the management and maintenance of the building energy system.

This research is part of the ongoing project “KlimaKit – Drive the change of the energy refurbishment market in South Tyrol. A strategy for social housing associations and public administration” founded by the European Regional Development Fund – Investment in growth and employment ERFD 2014-2020.

2. DEFINITIONS

COLLECTIVE AUTHORSHIP

CONTENT

2.1 PROCUREMENT

REGENERATIVE ECONOMY

The transition to a Regenerative Economy is about seeing the world in a different way – a shift to an ecological world view in which nature is the model. The regenerative process that defines thriving, living systems must define the economic system itself [1]. A Regenerative Economy is one that redefines wealth in terms of several kinds of capital, not just financial, but living, ecological, cultural, social, experiential, spiritual, intellectual and material. See also Doughnut Economics [2] that defines social and planetary boundaries

EGO, ECO, SEVA

The approach to sustainability that moves beyond our earlier egotistic mindset, the current eco approach and sees ourselves, and our buildings as 'part of the natural world eco-system' and not 'apart from natural world eco-system.'

THE FOUR LAWS OF ECOLOGY

Barry Commoner in The Closing Circle [3] defined the Four Laws of Ecology as

Everything is connected,
There is no waste,
Nature knows best and
There is no free lunch

WHO DEFINITION OF HEALTH

The World Health Organisation has defined health as "… a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity …"[4]

PROCUREMENT

Procurement is the process of purchasing goods or services. There are many different routes by which the design and construction of a building can be procured. A 2012 RIBA [5] survey suggested that procurement routes commonly used by respondents were: Traditional contract 86%, Single-stage design and build 41%, Two-stage design and build 39%, Management contract 18%, PFI 10%

REGENERATIVE SUSTAINABLE PROCUREMENT

Regenerative Sustainable procurement is the process of adopting procurement strategies and making decisions in a way that delivers added or co-benefits with respect to social, ecological, economic and cultural factors.

PQQ

The Pre-Qualification Questionnaire (PQQ) purpose is to assess the capability and competency of the supply chain (contractor, sub-contractor and suppliers) to complete the work, and to provide the opportunity for the supply chain to demonstrate a track record through the submission of evidence.

COLLABORATION

Collaboration can be defined as follows: The act and arrangements for two or more parties working together towards an agreed set of objectives. Establishing collaborative practices across the project supply team is of vital importance for regenerative and sustainable projects, where learning, development and sharing of regenerative tools and methods may be new to members of the supply chain. Construction projects often assemble diverse disciplines, many of whom will not have worked together before. Collaboration involves coordination and integration of often complex information, procedures and systems.

SOFT LANDING

It is generally accepted that buildings in operation do not perform as well as they could, or indeed as they were designed to, resulting in a significant performance gap between predicted and achieved performance. Often this is the outcome failings across the building delivery cycle (in briefing, design and construction and operation exacerbated by separation of design, construction and operation. The term 'soft landings' refers to a strategy to ensure that a golden thread of information is established throughout the project from design to building in use, that a smooth, 'no surprise' transition from construction to occupation is planned & managed and that operational performance is optimised.

RESPONSIBLE CONSTRUCTION

An approach to the construction that seeks to be regenerative, to do more good than just being less bad, enabling a construction process that is ecologically sound, socially and financially just. Responsible Construction is Fair, Inclusive and Respectful for all involved in the delivery of a project, including product manufacture, on and off-site construction, demolition and disposal of materials and the community in which the project is based.

PRECAUTIONARY PRINCIPLE

The precautionary principle states that if a (process, action or product) has a suspected risk of causing harm, then the burden of proof that it is not harmful falls on those undertaking the design, specifying or procuring the (process, action or product). Application of the Precautionary Principle is key to promoting healthier materials and eliminating toxic materials from buildings.

EQUITY, EQUALITY AND DIVERSITY

Recognising and appreciating the diversity of people, not just on issues such as gender, ethnicity, disability and age, but also sexual identification, background, personality, life and work style. Equity is ensuring everyone has access to they need to be successful while Equality is treating everyone the same regardless of differences, JUST [6], BeCorp [7] and FIR Fairness Inclusion and Respect [8] are examples of programmes that guide and recognise organisations approach to Equity, Equality and Diversity.

2.2 CONSTRUCTION

ADVANCED MATERIALS

Alternative materials to those considered traditional, including prefabricated materials such as plasterboards, Glass Reinforced Gypsum (GRG); precast concrete, Glass Fibre Reinforced Concrete (GRG), etc. and sustainable materials such as recycled materials, biomaterials, etc.

CONSTRUCTION AND DEMOLITION WASTE (CDW)

"any waste generated in the activities of companies belonging to the construction, renovation and demolition sector and included in category 17 of the European List of Wastes from the Commission Decision 2000/532/EC. The category 17 provides for codes for several individual materials that can be collected separately from a construction or demolition site. It includes waste streams [hazardous and non-hazardous; inert, organic and inorganic] resulting from construction, renovation and demolition activities. CDW originates at sites where construction, renovation or demolition takes place. Construction waste contains several materials, often related to cut-offs or packaging waste. Demolition waste comprises all materials found in constructions. Renovation waste can contain both construction-related materials and demolition-related materials". (European Commission, 2016)

EMERGING MATERIALS

Innovative and cutting-edge materials in the construction industry, including materials changing their properties depending on the environment (phase-change materials) and restorative materials such as self-healing materials; materials improving the indoor/outdoor air quality; etc.

RESTORATIVE AND REGENERATIVE MATERIALS

Materials aiming to restore the built environment to a healthy state. Examples of restorative materials include self-healing materials; materials improving the indoor/outdoor air quality.

TRADITIONAL MATERIALS

Materials which have been used traditionally, mainly natural materials, for example, stone, reinforced concrete, mortars, gypsum plaster, bricks, timber, adobe.

CONSTRUCTION AUTOMATION

"Engineering or performance of any construction process, on-site or off-site, by means of teleoperated, numerically controlled, semiautonomous, or autonomous equipment." (Skibniewski, 1992)

ADDITIVE MANUFACTURING

"Additive manufacturing is the general term for those technologies that based on a geometrical representation creates physical objects by successive addition of material. These technologies are presently used for various applications in the engineering industry as well as other areas of society, such as medicine, education, architecture, cartography, toys and entertainment." (ISO/ASTM 52900-15, 2015)

CONTOUR CRAFTING TECHNIQUE

Additive fabrication technology that "uses computer control to exploit the superior surface-forming capability of trowelling to create smooth and accurate planar and free-form surfaces". (Khoshnevis & Dutton, 1998)

D-SHAPE TECHNIQUE

Large scale 3D printing technology based on layer-by-layer deposition of sand material that is aggregated with particular binders (Colla & Dini, 2013).

EUROCODE

Eurocodes are a series of 10 European Technical Standards that provide a common approach to the structural design of buildings and other civil engineering works. These standards intend to help make European companies more competitive (Eurocodes, 2019) and lead to a uniform level of safety in the construction industry. Eurocodes apply to structural design of buildings and other civil engineering works including: geotechnical aspects; structural fire design; situations including earthquakes, execution and temporary structures (Eurocodes – Building the future, 2019).

DIN

DIN is the acronym for "Deutsches Institut für Normung" (German Institute for Standardization), who developed DIN as a set of technical standards that specifies requirements for products, services and processes. These standards are reviewed every 5 years (DIN, 2019)

BSI

BSI "British Standards Institution". As the pioneer of standards for management systems, BSI is now the world's largest certification body. These standards set out an agreed good practice, designed to make things better, safer and more efficient (BSI – What is a Standard, 2019).

ISO

ISO is the acronym for "International Organization for Standardization" which has developed and published 22598 documents that provide requirements, specifications, guidelines or characteristics that can be used to ensure that materials, products, processes and services are fit for their purpose (ISO, 2019).

LEED

LEED, 'Leadership in Energy and Environmental Design', is an ecology-oriented building certification program run under the U.S. Green Building Council (USGBC). LEED provides a framework to create healthy, highly efficient and cost-saving green buildings (LEED, 2019).

BREEAM

BREAM is the acronym of “Building Research Establishment Environmental Assessment Method” which identifies a leading sustainability assessment method in Infrastructure and Building Projects (BREAM, 2019).

DGNB

DGNB “Deutsche Gesellschaft für Nachhaltiges Bauen” (“The German Sustainable Building Council”) which has developed a unique certification system for sustainable buildings. The 50 sustainability criteria of DGNB assess the quality sections ecology, economy, socio-cultural aspects, technology, process work-flows and site are certified (DGNB, 2019).

2.3 USE & OPERATION

FACILITY MANAGEMENT

The European Committee for Standardisation’s (CEN) EN 15211-1 defines Facility Management as the “the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities”.

ISO 141011

2017 defines Facility management (or Facilities Management or FM) as a professional management discipline focused upon efficient and effective delivery of support services for the organisations that it serves, integrating “people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business.”

SUSTAINABLE FACILITY MANAGEMENT

The description of Sustainable Facility Management (SFM) illustrates how it offers the opportunity to engage users, operationalise strategic energy goals and link decision making to the global and local climate as well as the eco-system (Nielsen et al., 2016).

REGENERATIVE FACILITY MANAGEMENT

Regenerative Facility Management targets to achieve healthy state of people´s environment in short and long term by pushing solutions and resources beyond sustainability.

2.4 FUTURE LIFE

CIRCULAR ECONOMY

An economic model which emphasises a closed loop system of resource consumption and utilisation thus minimizing waste while encouraging re-use, recycling and protection of resources. This principle can be mutually beneficial between all stages of a building (design, procurement, construction, maintenance and recovery) through increased efficiency in inter-dependent stages, greater value recovery, lower disposal rate and reduced demand in raw materials & energy consumption. Principles of Circular Economy as defined by the Ellen MacArthur Foundation are

1. Eliminate waste, pollution, negative social & environmental impact,
2. Keep products and materials in use as long as possible,
3. Regenerate natural systems.

CRADLE TO CRADLE

C2C is a nature mimicking approach to design and manufacture process which removes waste generation by constantly reutilizing resource materials through a circulatory closed loop process. This system can be differentiated into Biological and Technical loops depending on the source material for the product. Biological loops generally contain consumption products from organic sources and can be biologically disintegrated into nutrient source. Service products on the other hand fall under Technical loops where post-use, the products must be recovered and disassembled to its constituent "technical nutrients" and reutilized in the manufacture process.

REUSE

Process of repurposing a resource as its originally intended function or for a different use altogether to mutually have environmental, social and economic benefits. It is a sustainable alternative tool to demolition of buildings or disposal of materials by deconstruction of structures to recover raw materials and retain value.

SECOND LIFE/ FUTURE LIFE

A sustainable design objective which ensures minimization of waste generation and reduction in consumption of resources by repurposing the building/product or its constituent resources after their designated life cycle to serve same or different functions.

ZERO WASTE

A design policy which utilizes responsible resource consumption, smart design and complete reuse or recycling of materials thus entirely eliminating waste production.

PHYTOREMEDIATION

Phytoremediation is the technique of utilization of greenery for in-situ repair, stabilization or improvement of the condition of the existing soil or ground water.

DESIGN FOR DISASSEMBLY

Buildings/products which are intentionally designed for easy recovery of its constituent parts for further usage after completion of the original function.

DISMANTLEMENT AND DECONSTRUCTION

Dismantlement is a process of careful disassembly of the comprising parts of a building for recycling and re use, thus retaining material value instead of demolition and destruction of resources. Demountable buildings are an example of this approach: Buildings which are manufactured and transported in parts and can be installed or dismantled on-site and recovered for re-use.

CIRCULARITY PASSPORT / MATERIAL PASSPORT

Circularity or Material Passport are information sharing systems which bridge the knowledge gap along the supply chain. This allows all stakeholders to gain detailed information about the product or building enabling maximum value recovery for large scale implementation of circular economy.

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3. PROCUREMENT

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CONTENT

3.1 STATE OF THE ART

3.1.1 PROCUREMENT FOR REGENERATIVE SUSTAINABILITY

Within construction, close to 100% of services, consultancy and products are out-sourced from the client or design team organisation to the sectors supply chain. Sustainable procurement is the transition between the sustainable design vision and the realisation of that vision. Within the regenerative sustainability paradigm, it is vital that the construction process of the project along with the facilities management of the project is undertaken in a manner that is not only socially just and ecologically sound but is regenerative in enabling human and ecosystems to thrive.
Bidding can be seen as fulfilling two functions, securing organisations with the capability (commitment, expertise and passion) towards sustainability, and agreeing on the price for the delivery, operation and possibly life cycle of design.

3.1.2 BACKGROUND AND CONTEXT

In this chapter, we explore sustainable procurement ‘state of the art’, introduce a view of regenerative sustainability procurement and propose a PQQ (Pre-Qualification Questionnaire) route for procurement that can be used and further developed by clients and design teams in the procurement of services and goods from the sectors supply chain.
This chapter builds on the work of RESTORE Working Group One (Sustainability Restorative to Regenerative) and Working Group Two (Regenerative Design) and prepares the foundation for Working Group Three, Construction and Buildings in use.
To provide a guide for client and design teams to gain deeper insights on procuring construction, resource, operational and life cycle services through a regenerative bidding paradigm,
To compare the most common construction procurement methods from the sustainability lens, to provide recommendations to consider for enriching procurement methods with more of a “regenerative approach”.
Working Group3, Subgroup 1 focuses on procurement as that vital link between the work of previous working groups (WG1 Sustainability Strategy and WG2 Regenerative Design) and the Regenerative Construction and Building Operations of WG3. Figure 3.1 demonstrates this link as mapped against the RIBA Plan of Work Stages 2013 [RIBA, 2013]

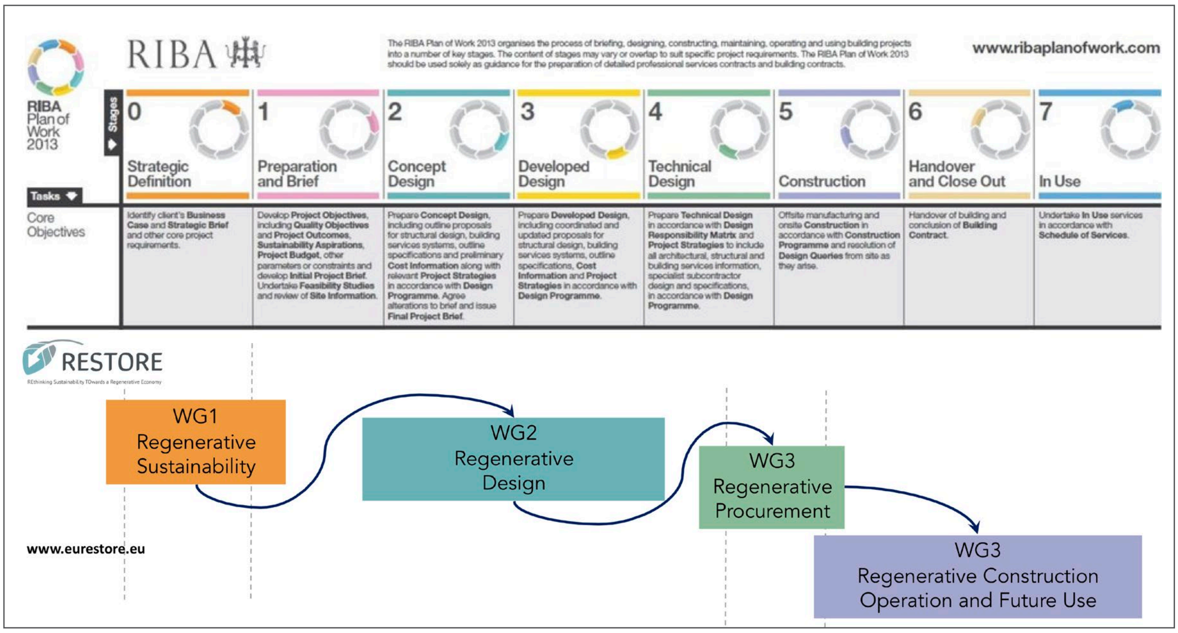


Figure 3.1 - Procurement – the link between the work of WG1 Sustainability Strategy and WG2 Regenerative Design and the Regenerative Construction and Building Operations of WG3 as mapped against the RIBA Plan of Work Stages 2013

3.1.3 REGENERATIVE SUSTAINABILITY DEFINITIONS AND PRINCIPLES

RESTORE Working Group One within Sustainability, Restorative to Regenerative, [Brown, M et al] established the following foundation for regenerative sustainability that is adopted and built upon in this publication, within this section focusing on their role, influence and importance within the bidding phase.

PLACE: Our relationship with place, ecology, nature, soil, bio-climate (The built environment sees Earth as a community, not a commodity)

ENERGY: Working towards restorative and regenerative energy, net-zero, carbon-neutral approaches and energy storage (locally owned, fossil fuel free and naturally replenishable)

WATER: Understanding net positive water, building influence, floods, drought, water stress (Applying and maintaining Natural and Ecological Water Cycles within the built environment)

WELLBEING: Provision of buildings and facilities that foster health, happiness, salutogenesis, biophilia, mindfulness, air, light, comfort (A built environment, in design, construction and operation that heal and improve inhabitant health)

CARBON: Reimaging Carbon with science-based targets, Carbon 350 ppm [1], Paris Agreement of 2.0 DegC global warming and Aspirational Target of 1.5 DegC[2], the social impact of carbon (Carbon that works within natural eco-systems)

RESOURCES: A future of healthy and responsible materials, responsible, transparency, conservation, circular economy (A circular, responsible resourced built environment founded on precautionary principles applied to planetary and people health)

EQUITY: Working towards equity, equality, fairness, inclusion, respect (A built environment equity that goes beyond the human community)

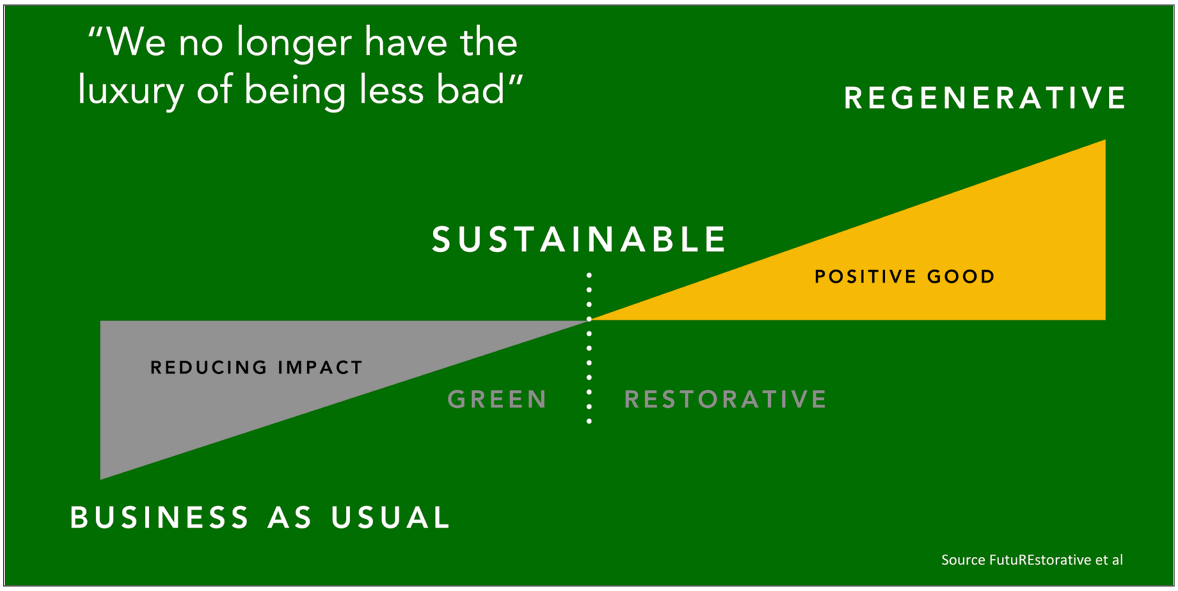


Figure 3.2 - From Business as Usual to Regenerative Sustainability (Brown, M et al)

1 www.350.org
2 The Paris Agreement https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

EDUCATION: The missing component of sustainability strategies for behaviour in the next generation and the next project development (An informed and inspired next generation of projects and people that achieve higher than the current)

ECONOMICS: From linear economies to regenerative economy, shared economy, circular economy (A built environment as material banks)

Working Group One established an essential and influential set of sustainability definitions for sustainability, restorative and regenerative [Brown, M, et al. 2016]. These definitions created the starting point for further exploration and development throughout the RESTORE Cost Action and resonated through this publication and importantly as a foundation for procurement of construction and operational services and materials.

SUSTAINABILITY: Limiting impact. The balance point where we give back as much as we take

RESTORATIVE: Restoring social and ecological systems to a healthy state

REGENERATIVE: Enabling social and ecological systems to maintain a healthy state and to evolve

Further, RESTORE Working Group One identified, initially as a prompt for discussion and further research a 'ranking' of the current Sustainability Tools, Standards and Certifications in respect of how they will maintain or further (business as usual) sustainability, restorative sustainability or regenerative sustainability.

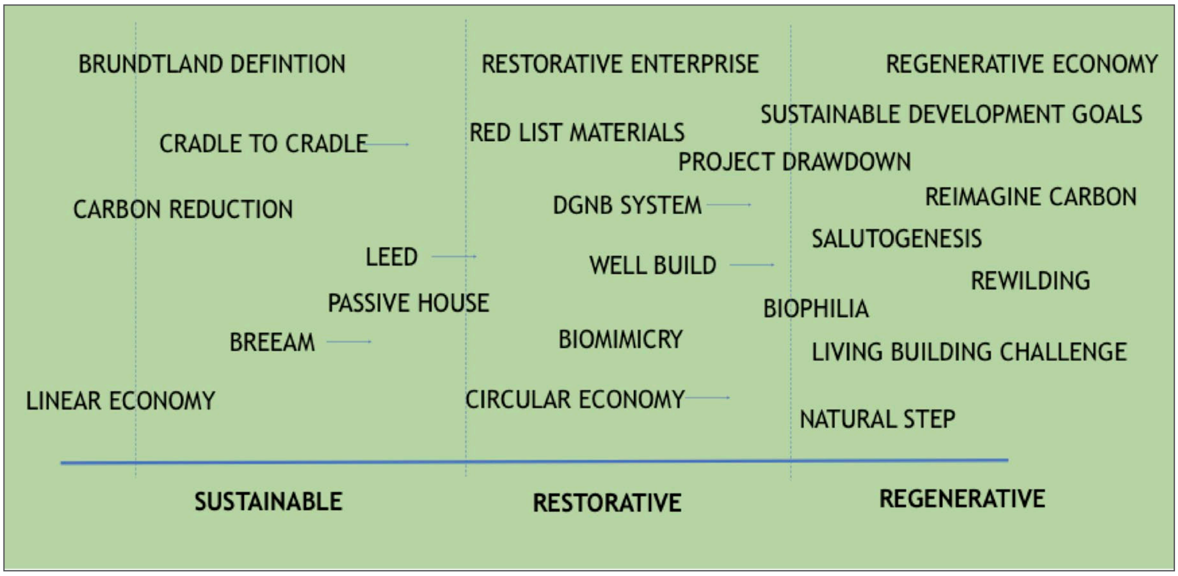


Figure 3.3 - Regenerative Sustainability Tools and Approaches (Brown, M et al)

3.1.4 PILLARS OF REGENERATIVE DESIGN

The Pillars of Regenerative Design developed and proposed in the Cost RESTORE Working Group 2 Publication [Naboni, Havinga. 2019] for design, also provides a robust set of pillars for regenerative construction and should form the basis of regenerative procurement strategies,

Pillar One: **Climate and Energy**

Pillar Two: **Ecology and Carbon**

Pillar Three: **Human Health and Justice**

3.1.5 THE UNTAPPED POWER OF REGENERATIVE PROCUREMENT

The procurement process can be seen as an invaluable tool to raise awareness and force change throughout the supply chain, however, this can only be achieved if the client and project follow through on the sustainability aspects vetted at procurement. The framework, recommendations and outcomes from WG3, as contained within this publication, will undoubtedly assist here, aligning procurement with regeneration construction, operations and future life to assure the realisation of regenerative buildings.
The level of sustainability questioning within PQQ's and Bidding documentation has undoubtedly deepened and improved over recent years. This has had the effect of raising the supply chain, (and client) awareness of sustainability matters. However, this may be superficial as those bidding will often respond with the best possible technical answer, coupled with often enhanced evidence, in order to attain a maximum score, knowing that not all sustainability issues used in bidding are followed through during construction.
It should be noted that there is the valid argument that asking mature sustainability questions at bid stages ensures the selection of supply chain with a sophisticated holistic understanding, competency and experience, whether or not specific sustainability approaches are relevant or implemented on the project.

3.1.6 SUSTAINABLE PROCUREMENT STANDARDS

ISO 20400
Procurement that has the most positive environmental, social & economic impacts possible over the entire life cycle. ISO 20400 [14] fundamentals are designed to guide an organisation in understanding the context and the drivers for an organisation and to establish an aligned sustainable procurement strategy then Action Sustainability's Shaun McCarthy (one of the contributing organisations in the development of ISO 20400) commented "Societal expectations are at an all-time high. It is no longer acceptable to do a few sustainability things in your organisation and ignore your supply chain. This standard can be a game changer if implemented the way it was designed to be used'.(McCarthy 2017)

ISO 26000
ISO 20400 [15] fundamentals covering core principles of sustainability and sustainable procurement are based firmly on the core subjects within ISO 26000. In turn, the ISO 2600 criteria are based upon the UN Guiding Principles of Human Rights and Business and aligned with the UN Sustainable Development Goals.

Sustainable Development Goals
Many of the risks, opportunities for regenerative stationarity at social, ecological and financial aspects sits within the supply chain procured to deliver projects. The Sustainable Development Goals SDG's provide a proven and globally accepted framework for ethical and sustainable procurement policies.

BREEAM (2018)
BREEAM NC 2018 refers extensively to sustainable procurement and incorporates ISO 20400 as the recommended sustainable procurement strategy (through providing additional credits where ISO 20400 has been adopted)

LEED
LEED for Existing Buildings includes Environmentally Preferable Purchasing (EPP) as a prerequisite, focusing on the Operations & Maintenance of the building and the site. The goals are amongst other the support of the local economy, avoid landfill, end-of-life scenarios excluding landfill. Further, the LEED programs promote the sustainable purchasing especially related to the choice of materials (e.g. use local environmentally sourced materials, develop a sustainable material policy), where is possible earn points for projects that implement, sustainable purchasing policies.

DNGB
Through the criterion "Sustainability aspects in the tender phase" the DGNB system strives to ensure that all decisions in procurement and bidding follow an integrated approach. Further, the bonus systems in the

2018 version awards tenders which recommend the use of recycling and secondary materials. In many other criteria regarding amongst other the environmental quality of materials, building site management and commissioning, an requisite is evidence that the sustainability and DGNB requirements have been integrated within tender documents.

ISO 14001 Environmental Management
The 2015 version of ISO 14001 standard introduced fundamental changes to the previous standard and extended the influence on the environment to an organisations supply chain. There are specific sustainable procurement requirements including evaluating the supply of goods, services and outsourced processes through taking a lifecycle perspective.

Living Building Challenge
The latest edition of LBC version continues to embrace the philosophy of 'imagining every act of construction making the planet a better place' With certification to Living Certification dependent on post-occupancy proving of energy, water and air compliance and performance, success of LBC depends on close collaboration between client, design, construction and facilities management.

3.1.7 EARLY CONTRACTOR INVOLVEMENT

Traditionally the client would appoint consultants to design and project managers to select the contractor, who in turn would procure trade contractors, services and materials. However, this is now seen to be a fragmented and adversarial approach that would not readily enable regenerative construction.
Early Contractor Involvement (ECI) is a critical approach where a contractor's skills are introduced early into a project to bring regenerative sustainability and design 'buildability' and cost efficiencies to the pre-construction phase.
The earlier the contractor is appointed, the higher the potential benefits they can bring to the project. Project and sustainability value is created in the previous stages of the project, without close and focused project management value can be destroyed through the construction phase..

3.1.8 PROCURING TO COLLABORATE

It is essential to establish collaborative principles as early as possible, communicating and reinforcing expected collaborative ethos and values during the procurement process, seeking evidence from potential supply chain members on collaborative experience and performance
Establishing collaborative practices across the project supply team is of vital importance for regenerative and sustainable projects, where learning, development and sharing of regenerative tools and methods may be new to members of the supply chain. Construction projects often assemble diverse disciplines, many of whom will not have worked together before. Collaboration involves coordination and integration of often complex information, procedures and systems.
Standards such as the Living Building Challenge require unique and special collaboration across the project team and throughout the life of the project cycle. 'Living' Certification (The 'full' Living Building Challenge Certification) is dependent on proving design intent and demonstrating, for example, net-zero energy over twelve months post construction as such certification will fall during the facilities management phase of delivery and require a high level of collaboration between design, construction and building operations from briefing stage to certification success.

3.1.9 SUSTAINABLE VALUE MANAGEMENT AND VALUE ENGINEERING

Given that Value Engineering has in recent years become to mean cost reduction, rather than its original intent of improving function, FutuREstorative [Brown, M 2016] proposed a definition for restorative value management and regeneration, to imagine if every value-engineering exercise made the world a better place

3.1.10 BIDDING: A REGENERATIVE SUSTAINABILITY COST MODEL

The cost of winning construction work through competitive bidding across the EU can be estimated as being on average € 76 million and further that the cost of 'not winning' bids is possibly € 64 million is unsustainable. FutuRE-storative [Brown, M, 2016] makes a case for a revised approach to bidding, one that is based on capability, sustainable profits and not lowest cost. Indeed, through decades of lowest price tendering, where out-turn costs are bloated from construction organisations regaining lost costs at bid stage we have lost understanding of the real cost of construction. There is a need for a regenerative sustainability cost model

	RESTORATIVE VALUE
VALUE MANAGEMENT	The ***strategic***-level exercise of maximising the project's net-positive sustainability capability Defining and establishing the sustainability philosophy and vision for the project
VALUE ENGINEERING	The ***operational***-level exercise of maximising the project's net-positive sustainability function of a building, component or process. Ensuring design and operational decisions remain focused on the project's restorative sustainability philosophy and vision

Figure 3.4 - Value Management and Value Engineering Defined for Regenerative Sustainability

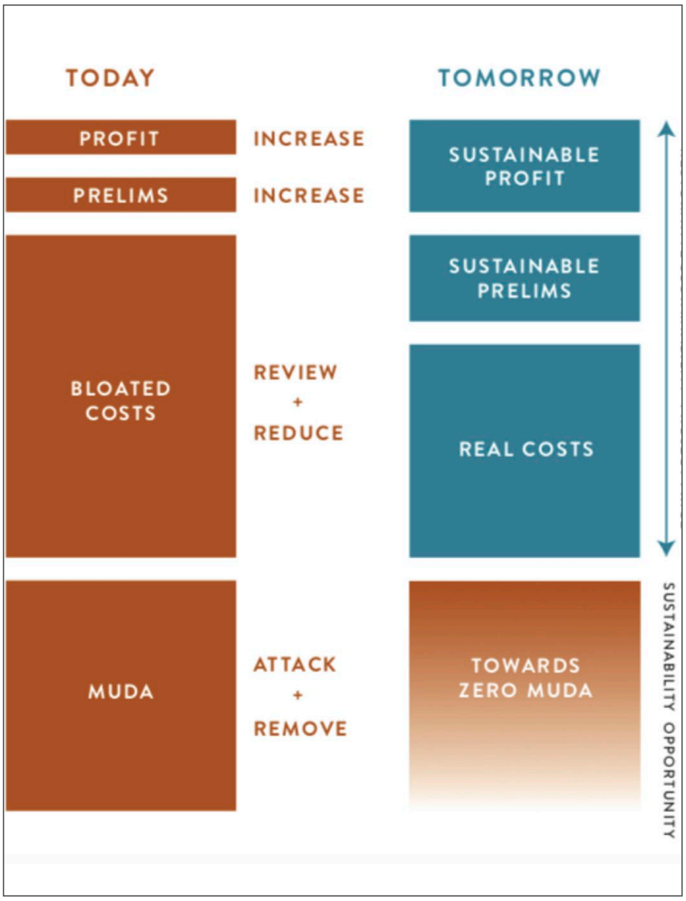


Figure 3.5 - Regenerative Sustainability Bid Cost Model

A Regenerative Sustainability Bid Cost Model

Sustainable profits – Fixed, agreed, what the organisation needs to develop sustainability, to invest in training, research and development

Sustainable margins – The correct level of margins for the project, ensuring correct sustainability infrastructure, accommodation, facilitation, training, continuous improvement

Sustainable costs – The real costs–the lean costs–of doing the task(s) with no historic unproductive element

Sustainability opportunity costs – The balance, derived from any remaining Muda[3]. Ideally targeted at 100% of the original Muda cost.

[3] MUDA the Japanese term identifying several forms of waste: Transport, inventory, motion, waiting, overproduction, over processing, defects and skills that are central to lean management systems. https://en.wikipedia.org/wiki/Muda_(Japanese_term)

3.1.11 PROCUREMENT FOR A CIRCULAR ECONOMY

Circular Economy principles (Ellen Macarthur Foundation[4])

- Eliminate waste, pollution, negative social & environmental impacts
- Keep products and materials in use
- Regenerate natural systems

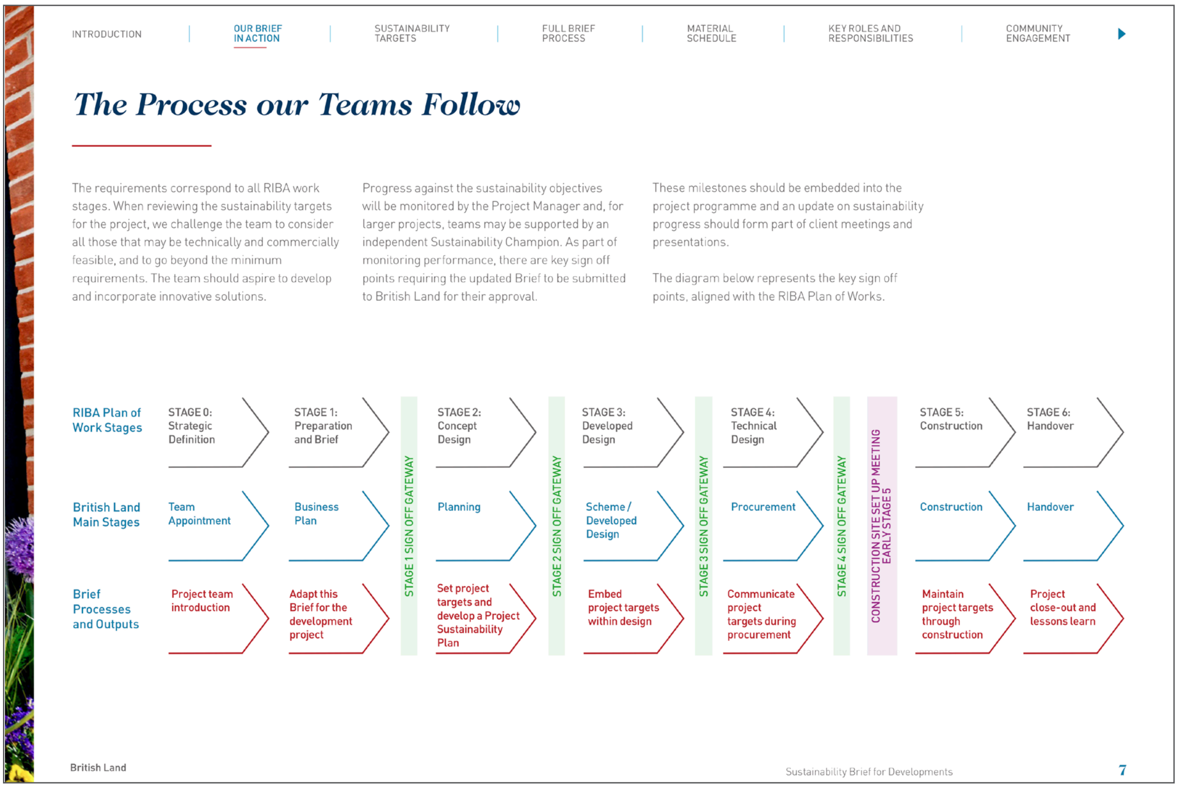
The built environment plays a vital role within the transition towards a circular economy. A Circular Economy should not be seen as a cost-adding exercise, but an essential investment towards the (financial, ecological and social) success of projects, and should be approached within this mindset. Consequently, time and resources spent on enabling and implementing circular economy mechanisms should be accounted for in the design evaluation and procurement stages.
Indeed, communication of and inclusion of Circular Economy principles and a project's aspirations at the procurement stage is vital in ensuring success against Circular Economy objectives.

3.2 SUSTAINABILITY PROCUREMENT CASE STUDY

The British Land Company plc is one of the largest property development and investment companies in the United Kingdom.
The British Land Sustainability Brief for Developments [26] supports the vision to create Places People

Figure 3.6_A - British Land Sustainability Brief for Developments

4 https://www.ellenmacarthurfoundation.org



INTRODUCTION | OUR BRIEF IN ACTION | SUSTAINABILITY TARGETS | FULL BRIEF PROCESS | MATERIAL SCHEDULE | KEY ROLES AND RESPONSIBILITIES | COMMUNITY ENGAGEMENT

The Process our Teams Follow

The requirements correspond to all RIBA work stages. When reviewing the sustainability targets for the project, we challenge the team to consider all those that may be technically and commercially feasible, and to go beyond the minimum requirements. The team should aspire to develop and incorporate innovative solutions.

Progress against the sustainability objectives will be monitored by the Project Manager and, for larger projects, teams may be supported by an independent Sustainability Champion. As part of monitoring performance, there are key sign off points requiring the updated Brief to be submitted to British Land for their approval.

These milestones should be embedded into the project programme and an update on sustainability progress should form part of client meetings and presentations.

The diagram below represents the key sign off points, aligned with the RIBA Plan of Works.

RIBA Plan of Work Stages	STAGE 0: Strategic Definition	STAGE 1: Preparation and Brief	STAGE 1 SIGN OFF GATEWAY	STAGE 2: Concept Design	STAGE 2 SIGN OFF GATEWAY	STAGE 3: Developed Design	STAGE 3 SIGN OFF GATEWAY	STAGE 4: Technical Design	STAGE 4 SIGN OFF GATEWAY	CONSTRUCTION SITE SET UP MEETING EARLY STAGE 5	STAGE 5: Construction	STAGE 6: Handover
British Land Main Stages	Team Appointment	Business Plan		Planning		Scheme / Developed Design		Procurement			Construction	Handover
Brief Processes and Outputs	Project team introduction	Adapt this Brief for the development project		Set project targets and develop a Project Sustainability Plan		Embed project targets within design		Communicate project targets during procurement			Maintain project targets through construction	Project close-out and lessons learn

British Land   Sustainability Brief for Developments   7

Figure 3.6_B - British Land Sustainability Brief for Developments

Prefer – places that promote wellbeing and improve productivity; places considered part of their local communities; places designed for the future, flexible and adaptable as the world changes; places where local people develop skills and businesses grow.

Providing a briefing document for project teams to be ambitious in achieving the greatest positive social and environmental outcomes through their work on developments, the Sustainability Brief provides a process and guidance for setting and delivering best practice sustainability goals on projects.

3.3 REGENERATIVE SUSTAINABILITY PROCUREMENT

A Pre-Qualification Questionnaire for Regenerative Sustainability
The following PQQ template details areas of regenerative sustainability that a client (or the design team acting for a client) should be considering, and seeking evidence of understanding, approach and experience from the potential construction supply chain. These are questions that should be considered and addressed through PQQ responses, and in further detail within interview scenarios.

The template should be tailored to meet project specifics.

A customisable version of the Regenerative Construction PQQ can be downloaded from the RESTORE website.

Assessing Regenerative Sustainability Capability

A PQQ (Pre-Qualification Questionnaire) Template for Regenerative Sustainability Projects

The following template details areas of regenerative sustainability that a client (or the design team acting for a client) should be considering, and seeking evidence of understanding, approach and experience from potential construction supply chain. These are questions that should be considered and addressed through PQQ responses, and in further detail within interview scenarios.
The template should be tailored to project specifics.
It is based on the work of RESTORE Rethinking Sustainability Towards a Regenerative Economy.

THEMES	Questions	Minimum Response	Good Response	Excellence Response
1 PLACE: Reference: • RESTORE Sustainability: Restorative to Regenerative • 4 Laws Ecology • Ego/Eco/Seva	Please provide evidence of your • Ecological Understanding, including the importance of your relationship with the land, communities and cultures *during construction.* • Application of 4 laws of ecology *within construction/operation approaches* • How the shift from Ego to Eco to Seva is reflected in your sustainability visions, strategies and plans.	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate organisations ecological commitment	Good Understanding with extensive experience, Has a case study in the public domain that illustrate organisations ecological commitment Experience of project with appropriate sustainability certification standard (see below)

THEMES	Questions	Minimum Response	Good Response	Excellence Response
2 ENERGY: Reference: • RESTORE Sustainability: Restorative to Regenerative	Please provide evidence of your approach to • regenerative renewable energy • constructing without fossil fuel-based energy	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate approach to use of renewables during the construction phase	Good Understanding with Extensive experience, Has a case study in the public domain. Experience of project with appropriate sustainability certification standard
3 WATER: Reference: • RESTORE Sustainability: Restorative to Regenerative • Living Building Challenge	Please provide evidence of • Understanding ecological water cycles, and water flows in relation to the construction and operational phases of the building.	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate approach to water ecology during the construction phase	Good Understanding with Extensive experience, Has a case study in the public domain. Experience of project with an appropriate sustainability certification standard
4a WELLBEING: (The Construction Working Environment)	Please provide evidence of • How have you provided, enabled or fostered a working environment that improves the health and wellbeing of construction, manufacture and operational personnel. (refer to the WHO definition of health that goes beyond physical health)	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate approach to ‘improving’ health and wellbeing during the construction phase	Good Understanding with Extensive experience Has a case study in the public domain Experience of project with an appropriate sustainability certification standard

THEMES	Questions	Minimum Response	Good Response	Excellence Response
4b WELLBEING: (Biophilia) Reference • 14 patterns of Biophilic Design	Describe your understanding, importance and influence of biophilia and biophilic design. Please provide evidence of • biophilic, or connectivity with nature approaches within own organisation • biophilic design workshop (leading, participation) • biophilic application during the construction phase • (wellbeing) co-benefits that have arisen from your biophilia related activities	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate connectivity with nature, biophilic design workshops and co-benefit results	Good Understanding with Extensive experience, Has a case study in the public domain Experience of project with an appropriate sustainability certification standard
5 CARBON: Reference • Carbon Definitions	Please provide evidence of how • You construct in manner that is net zero carbon (i.e. the project sequests more carbon than it emits) in relation to reducing Fugitive carbon and increasing the Durable and Living carbons. • How will you apply your approaches to this project	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate connectivity with nature, biophilic design workshops and co-benefit results	Good Understanding with extensive experience, Has a case study in the public domain. Experience of project with an appropriate sustainability certification standard

THEMES	Questions	Minimum Response	Good Response	Excellence Response
6a RESOURCES: (Materials) Reference • Red List • Precautionary Principle	How do you • ensure Red List (or similar) compliance for the materials incorporated into your projects • how will you apply the precautionary principle in specification and procurement to this project	Limited Understanding Has limited experience of delivery.	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate prevention of chemicals of concern and / or application of the precautionary principle	Good Understanding with Extensive experience, Has a case study in the public domain. Experience of project with appropriate sustainability certification standard construction that embraces the Red List
6b RESOURCES: (Waste) Reference • Material Conservation Plan	Please prepare • a sample material conservation plan for the project using the template provided.	Limited Understanding illustrated in material conservation Has limited experience of material conservation	Good Understanding with experience illustrated in material conservation Provides evidence of at least 1 past project to illustrate	Excellent Understanding illustrated in material conservation with Extensive experience, Has a case study in the public domain. Experience of project with appropriate sustainability certification standard
7a EQUITY: Reference: • Just	Please provide evidence of how • your construction process / facilities management operations is undertaken in a manner that is socially and culturally just, is fair, inclusive and responsible (FIR)	Limited Understanding Has limited experience	Good Understanding with experience. Provides evidence of at least 1 past project to illustrate	Excellent Understanding Has a case study in the public domain. Experience of JUST or similar construction that embraces social justice

THEMES	Questions	Minimum Response	Good Response	Excellence Response
7b EQUITY: (SDG's) Reference • Sustainable Development Goals SDG's	Please provide evidence of how you • embrace the Sustainable Development Goals and progress, or contribution made against the 17 goals. • How will you apply the SDG's to this project?	Limited Understanding of SDG's Has limited experience	Good Understanding of SDG's Provides evidence of at least 1 past project to illustrate application of SDG's and results	Excellent Understanding of SDG's Has a case study in the public domain. Experience of project with appropriate sustainability certification standard that embraces SDG's
8a EDUCATION: (Learning)	Please provide evidence of how • your organisation and your supply chain receive and update your sustainability learning, research and development for continuous improvement in respect of regenerative sustainability • how will you ensure highest levels of awareness and competence in respect of regenerative sustainability for all involved in this project?	Limited exposure to sustainability learning, research and development for continuous improvement	Good exposure to sustainability learning, research and development for continuous improvement Provides evidence of at least 1 past project to illustrate application sustainability learning, research and development for continuous improvement	Excellent Understanding with extensive experience of involvement in sustainability learning, research and development for continuous improvement Has a case study in the public domain
8b EDUCATION: (Advocacy)	Please provide evidence of how • your organisation and your supply chain will share your sustainability learning, research and development, to inspire others.	Limited activity to share sustainability learning, research and development, to inspire others.	Good activity to share sustainability learning, research and development, to inspire others. Provides evidence of at least 1 past project to illustrate sharing	Excellent Understanding with extensive experience of involvement in activity to share your sustainability learning, research and development, to inspire others. Has a case study in the public domain

THEMES	Questions	Minimum Response	Good Response	Excellence Response
9a ECONOMICS: Reference: • Doughnut Economics	Using the Doughnut Economics framework as a guide, • provide evidence of how your approach to sustainability ensures planetary boundaries are not exceeded and that a social justice foundation is maintained	Limited Understanding Has limited experience of delivery.	Good Understanding Provides evidence of at least 1 past project to illustrate construction management within a doughnut economic context	Good Understanding with Extensive experience, Has a case study in the public domain. Experience of project with appropriate sustainability certification standard
9b ECONOMICS: Reference: • Circular Economy	Please provide evidence of • Your application of circular economy in construction, material supply, operation and life cycle of buildings.	Limited Understanding Has limited experience of circular economy delivery.	Good Understanding Provides evidence of at least 1 past project to illustrate application of circular economy in construction	Good Understanding with Extensive experience, Has a case study in the public domain. Experience of project with appropriate sustainability certification standard

NOTE: Examples of Appropriate sustainability certification standard(s) include, but not limited to Living Building Challenge, Well Build Standard, One Planet Living, Building with Nature, Cradle to Cradle, Carbon Trust, BREEAM (Platinum) LEED (Platinum) DGNB (Platinum)

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3.4 CONTRIBUTIONS FROM TRAINING SCHOOL TRAINEES

The following are contributions from trainees at the Working Group 3 Training School held in Bolzano, Italy in March 2019. Each trainee selected a WG1 theme list against the WG3 Procurement theme.

3.4.1 PROCUREMENT TOOLS FOR REGENERATIVE ARCHITECTURE

KEY THEME OF WG 1: Economics
THEMES OF WG 3: Procurement
Author: **ADRIAN KRĘŻLIK**

The key aspects of regenerative architecture are to nourish the natural and social environment[5]. A building should create a positive impact on society strengthening human interaction. At the same time, the regenerative architecture expresses gratitude to nature and humans by bringing fresh air, clean water and housing for animals and plants. The following article examines methods that could be applied in the economic aspect of the procurement phase.

Budgeting Lifecycle not just Construction
The procurement phase is crucial for the entire building life cycle when an investor in (or without) collaboration with stakeholders such as designers, engineers, future occupants, facility managers determines the strategies, schemes and budget. The paradigm of the circular economy and continuing the life of a building (or a site) must be reflected in the initial decision-making process. Collaboration, transparency and common effort are the effective methods that enable the construction of architecture. While communication is one of the most difficult aspects of the investment process[6]. Close collaboration and common effort, that begins at the very initial stage of the project, could make this aspect easier. The integrated approach enables all the parties involved in design, construction and maintenance process to take conscious and informed decisions, negotiate solution faster and more efficient. While one directional feedback implies solutions, even if there are unfeasible in the posterior project phases, the peer-to-peer approach involves all the participants into the decision-making process. Transparency means that the information needed to take decision must be available, and well-organized, to all the stakeholders. Only when all the parties involved are able to determine the scope of the project, possible overlaps, the evaluation and selection criteria, schedule and submission deadlines and react as accordingly. In traditional design and investment phases, tendering follows the construction documents. Such an approach seems to be an obsolete concept[7] that looks on architecture as a separate object, not related to context, underestimating its connection to the environment.[8]
There are methods and tools available to estimate Life Cycle cost. LCCA[9] is a concept developed by the National Institute of Standards and Technology that assesses the total cost of facility ownership, that considers all costs of acquiring, owning, and disposing of a building or building system. The same institute developed software called Building Life Cycle Cost (BLCC5)[10] or Energy Escalation Rate Calculator (EERC). There are also some dedicated tools for specific branches, though they contradict the idea of holistic design, such as 4 WASH[11] developed by Sanitation and Water for All look at the aspect of water in the building system.
Some branches[12] of the Real Estate sector are familiar with similar budgeting models (discounted cash flows-DCF) but restricted to design construction and operation, and based on profit only. Such an approach

5 Raymond J. Cole (2012) Regenerative design and development: current theory and practice, Building Research & Information
6 Hoezen, Mieke & Reymen, Isabelle & Dewulf, Geert. (2006). The problem of communication in construction
7 Kane, G. (2012). The Green Executive Corporate Leadership in a Low Carbon Economy
8 Ngowi, A. B. (1998). Is construction procurement a key to sustainable development? Building Research & Information
9 https://www.wbdg.org/resources/life-cycle-cost-analysis-lcca
10 https://www.nist.gov/services-resources/software/building-life-cycle-cost-programs
11 http://sanitationandwaterforall.org/tool/irc-wash-costing-and-budgeting-tools/
12 Demuner-Flores, María & López Romero, Nancy. (2017). Hotels City Express valuation by the method of discounted cash flows. 56-80.

could be observed among the properties owned and operated by the same companies. For example, large hotel chains decide a budget for a new investment using complex economic models, they estimate the cost of construction, maintenance of the building, and compare it with the expected time needed for Return on Investment. The calculation does not include directly the environmental aspects of the operation or second, and further, lives of site or materials. Indirectly minimizing the cost of operation decrease the negative impact of a building on the environment. Some of the largest hotel chains started to implement some so-called green strategies for the operation or apply for sustainable certificates[13], mostly as great marketing tools. Since the DCF method is based on construction and operation it takes a similar path as regenerative design. It would be interesting to study the relation between early stage budgeting and environmental impact of buildings on. Such a large sample could be a great starting point for establishing good procurement practices, workflows, collaboration methods that could be applied to regenerative design, construction and operation.

Recently innovation new approaches in public procurement have been observed. Ralph Rheither of IBMN Nederland[14] has prototyped an alternative schedule for tendering and bidding. He advocates for pushing the tendering to the procurement phase and to include entire building lifecycle as a tool to design well-performing architecture. By this method, the budget of the project could be distributed in a more sustainable way. Changing the hierarchy, applying the latest technological solution, emphasizing the operation of the building, results in a better quality architectural solution, material selection, and wellbeing of future users.

Such an attitude goes along with principles of the MacLeamy Curve[15] that maps the ability to impact the life cycle of a building, arguing that initial project time has the highest influence and requires the lowest expenditures to do so. Such a scheme brings benefits to the environment, quality of architectural solutions and to the local society. Performance-based tendering[16] in the early design phase encourages architects and engineers to look for sustainable, often passive solutions, use durable materials, a better understanding of local climatic conditions or lifestyle. Following Michael Hensel outline defined in Performance-Oriented Architecture[17], there are four interlocking categories: Local Communities, Local Physical Environment, Spatial Organization and Materials. Financial planning should take all the above categories in the budgeting to ensure that the architectural object is well-performing. It means that the operating budget should include the social and spatial aspects of a building. Finally shifting tendering at the initial stage of an investment process requires perspective planning from the client's part, project manager, adequate public procurement regulations and laws.

Fostering Local Economy

In the procurement phase, regulation could boost the local economy[18] and enhance its competitiveness at the same time: for example, by choosing local/traditional building techniques participants of the procurement phase to ensure the economic growth of the region. As a consequence of such a decision, local architectural firms and engineers are more willing to participate since the construction method lies in their competences. This could be a great tool to oppose to the dictate of international corporations, expensive standards and certificates. In most cases, the professionals would use their local network of contacts to look for experienced contractors, suppliers and other participants of the construction process. As a consequence, the use of local resources, manpower, knowledge transfer, more equity could be achieved. In recent years Small and Medium Enterprises in Spain or Italy[19] formed consortia (or other organized groups) to become more competitive in the procurement phase, especially for the projects that need more experience and manpower.

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13 https://www.usgbc.org/articles/hotels-worldwide-are-going-green-leed, accessed 16.03.2019

14 Rheiter, R. (2012)Schooldomein Aanbesteding op Total Cost of Ownership (page 46-47)

15 Weisheng, L.(2015). MacLeamy Curve - With figures.

16 Gruneberg, S. Hughes, W. Ancell, D. (2007) Risk under performance-based contracting in the UK construction sector, Construction Management and Economics

17 Hensel, M (2013). Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment

18 A councillor's guide to procurement issued by Local Government Association emphasize the role of local SME as a one of the methods of sustainable growth

19 such as Lombardini22

Product as a Service
Recently some suppliers have been testing alternative sales models of their physical products that are based on the experience of IT companies. Product as a Service (PaaS)[20] business model prefers long-term supply and maintenance contracts rather than traditional sales strategy. It has multiple benefits both for the supplier and for the client or Facility Manager. By signing a long-term contract, a company ensures a stable cash flow, an opportunity to build a good relationship with the customer, and to develop their product along with the (changing) needs of the customer. The client receives a better quality and durable product. Facility Manager is less concerned about product maintenance and does not require additional competence and training for their employees. The producers are responsible for the entire lifecycle of a product, not a client or as it often happens today no one. In the consequences, the supplier would look for circular economy strategies and design material in such a way that it could be dismantled, decomposed and reused again or sold to other parties. The ownership of the product implies a more sustainable attitude and solutions.

Conclusion
Several strategies for the procurement phase presented above effects in the entire lifecycle of the building (or site) and have the potential to foster a regenerative impact of architecture on the environment and social issues. They are combing building strategies developed in the past, that have been abandoned along with the rise of an international style and neoliberal economics, with new business models emerging with the concepts of sharing economics, social and spatial prototyping. A continuous feedback loop between public and private procurement strategies should innovate existing models.

3.4.2 IMPORTANCE OF PLACE IN PROCUREMENT

KEY THEME OF WG 1: Place
THEMES OF WG 3: Procurement
Author: **DENISA PETRUS**

Setting the place is as important as curating the spaces inside of the building. From the procurement phase, it can be ensured that it will facilitate the main necessities for its' users and as well bring value to the city and urban network of public spaces, green areas and altogether its' community. Aside from this contribution to a more sustainable approach through conceptual design, it can be improved through assuring the implementation of management strategies and active regenerative systems.
The site constraints and requirements are controlled first hand by the local site regulations, which should conduct a balanced proportion of built terrain versus infrastructure, waste facilities and green areas. When approving new local regulations, the authorities might suggest the optimal land usage and functions which will easily connect the city and as well protect and encourage the presence of local fauna, ecosystems and nature's cycles all in all. Moreover, new incentives can be introduced towards developing on-site strategies to encourage and sustain the flow in nature such as water circulation from rainfall collection to irrigation. Each site has its' contribution to the local micro-climate, be it the greenhouse effect of poor building solutions or soil setting with tree-planting in hilly places. This can be regulated in the procurement stage through filling reports and scoring, evidence-based criteria that help or prevents obtaining a construction permit.
The effects of detailed and revised regulation could as well raise the interest to rethink the development of professionals, training of workers and end-users as well as the usage of tools in optimization, data collection and analysis. Individual data collectors from each project can be united in a data cloud for specific areas and be accessible for the future setting of new projects. For example, the BIM databases can retain and contribute to a bank for materials which as part of a building's passport will be useful throughout all stages of construction, maintenance and second life. Nonetheless, storing a database with company profiles and ensuring a higher degree of transparency on the market can improve the tender and contracting conditions. Furthermore, it will be an incentive for all parties involved in the construction and maintenance to

[20] https://www.theguardian.com/business/2019/feb/04/kitchen-for-rent-ikea-to-trial-leasing-of-furniture , access 16.03.2019

optimize the usage of materials, duration of open construction sites and resources in general: be it water and electricity or human power. Lean management can minimize costs and the impact on site and the soil while shortening the duration of the open construction site. Having information about the place of construction prior to starting a project can identify site faults like moisture and pollution and thus ameliorate late-occurring issues by implementing a hazard-management plan. Waste streams could be followed online with second-hand markets as side collaborations to diminish the waste on building sites, as well as creating banks of materials that will be available to be up-cycled once the building has passed it's 'first life'.
Shortening the duration of open building sites could be key to protecting the environment. Preparing the soil beforehand to assure the construction site run smoothly. For example, an industrially polluted soil can be organically treated using specific plants that in time are digesting the toxic contents. Foreseeing and avoiding any possibility of an abandoned site before the construction is complete could play a big part starting from the procurement phase. This includes covering risks and long-term contracts and using an annual assessment of companies following their background. Estimating cost calculations should consider higher inflation rates and shadow costs. In the latter instance, a shadow price is assigned to goods that are not generally bought and sold as separate assets in a marketplace, such as production costs or intangible assets. Stakeholders' engagement should be more active in the whole process of planning, tender and decision-making. Cutting costs on the construction site can also be done by constantly optimizing the planning (Gantt charts) according to daily changes. For example, there is an estimated 37% lost time on a construction site which can be eliminated when the workers have a constant workflow or properly appointed shifts. Detailed planning and estimations before and during construction should ensure a more effective building process while making sure the users and building facilities managers continue a similar rhythm when contouring the energy use and maintenance of the place.
A place reaches its full potential and uses when well-programmed, flexible and further-transformable at the same time. The users are the ultimate contributors to its success or failure as a regenerative project. The ability to fulfil users' requirements and taste will assure long, protected life and nonetheless guarantee a "second life". People's ability to attach to places and create a history around them will provide multiplied reasons to prolong a building's existence and even recreate it long after the physical structure and finishes pass their ability to shine and thrive. In this matter, it is extremely helpful if the building components on site are easy-accessible for machines on site, replaceable, dismantlement-able, prefabricated or simply being part of non-over-complicated building systems. Accessibility on site to all groups of people, be it against social segregation or designed for people with disabilities will be a definite plus together with designing a safe, well-lighted, noise and weather-protected, inviting place.

3.4.3 BUILDING MATERIAL SPECIFICATION: A KEY STEP TOWARDS REGENERATIVE DESIGN

KEY THEME OF WG 1: Resources (materials)
THEMES OF WG 3: Procurement
Author: **LOUISE HAMOT**

Building material procurement is seen as a key element of design on our journey towards a regenerative built environment. In specifying a building material, we should address all eco-systemic questions relating to regenerative design, such as: is it harmless? Does it create resource depletion? Will it last? Is it energy intensive to produce? Is it socially responsible? Will it support the local community and economy? and Will it participate in the creation of a beautiful environment?

Figure 3.7 - TUVALU project in Aubervilliers (France)

The synergy between the built environment and material procurement is an obvious one: this selection step forms a fundamental link between concept and construction. How can we push towards regenerative architecture, if we are not addressing the impact of material selection?

Moreover, the very existence of materials results from extraction, process and transportation, connecting them to a wide population and geographical region. Through the TUVALU[21] project in Aubervilliers (France), the artist Stephan Shankland illustrates the effects of urban metabolism by showing how linked we are to our built environment. In his art installation he reveals, for instance, the presence of plants from Tuvalu, a Polynesian archipelago, often found on construction sites.

Building materials represent about 50%[22] of our global resource consumption and is one of our primary sources of waste generation. The paradigm of the circular economy and continuous life of a building (or a site) through re-use for instance, should be considered in the initial specification decision-making process in order to cut down extractions and material manufacturing. The C2C certification[23] (cradle-to-cradle) can be a useful inspiration on how to rethink the way we make our building materials.

In summary, building materials procurement raises social, health, wellbeing, environmental and durability issues, along with more common technical and economic ones. The design team need to recognise and understand the social, environmental and economic responsibility, which will impact how regenerative a building can be over the course of its life.

HEALTH: Chemicals & Air Quality

Awareness concerning the health hazards of building materials for construction workers, manufacturers and building occupants has recently increased in importance. This explains why more certifications include these aspects within their scope, such as the WELL Build Standard[24].

It is common to find Formaldehyde in wood glue, Creosote, Arsenic or Pentachlorophenol in wood treatments, Volatile Organic Compounds in carpets, paints, flame retardants in coatings, Phthalates in PVC, to name just a few; all of which are chemicals proven, or highly suspected, to originate cancer and impact indoor air quality[25]. As our current building trend is to ensure improved air-tightness in order to reduce heat losses and as the time we spend inside buildings - about 90%[26] of our time - non-hazardous materials are a top priority.

The International Living Future Institute, a non-profit organisation who devised and manage the Living Building Challenge, compiled a Redlist[27] of building materials to avoid in buildings along with the material database Declare[28] requiring manufacturers to be transparent in respect of the ingredients they use. This has triggered some manufacturers to change their processes, removing harmful chemical from their materials and manufacturing, for , Mohawk now produces a VOC-free carpet and ECOS Paint that produces healthier paints.

A regenerative design team should specify building materials with the knowledge of the ingredients that make up the products, working with the industry to continue to develop alternative healthy material options.

SOCIAL: Local Community & Equity

There are numerous agents involved in the extraction, manufacturing, transport and fabrication of materials. There are two ways that specifications that can support communities and equity in reducing impacts upon them.

The first is specifying local materials that will engage a local workforce, utilise local skills and craftsmanship, providing support to local employment.

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21 http://www.artcop21.com/events/tuvalu-_-an-island-in-the-heart-of-a-world-in-mutation/

22 Ruuska Antti, Hakkinen Tarja, Material Efficiency of Building Construction, VTT Technical Research Centre of Finland, Buildings ISSN 2075-5309, 2014. It must be noted that other sources indicate 30% and 75%.

23 https://www.c2ccertified.org/

24 WELL Standard v2, Material Section, X01-02-08-09-10-11-12 https://v2.wellcertified.com/v2.2/en/materials/feature/13

25 WHO names some of them and ILFI as well

26 Klepeis E. Neil & others, The National Human Activity Pattern Survey (NHAPS): A Resource for Assessing Exposure to Environmental Pollutants, US, 2001

27 https://living-future.org/declare/declare-about/red-list/

28 https://living-future.org/declare/

Specifying local materials can have other benefits, through years of local craftsmanship developed according to local materials naturally aligned to local conditions. Engaging with local skills not only supports the community but is more likely to ensure more robust materials as well. This can also create other opportunities. As an example, the tallest straw and wood building in France[29], (Jules-Ferry social housing, in Saint-Dié-des-Vosges) engaged with a local manufacturer making wooden pallet to build wooden boxes for the straw in order to avoid straw wastage. This improved the construction process and durability of the building and since then the manufacturer offers both products.

The second is through specifying products from manufacturers whose ethics and governance ensure gender equality and responsible working conditions. The JUST program[30], created by The International Living Future, is an example of a platform which discloses how organisations treat their employees and where and how they make financial and community investments. BCorp[31] certification aimed at any businesses can also be a reference to choose firms which consider carefully their workers, customers, community and the environment.

ENVIRONMENT: Resources & Carbon & Future Life
How far away do the materials come from? Do they require an energy-intensive process to extract and manufacture? How are they transported? Do they participate in natural resources depletion?

The building industry is responsible for about 40%[32] of global carbon emissions, mainly through building material manufacture. Life cycle assessment tools to calculate Global Warming Potential and other ecological impacts are emerging to help design teams to understand the embodied carbon footprint of building materials.

Plug-in's to BIM modelling software like Tally (adapted to the American market), OneClickLCA (global market) or HBERT (British) enable the comparison of design carbon emissions, allowing decisions to be taken accordingly. The methodologies of these tools still need alignment, but they provide a readily available quantitative understanding of a building's carbon emissions impact.

International databases such as Environmental Product Declaration (EPD), INIES (France), BAU-EPD (Austria), GaBi (Germany), ICE database (UK) and others also enable access to resources and carbon emission data of product/type of building materials to choose accordingly.

Specifying local materials will once again have beneficial impacts, by reducing transport and potentially costs, because they may be naturally more adapted to the weather conditions and therefore will require less maintenance over the building lifetime.

Choosing local materials within a circular economy framework will reduce resource depletion and transportation impacts. More and more databases and applications exist to take advantage from the burgeoning second-hand and reuse market, like the VEOLIA app showing deconstruction sites and resources, BAMB database, or smaller scale networks like ROTOR (Belgium), BELLASTOCK (France). Finally creating building materials passports at the procurement stage and specifying the ones to be able to build in layers, will enable the materials to continue their life following gets deconstructed.

MATERIALS: Wellbeing & biodiversity
Finally, we need to consider the impacts of materials on wellbeing at both human scale and on other species. Natural materials, for instance, can create an inherent desire to touch and improve communication with the building, becoming an element of biophilic design. Natural materials can improve species

29 Podcast about straw construction: https://www.franceculture.fr/emissions/terre-terre/matiere-portraits-33-la-paille
30 https://living-future.org/just/
31 Certified B Corporations https://bcorporation.net/
32 WGBC figure

habitat, although species can in some cases adapt and thrive in our concrete non-porous urban landscape. However, natural materials create permeability which can enhance biodiversity and connectivity by attracting a biodiverse range species.

Finally, specifying robust materials with long life and low maintenance will support the durability of the building. Some progressive projects like new towns in France or in the UK like Basildon, which embedded sustainability principles such as access to nature, social inclusion, and art in public space, are now becoming depopulated due to the use of low-quality and low-cost materials that have resulted in faster degradation.

The transition to healthy materials for regenerative buildings requires time and effort and with the range of topics to be addressed can be seen as staggering. However, the earlier in a project these aspects are tackled, the greater the chance of having a positive impact. To date, materials have been considered at a distance, although they should be at the heart of all this to be able to live in symbiosis in sustainable ecosystems.

3.4.4 ADDRESSING WASTE IN PROCUREMENT

KEY THEME OF WG 1: Resources (waste)
THEMES OF WG 3: Procurement
Author: **IUGA TUDOR**

Waste represents an element eliminated, made surplus or discarded as no longer useful (for the initial user/buyer) or required after the completion of a process. The construction industry has one of the largest impacts on the production of world waste, as a material. However, other types of waste should be considered, for example the avoidable loss of time, money or energy.
Initially one would think that the majority of the construction-related waste is caused by the construction stage. This is only partially true (waste is only evidenced during construction): with a waste efficiency strategy realised and implemented during the previous stages, the entire life cycle waste production (including the construction one) can be significantly reduced.
The well-known (but not enough applied) waste hierarchy[33] that should be at the base of a detailed strategy consists of measures for prevention → minimisation → reuse → recycle → energy recovery → disposal. Considering the whole life cycleapproach, the hierarchy should be applied for every stage of the process.

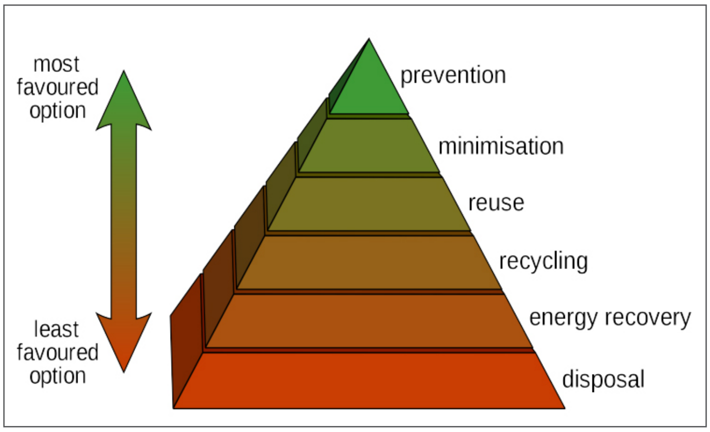

Figure 3.8 - Waste Hierarchy

We should however, start with the end in mind and focus on the most waste productive operations. As an example, even though a lot of people support and have high expectations from the straw bale movement & regulations recently appeared in the more developed countries, the reality is that it won't make any noticeable difference on the global[34] scale as an overwhelming majority of ocean plastic pollution comes from a few Asian rivers (caused by the bad waste management implementation in the local communities).
That's why the procurement/design

33 "Waste hierarchy - Wikipedia." https://en.wikipedia.org/wiki/Waste_hierarchy. Accessed 9 May. 2019.

34 "the plastic straw ban is futile | The Arcturus Project." 6 Mar. 2019, https://arcturusproject.com/2019/03/06/the-plastic-straw-ban-is-futile/. Accessed 9 May. 2019.

phase is so important: with a proper waste strategy started from WRAP's five key principles to reduce waste[35], the possibilities of waste occurring during the construction, operation and second life stages can be dramatically reduced.
As Stewart Brand said[36] in "How buildings learn": "Every building is a prediction and every prediction is wrong". Nevertheless, here are a few ideas that could be considered during the procurement/design stage in line with the waste hierarchy:

→ chose local companies as partners for design & consultancy;
→ adopt a minimalistic design approach by specifying only the necessary materials (e.g. less architectural only elements, no speculative finishes, etc.),
→ specify locally produced materials;
→ adopt WRAP's principles (Design for reuse and recovery; Design for Off-site Construction; Design for Materials Optimisation; Design for Waste efficient procurement; and Design for Deconstruction and Flexibility).

A "Materials Efficiency Strategy"[37] can guide the investors, project managers, design teams, builders and facility managers to reduce the overall materials consumption (including the reduction of waste production), while a "Site Waste Management Plan" can highlight the best routes for reducing the impact of the already created construction waste. Both of the above-mentioned documents are becoming more and more common practice as their implementation offers sustainability credits for sustainable certification systems (e.g. BREEAM[38]).

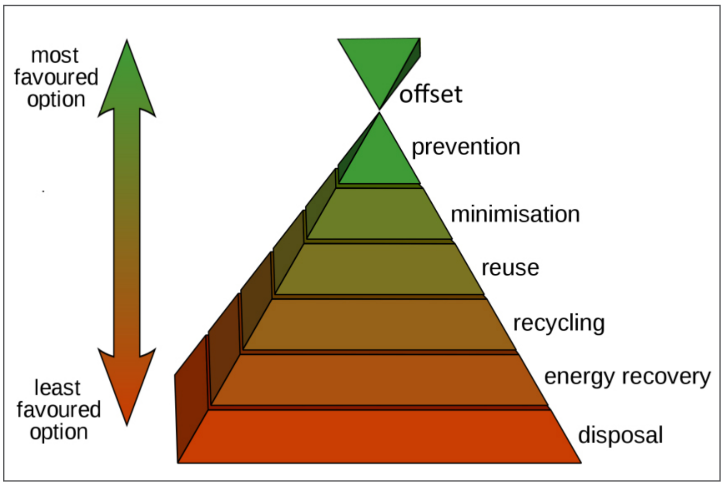

Figure 3.9 - Proposed 'Offset' Waste Hierarchy

With reference to Regenerative construction and operation, at top of the classic waste hierarchy, a new item could be added on the list: offset the produced waste (or at least the disposed one, as a start). This could be implemented by specifying recycled materials and products or by supporting construction waste recycling schemes. These principles could be included in the tender documentation and form part of the criteria to select the design and build companies. Ellen Macarthur Foundation circular economy "butterfly" diagram[39] can also be used as a source of inspiration.

For a real and sustainable reduction of construction waste the power of the market should be exploited through more challenging dedicated tools, guides, frameworks and especially through voluntary certification systems that can be used as marketing material to increase the value of the projects. Creating incentives that every investor/ team member can relate too (waste reduction for a profit?) might be the way to go.

35 "Designing out Waste: a design team guide for civil engineering - Wrap." http://www.wrap.org.uk/sites/files/wrap/Designing%20out%20Waste%20-%20a%20design%20team%20guide%20for%20civil%20engineering%20-%20Part%201%20%28interactive%291.pdf. Accessed 9 May. 2019.

36 "How Buildings Learn" by Stewart Brand | Penguin Books; (October 1, 1995) ISBN-13: 978-0140139969

37 "Greengineers – Helping partners to design, build & certify better buildings | Services: BREEAM related studies" http://www.greengineers.net/. Accessed 9 May. 2019.

38 "BREEAM." https://www.breeam.com/. Accessed 9 May. 2019.

39 "Circular Economy System Diagram - Ellen MacArthur Foundation." https://www.ellenmacarthurfoundation.org/circular-economy/infographic. Accessed 9 May. 2019.

3.4.5 EDUCATION IN PROCUREMENT

KEY THEME OF WG 1: Education (learning)
THEMES OF WG 3: Procurement
Author: **JONAS MANUEL GREMMELSPACHER**

Introduction
The built environment, as a significant contributor to energy use and of carbon emissions, has a significant responsibility to address global warming[40]. Buildings are subject to numerous regulations to reduce energy consumption during the operational stage within their life-cycle. Through implementing life cycle assessment (LCA), the embodied energy of building materials as well as energy consumption during the construction stage is highlighted[41]. The implementation of adequate measures for low-impact design has to commence in early design stages of a building and is a key aspect for procurement. In order to foster regenerative buildings, the competence and education of all stakeholders are crucial. Conscious and well-informed players involved at the procurement stage can establish the key parameters towards a regenerative development.

Quality Education as a cornerstone for Regenerative Procurement
Collaborators in building procurement compose of several groups with different backgrounds and interests. The incorporation of these interests into a design that follows regenerative design guidelines requires the considerable collaboration of the stakeholders. The main challenges are the determination of interconnections to connect the stakeholders and to demonstrate the effects that an action or decision has on others.
The fourth goal of the 17 sustainable development goals established by the UN in 2015, is Quality Education[42]. "provide equitable and quality education to all human beings." The target for the goal of quality education that interlinks to education for regenerative procurement is: "By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development."[43]. Thus, a clear objective is to ensure education for sustainable development and therefore positively affect awareness and action for sustainability.
Stakeholders within the procurement phase include architects and engineers, investors and building owners representing a multiple discipline group, building space occupants, neighbours and public. The municipality has to be involved in construction projects, alongside governance regarding building regulations. The facility management team that acts traditionally in the occupational phase, must also play a role in the initial procurement stages of a building. In Restore WG3, the involvement of space occupants, facility managers, municipality and neighbours has been fostered to reach a better interconnection of designers, users and other groups.
With architects, construction, services and facilities engineers, educational strategies towards sustainability awareness are already implemented in many degree programs, this, however, does only rarely apply to awareness for regenerative sustainability[44]. Creating awareness must be seen as an improvement, the

40 'Clean energy for all Europeans', Energy - European Commission, 20-Oct-2017. [Online]. Available: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans. [Accessed: 01-May-2019].
41 N. Østergaard et al., 'Data Driven Quantification of the Temporal Scope of Building LCAs', Procedia CIRP, vol. 69, pp. 224–229, Jan. 2018.
42 'Education - United Nations Sustainable Development'. [Online]. Available: https://www.un.org/sustainabledevelopment/education/. [Accessed: 01-May-2019].
43 'Goal 4.:. Sustainable Development Knowledge Platform'. [Online]. Available: https://sustainabledevelopment.un.org/sdg4. [Accessed: 01-May-2019].
44 M. A. Ismail, N. Keumala, and R. M. Dabdoob, 'Review on integrating sustainability knowledge into architectural education: Practice in the UK and the USA', J. Clean. Prod., vol. 140, pp. 1542–1552, Jan. 2017.

tactics and necessary tools for sustainable building design and for construction site managers need to become a mandatory education content. The interconnection of the fields of architecture and engineering needs to be addressed by improved collaboration.
For parties like investors, building owners, building occupants and neighbours a general sensitivity towards sustainability through the Sustainable Development Goals (SDG's) is desirable. The mission set by the SDGs is ambitious, not the least for the reason that both young people as students require education but also general society and public that has passed the main educational stages.

Conclusion
Due to the wide range of actors involved, education approaches have to be tailored to individual groups. Regenerative sustainability in building-specific education must be focussed in order to equip professionals and non-professionals with the skills to plan, build and operate buildings in a regenerative manner. By addressing professionals within the built environment, it would be possible to shift in the mindset of the industry from one of the largest contributors of carbon emissions and resource depletion to a carbon positive circular economy.

3.4.6 CARBON IN PROCUREMENT

KEY THEME OF WG 1: Carbon
THEMES OF WG 3: Procurement
Author: **ANASTASIA STELLA**

Introduction
The built environment places incredible pressure on the natural environment. In the European Union, it accounts for 50% of all extracted materials, 42% of the final energy consumption, 35% of greenhouse gases (GHGs) emissions and 32% of waste flows[45]. James Drinkwater, the World Green Building Council Europe director, states "The recent IPCC report46 removes all doubt: to achieve the aims of the Paris Agreement[47], the building and construction sector must decarbonize by 2050. With nations all over the globe tackling operational emissions from buildings, we must now address our total emissions impact."[48]. As Building Regulations diminish operational emissions towards zero and the energy grids head towards decarbonization, the embodied CO_2 emissions associated with supplying materials becomes the dominant source of carbon impacts from the building sector. However, as Bill McDonough states, carbon is not the enemy, but global warming is the result of a "design failure"[49]. Towards a regenerative approach, according to Bill McDonough, the world should exploit carbon as an asset[50] that's merely in the wrong place[51]. This article focuses on regenerative strategies to achieve decarbonization including carbon positive strategies during the procurement stage of a building.

Reimagining Carbon
Instead of demonising carbon as the main chemical culprit in accelerated climate change, the real challenge is to reimagine our relationship with it[52]. Towards this direction, a new mindset is emerging, which sees managing climate change-causing carbon as an opportunity rather than a liability. Part of this changing perspective is carbon productivity, which focuses on practical solutions that grow businesses

45 Pomponi, F and Moncaster, A (2016). Reducing Embodied Carbon in the Built Environment: A Research Agenda. In: International Conference on Sustainable Ecological Engineering Design for Society, 14-15 Sep 2016, Leeds Beckett University, UK.
46 https://www.ipcc.ch/site/assets/uploads/2018/11/pr_181008_P48_spm_en.pdf
47 https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf
48 Bionova Ltd (2018). The Embodied Carbon Review: Embodied Carbon Reduction in 100+ Regulations & Rating Systems Globally.
49 McDonough, W (2016). Carbon is not the enemy. Nature 539, 349–351 (17 November 2016)
50 https://blogs.scientificamerican.com/observations/new-view-carbon-is-not-the-enemy/
51 https://www.greenbiz.com/article/rethinking-carbon-new-economy
52 https://www.greenbiz.com/article/its-time-reimagine-carbon

by radically de-coupling them from using fossil fuels and optimising the value created, maximising the return on carbon invested[53]. In this way, carbon productivity involves generating radically greater economic, social and environmental value from the carbon we use[54].

Additionally, Bill McDonough frames the new language of carbon, which recognizes the material and quality of carbon. He identifies three categories of carbon[55]. Firstly, the 'living' carbon, which is organic, flowing in biological cycles, providing fresh food, healthy forests and fertile soil. Secondly, the 'durable' carbon, which is locked in stable solids, long life, re-useable, circular economy products[56] and finally 'fugitive' carbon, which is the unwanted and toxic carbon, released by burning fossil fuels, waste to energy plants etc. Finally, 'working' carbon is a subset of all three categories and defined as a material being put to human use.

Regenerative Strategies towards carbon positive in procurement

Reimagining carbon as an asset requires that it is considered it afresh in all its forms, from efficiency savings to ecological sequestration. According to Martin Brown the main strategies to improve footprints are by reducing 'fugitive' carbon, by locking it into buildings and circular economy products as 'durable'carbon, and by increasing 'living' carbon through restoration and regeneration of carbon sinks[57]. Additionally, it is crucial that the value of construction is measured through units of carbon emitted, which can be considered as Construction Carbon Productivity.

Procurement is a very critical stage for the implementation of these strategies. Depending on the type of procurement, it can firstly involve the creation of regenerative design and secondly all the actions for the procurement of contractor, suppliers and facilities managers. Therefore, it contains all the actions that ensure that a carbon positive design is delivered with the expected performance. During this process, it is crucial that there are practical strategies, methodologies and tools that facilitate the carbon positive design, as well as specified questions or selection criteria for the right choice of the main stakeholders such as contractor, suppliers and facilities managers.

To begin with, a key aspect towards the carbon positive strategies during procurement is the choice of products which allow the increase of 'durable' carbon. This means circular economy products with inherently low embodied energy and carbon, higher recycled content and high levels of durability, which require less maintenance, repair, and refurbishment. Additionally, it is important that local materials are used, decreasing transport- related carbon emissions ('fugitive' carbon). During the process of materials selection, the transparency of products' manufacturing process, chemical content and carbon emissions plays a significant role. Even though there is still a lack of transparency in the industry[58], innovative tools have recently been developed that allow practical construction carbon measurement, benchmarking[59] and carbon productivity measurement[60]. Besides, the integration of LCA and BIM atomizes the LCA conduction, allowing the use of LCA as a decision-making tool. While until recently LCA was mostly used for documentation purposes, due to its increased complexity, now LCA can be used throughout the design process to take consequence-based decisions[61].

Furthermore, the effective design of a building can contribute to embodied carbon reduction[62]. A key strategy towards this direction is a decrease in the amount of the materials required throughout the entire life cycle. Steps to achieve this is the optimization of the layout plan as well as the structural system, the optimization of components' service life, the creation of low maintenance design as well as

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53 http://carbonproductivity.com/

54 http://www.ethicalcorp.com/content/save-planet-we-must-learn-new-language-carbon

55 McDonough, W (2016). Carbon is not the enemy. Nature 539, 349–351 (17 November 2016)

56 https://fairsnape.com/2018/11/14/rethinking-carbon-its-not-the-enemy/

57 https://www.raconteur.net/business-innovation/restorative-business-carbon

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62 Lupisek, A, Vaculikova, M, Mancik, S, Železná, J, & Růžička, J (2015). Design Strategies for Low Embodied Carbon and Low Embodied Energy Buildings: Principles and Examples. 7th International Conference on Sustainability in Energy and Buildings, Energy Procedia, Volume 83.

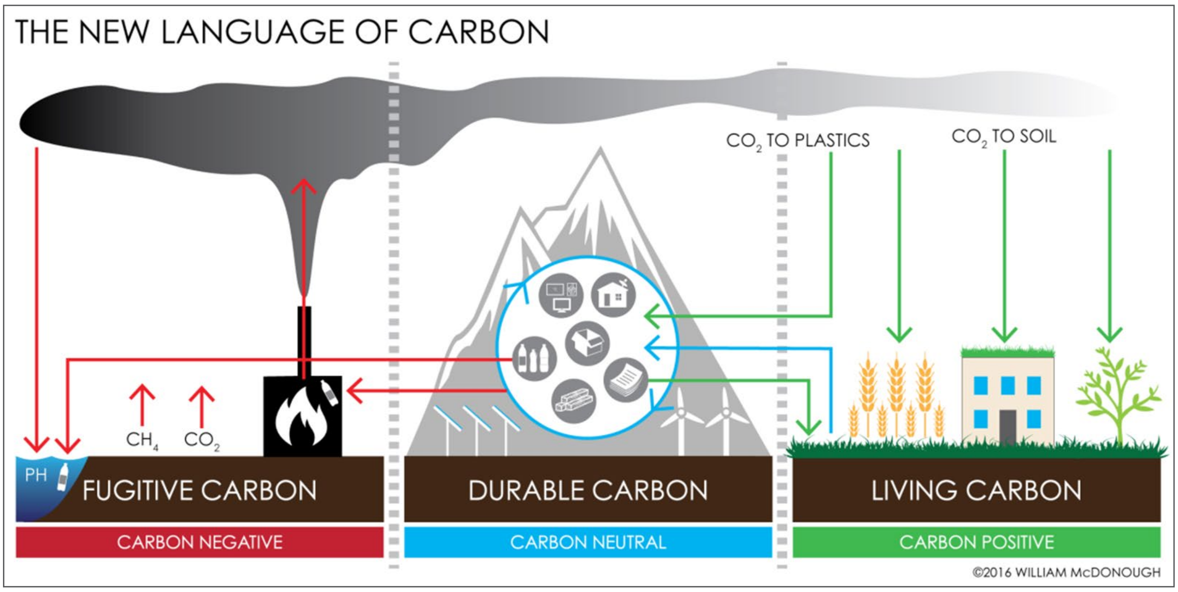

Figure 3.10 - New Language of carbon by Bill McDonough (Source: http://www.mcdonough.com/new-language-carbon/)

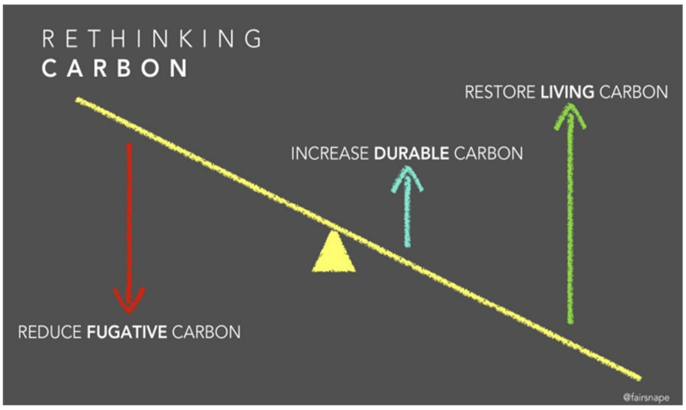

Figure 3.11 - General rethinking carbon strategies by Martin Brown (Source: https://fairsnape.com/2018/11/14/rethinking-carbon-its-not-the-enemy/)

flexible and adaptable design[63]. Another key strategy is the design for deconstruction and disassembly that allows the reuse and recovery of construction materials, reducing the embodied energy and emissions of CO_2[64]. While these strategies mostly aim at 'fugitive' carbon reduction and 'durable' carbon increase, McDonough proposes designs that restore 'living' carbon. Based on the idea of 'buildings like trees' he approaches building designs as photosynthetic and biologically active, accruing solar energy, cycling nutrients, releasing oxygen, fixing nitrogen, purifying water, providing diverse habitats, building soil and changing with the seasons[65]. Some examples of his buildings based on this idea are the Hero Global Center for Innovation and Technology and Park 20|20 and Schiphol Trade Park.[66]

Finally, it is significant that in the procurement stage there are specified questions or selection criteria that facilitate the right choice of the main stakeholders. Through their answers, the potential stakeholders should provide pieces of evidence about their carbon positive construction strategy as well as the how they would implement it in the particular project. Their response should be evaluated based on their level of understanding about the net zero carbon and the level of their experience with corresponding projects or projects with appropriate sustainability certification standard.

63 Lupisek, A, Nehasilová, M, Mancik, S, Železná, J, & Růžička, J, Fiala, C, Tywoniak, J,& Hájek, P(2017). Design strategies for buildings with low embodied energy. Proceedings of the Institution of Civil Engineers - Engineering Sustainability 2017 170:2, 65-80

64 http://etd.fcla.edu/UF/UFE0024439/saleh_t.pdf

65 McDonough, W (2016). Carbon is not the enemy. Nature 539, 349–351 (17 November 2016)

66 http://www.triplepundit.com/story/2016/excess-carbon-emissions-are-failure-design/21136

Conclusion

A rethinking of the way we approach our relationship with carbon is required in order to achieve the Paris Agreement[67] aims. The new language of carbon makes it clear that the construction industry should not only focus on the decrease of fugitive' carbon, but also on the increase of 'durable' and 'living' carbon. Key strategies to achieve this during the procurement regard the materials choices, the effectiveness of the assessment methods, the effectiveness of the design and the right choice of main stakeholders. However, the levels required will not occur without the active leadership and collaboration of governments and businesses globally. it is crucial that carbon positive is supported and promoted by the global regulations (e.g. World Green Building Council), certification systems (e.g. BREEAM, LEED, DGNB etc) and building codes, while at the same time the documentation and transparency of the embodied carbon of the various materials and products get increased.

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Early Contractor Involvement (ECI) See https://www.designingbuildings.co.uk/wiki/Early_contractor_involvement

ISO 14001 Environmental Management https://www.iso.org/iso-14001-environmental-management.html

ISO 20400 https://www.iso.org/standard/63026.html

ISO 26000 https://www.iso.org/iso-26000-social-responsibility.html

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67 https://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf

4. CONSTRUCTION

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CONTENT

4.1 STATE OF THE ART

Regenerative construction aims to reverse the damage caused by the construction activity, by using strategies to improve health, quality of life and productivity of its inhabitants. During the building construction process, regenerative sustainability can be incorporated into three key aspects: materials, technologies and tools.

a) Materials

The science of materials is a very active area of research. For instance, the COTEC Foundation for Technological Innovation estimates that, in the EU, 1,400 research projects have been developed in this area in recent years. The current advanced and emerging research works – developed in other industries such as electronics or aerospace sectors - are beginning to be applied to construction. The research works that are being conducted to improve traditional building construction materials are:

- For steel, researchers are mainly focused on extending their lifespan (as currently, the useful life of steel is about 35 years) and also improving their performance. In particular, new alloys are being developed which have a component capable of repairing the microcracks occurred due to the efforts (Dawood and Rizkalla 2010; Jaworski and Trzepieciński 2016).
- For concrete, studies are mainly analysing on how to produce green or self-healing concrete as well as increase its durability by decreasing the diffusion of chlorine and applying nanoparticles of silicon dioxide (SiO2) and titanium dioxide (TiO2), as well as using carbon nanotubes (Wu et al., 2012, Van Tittelboom and De Belie, 2013).
- For polymers, research studies are focused on self-healing or self-cleaning. Titanium dioxide, when activated by ultraviolet light, is able to stimulate the electrons and thus achieve a high oxidizing capacity. In this way, the nanoparticles eliminate the bacteria and break down organic compounds, achieving clean and dry surfaces (hydrophobic capacity) (Wu et al., 2008).
- For gypsum and plasterboards, organic and inorganic phase change materials (PCMs) are incorporated to improve the thermal energy storage of buildings (Zhou et al., 2012, Liu et al., 2017, Guarino et al., 2015).

Furthermore, increasing social concern regarding environmental issues and the higher demand of indoor comfort in buildings, has resulted in numerous research works attempting to replace traditional construction materials with other materials with a lower environmental impact (Marrero et al., 2012, Lawrence, 2015, Friedrich and Luible, 2016a). In this sense, there are many research studies exploring the behaviour of building composites incorporating different waste streams: agricultural (wood, cork, rice hsk, hemp fibres, straw) (Walker and Pavía, 2013, Friedrich and Luible, 2016b); industrial (slag and sludge, rubber, textile fibres, plastics, polyurethane,)(Gutiérrez González et al., 2012); etc.

Among industrial wastes, construction and demolition waste (CDW) has been widely used as an alternative to natural raw material following a circular economy criterion (del Río Merino et al., 2018, Morales Conde et al., 2016). In particular, ceramic, concrete and insulation waste materials have been incorporated in concrete, mortars and gypsum.

For the specific case of gypsum, incorporating different CDW may result in improved surface hardness (e.g. ceramic and concrete waste) (del Río Merino et al., 2018); greater compression resistance (e.g. plasterboard and glass waste) (Villoria Sáez et al., 2018); lower density and better thermal behaviour (e.g. expanded and extruded polystyrene waste) (San Antonio González et al., 2015); and better water absorption (e.g. plastic waste) (Vidales Barriguete et al., 2018). However, these CDW waste additions usually result in improving the analysed aspect (thermal behaviour, water absorption, density), but decreasing the mechanical resistance and thus additives and fibres are needed as reinforcement. Therefore, recent studies focus in combining two or more different waste streams in order to achieve an optimal compound, showing a balance between the properties (mainly resistance-density) (del Rio Merino et al., 2019).

b) Technologies

Today, innovative technologies such as automation and robotics are increasingly introduced into the construction sector with the aim to contribute in the development of mechanisms and processes for the transformation of industry towards more sustainable solutions (Pan et al., 2018; Agustí-Juan et al., 2017) that can reduce cost and energy consumption whilst at the same time can offer benefits to the society including customized and lower cost products according to the individual needs (Huang et al, 2013). This direction of investigation has been initially introduced in industries like automotive and aerospace, mainly in advanced industrialized countries and which today has expanded worldwide with aims, among others, to achieve precision, cost minimization, maximization of productivity and safety (Kangari & Yoshida, 1990). Over the years, the constructor sector has taken advantages of these developments and has applied various automated and robotic techniques, with examples being divided according to the application of the selected technology for on-site or off-site manufacturing, the application of the mechanism, the task to be implemented and the material used (Bock, 2015). Examples where automation and robotics have been applied in the construction industry include robots for timber construction (Willmann et al., 2016), robots for façade finishing using foam concrete material (Lublasser et al., 2018), robots for steel structure assembly (Chu et al., 2013; Jung, 2013), drones for masonry construction (Goessens et al., 2018) and robots for bricklaying (Dörfler et al., 2016).

Another direction of applying automation and robotics, which recently has gained significant attention in industries like automotive, aerospace and bio-medicine, is that of Additive Manufacturing (AM). The AM technology, as a promising and alternative production process, has also been introduced in the construction sector (Wu et al., 2016) with a number of advantages to be obtained including: the production of complex geometries with precision, in less time, but also at reduced cost compared to conventional manufacturing techniques (Buswell et al., 2007). Also, the reduction of material waste due to the use of moulds (Camacho et al., 2017) contributed to the reduction of carbon emissions and minimization of exposure of workers to hazardous environments (Warszawski & Navon, 1998).

Various techniques are presented in the literature, which follows similar principles with the 3D printing technology (Fused Deposition Modelling (FDM), Selective Laser Sintering (SLS) and Inkjet Powder Printing). However, the application of Additive Manufacturing (AM) in construction requires special attention due to the special constraints and limitations of large-scale manufacturing and for this reason, examples are distinguished according to the technology applied, the use of the material and the scale of implementation (Ghaffar et al., 2018). A well-known technique, Contour Crafting (CC) (Khoshnevis & Dutton, 1998) is followed by other techniques including D-Shape (D-Shape, 2008), Concrete Printing (Lim et al., 2012), additive manufacturing (AM) of concrete (Bos et al., 2016) and CONPrint3D (Nerella et al., 2016). The most applicable is the AM method based on the layer-by-layer deposition of materials leading to the development of a solidified product using material extruders and nozzles as the main mechanisms involved (Khoshnevis & Dutton, 1998; Lim et al., 2012). Materials such as plastic, ceramic and metal can be used, however, in the construction sector, special attention is given in the application of concrete-based material. In addition to techniques that use concrete as the main material, the sustainable aspect of AM methodology can be enhanced through the use of materials that contains ecological and environmentally friendly properties such as clay and adobe-based mixtures (Bechthold, 2016; Kontovourkis & Michael, 2017; (Kontovourkis & Tryfonos, 2018), while maintaining in parallel their construction and structural properties.

c) Tools

Construction is a complex industry, that requires a set of standards and regulations to guarantee widely acceptable quality and conformity of buildings. EUROCODE is one of the most used European Construction Standard, which provides a common approach not only for the building's design but also for civil engineering works and construction products.

Harmonized European standards are very important to create a common technical language used by all actors in the construction industry, helping to:
- define requirements;
- declare product performance;
- verify compliance with requirements and demands.

The usage of harmonized standards ensures a common assessment method for construction products as well as guarantee a single European scheme for declaration of product performance. These actions remove barriers to trade and thus help improve the competitiveness of the construction sector (EC, 2018). Initiated in 1975, EUROCODE consists of 10 parts, each separated in sub-parts to clarify the specific construction activity:

EN 1990 Eurocode: Basis of structural design
EN 1991 Eurocode 1: Actions on structures
EN 1992 Eurocode 2: Design of concrete structures
EN 1993 Eurocode 3: Design of steel structures
EN 1994 Eurocode 4: Design of composite steel and concrete structures
EN 1995 Eurocode 5: Design of timber structures
EN 1996 Eurocode 6: Design of masonry structures
EN 1997 Eurocode 7: Geotechnical design
EN 1998 Eurocode 8: Design of structures for earthquake resistance
EN 1999 Eurocode 9: Design of aluminium structures (Eurocodes, 2018)

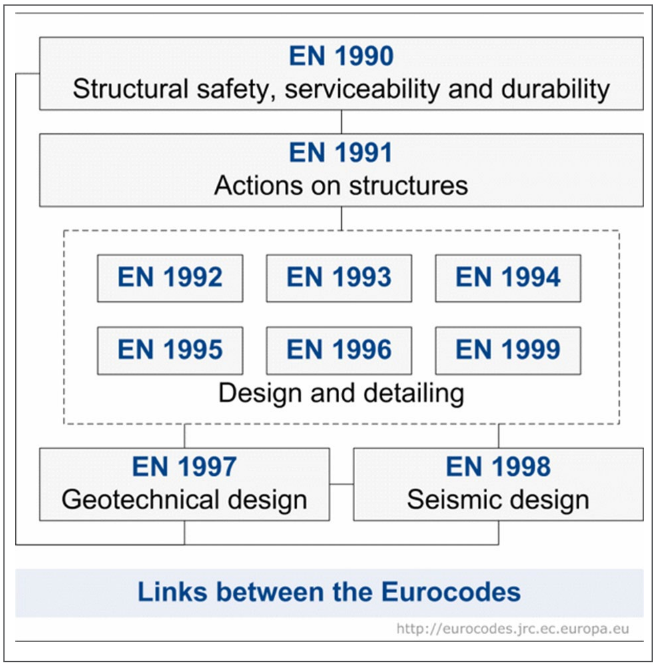


Figure 4.0 - Links between the Eurocodes

Other well-known standards, used for many years, DIN *(DeutscheInstitute for Norming)* or BSI (British Standard Institute), have been mostly replaced by EN Standards and lately by ISO *(International Organization for Standardization),* but when they are still valid in cases when EN or ISO are missing for specific construction activities or products. The difference between ISO and EN standards is that EN standards following the decision of the European Council have to be adopted and implemented in the member states, as national standards without any changes and without delay – and the corresponding national standards have to be withdrawn at the same time (Wurth, 2018).

ISO considers the construction industry as one of the key sectors in many national economies. In 2013 they summarised standards dedicated to construction industry comprising ISO/TC 59 - *Buildings and civil engineering works* and its 109 standards. It is worth mentioning that an essential part of this standard is dedicated to sustainable construction ISO/TC 59/SC 17 - *Sustainability in buildings and civil engineering works,* which deals with issues ranging from general principles and environmental declarations for building products, to the framework of methods to assess environmental performance and the development of indicators for sustainability (ISO, 2012).

In addition to building's design and implementation standards, certification systems have been developed, such as LEED (Leadership in Energy and Environmental Design), BREEAM *(Building Research Establishment Environmental Assessment Method),* DGNB *(Deutsche Gesellschaft für Nachhaltiges Bauen),* etc.

Table 4.1 - Overview of certification schemes, countries and release

Certification Tool	Year	Country	Certification for urban communities [10]
BREEAM	1990	UK	BREEAM - Communities
HQE	1996	France	HQE - Aménagement
LEED	1998	USA	LEED - ND
CASBEE	2001	Japan	CASBEE - UD
Green Star	2002	Australia	Green Star - Communities
DGNB	2009	Germany	DGNB - NSQ

The American LEED puts a very large emphasis on ecological aspects, the British BREEAM integrates economic parameters, and the youngest one, German DGNB, adds technical and social criteria. Over the years, the labels have become similar to each other in many respects, yet still retain market-specific and object-specific features (Hamedani, A. Z., & Huber, F., 2012).

Table 4.2 - Comparison of three of the main certication schemes and their features

	BREEAM Communities	LEED - ND	DGNB - NSQ
Title	Building Research Establishment Environmental Assessment Method (for) Communities	Leadership in Energy and Environment Design - Neighbourhood Development	German Sustainable Building Council - New City Districts (Deutsche Gesellschaft für Nachhaltiges Bauen - Neubau Stadtquartiere)
Developer	Building Research Establishment (BRE)	U.S. Green Building Council (USGBC)	German Sustainable Building Council (DGNB)
Country of origin	United Kingdom	United States of America	Germany
Release	2009	2009	2011
Groups of Criteria	- Climate & Energy - Resources- Place Shaping- Transport & Movement- Community- Ecology & Biodiversity- Business & Economy- Buildings	-Smart Location & Linkage- Neighbourhoods Pattern & Design - Green Infrastructure & Buildings- Innovation & Design Process- Regional Priority Credits	- Ecological Quality- Economical Quality- Sociocultural & Functional Quality- Technical Quality- Process Quality
Rating System	Outstanding Excellent Very Good; Good; Pass	Platinum Gold Silver Bronze	Gold Silver Bronze
Certification phases	- Planning- Project completion	- Planning- Construction - Project completion	- Planning- Construction - Project completion
Certification Institute	Building Research Establishment (BRE) Global	Green Building Certification Institute (GBCI)	German Sustainable Building Council (DGNB)
Assessment Method	Third-party, Education and Accreditation through BRE Global	Third-party, Education and Accreditation through GBCI	Third-party, Education and Accreditation through DGNB
Certified Projects	-	100 registered, 2 certified (2011.08.30)	-
Website	www.breeam.org	www.usgbc.org	www.dgnb.de

The degree of sustainability of building materials and products can be determined by using an Environmental Product Declaration (EPD) (Rambøl on behalf of GBCF, 2014). EPDs 'should' include, the following four sustainability indicators, that are critical for the characterisation of a material and product:

- Global Warming Potential (GWP)- greenhouse gases effect
- Hazardous and dangerous substances
- Material resources
- Emissions to indoor climate and environment

The documentation and classification of a building product are often done at a national level, thus resulting in national EPD-databases (Rambøl on behalf of GBCF, 2014), (Laura Sariola & Ari Ilomäki, 2016). The formation of an EPD-database is based on available data from PCR and LCA (The Building Information Foundation RTS, 2016), hence, when comparing building products included within different EPD-databases, it is necessary to consider this aspect prior to final selection and incorporation of a building product into projects (Rambøl on behalf of GBCF, 2014). Having the same application and placement in a building is the key condition that must be fulfilled in order to compare different products and proceed with the selection of the most appropriate in each case according to EN15804:2012+A1:2013 (CEN, 2013).

4.1.1 SURVEY METHOD

The RESTORE WG3.2 survey was developed to understand the current situation of sustainability in the construction sector, to identify the challenges and the difficulties of implementing Sustainable Construction in Europe. This survey was developed considering three main construction aspects: materials, technology and tools. For this reason, the questions asked in the survey were structured according to the following scheme:

GENERAL INFORMATION ABOUT THE RESPONDENTS

MATERIALS

- Traditional materials: Materials which have been traditionally used and are usually placed on site, such as stone, reinforced concrete, mortars, gypsum plaster, bricks, wood, adobe.
- Advanced materials: Alternative materials to those considered traditional, including prefabricated materials such as plasterboards, Glass Reinforced Gypsum (GRG); precast concrete, Glass Fibre Reinforced Concrete (GRG), etc. and sustainable materials such as recycled materials, biomaterials.
- Emerging materials: Innovative and cutting-edge materials in the construction industry, including materials changing their properties depending on the environment (phase-change materials) and restorative materials such as self-healing materials; materials improving the indoor/outdoor air quality.

TECHNOLOGY

- Traditional technologies: Technologies that have been traditionally used and are usually implemented during all construction stages on site, such as concrete mixers, excavators, tower cranes, hand tools, etc.
- Advanced technologies: Technologies that are currently implemented to a large extent to assist conventional processes in most of the construction stages, including Computer-Aided Design (CAD) and Building Information Modelling (BIM), Computer Numerical Control (CNC) Machines, Robots, etc.
- Emerging technologies: Innovative and cutting-edge technologies with very few implementations currently in the construction industry such as the Internet of Things (IoT), Augmented Reality, Drones and 3D printing for cement-based/clay-based materials.

TOOLS

- Construction Standards: ISO, EUROCODES, DIN, BSI, etc. used in Residential, Commercial, Industrial and Iconic Buildings;
- Construction Certification Systems: LEED, BREAM, DGNB, etc. used in Residential, Commercial, Industrial and Iconic Buildings;

The survey was structured into five sections. In the first, respondents were asked to indicate about their experience and general information.

In sections 2 and 3 (materials and technologies) respondents were asked to indicate to what extent do they use traditional/advanced/emerging materials or technologies in each stage of the construction process: foundation, structure, façade, interior partitions and finishing. Respondents had to answer on a 5 options scale of “I don’t implement it at all”; “10-20%”; “20-50%”; “50-90%”; “I always implement them”. Also, those respondents using emerging materials and technologies, were further asked to indicate for which type of buildings they implement them: Residential, Commercial, industrial and Iconic/Singular Buildings[1].

The 4th section of the survey was dedicated to the tools used by the respondent to ensure and facilitate their sustainable buildings such as Standards and Certification system used. Regarding the Construction standards, they might select between ISO, EUROCODE, DIN, BSI or they might indicate local/national standards they have used. It was also very important, to understand the type of buildings for which they use a specific type of standard, so the question has been raised for four main types of buildings: Residential, Commercial, industrial and Iconic/Singular Buildings. The same questions have been raised aiming to understand the Certification Systems frequently used in the Construction Industry in Europe, indicating LEED, BREAM, DGNB or none of them, either because the respondents use a local certification system, or because they don’t certify their buildings because of different reasons.

The last section of the survey is set out to cover a general question of defining the Sustainable Construction by the respondents, as well as to give them the opportunity to offer their practical experience in this field.

The survey was sent to more than 150 professionals covering different construction agents and 64 responses were received from all over Europe. Respondents are mainly architects (43.8%) and engineers (39.1%) followed by project managers and investors. The number of years of professional experience of the respondents is high, as 37.5% of the respondents have over 20 years of experience and 26.6% between 10-20 years (Figure 4.1).

The results have been analysed based on the questions asked in the survey.

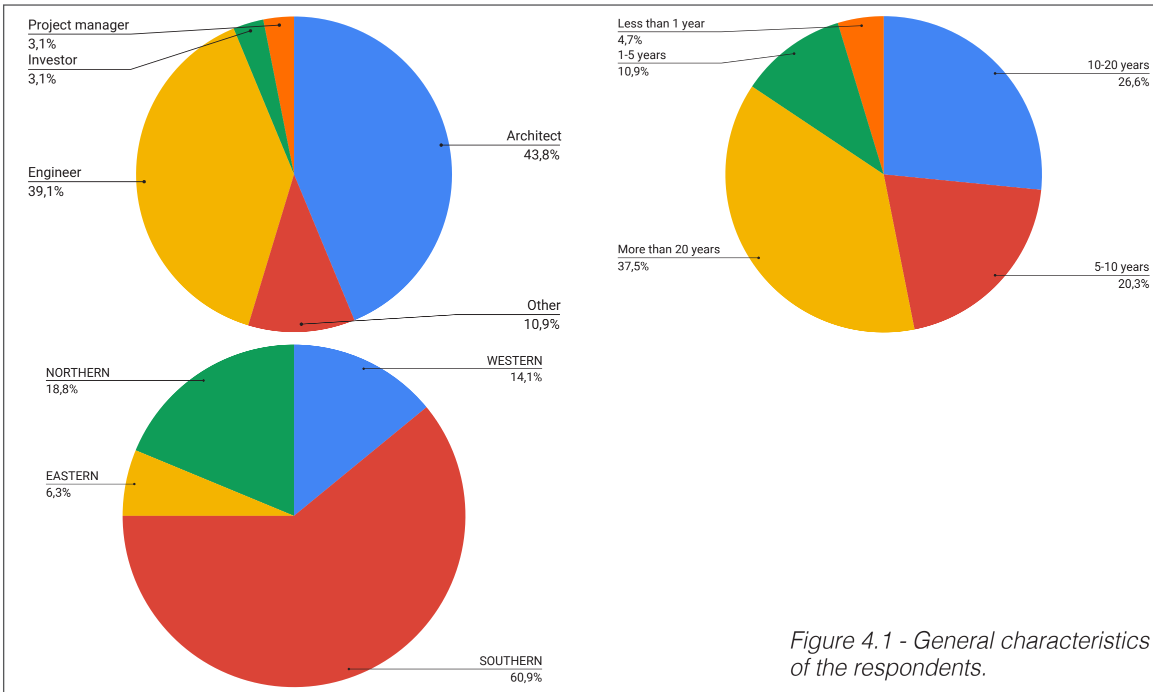


Figure 4.1 - General characteristics of the respondents.

[1] “Iconic architecture is defined as buildings and spaces that are (1) famous for professional architects and/or the public at large and (2) have special symbolic/ aesthetic significance attached to them.” (Sklair, 2005)

4.1.2 SURVEY RESULTS

This section shows the results obtained in the survey for each of the sections: materials, technology and tools. These results can be summarized in the following headlines:

- Advanced and emerging materials and technologies are poorly used within the construction sector, as very few respondents claim to use them in more than half of their projects. These materials and technologies have a higher rate of application in new building construction rather than in building renovation.

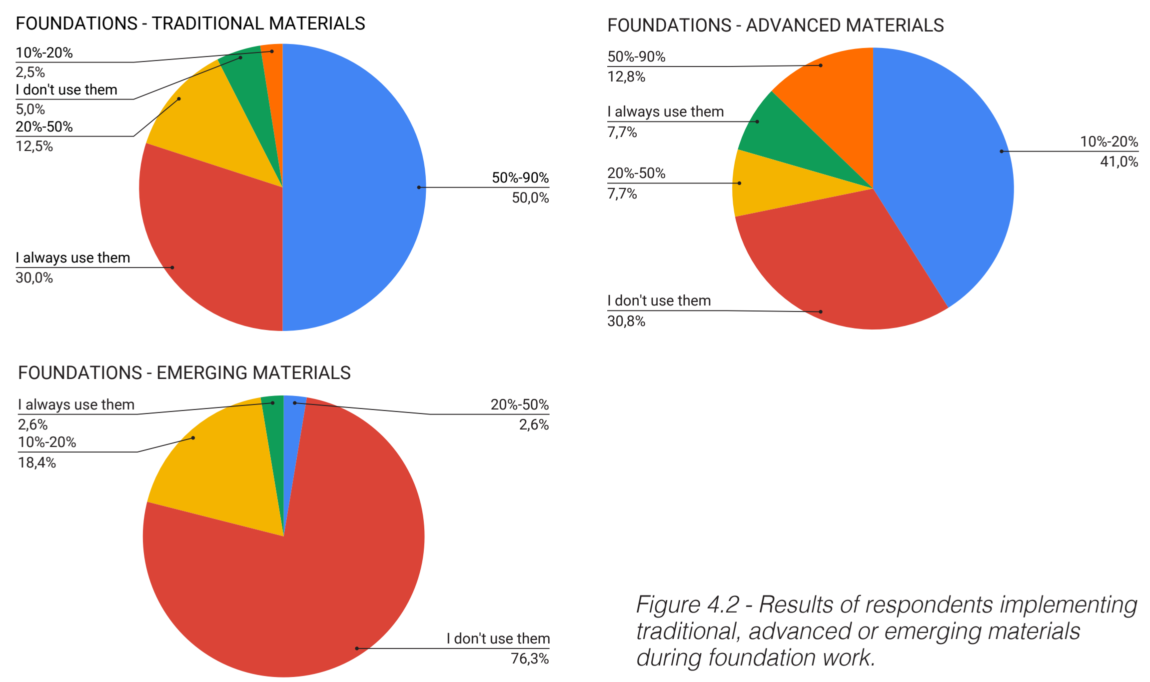


Figure 4.2 - Results of respondents implementing traditional, advanced or emerging materials during foundation work.

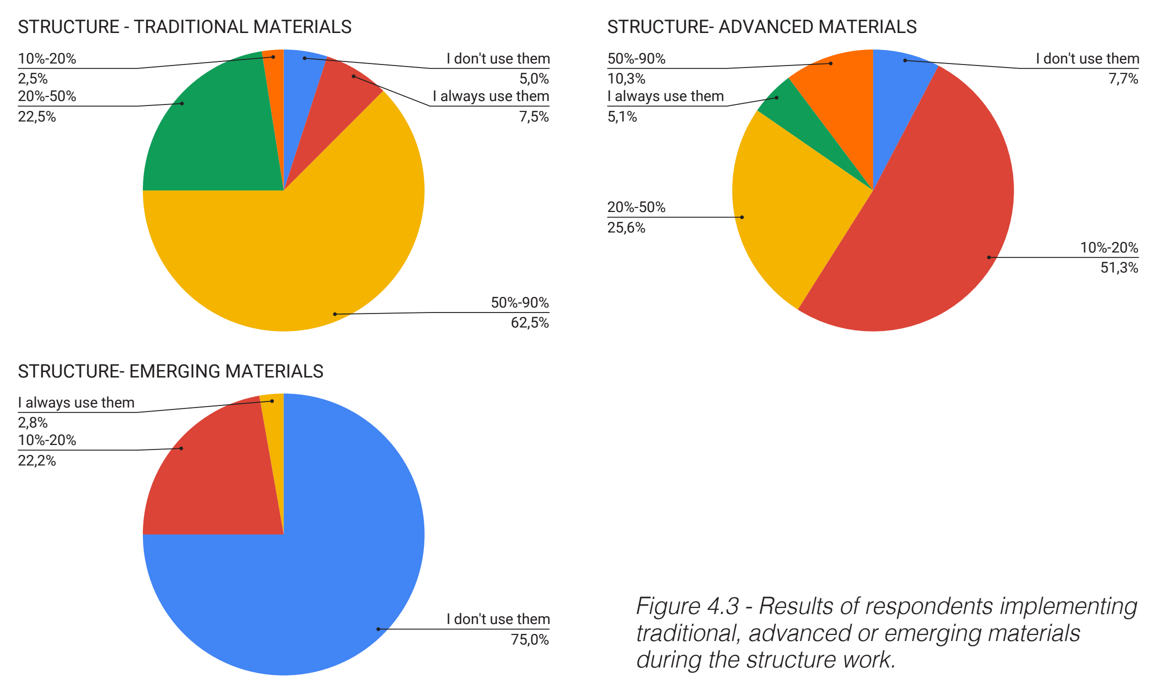


Figure 4.3 - Results of respondents implementing traditional, advanced or emerging materials during the structure work.

- The building façade, interior partitions or finishes were pointed out as the phases in which emerging materials and tools can be easily implemented.
- There is a lack of regenerative sustainability tools used for the construction industry, especially in the Southern European Countries. The results indicate that Southern Europe uses Eurocodes while Northern and Western Europe prefer ISO. On the other hand, most un-certified buildings are located in Southern Europe, while other regions, choose LEED or BREAM, and in few cases in Western Europe, DGNB.
- Some of the barriers to implementing emerging materials, technologies and tools, which were raised by the respondents, include the lack of training, the lack of necessary information and the higher cost.

MATERIALS

This section shows the results obtained regarding the level of implementation of sustainable materials in the building construction process in Europe.

Figure 4.2, shows the percentage of respondents who implement traditional,advanced and emerging materials during the execution of the foundations. It is seen that over 80% of the respondents commonly use traditional materials for the foundation of their buildings (above 50% of their projects), from out of which 30% state to use them always. Advanced and emerging materials are little used within the respondents, as only 20.5% and 5.2% respectively claim to use them in more than half of their projects.
Figure 4.3, shows the percentage of respondents who implement traditional, advanced and emerging materials during the execution of the building structure. Results show that over 70% of the respondents commonly use traditional materials for the structure of their buildings, whereas the remaining 30% use traditional materials in less than 50% of their structures. Advanced materials are less implemented, only by 15.4% of the respondents as well as emerging materials, which only 2.8% of the respondents implement them in more than half of their projects.

Regarding the implementation of traditional, advanced and emerging materials during the execution of the façade, Figure 4.4 shows that 37.5% of the respondents commonly use traditional materials. By contrast, advanced and emerging materials were commonly implemented (in more than 50% of the façades), by 15.4% and 2.7% respectively.

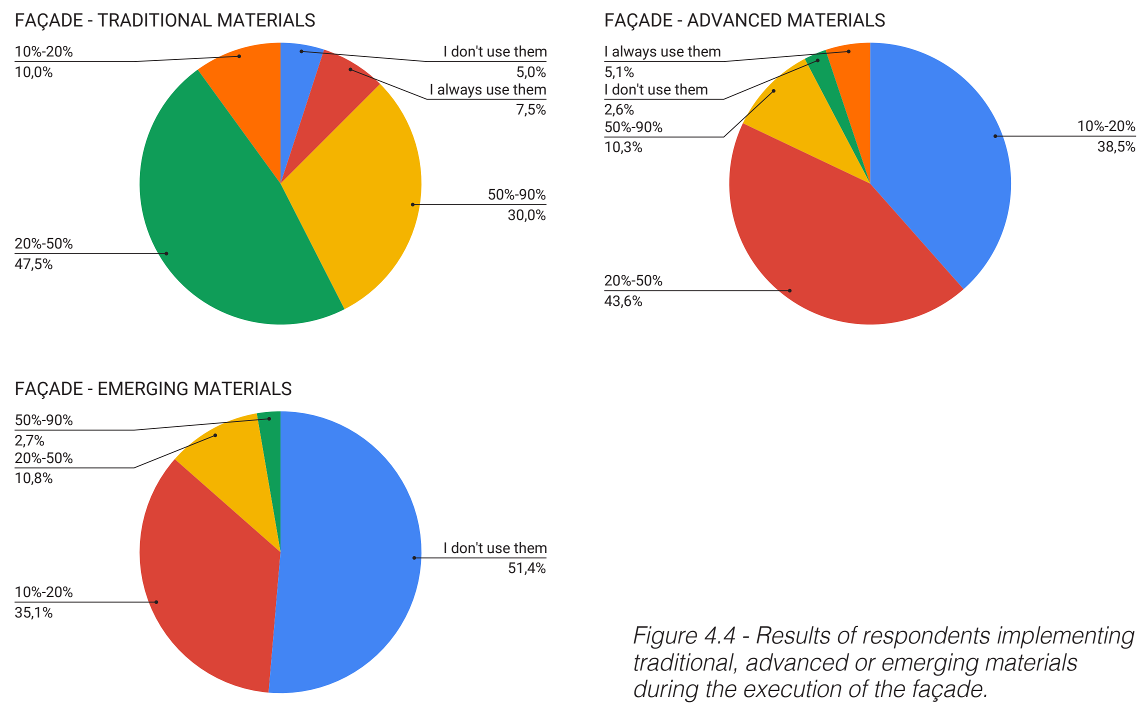


Figure 4.4 - Results of respondents implementing traditional, advanced or emerging materials during the execution of the façade.

Furthermore, regarding the materials used for the interior partitions (Figure 4.5), results show that 12.8% of the respondents always use traditional materials for the interior partitions and 28.2% of the respondents implement them in over 50% of their projects. By contrast, advanced materials were always implemented by 5.3% of respondents, whereas 2.9% of respondents claim to commonly implement emerging materials (between 50-90% of their projects).

Figure 4.6, shows the percentage of respondents who implement traditional, advanced and emerging materials during the execution of internal finishes. In this sense, 48.7% of the respondents commonly use traditional materials for the internal finishes of the buildings, from out of which 15.4% state to use them

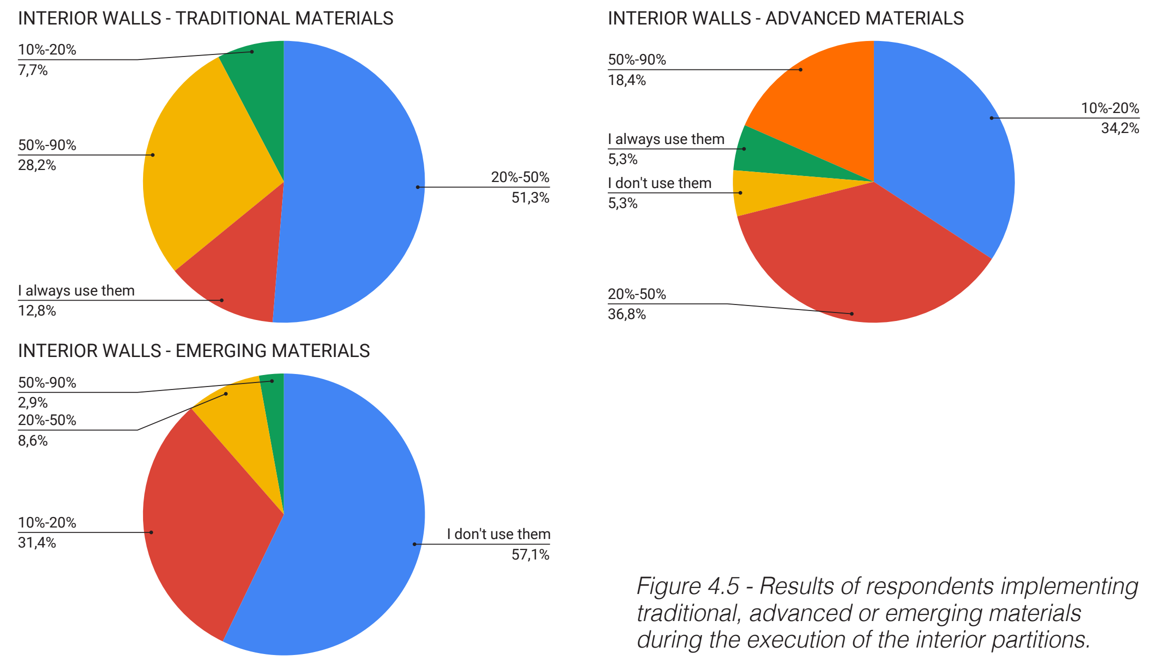


Figure 4.5 - Results of respondents implementing traditional, advanced or emerging materials during the execution of the interior partitions.

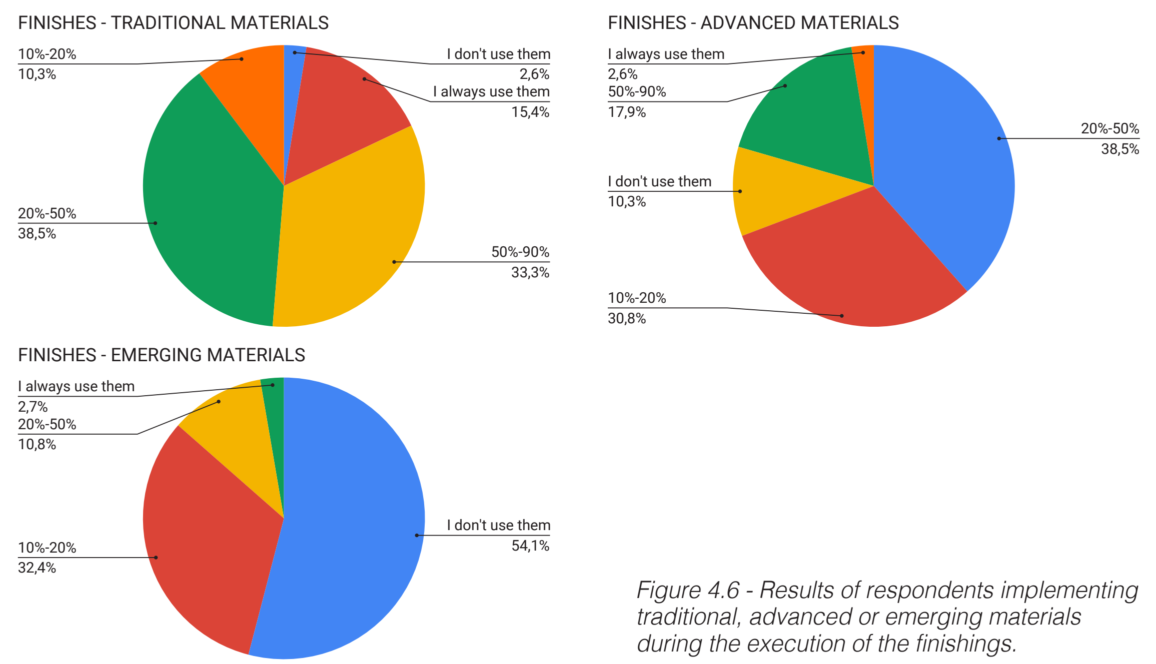


Figure 4.6 - Results of respondents implementing traditional, advanced or emerging materials during the execution of the finishings.

always. Advanced and emerging materials are commonly used by 20.5% and 2.7% respectively.

Furthermore, respondents were asked to identify at which of the five building construction stages is it easier to implement or use emerging/innovative materials. Results from Figure 4.7 show that the majority of the respondents (30%) consider the building façade or finishes as the building activities were emerging materials can be easily implemented. By contrast, ground movement activities, building foundation and structure are the three stages were few respondents (below 7%) believed to implement emerging materials easily.

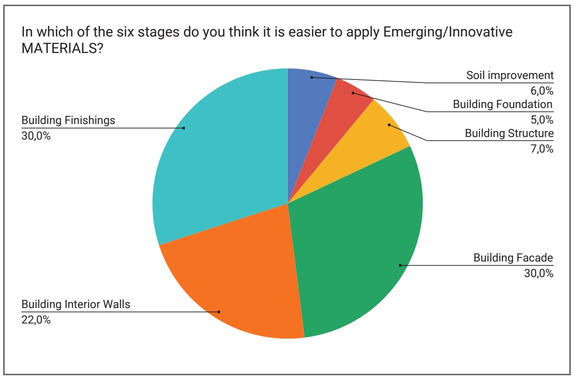


Figure 4.7 - Building stages where it is easier to implement emerging materials.

Respondents who have used emerging materials were asked about the type of building where they incorporated such materials. Figure 4.8 shows that commercial and iconic buildings are the major building types were emerging materials were incorporated in a newly built project, followed by residential buildings.

Moreover, Figure 4.9 shows that iconic/singular and residential buildings are the most common building type of construction where emerging materials were incorporated in a building rehabilitation project.

Regarding the type of building stakeholders which have implemented emerging materials in their projects, it was found that architects and engineers were the major agents implementing these materials, accounting for 37.5% and 29.2% respectively (Figure 4.10).

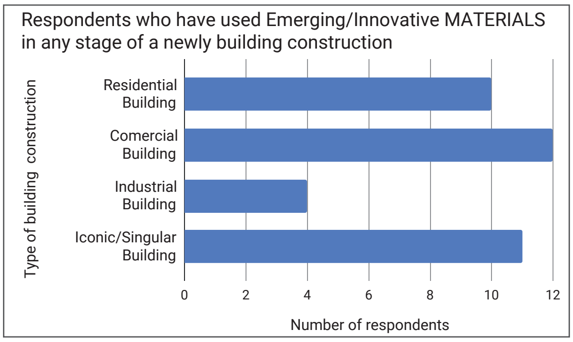


Figure 4.8 - Type of building construction where respondents implemented emerging materials in a newly built construction project.

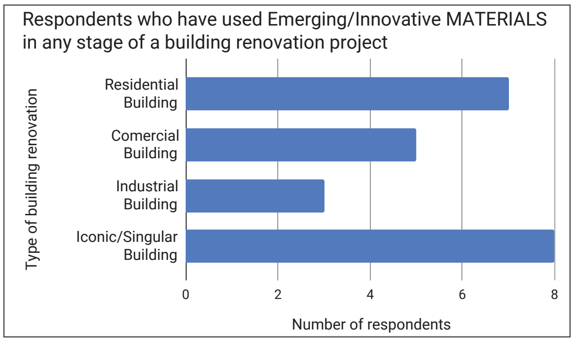


Figure 4.9 - Type of building construction where respondents implemented emerging materials in a building renovation project.

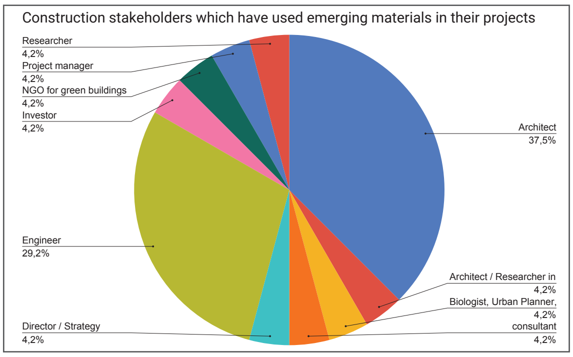


Figure 4.10 - Construction stakeholders which have used emerging materials in their projects.

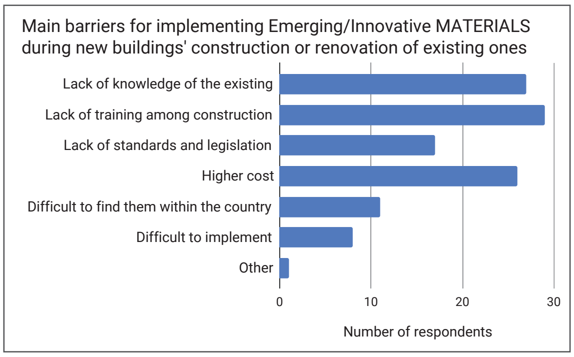


Figure 4.11 - Main barriers to implementing emerging materials

Finally, Figure 4.11 shows the main barriers to implement emerging materials in a building project. In this sense, results show that lack of training among construction stakeholders and lack of knowledge of the existing emerging materials are the main barriers identified by the respondents. The high cost of these materials was the third drawback highlighted by the respondents. By contrast, only a few respondents answered that emerging materials were difficult to implement or to find within the country.

TECHNOLOGIES

This section shows the results obtained regarding the level of implementation of technologies in the building construction process in Europe.

Figure 4.12 shows that the respondents involved at the stage of Soil Improvement[2] are more familiar with the use of Traditional technologies with the answer '50-90%' to be selected by 42.5% and second the answer 'I always use this technology' by 25.0%. In contrast, the number of stakeholders who are using Emerging technologies for Soil improvement is very limited with 68.6% to answer 'I do not use them at all'. The responses regarding the use of Advanced technology during Soil improvement show a balance of choices among the answers 'I do not use them at all', '10-20%', '20-50%' and '50-90%' with 2.1%, 26.3%, 21.1% and 21.1% respectively.

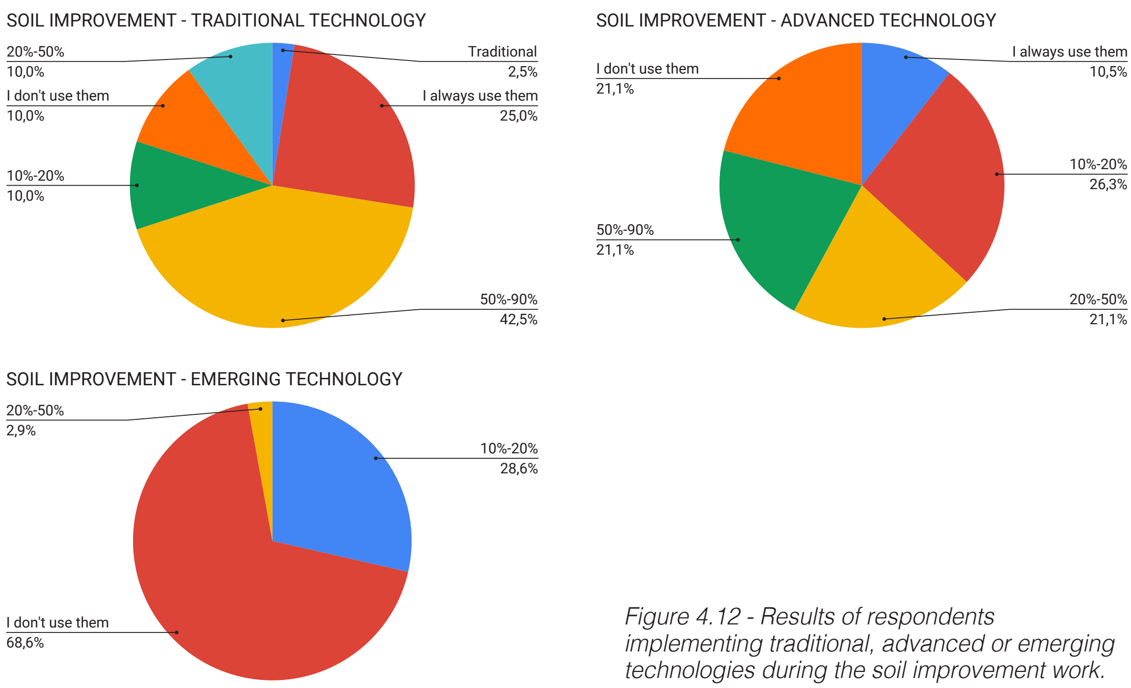
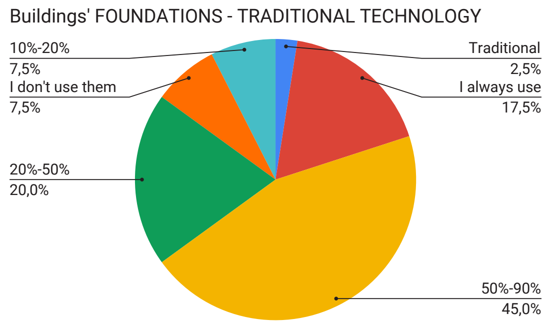
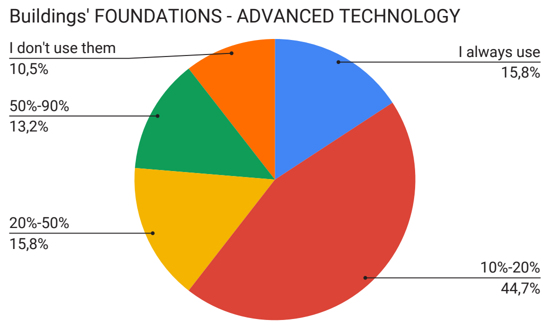


Figure 4.12 - Results of respondents implementing traditional, advanced or emerging technologies during the soil improvement work.

Figure 4.13 shows that the respondents involved in the stage of Buildings' foundations are more familiar with the use of Traditional technologies with the answer '50-90%' to be selected by 45.0%, while the second most popular responses to be '20-50%' and 'I always use this technology' with 20% and 17.5% respectively. However, the level of use of Advanced technologies by respondents is very low, with 44.7% responding '10-20%'. Finally, with Emerging technology, little implementation is observed since the response 'I do not use them at all' is selected by 66.7% with the second most popular response '10-20%' with 30.6%.

[2] "Soil improvement is an old geotechnical practice. Its objective is the modification of the properties of the soil, including deformation, strength, permeability, and chemical characteristics to better adapt the soil to given needs." (Chameau and Santamarina, 1989)





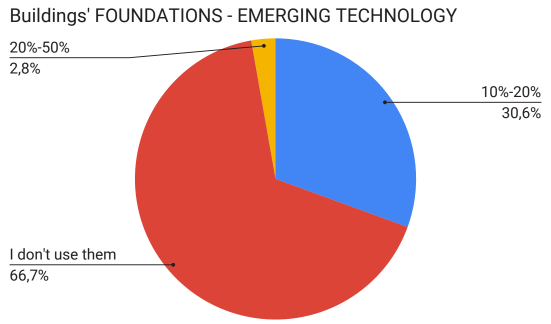
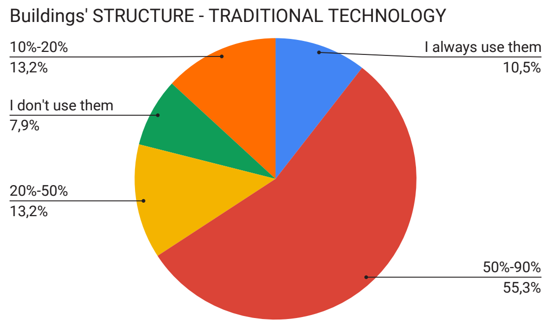
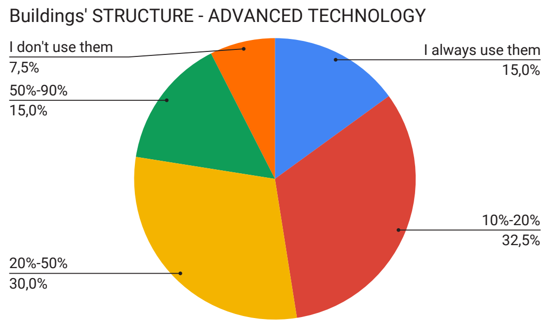


Figure 4.13 - Results of respondents implementing traditional, advanced or emerging technologies during the buildings' foundation work.

Figure 4.14 shows that the respondents involved in the stage of Buildings' structure are more familiar with the use of Traditional technology with the answer '50-90%' selected by 55.3% and the answers '20-50%' and '10-20%' in the same rate by 13.2%. However, with Emerging technology, the most popular answer is 'I do not use them at all' selected by 64.9% and the second most popular the response '10-20%' is selected by 24.3% respondents. Finally, in the use of Advanced technology, the results are more encouraging with the answers '10-20%' and '20-50%' selected by almost 30% of the respondents, indicating that there is a slight increase in the use of Advanced technology for Buildings' structure.





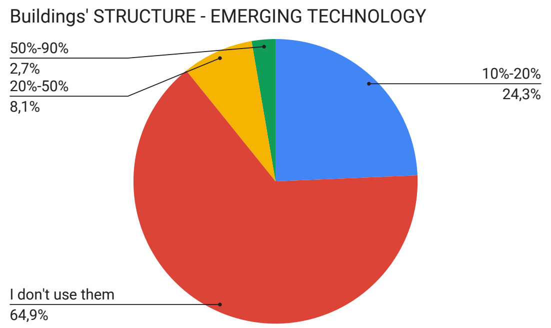


Figure 4.14 - Results of respondents implementing traditional, advanced or emerging technologies during the buildings' structure work.

Figure 4.15 shows an increasing trend in the use of the three categories of technologies for Buildings' façade. More specifically, in the question of using Traditional technology, 38.5% selected the response '50-90%' and 35.9% the response '20-50%'. Regarding the use of Advanced technology, the response '20-50%' is first with 35% and the response '10-20%' is second with 22.5%. As for Emerging technologies, although the first and most popular choice of respondents remains the response 'I do not use them at all' with 51.4%, there is an increasing trend in regard to the second best answer that is '10-20%' with 32.4% and in the third best answer that is '20-50%' with 13.5%, indicating greater acceptance and use of Emerging technologies at the level of exploration and construction of Buildings' facade.

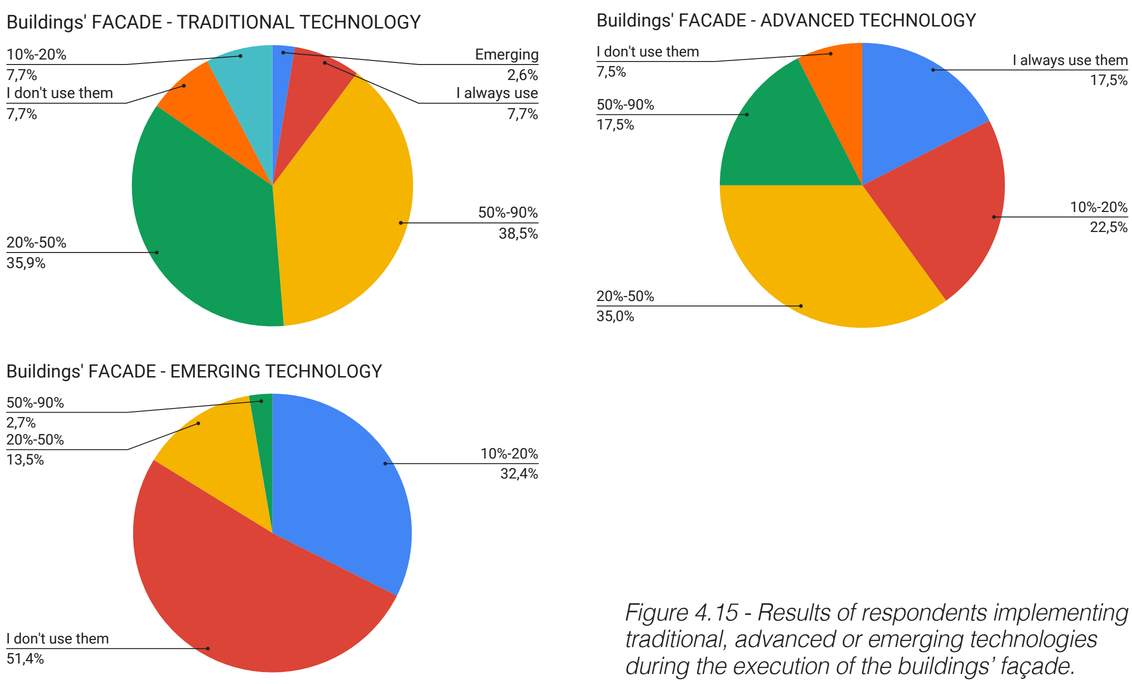


Figure 4.15 - Results of respondents implementing traditional, advanced or emerging technologies during the execution of the buildings' façade.

Regarding the implementation of technology for Buildings' interior walls, Figure 4.16 shows that in the case of Traditional technology the most widespread answer is '50-90%' that is chosen by 43.6% with the second most popular the responses '20-50%' and 'I always use this type of technologies' with 17.9% and 15.4% respectively. With regard to the use of Advanced technologies, the most widespread answer is '20-50%' that is selected by 40.5% and second the answer '10-20%' that is selected by 21.6%. Finally, with Emerging technologies, the answer 'I do not use them at all' is first with 63.9% and with the large difference from the second one that is '10-20%' with 27.8%.

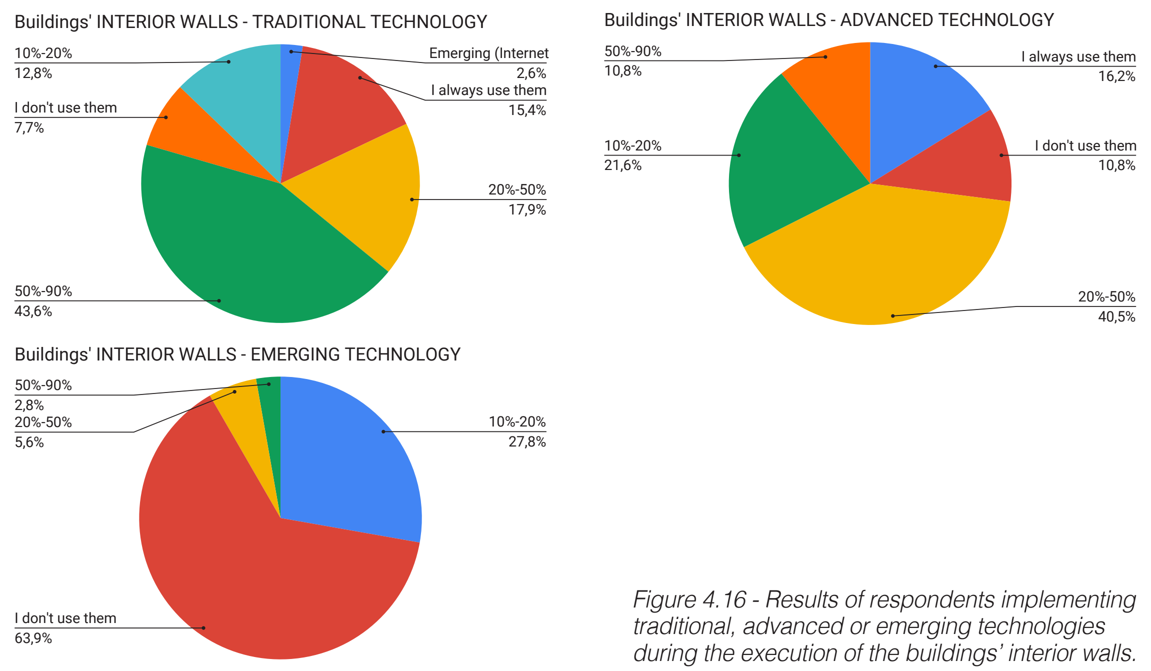


Figure 4.16 - Results of respondents implementing traditional, advanced or emerging technologies during the execution of the buildings' interior walls.

Figure 4.17 shows the results of implementing technology for Buildings' Finishings. Specifically, with regard to the use of Traditional technologies, the answer '50-90%' is selected by 41% with the answers '20-50%' and 'I always use this type of technologies' to be in the second place with the same percentage, i.e. 17.9%. For Advanced technologies, the answer '20-50%' has been mostly chosen with 32.4%, while the second place is shared among four answers, i.e. 'I do not use them at all', '10-20%', '50-90%' and 'I always use this type of technologies' with 16.2%, 18.9%, 16.2% and 16.2% respectively. Regarding the use of Emerging technologies, the first answer is 'I do not use them at all', which is selected by 52.8%, with the second answer '10-20%' at 38.9%.

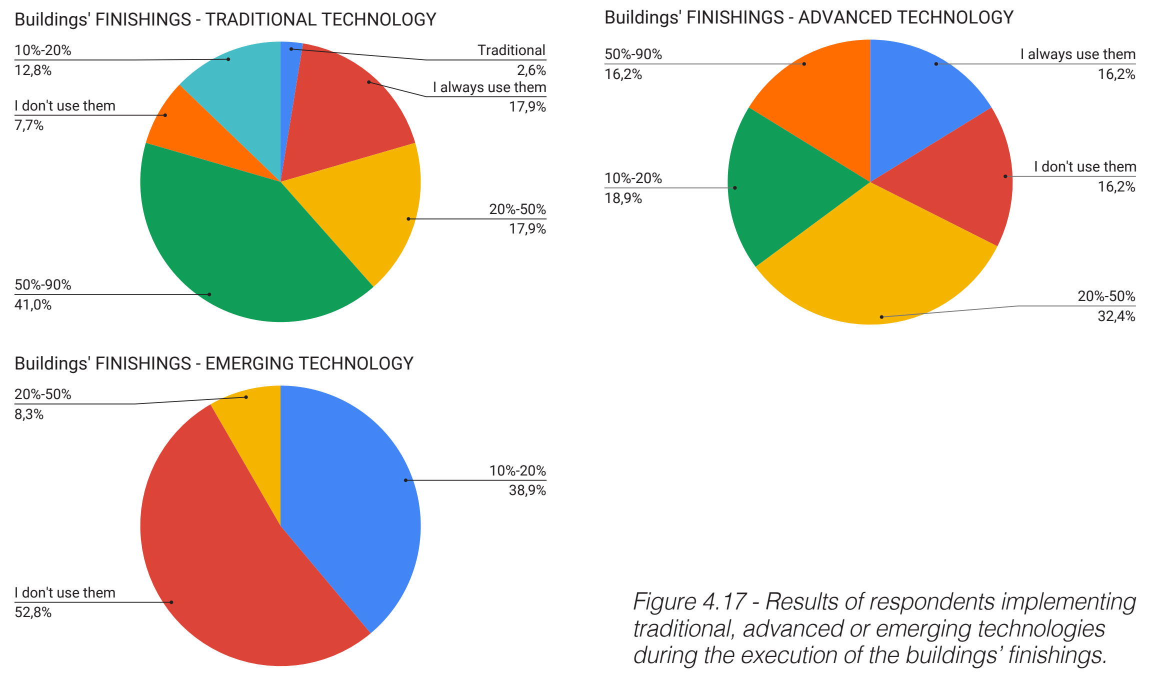


Figure 4.17 - Results of respondents implementing traditional, advanced or emerging technologies during the execution of the buildings' finishings.

In addition, respondents were asked 'In which of the six stages do you think it is easier to apply Emerging/ Innovative TECHNOLOGIES?' with the results shown in Figure 18. Buildings' façade is selected first with 29.1% of the respondents. In the second place, two answers with equal results of 19.1% are the Buildings' structure and Buildings' finishings, while in fourth place and very close is the Buildings' interior walls with a response rate of 18.2%. Buildings' foundation and Soil improvements are in the last position with the rate of responses 8.2% and 6% respectively.

The results in the question 'If you have used Emerging/Innovative Technologies in any stage of a new building or building renovation, please specify the type of buildings' show that the use of Emerging technologies has a higher rate of application in new building construction than building renovation. Figure 4.19 shows that residential and commercial buildings are the major building types where emerging technologies were incorporated in a newly built project, followed by iconic buildings.

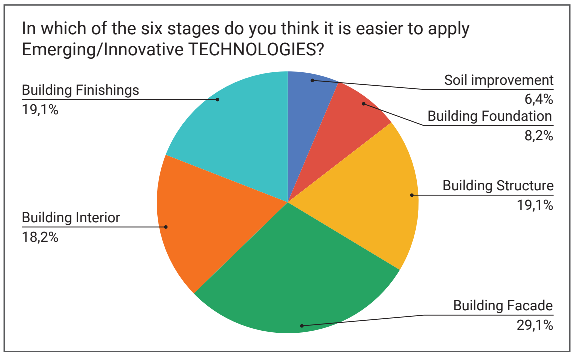


Figure 4.18 - Building stages where it is easier to implement emerging technologies.

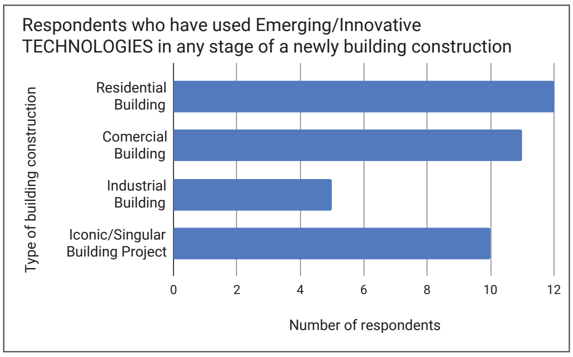


Figure 4.19 - Type of building construction where respondents implemented emerging technologies in a newly built construction project.

In addition, Figure 4.20 shows that commercial buildings are the more common building type of construction where emerging technologies have been incorporated in building rehabilitation projects, followed by residential and iconic projects. Regarding the type of construction stakeholders which have implemented emerging technologies within their projects, Figure 4.21 shows that architects and engineers were the major agents implementing these technologies with 47.6% and 14.3% respectively.

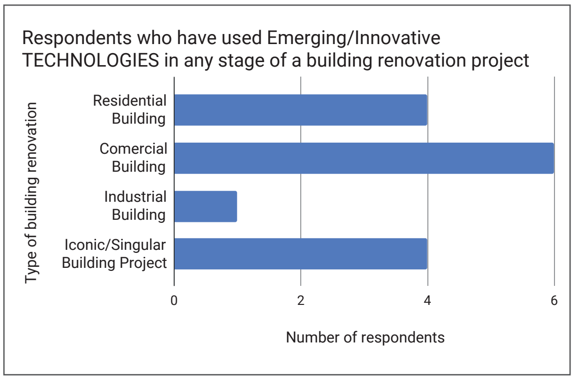


Figure 4.20 - Type of building construction where respondents implemented emerging technologies in a building renovation project.

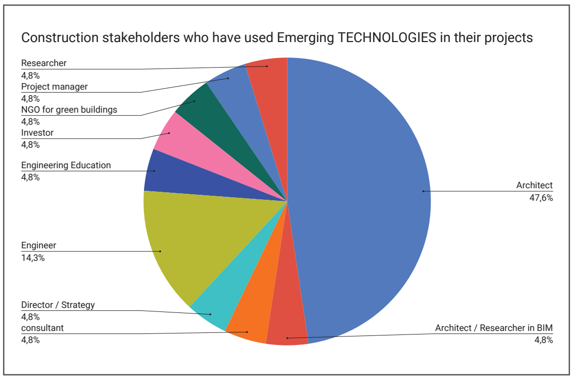


Figure 4.21 - Construction stakeholders who have used emerging technologies in their projects.

Finally, for the question 'Which are the main barriers for implementing Emerging/Innovative Technologies during new buildings' construction or renovation of existing ones' the answer 'Lack of training among construction stakeholders' has the highest rate of response. The 'Lack of necessary information' and 'Higher cost' with an equal rate of response are the second most selected answers by respondents. The answers 'Difficult to implement', 'Difficult to find them within the country' and 'Other' were answered by few respondents (Figure 4.22).

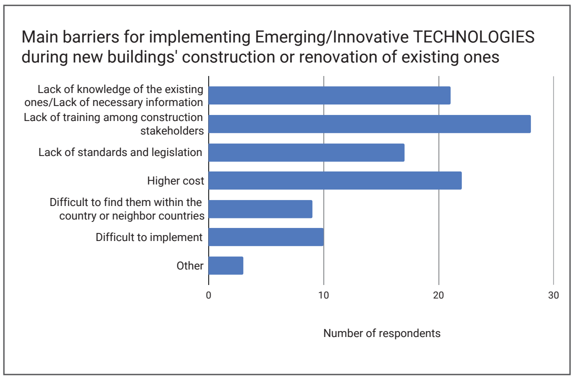


Figure 4.22 - Main barriers for implementing emerging technologies.

TOOLS

This section will be showing the results obtained from the 4th section of the survey dealing with the TOOLS, which contribute, to the sustainable construction processes in Europe such as Contraction Standards and Building Certification Systems.

Initially, the respondents were asked to identify the type of Construction Standard used during construction of four main types of buildings Residential, Commercial, Industrial and Iconic/Singular Buildings.

The results presented in Figure 4.23, implying that 37.5% of respondents use EUROCODE as an implementation standard for Construction process of Residential Buildings, 31.3% use ISO, 12.5% of them use the German Standard DIN and only 3.6% use BSI. In addition, 8.9% use other local/national standards and only 6.3% doesn't use any standard.

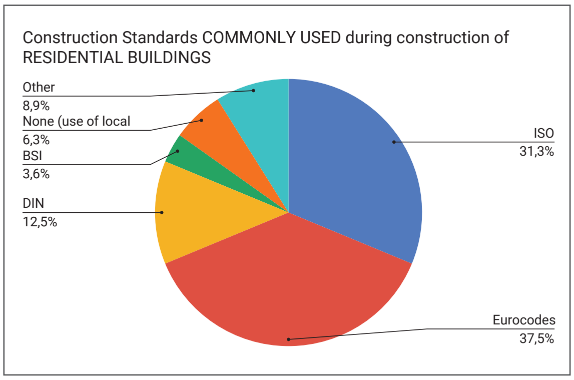


Figure 4.23 - Construction Standards Commonly Used during the construction of Residential Buildings.

The same impression is gained from the results regarding Construction Standards used for the construction of Commercial and Industrial Buildings, where 38.5% respectively 37.5% have preferred Eurocodes. 29.4%-30.0% ISO, 10.9%-12.8% have used DIN and 3.7%-4.5% use BSI, while more than 10% use other national standards and only 5.5%-6.4% don't use any of them (Figure 4.24).

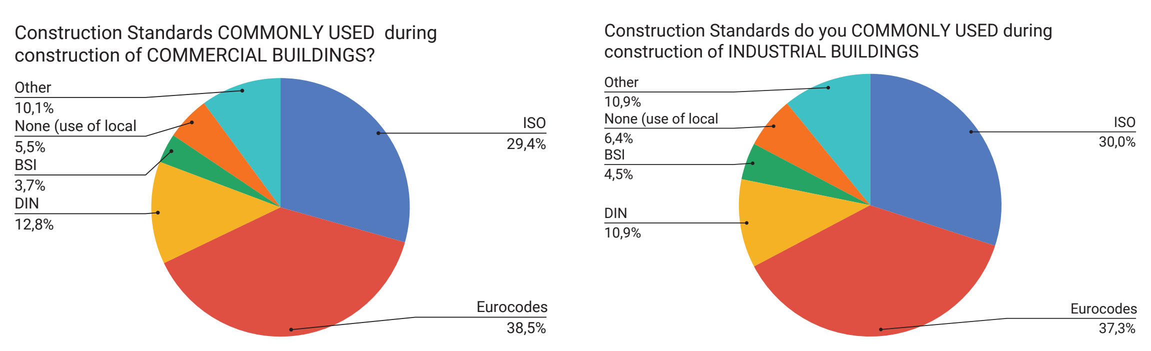


Figure 4.24 - Construction Standards Commonly Used during the construction of Commercial and Industrial Buildings.

When it comes to Iconic/Singular buildings, which stands aside from the usual type of buildings the most used type of construction standard is Eurocode 32.8%. But compared to other types of buildings, during the construction of Iconic Buildings, 12.1% of respondents preferred to use the national/local standards, while more than 7% don't use the standards at all. The other 30.2% use ISO, 11.2% use DIN and 6% use BSI (Figure 4.25). Besides, when asked to identify the reason why the respondents don't use any of the official Construction Standards, the most frequent answer was usage of local/national standards required by law. But there were also answers indicating that application of construction standards increases the project cost or that they don't use because it is not mandatory and the investors are not interested.

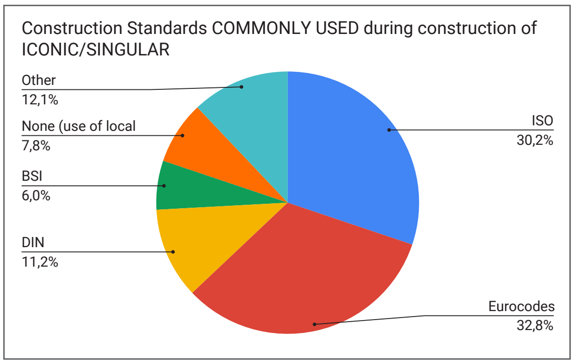


Figure 4.25 – Construction Standards Commonly Used during construction of Iconic/Singular Buildings.

When it comes to Certification Systems used during for different types of Buildings, the majority of respondents indicate that they use other Local or national Certifications from 40.8% in Residential Buildings to 35.4% in Iconic Building. The other significant result is that the respondents doesn't use any of the Certification Systems at all especially during construction of Industrial Buildings 34.7% and less in construction of Iconic/Singular Buildings 28.3%.

Regarding the well-known certification systems, the most used is LEED from 18.2% in Iconic Buildings to 13.9% in Industrial buildings, followed by British Certification Method BREAM from 13.1% in construction of Iconic/Singular Buildings to 8.9% in Industrial Buildings and the less used is German Sustainable Certification System DGNB, from 5.1% in Iconic Buildings to 2.0% in Industrial Buildings. The common reason given by the respondents for not using a Certification System is lack of requirement by the investor and in Industrial Buildings, this goes up to 58.3%.

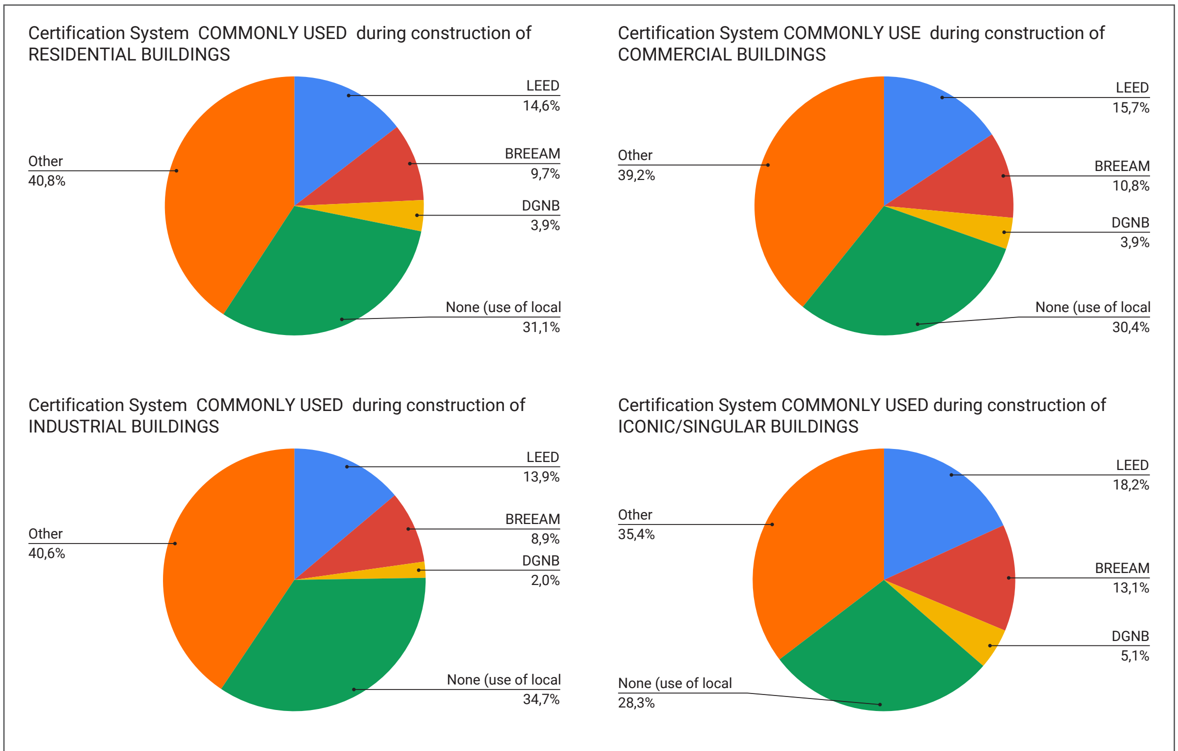


Figure 4.26 - Certification Systems Commonly Used during the construction of Residential/ Commercial/ Industrial and Iconic-Singular Buildings.

Finally, as presented in Figure 4.27, considering the origin of the respondents, it may be noticed that Southern Europe uses Eurocodes while Northern and Western Europe prefer ISO Standards.

While it can be easily noticed from Figure 4.28, that the most un-certified buildings are located in Southern Europe while other regions, choose to use LEED or BREAM, and in few cases in Western Europe, DGNB.

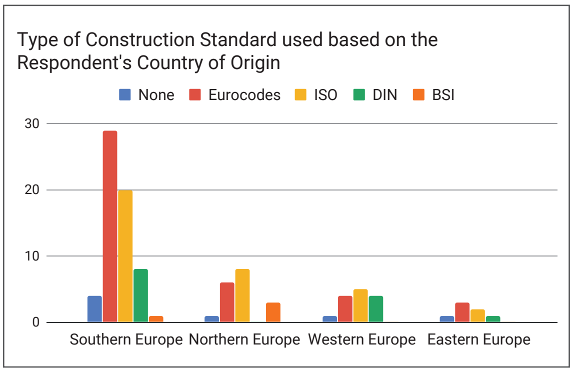


Figure 4.27 - Construction Standards Used based on the Respondent's Country of Origin

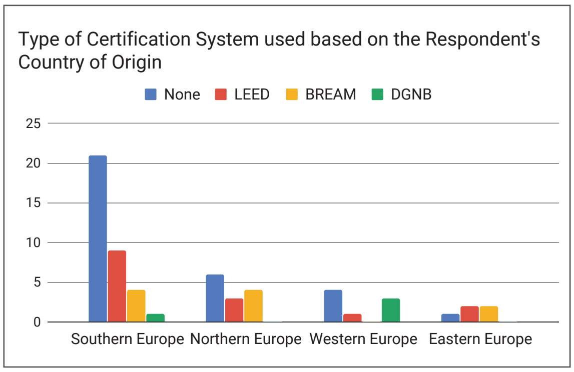


Figure 4.28 - Certification Systems Used based on the Respondent's Country of Origin

4.2 GAP ANALYSIS

In general, **regenerative sustainability is poorly implemented in Europe**. Materials, technologies and tools, capable of improving the wellbeing of the society, are not commonly implemented mainly because of the lack of knowledge, training and higher costs. Some recommendations to promote regenerative sustainability in the construction phase of a building include: (1) increase awareness and knowledge among construction actors of the different possible regenerative materials, tools and technologies; (2) develop guidelines and manuals; (3) develop specific regulations to promote the construction of regenerative buildings; and (4) efficient economic incentives.

The following subsections show the conclusions reached in the state-of-the-art and highlight the gaps and recommendations to help promote the use of regenerative sustainability in the building construction.

4.2.1 MATERIALS

From the state-of-the-art analysis, it can be concluded that advanced construction materials (i.e. alternative materials to those considered traditional, including prefabricated materials and sustainable materials) and emerging materials (i.e. innovative materials, including restorative materials such as self-healing materials; materials improving the indoor/outdoor air quality; etc.) are not widely used in Europe, but they are beginning to be applied in very singular 'iconic' buildings.

In order to increase and promote the use of emerging materials, which can provide a net positive benefit to the environment, the following recommendations are identified:

- Seek the government's commitment, by establishing economic incentives, to promote the use of advanced recycled materials and emerging regenerative materials in their works. Therefore, it is advisable that manufacturers producing these materials specify the positive environmental, economic or social benefits acquiring a label or certification.

- Develop specific regulations to promote the use of advanced and emerging materials, which set quality specifications for these materials. In addition, labels could be used to mark and classify the degree of social, economic or environmental sustainability, (for example, the ILFI Declare Label (REF) that reflects labelling used in the food industry).
- Increase awareness and knowledge among designers regarding the existing emerging regenerative materials in order to promote their use in building projects.

If manufacturers can provide to designers the real benefits of using regenerative materials, the use of these materials will considerably increase, as currently in façades and partitions where manufacturers of regenerative materials are more active.

4.2.2 TECHNOLOGIES

The state-of-the-art analysis of results regarding the implementation of technologies by construction stakeholders shows that while Traditional technologies are currently widely used, Advanced technologies are implemented at a very low percentage (under the half of cases compared with the Traditional technologies).

It is noted that Advanced technologies are easier to be applied to tasks that deal with the development of secondary structural elements such as Buildings' façade, interior walls and finishes work rather than of structural system.

Regarding Emerging Technologies very few or almost no applications are observed, indicating that innovative technologies are in a very early implementation in the construction sector with a higher rate of application in new building construction (with particular emphasis on residential buildings) than in building renovation.

These results indicate that there is hesitation in the application of Emerging/Innovative technologies, due to a number of reasons that include the lack of training, the lack of necessary information and the higher cost.

Emerging/Innovative technologies have the potential to deliver economic and ecological benefits. At the same time, they can improve construction quality, higher productivity rates, reduce materials, construction time, costs and negative environmental impacts. In order to achieve these benefits, a number of additional research investigations would be required.

In support of emerging technologies, it will be necessary to develop:
- Guidelines for implementation and technology readiness
- Relevant training and provision of information.

4.2.3 TOOLS

The results of an undertaken survey regarding the implementation of regenerative sustainability tools such as Construction Standards and Certification Systems of different types of buildings show that, in general, there is a lack of these types of tools used in the construction industry, especially in the Southern European Countries.

While summarizing the results indicated for the most used Construction Standard in Residential, Commercial, Industrial and Iconic Buildings from different regions in Europe, it can be noticed that Southern Europe uses Eurocodes as the most preferable standard, while Northern and Western Europe prefer ISO.

On the other hand, while assessing the level of buildings certification according to the well-known sustainability systems, such as LEED, BREAM or DGNB, it can easily be observed that the most uncertified buildings are located in Southern Europe reasoning that the sustainability certification increases the building costs which is not acceptable by the investor, or that such certification is not required by national legislation. Meanwhile, other regions, choose to use LEED or BREAM, and in few cases in Western Europe, DGNB.

Regenerative tools are proven to ensure internationally acceptable quality and sustainability of construction. As of survey results, extended research would be recommended, particularly in the countries responding that they don't use Construction Standards or Certification Systems, aiming to perceive the reasons behind. It is also important to understand the categorization of buildings into public and private where the sustainability tools are not facilitated so further recommendations for improvements will be given.

4.3 CONTRIBUTIONS FROM TRAINING SCHOOL TRAINEES

4.3.1 RESOURCES AND MATERIALS – A SHIFT FROM SUSTAINABLE PRACTICES TO REGENERATIVE PROCESSES IN THE CONSTRUCTION INDUSTRY

KEY THEME OF WG 1: Resources (Materials)
THEMES OF WG 3: Construction
Author: **AMIT ANAFI**

Introduction

The built environment is a huge influencer on 'sustainability', we spend over 90% of our time working, living and playing within our buildings. Buildings, and the manner in which we design, construct and maintain them have been a significant contributor to climate breakdown we are witnessing. Restorative and regenerative approaches can flip this, enabling buildings to become part of climate regeneration solutions.[1]

The construction stage can and should be the momentum to pull together all sustainability strategies and build, for the benefit of the present and for future generations regenerative buildings that secure a better future.

The case of the construction industry

The ecological footprint of the construction industry is huge, it requires large quantities of raw materials, some of them are now almost exhausted. The U.S. Green Building Council (USGBC) reports that the construction industry accounts for 40% of worldwide energy use [2].
Sustainable and regenerative construction management means far more than building environmentally-friendly structures. It is a combination of sustainable construction practices, techniques and the use of sustainable building materials in order to reverse waste generation, generate positive environmental impact and to guarantee second and third life cycles of our buildings. The construction industry, especially during demolition phases, produces a large amount of "waste". According to a report by the World Bank in 2012, there is a global collective of 1.3 billion tons of solid waste every year. Building material accounts for half of the solid waste generated every year worldwide [3]. To change and reverse this quickly and effectively, the industry should invest in effective procurement procedures, follow sustainable construction management methods and invest in sustainable construction materials and software.

Practical paths for sustainable and regenerative construction materials' use

Application of the following paths could allow construction companies, general contractors, developers and owners to shift to a regenerative construction site management:

1. Use alternatives to traditional construction materials – the selection of materials should occur right from the beginning of each project. One of the main materials used in the construction industry is concrete. The process of production of concrete materials reached 1.48 ± 0.20 Gt CO_2 in 2017[4]. Green building materials like Rammed earth, Hempcrete, bamboo, recycled plastic, wood, Mycelium, ferrock, Ashcrete and Timbercrete [5] are all alternatives to using concrete.

2. Use safe and non-toxic materials – today we have access to different "red lists" that address the level of toxicity or harmful content of building materials. Different sustainability protocols cite lists and transparency programs such as DECLARE and material verification schemes such as REACH, C2C and EPD. Today we witness more discussion on healthy buildings and of greater transparency in what we specify and procure and of eliminating toxic materials from construction[6].
3. Implement Just-In-Time production. Just-In-Time (JIT) delivery is an inventory management approach designed to allow better construction and material management by "receiving goods only as they are needed for production processes". While JIT delivery is most often correlated with combating the issue of inventory waste, it is also perfectly applicable to maximize all of the eight wastes defined by lean[7] processes (Defects, Overproduction, Waiting, Non-Utilised Talent, Resources, Transportation, Inventory Excess, Motion Excess and Extra Processing) (D.O.W.N.T.I.M.E) thus making construction site's flows and material use more efficient.
4. Integrate alternative sustainable construction methods - Prefabricated construction materials and methods can be highly sustainable. It takes up to 67 percent less energy to manufacture a prefab building than it does to build a conventional structure on site, according to Clearview Modular Buildings[8]. And the same study shows that when lifecycle costs are factored in, prefabricated buildings deliver a lifetime energy saving of up to 90 percent.

Main tools and principal benefits

In order to achieve and control the measures mentioned above, today's technology comes to our aid. Tools such as Building Information Modelling (BIM) and Life Cycle Assessment (LCA) procedures have the potential to include information about embedded energy of materials, material specification and exact requested quantities.

With the available data for architects and other stakeholders, this can also decrease inefficiency between the office and site through better communication. Information related to quantity take-off can be extracted from the BIM model, allowing accurate bid procedures change management along the process. Other data relating to cost, time and resources can be monitored in order to smooth project management in the execution phase and to facilitate maintenance procedures during the complete life cycle of the building, including end-of-life management of single materials and components. The principal benefits that can be achieved by the application of the practical paths mentioned above, regarding the management of resources and materials during the construction phase are numerous:

- Recyclability of demolished materials and zero waste production during construction;
- Actively preserve and regenerate natural resources and existing ecosystems;
- Improved health and wellbeing for construction workers and future tenants;
- Efficient Use and assembly of Materials creating a positive effect on second life cycles.

Conclusions

During the whole life cycle of a building, from initial concept throughout the design, construction, occupation and future life, the realisation phase – site preparation, demolition, construction and final delivery - offers a unique possibility to take sustainability a step further towards regenerative practices. Accurate and attentive use and application of innovative, non-toxic, recycled and recyclable materials, the use of innovative construction techniques and applying efficient maintenance management plans can secure the delivery of better and healthier buildings.

Raising awareness to the need for a positive impact on the environment during construction, emphasizing on health and wellbeing of workers [9], controlling the materials we use during construction and eventually compensating carbon footprint investing in other green projects and communities will guarantee a positive and regenerative effect on our life and on the future of our planet.

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4.3.2 RETHINKING WASTE MANAGEMENT TOWARDS A REGENERATIVE CONSTRUCTION

KEY THEME OF WG 1: Resources (waste)
THEMES OF WG 2: Construction
Author: **ALEJANDRA VIDALES BARRIGUETE**

Prior to the industrial revolution, humanity used natural resources without causing significant environmental impacts on nature. The raw materials used were extracted and waste was generated in such a way that nature itself was capable of absorbing through natural cycles.

Currently, the use of natural resources and production of large amounts of waste are considerably greater, generally linked to the "throwaway" society and linear economy [1]. Therefore, adequate waste management is essential in order to turn construction waste into secondary resources and in turn reduce the consumption of natural raw materials [2].

Increased environmental awareness is causing a shift in society, modifying aspects of lifestyle, consumption and production. It is in this new paradigm, where sustainable construction is considered, aiming to reverse all possible environmental impacts caused by the construction industry, including waste generation [3]. This can be achieved through policies and regulations that include requirements which help to achieve the EU recycling target set for 2020 which was by the Waste Framework Directive 2008/98/CE. This Directive sets definitions regarding waste and establishes the waste hierarchy, prioritizing waste prevention, reuse and recycling against elimination [4].

Therefore, the waste hierarchy (reuse, recycling and valuation) play a vital role for a change in mindset from the predominant linear economy model towards a circular economy model. The circular economy raises a new paradigm of intelligent design based on the closure of the life cycle of products loop, as occurs in nature. Main advocates of the circular economy, such as Ellen McArthur, point out that it goes far beyond just recycling, it is also about design and innovation, the reuse of resources, the opening of new markets, the creation of value and, to a larger extent, job creation [5].

Similar to the automobile industry, where 60% of the weight of a new car comes from recycled material [6], the construction industry embraces similar solutions without losing good practices that reverse the waste generated during the execution of the work [7].

For the manufacture of construction materials the incorporation of waste "traditional materials", is an alternative approach in line with the target set by the Waste Framework Directive. The use of secondary materials, is one of the most important factors towards a circular economy model and thus zero waste in construction[8].

The construction sector is not an exception, circular economy opportunities should be seized by proposing recycled, recyclable and durable materials. Likewise, construction companies could also have a certification label, which assesses the use of resources, energy and waste of the company working process/procedure (similar to other certifications systems used for buildings or products). Something similar to what is done in buildings and from which we obtain an energy label (A-B-C-D-E-F). Unifying these criteria, construction companies would try to improve in these aspects in order to be in the market.

In this way, society would consider that construction contributes to the sustainability of the planet, changing practices and is respectful to its environment, saves resources, minimizes waste and overall considers the future of society.

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4.3.3 THE CARBON FOOTPRINT OF CONSTRUCTING

KEY THEME OF WG 1: Carbon
THEMES OF WG 3: Construction
Author: **PAULA HILD**

A Carbon Footprint of a building or construction project expresses the total amount of greenhouse gas (GHG) emissions caused by building life cycle stages, related to design, materials, construction, operation, maintenance, refurbishment and end-of-life.

The approach generally bases on Life Cycle Assessment (LCA) follows the ISO 14040–44 guidelines, but limits its focus to one impact category only, the Global Warming Potential (GWP)[3]. Carbon Footprint methodologies include for construction sites (a) on-site activities (energy use, travel on site, on-site assembly, soil treatment, waste treatment, water and wastewater pumping) and (b) off-site activities associated with the construction process (commuting of the workers, off-site assembly, transport of materials and products, transport of soil and waste) [1].

As an example, the ConstructCO_2 online tool [2] supports the mapping of carbon emissions of construction activities and provides benchmarks. In average, the total Carbon Footprint from construction processes of the projects using the online system splits as follows[4]:

- 6.5% management (management team travel to and from the construction site),
- 39.5% operative travel[5],
- 4% visitor travel[6],
- 13% material deliveries[7],
- 18% plant (machinery usage on construction site),
- 16% utilities (electricity), and
- 3% waste disposal.

[3] The international and European standards, ISO 21931 and EN 15978 describe the life cycle of building and construction works. The indicators for assessing the sustainability performance of new or existing buildings relate to their design, construction, operation, maintenance, refurbishment and end-of-life. In this context, the construction stage generates impacts related to transports and the construction-installation process.

[4] Benchmarks extracted from the website the 18th of April 2019: https://www.constructco2.com/

[5] Operation covers: staff travelling to and from site; and material transit on site and construction vehicles used in operation. [3]

[6] Visitors travelling to site to observe the construction process. [3]

[7] Deliveries include material transportation from market to construction site. [3]

Case studies representing the Carbon Footprint of construction works, compared with the materials and the in-use phase of a building, (emissions from building energy use)

- Run Shaw Architectural Building at Southeast University in Nanjing, the construction stage carbon = 0.3%, compared to 85.4% of the operational phase (50 years), 12.3% for materials impact, and 2% for the demolition stage. [4]
- New build Curtin University Western Australia, the carbon footprint of the construction stage[8] accounts for 2%, compared to the usage stage of 50 years (85%) and the supply of construction materials (13%).[5]
- Urban buildings of Xiamen in China, the construction stage accounts for 6% to 17% of the total annual carbon footprint9, compared to the use phase (34%-51%) and the materials (32%-58%). [6]

Concerning the results of the above carbon footprint studies, the impact of the construction activities varies from 0.3% to 17%. In all the studies reviewed, the use phase dominates the carbon footprint of a building. However, even when the carbon footprint of a building does not include energy use during the occupation, the construction works are much less in comparison to the materials.

In a study of a masonry construction dwelling unit in the UK, the use phase covers GHG emissions related to maintenance, repair, replacement and refurbishment – but does not include the energy and water use and resultant carbon emissions related to the building's usage. In this case, the construction process stage accounts for 12% of the total carbon footprint[10], compared to the use phase of the building (17%), the impact of the production of the materials (50%) and the end of life (21%)[11]. [7]

In a holistic approach towards regenerative thinking in construction, the assessment of building life cycle stages is based upon a mixture of indicators and methods. More important than the assessment of the construction phase is the provision of guidance from regenerative design. Such guiding methodologies for the building sector are lean management [9] and BIM (Building Integrated Modelling); they intend to foster the sustainability of construction phase of buildings projects by among other things enhancing efficiency in the construction process and providing information about the building materials used.

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[9] The impact of the carbon emissions of building construction compared to the total Carbon Footprint of urban buildings per annum varies over the study period from 2005 to 2009: 6% (2005), 8% (2006), 17% (2007), 15% (2008), 9% (2009).

[10] This Carbon Footprint study follows the European TC350 standards and covers the following life cycle stages of a simple masonry construction dwelling: A1-3 Product, A4 Transport, A5 Construction, B2-5 Refurb and replace, C1-4 End of life.

[11] The construction process stage includes the construction installation process (3%) and the transports related to the construction work activities (9%).

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CONTENT

5.1 STATE OF THE ART

The operation of buildings is most often the responsibility of the Facility Management (FM) profession– either as in-house or outsourced service. Facility Management, in particular, can shape the sustainable interdependency between the built environment, the natural environment and the organizations´ business environment (Junghans, 2011).

According to Elmualim et al. (2010), Facility Managers have a great role in contributing to the reduction of the built environment.

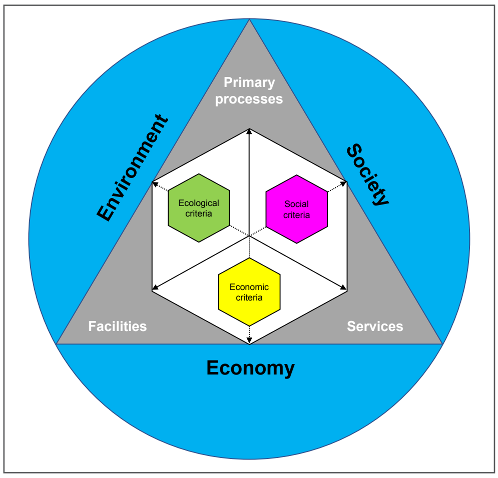

Figure 5.1 - The SFM model (Junghans, 2011; Junghans & Olsson, 2014)

It is even more essential to identify how Facility Management can even regenerate the built environment. This can have an impact on the environment and hence advancing the sustainability agenda across the three bottom-line strands of sustainability, the economic, environmental and social FM service processes have both direct and indirect influence on the building environmental performance metrics. According to Aaltonen et al. (2013) by relatively light changes and modifications to the FM service processes, quite extensive environmental benefits can be achieved.

Based on the literature review (Junghans, 2011) direct influences on the sustainable development of the built environment are seen within the three main areas of responsibility:

- support of primary processes,
- development of space and infrastructure and
- development of people and organisations.

From the perspective of a circular economy, Facility Managers organise and control the physical resources that flow through a location, as well as the services for the people who work within the facility. The majority of resource consumption impacts come from the provision of daily services to users, such as the electricity to light and power equipment, ventilation and heating, and the consumption of material resources like food, water, and e.g. ice supplies. In addition to the resource use within the building, it is also important to investigate logistics: how people and resources travel to and from the building, and the impacts associated with these movements. The ownership of material flows within the built environment sector seems to be an important possibility for circularity, but realizing it is challenging. The circular economy principle of systems thinking is central, identifying where synergies and divergences lie and the potential for unintended or perverse consequences. Collaboration has been identified as a key requirement for progressing the circular economy (Adams et al., 2017). The approach requires consideration of the eco-system of practices, decisions and processes impacting on long term energy ambitions of buildings and their organisational owners.

There are three levels of management which are core in decision-making for Facility Management of a sustainable building: strategic, tactical and operational (Atkin, 2015). Coordinated information and communication in developing (Regenerative) Sustainable Buildings and between the different management levels of strategic, tactical and operational will aid in efficient and effective Sustainable Facility Management (SFM) in a life-cycle perspective (Haugen and Klungseth, 2017). SFM differentiates itself from FM through its "consideration not only of core business and support functions, but also relations within the local and global society as well as the climate and the ecosystem" (Nielsen and Galamba, 2010). Additionally, Jensen et al. (2008) state that FM is extending its scope from a single building to the building peripherals and the built environment – the competencies are an implementation of new and sustainable technologies and practices in the built environment. This has happened and it is more typical to discuss also urban Facility Management which is including more than one building perspective. Dilmegani et al. (2014) state that comprehensive digital transformation goes beyond online services and requires looking for opportunities to improve.. Tools such as energy efficiency maturity matrices are developed to support future sourcing processes for energy-efficient buildings as a prominent part of the broader field of sustainable building renovation and maintenance. The future will show when building clients to a larger extent will embrace sourcing strategies instead of mainly focusing on specific technical improvements. The new International standards for Facility Management (ISO 18480 series) might support this change process, as it includes a sourcing approach, from a strategic level to an operational level, to add more value and to optimize costs (Stenqvist, 2018). ISO 41001:2018 specifies the requirements for a Facility Management (FM) system when an organization:

a) needs to demonstrate effective and efficient delivery of FM that supports the objectives of the demand organization,
b) aims to consistently meet the needs of interested parties and applicable requirements and/or
c) aims to be sustainable in a globally-competitive environment.

The requirements specified in ISO 41001:2018 are non-sector specific and intended to be applicable to all organizations, or parts thereof, whether public or private sector and regardless of the type, size and nature of the organization or geographical location.

The transition to a sharing economy presents a huge chance for procurement and for facility professionals. For the past 15 years, Procurement and Facility Managers have successfully focused on the ways in which Facility Management businesses are able to run in a more (cost) effective way. Brinkø et al. (2014) have investigated that Facility Management literature from the field of Space Management provides guides for the design of non-territorial office spaces as well as other shared spaces and facilities within a given organisational and physical setting. However, this literature rarely deals with sharing on a broader scale or sharing with actors outside of one's own organization. From the literature on Urban Planning as well as Universal Design, there are perspectives on the design of public shared urban spaces such as parks and squares, but this literature rarely moves inside buildings. Alexander and Brown (2009) discuss Community Facilities Management where they have begun building a bridge between these two fields but have so far not moved into the systematic use of shared space between organisations and neither has the field of Urban FM.

According to Brinkø et al. (2014) the societal movement for more and more people living in cities, space will inevitably become a scarce resource. Sharing facilities that are already present and often stand empty for many hours during the day or week can have many benefits. A shared strategy for a new type of sustainable Property and Facility Management, where the prospective gain of these spaces can be maximised while the use of resources for building new can be minimised. In addition, it can also be a way of creating new contacts by increased interaction with a larger group of people, or an alternative way for a company to demonstrate Corporate-Social Responsibility (CSR). There has been some effort in examining the lack of regulation on technical aspects of completed sustainable buildings in urban areas. For example, the lack of regulation for solar panels in urban areas makes these sustainable buildings vulnerable to shadowing effects of newly built surrounding buildings (Lobaccaro et al., 2017).

Scientists use Sustainable Facility Management (SFM) mainly for ecological construction technologies or for techniques optimization to lower the energy consumption of existing buildings (Junghans, 2011). E.g. in the Scandinavian context, the main focus has been on environmental sustainability (Elle et al., 2004). Balslev et al. (2009) claim that Sustainable Facility Management is an umbrella for various ways of reducing flows of energy, water and waste in the daily operation of the buildings, for instance by regularly monitoring the consumption, by using green accounting, by applying policies for sustainability and enhanced user awareness. However, in the operation of living buildings International living building institute describes how operations are integrated with and mimics natural processes, and obtains all necessary resources for operation from the natural environment (rainwater, wind, sunlight and where possible natural materials), and in doing so achieves a net-zero impact on the environment. Säynäjoki et al. (2013) state that buildings are a major contributor to climate change. The building in use phase has traditionally been the focus area, but the importance of the construction phase has increased with the emergence of energy-efficient buildings. Life-cycle assessment (LCA) is arguably the best method to assess and analyse the emissions caused by buildings. However, within LCA there are two very different approaches – process LCA and input-output (IO) LCA – which lead to different results.

There are also differences across countries. The current practice of housing administration in Denmark plays a central role in housing in sustainable development due to the large resource consumption (Balslev et al., 2009). The barriers and commitment of the Facility Management profession to the sustainability agenda was revealed by a survey of the experiences of Facility Managers in the UK. The findings demonstrate that "time constraints, lack of knowledge and lack of senior management commitment are the main barriers for the implementation of consistent and comprehensive sustainable FM policy and practice" (Elmualim et al., 2010).

In the USA, Sustainable Facility Management is described by Hodges (2005) as: "Reduction in water consumption, operations and maintenance (O&M) costs, building-related illnesses, waste and pollution, and increases in the comfort and productivity of occupants are also significant benefits of sustainable and green building practices. The primary incentive for following sustainable and green building practices is the reduction in energy consumption and the subsequent reduction in reliance on fossil fuel to produce that energy."

The scope of FM has been broadened from purely technical matters, i.e. the smooth operation and maintenance of Facility to overall Real Estate Management over the last 10 years. Rondeau (2006) states: "In a number of organizations Facility Managers have moved from the boiler room to the board room." Scandinavian research engineers have compiled a "Facility Management value map" which measures the added value produced by FM. Taking account of its use of resources, its processes and products, and its influence on the environment and on companies' core processes (Jensen et al., 2008). According to Støre-Valen and Buser (2019), the development of Sustainable Facility Management (SFM) practices requires an active and integrated engagement of the FM organization. The concept of sustainability and its different dimensions and implications seems to be well understood now by the practitioners. What seems to be lacking, though, is the possibility of convincing the end-users, who are expected to operate and maintain the facility, to act according to the standards that these solutions require. It appears to be easier to focus on the technical aspects than on end-user behaviour. The practitioners reported a shortage of social competencies and tools to deal with the situation, and despite increasing awareness of smart technology, they lacked solutions to engage the end-users in optimizing the facility. Besides, not all FM companies were well equipped to face the challenges imposed by the sustainable agenda; the small and medium enterprises, in particular, seemed to be struggling to implement the different dimensions of sustainability. There is a need for frameworks and concrete tools to help FM practitioners to integrate the social and cultural aspects of sustainability. It identifies end-users, both in housing and in offices, as creating a bottleneck to the implementation of sustainable FM.

Recent researches of the use of smart technologies for operational management have shown that there is no linear effect. There are significant success examples of smart buildings, such as the Edge offices building project in Amsterdam. This building uses IOT connectivity to maximise comfort and energy efficiency. It is currently considered the greenest building in the world. It demonstrates a modern workplace building as a driver for health, sustainability and innovation. However, Darby (2018) argues that there are inherent difficulties with expectations for smart homes and with making them viable, and with definitions and roles of 'users' in smart systems. Others, such as Qi and Shen (2018), indicate that despite the well-development of smart living space, Smart Home is still more like a luxury product than a daily necessity for most families. Operations management issues are essential for new technology to be accepted by the mass consumer market.

One way to improve the operational management of buildings can be done by using the Remote Operations Centre (ROC). In the case of Bullitt Center in Seattle, which is regarded as the worlds greenest commercial building ROC is regarded as the brain of the building which behaves like a living entity. In view of its CEO Denis Hayes, living buildings need cerebral cortexes and Central Nervous System to function which uses big data helps to see patterns.

Through the ROC, traditional processes are transformed and redefined to optimize the operations of buildings and maintenance, providing monitoring, control and mitigates risks across various geographical sites through a connected platform as well as a swift response from a mix of stationed and mobile dispatch team.

However, lessons learned from other industries, have shown that high costs can limit the increase of investments in this technology ((Farrelly and Records, 2007) despite its economic potential in the long term. In order to ensure comprehensive management of the building performance and the related costs of ownership/occupancy, there is a need for guaranteed and/or shared energy-saving partnerships using competitive and performance-based contracts management. Another performance-based tool is to create comfort and satisfaction assessment (Comfort Meter), bringing comfort and productivity of the occupants at the heart of the operations management (Qi and Shen, 2018). Moreover, in Well Build standard, 90% of an organisations cost is in people and only 1% in energy (9% in rates etc.) which explains the interest in Well Build approaches.

Another way to examine the linkage between technology and operational management is to see it as a strategic process to achieve the goal of the building among its inhabitants and also to create for him or her a competitive advantage among other buildings. The problem is that the OM (operational manager) is not generally involved in strategic decisions of companies or organizations regarding integrating new technologies. This is generally a prerogative of senior managers. However, OM can be part of the development process and certainly part of the implementation (Brown et al., 2005).

The participatory design and user involvement are the topics which are important in sustainability and maintainability of the buildings. Facility Managers are the main operators of buildings and they should be included to a great degree in the design and construction phases leading to e.g. an energy performance gap (Whyte et al., 2016; Fedoruk et al., 2015).

Facility Managers have important knowledge for operational purposes, this should be taken into the design phase. Regenerative Design describes processes that restore, renew, or revitalize their own sources of energy and materials, creating sustainable systems that integrate the needs of society with the integrity of nature. There is also a need to understand what functionality and usability aspects are important in the design and construction of sustainable buildings (Lindkvist, 2018). There are challenges in getting different practices to collaborate, for example, technical developers often view users in terms of a knowledge deficit leading to an acceptance of views that conform with specified project goals (Skjølsvold and Lindqvist, 2015). Considering Facility Management at a nearly design stage e.g. motivated by a Soft Landings (see chapter 3 Procurement) approach, this could potentially reduce the efforts for maintenance during the operational phase of buildings. Early adoption of Facility Management in the design phase will contribute to reducing the needs for major repairs and alternations that will otherwise occur at the operational phase. There is an integrated data source providing information support for the building lifecycle. It is envisaged that Building Information Modelling (BIM) would fill the gap by acting as a visual model and a database throughout the building lifecycle (Wang et al., 2013)

The perspective of usable sustainability is important (Nissinen et al., 2012; Kostiainen and Nenonen, 2016). Engaging users to behave in an energy efficient way for buildings in use is important to ensure sustainable buildings can reach their potential, however, energy behaviour engagement is often the focus of inhabitants in their homes rather than that of commercial buildings (Hargreaves, 2016; Bull and Janda, 2017). The key to delivering sustainable development is to provide environments which promote and enhance the health and wellbeing of the building occupants so that they can flourish. Cundall´s research demonstrates that in healthy office environments, productivity increases, absenteeism reduces and concentration improves. In the home, sleeping patterns improve, respiratory issues decrease and even fitness can increase. Cundall is one of the forerunners in improving the way we live, work and is committed to delivering spaces that enhance the occupant's health and quality of life[1] . The notion of engagement is essential to develop the social potential of positive energy behaviour in buildings. This requires competencies for transdisciplinary collaboration. Facility Management influences the interdependency between the company and its environment, including the companies' real-estate asset and infrastructure related constructions. Additionally, it is important to identify the difference between different profiles of user, e.g. social impacts are different for different social groups.

[1] see https://cundall.com/Services/Health-and-wellbeing/Health-and-wellbeing.aspx

The present knowledge regarding Sustainable Facility Management SFM is limited and incoherent, and there is a need to establish more research-based knowledge in order to define relevant strategies for different types of organizations and Facility (Jensen et al., 2008). Megatrends outlined in the 1980s still shape how FM develops. Digitalization supports sustainability not only through workplace change and building design but also through performance measurement, certification schemes and an awareness of the wider urban context (Bröchner et al., 2019). The introduction of regulations of management of energy of commercial buildings in use could have a huge potential on the reduction of emissions in cities by developing common standards. Ottelin et al. (2018) state that the welfare state has important features that improve the carbon equity between the citizens. This sets new targets for commercial Facility Management and provides a good ground for work towards regenerative community-based Facility Management (CbFM). To achieve absolute decoupling, required to reduce environmental impacts caused by economic activities, they suggest policies promoting public and private green investments. In addition, increased carbon pricing would enhance green investments and drive environmental innovation.

Policies and schemes for sustainable buildings should be linked to sustainable FM more clearly (Bröchner et al., 2019). Life cycle assessments for new sustainable buildings and for sustainable refurbishment requires analyses of the ecological footprint and emissions over planned lifetime periods in addition to energy use and energy balances for the recommended and applied technical solutions and management issues. The sustainability certification schemes and an awareness of the wider urban context are there to stay (Bröchner et al., 2019).

Whilst Facility Managers may be at the forefront of delivering sustainable assets and hence further the venture for mitigation and adaptation to climate change. The overwhelming barrier for implementing sound, sustainable FM is the lack of consensual understanding and focus of individuals and organizations about sustainability. There is a knowledge chasm regarding practical information on delivering SFM. Sustainability information asymmetry in design, construction and FM processes render any sustainable design as sentiment and mere design aspiration. Skills and training provision, traditionally offered separately to designers and Facility Managers, needs to be re-evaluated.

Regenerative Sustainability education and training should be developed to provide effective structures and processes to apply sustainability throughout the construction and FM industries coherently and as common practice (Elmualim et al., 2010)

5.2 GAP ANALYSIS

What still needs to be discussed, investigated and realized in short and long term plans is, how FM can contribute to the regenerative social and ecological development of the built environment. Possible assumptions are that FM can enhance this development directly through improved use of resources, FM processes and sustainable FM products as well as indirectly through its influence on the economic, social and ecological environments (Junghans, 2011). However, it is important not to regard these three dimensions separately, but as an integrated system including society, the environment and the economy.

There is a need now for Regenerative Facility Management to set targets for a social, ecological and economic regenerative future. It is important to identify the impact and opportunities for a regenerative approach to both construction and operations in addition to a regenerative use of buildings.

Social Targets for Regenerative Facility Management:

- supply of the balanced amount of buildings for work and life, developing mixed-use and hybrid facilities in the context of urban regeneration,

- physical and psycho-social wellbeing, alongside compliance with health, safety and security requirements including
- identification of different social groups and different social impacts – resilient buildings and resilient neighbourhoods integrate different social groups and provide synergy,
- communication of the regenerative values for users – this increases the awareness of regenerative actions.

Future Sustainable Facility Management needs to emphasise a holistic wellbeing in workplaces. Indoor environment should be a safe place that not only responds to basic human physical needs but also meets occupants' psychological needs, enhances their abilities and supports their happiness. As FMs are trying to optimise energy performance of their buildings, in terms of installed services and building fabric, it is essential for them to also consider how they can help the occupants to better control and spend their human energy and develop synergy.

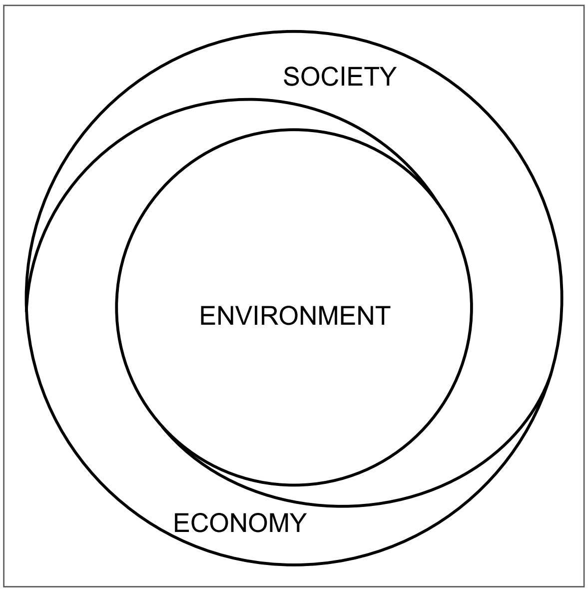

Figure 5.2 - Regenerative Facility Management (applied from the picture by Ramírez, Kalinowska-Wichowska, Petrus and Jiménez Pulido in Training School 2019)

If building occupants are not physically comfortable they are less likely to be able to concentrate on their tasks and work effectively. This is known as 'presenteeism' i.e. when an employee is present at work but cannot perform efficiently. Presenteeism, as well as absenteeism, can cost organisations significantly. The role of Facility Management in providing a comfortable indoor environment is broadly recognised. An additional indoor environmental factor that can affect occupant wellbeing is space utilisation. FMs should try to better understand the occupants' type of work, as well as their company's strategy and direction to create a space to support the needs. FMs should collaborate with their HR and ICT teams to ensure their buildings are efficient in terms of occupant density, functionality (fitness for purpose), layout, furniture, ICT, and indoor facilities (e.g. restaurant, shower rooms, meeting rooms with video conferencing facilities, etc.). In addition to personal workstations, providing designated areas for collaboration, contemplation and formal and informal meetings can significantly contribute towards workplace wellness. The focus needs to be more also on the network of places while work is not anymore so time and place dependent. Workplace as a service is a potential for new restorative facility services for users' health, wellbeing and productivity.

FMs should focus not only on the physical factors of buildings but also on the psychological experience of people in the workplace. Many factors in the workplace can influence occupant psychological wellness. Access to nature, for example, is thought to have benefits for wellbeing. Growing evidence, based on the biophilia hypothesis, suggests that access to nature, outside views and indoor natural features reduces mental fatigue and improves individuals' ability to deal with stress and other work/life-related issues. Opportunities for FM research are created by sustainability, combining environmental and social aspects.

Within organisations, employee issues and risk management are emphasized, but it needs to be widened from physical elements to socio-psychological elements. Digitalization supports sustainability not only through workplace change and building design but also through performance measurement – new service platforms, sensor data and data-analysis provide new insights to Sustainable Facility Management (Bröchner et al., 2019). Almost every FM function can be done more efficiently through technology. From using sensors to detect burned-out light bulbs to automating workflows by using an online platform that informs vendors to perform repairs, technology speeds up processes while enabling greater transparency as everyone involved is able to see which stage a request is at. Operations can be further optimized using building usage and performance data to obtain information such as when and how many employees are in the office. Doing so not only allows one to capture data that was previously untracked in paper-based systems, but it also generates more data that can be analysed to meet user organisation´s priorities. For example, office space can be reduced to save cost while new revenue streams can be created by renting out unneeded space for short term leases.

Ecological targets for Regenerative Facility Management:

- reduction of resources with the focus on circular economy and sharing,
- usage of recyclable building material and improvement of multi-project integration in order to recycle materials,
- consideration of separability of used material for re-use and developing new practices and services to make it easy for different stakeholders,
- reduction of energy consumption and usage of renewable energy sources – inspection of reduction by using digital services and data in an innovative way,
- reduction of space requirements,
- safeguarding the ability to maintain and de-construct buildings,
- prevention of materials that cause harm to people or the environment based on precautionary principle specification.

In terms of the energy system, there is a lot of focus on technical solutions (e.g. Viitanen and Kingston, 2013), but an energy system is not just the technical solutions and services, it is also the consumers and users of the system. Energy can be around 1 % of the total costs. There are regulations for the energy system focus on planning, building and design, while regulations for energy in use are scarce even though impacts on the climate effect of different management regimes, utilization and consumption are evident. So far there is no follow up regulations to know if objectives set out in design are being met in operations.

Little attention is paid to the maintainability of green buildings – however, it might not quarantine, that all dimensions of sustainability are in full use, e.g. social and economic views. A new language of carbon, (McDonough, 2016) distinguishes between three types: Living carbon: “organic, flowing in biological cycles, providing fresh food, healthy forests and fertile soil; something we want to cultivate and grow.”; Durable carbon: “locked in stable solids such as coal and limestone or recyclable polymers that are used and reused; ranges from reusable fibres like paper and cloth to building and infrastructure elements that can last for generations and then be reused.” Fugitive carbon: which “has ended up somewhere unwanted and can be toxic; includes carbon dioxide released into the atmosphere by burning fossil fuels, ‘waste to energy’ plants, methane leaks, deforestation, much industrial agriculture and urban development.”

There is a knowledge gap in research on the maintainability of green buildings to ensure green Facility Management. Chew et al. (2017) proposed research framework to the green maintainability of different typologies of buildings and especially green building technologies. With smart building technology systems are becoming increasingly sophisticated these days, Facility Managers can take energy efficiency and sustainability to new levels. For example, highly advanced energy management systems can detect complex usage patterns and adapt energy usage precisely for specific occupants. The rise of apps has also created on-demand temperature and lighting apps that office workers can download on their mobile devices to control temperature and lighting in an individual office or zone, rather than an entire floor. This creates a win-win situation where the Facility Management organisation benefits from energy savings while giving employees a sense of control over their environment.

In order to influence a more consistent reduction of carbon emissions in use, the identification of how to regulate for energy management of buildings in use is needed. However, one can also see signals that it is time to reimagine the relationship with carbon, the element most critical to life on Earth – and yet now increasingly demonized as the main chemical culprit in accelerated climate change.

While there are certification schemes to aid in this, there take up is primarily based on the initiative of the building owner. Certification schemes like BREEAM Communities provides a criterion for Community Management of Facility aiming to support a community's active involvement in developing, managing and/ or owning selected facility. This approach neglects the method on how to get a community prepared to implement BREEAM and does not set up an approach to monitor progress but examines criteria through document-based evidence – in this way it is more reflective than intuitive (Lindqvist, 2018).

Economic Targets for Regenerative Facility Management:

- building space optimization for more efficient usage and using digital technology, services and data to monitor effectiveness, collect and provide feedback data about the use patterns – Building information modelling (BIM) and different ways to use virtual and augmented realities as means of visualization can help,
- optimization of building life-cycle costs – involving different stakeholders to design, construction, hand-over, use, maintain and re-develop the buildings in long-term, circular economy perspective,
- facilitating the most efficient Management methods – lean and new innovative models and practices, enhanced by digitalization, ecosystem practices, responsible procurement,
- using e.g. green bond as the basis of Financial Management,

The essence of the change towards Regenerative Facility Management is the realisation that it is a people-orientated discipline, coupled with the practicalities and technicalities of the building services industry. Regenerative Facility Management is a transformation from service provision to a proactive decision-making role in how the different working environments are designed, maintained, used in a regenerative manner and which are the services and service-channels strengthening the regenerative ethos not only within a building but also in the surroundings. Procurement can encourage different stakeholder to responsible materials and services as part of a regenerative ecosystem.

The Better Buildings Partnership (BBP), a collaboration of property owners working together to improve the sustainability of existing building stock, released in 2009 a widely cited document, 'Green Lease Toolkit' which provides a guide to definitions, and model green leases clauses (Bugden et al, 2013).

Green bonds can mobilize resources from domestic and international capital markets for climate change adaptation, renewables and other environment-friendly projects. They are no different from conventional bonds, their only unique characteristic being the specification that the proceeds be invested in projects that generate environmental benefits. In its simplest form, a bond issuer will raise a fixed amount of capital, repaying the capital (principal) and accrued interest (coupon) over a set period of time (Weidmann, 2017). Such economic approaches enhance all stakeholders to include sustainability issues at a different level in economic considerations.

Towards regenerative targets and facilitating the change

To reach the goals of sustainable development, we need to develop the knowledge and theoretical frameworks that can be applied to and be used in practice. The recent ISO FM definition proposes that Facility Management aims to be sustainable in a globally-competitive environment. However, it appears narrow and should be extended to recognize facility' life-cycle issues as well as broader urban and social concerns (Bröchner et al., 2019. It is essential to goal for continuous optimization to maximize the benefits for environment and users and assure that the initial state is maintained or enhanced.

The steps towards regenerative Facility Management are e.g. the following:

1. From scheduled maintenance towards on-demand maintenance.
2. From recycling only towards self-sufficient solutions.
3. From a linear economy towards future life economy.
4. From human intelligence towards artificial intelligence.
5. From the passive user towards the active user.
6. From monitoring single indicators towards monitoring integrated indicators of co-operation and connections.
7. From maintenance by service provider towards maintenance with user and prosumer.

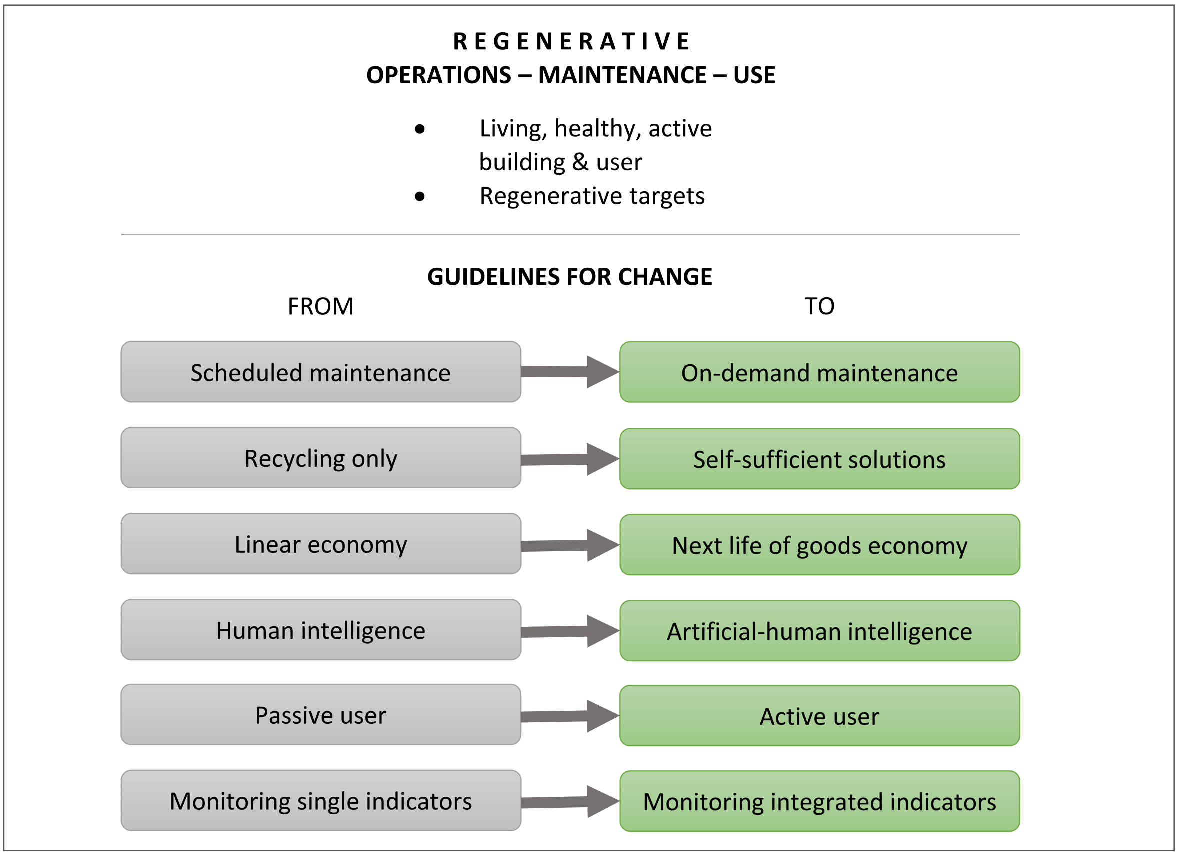

Figure 5.3 - Towards Regenerative Facility Management (workshop summary in Koper 2018)

5.3 CONTRIBUTIONS FROM TRAINING SCHOOL

5.3.1 TOWARDS A REGENERATIVE BUILT ENVIRONMENT: COMPLEMENTARY ACTIONS ADDRESSING ENERGY, MAINTENANCE AND OPERATION IN BUILDINGS

KEY THEME OF WG 1: Energy
THEMES OF WG 3: Maintenance and Operation
Author: **MANUEL DE-BORJA-TORREJON**

The restorative-regenerative mindset of the ongoing COST Action “RESTORE”[1] provides a strong message. It claims that the introduction of the sustainability concept of been essential in addressing climate change and its negative impact, but additional actions are necessary to remedy the damage that humans are causing. In this sense, the restorative-regenerative approach considers that being sustainable is linked to having a neutral impact. This is based on the notion of sustainable development presented in 1987[2], which calls on us not to compromise the possibility for future generations to meet their needs when meeting ours. In contrast, being restorative or regenerative would imply having a positive impact. More specifically, Restorative is interpreted as “restoring social and ecological systems to a healthy state”, and Regenerative as “enabling social and ecological systems to maintain a healthy state and to evolve”[3].
This paper focuses on the theme Energy of RESTORE working group 1 (WG1), from the perspective of the theme Maintenance and operation of WP3. Two possibilities of addressing those themes from a restorative-regenerative view are discussed.

From estimated to actual efficiency

A study on the energy performance of LEED buildings shows that around half of the analysed buildings performed worse than expected, and several of them used more energy than the code baseline[4]. This deviation between estimated and actual performance, known as performance gap, is widely present among existing buildings, despite having been built or renovated under regulations and standards which promote high energy efficiency. Whilst this is usually attributed to the influence of users, nonetheless, other factors should be considered:

Non-technical factors, such as (i) lack of involvement of specialists and Facility Managers during the first project phases, and (ii) limited integration of users as part of the building design and operation. Technical factors, such as (iii) over-dimensioned and complex technical systems, (iv) low level of calibration and incompatibilities between systems, and (v) absence of digital solutions to support the building operation.

This situation calls for measures to bridge the performance gap in buildings. Shift towards bottom-up and collaborative project development, technical experts can contribute in decision making from an early stage, aiming at improving the passive design of the building and the suitability and operability of the complementary active system. Taking advantage of digitalisation, including support in identifying system failures and in optimising system operation based on feedback and predictive tools. It also includes the potential for raising awareness of Facility Managers and users regarding the impact of the building use on its performance, and for improving the understanding of the reasons causing users' dissatisfaction, which commonly lead to inefficient building operation.

Application of these actions offers potential savings in resources, energy and operation costs, but also an increment of the value of buildings derived from improved energy efficiency and indoor quality. This counts towards arguments to overcome possible challenges, which might include supplementary commitments in terms of closer interaction between parties involved and initial expenses, compared to standard practices.

From individual to regenerative facility footprints

Europe aims to reduce its building sector's emissions by 90% by 2050[5]. To this end, the implementation of high energy efficiency standards for new buildings has been promoted, e.g. nearly-zero energy standard[6]. Nonetheless, new buildings represent a small share of the building stock, which constrains the impact of this measure. Furthermore, the renovation of existing buildings is not being effective, despite the increasing awareness of its relevance. Apart from issues related to the performance gap after renovation, as commented above, renovation rates are poor, sometimes due to technical limitations, but also other factors like economic obstacles or formal constraints (e.g. historical protection).

Thus, it might be convenient to understand buildings not as independent elements but as an integrated part of the built environment. Regarding Energy, it can be considered that even if a building produces by itself the amount of energy it consumes, this alone might limit its environmental impact but it would hardly allow it to play a restorative-regenerative role. In addition, expanding the individual boundaries of a building to a context-related magnitude would enable to explore synergies between buildings in order to collectively enhance their restorative-regenerative significance. This includes considering energy flows in the area and further features such as social and cultural aspects (WG1 theme Place). As an example, NOI Techpark[7], waste heat from surrounding factories is used for heating in the new building, where renewable energy is produced to supply its facilities as well as the historical building and cafeteria next to it; the standard of the historical building is less efficient despite renovation due to preservation constraints, but it contributes with its cultural character to the complex, while the cafeteria provides the community with a complimentary service.

This is in line with the concept of smart cities, where buildings are not just passive energy consumers, but play a complementary active role, producing and storing energy in addition to energy consumption in a flexible way to regulate energy distribution and to integrate renewable energies. Studies show that new buildings, along with existing buildings, possess a considerable demand-side management potential[8,9,10]; this is the capacity for adapting their energy demand e.g. to reduce peak-loads in the energy network or to preferably consume energy when it is produced from renewable sources or at lower prices. Considering this, the building stock, including buildings with renovation constraints could be suitable to participate within a smart grid, contributing to more effective use of energy and the decarbonisation of the building sector.

Regulations may be able to play a catalytic role in promoting regenerative integration between buildings. In addition, findings and lessons from research and built projects should contribute to overcoming possible obstacles derived from technical issues in managing energy flows between buildings and systems.

Conclusion

The paradigm change in sustainable development from limiting negative impact toward achieving a positive effect requires additional efforts. Two possible measures, linked to the energy and maintenance and operation themes are discussed: (i) bridging the performance gap through collaborative building design and management with enhanced digitalisation; (ii) shifting from individual to regenerative building footprints through synergies across the built environment and active participation of buildings as integrating components of the overall energy eco-system. It is to be emphasized that combined action, rather than individual measures, would more effectively contribute to restore, maintain and enhance our social and ecological system.

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5.3.2 EDUCATION IN FACILITY MANAGEMENT REGENERATIVE SUSTAINABILITY

KEY THEME OF WG 1: Education (advocacy)
THEMES OF WG 3: Maintenance and operation
Author: **MARTA SABATER FORTEZA-REY**

Our seemingly small actions can have an enormous impact on the global environment. Our consumer culture pushes us to acquire products that we don't need, products with a low economic cost yet with a high environmental cost. This trend will worsen as our population is rising year by year, and so will our demands.

We have to change from the personal scale if we wish to reach a more balanced situation and as the teenage climate activist Greta Thunberg [1] tells us, "we are never too small to make a difference".

The current unbalanced relationship between needs created by humans and existing resources on Earth needs to shift and to change towards regenerative thinking.
From an economic point of view, beyond the circular economy, inspired by and in balance with nature, the regenerative economy is related to rebirth of life itself [2]. This includes sharing products and services; reducing waste generated and consumption of raw materials, recycling, repairing and remanufacturing products; using renewable energy sources. From a social perspective, regenerative sustainability will require the mobilisation of all actors at all levels, from personal to community interaction, passing into government and education.
This paper considers how education can be a catalyst for change towards regenerative sustainability from the point of view of a building's operation.

This article will focus on adult education, a really challenging target if we consider how illiterate we are on regenerative sustainability. Indeed, in the main, we have been living our lives ignorant of the environmental consequences of our actions.
To be successful in teaching regenerative sustainability, we need to consider three main aspects:

1) Transparency. Tell the Truth

Awareness of the global environmental situation and what our particular contribution is. We need to reach the people's attention using local networks, the internet, social media, to show environmental commitments, as well as the more important figures related to our activity whether it be private, corporate or belonging to public administration, etc. Some of the aspects that we need to show from the operation will be:
- Sustainable policy
- Explaining the energy-saving measures, and using smart meters to engage people to see the consequences of these measures.
- Energy consumption
- Energy budgeting

2) Training. Live in a more sustainable way

Provide the necessary tools in order to be able to follow sustainable choices in daily tasks. This training has to be universal and cover all the stages and degrees of literacy.
Some examples:
- Training policy
- Courses, online or face-to-face regarding: Sustainable Development Goals, Renewable energies, and climate change
- Workshops about specific subjects: for example, decoding the energy bill, Green roofs
- Games can also contribute when trying to change habits. In particular Games that have been created to make people aware of the precarious global situation include World Without Oil [3] exploring problems in a world with no petrol; Superstruct [4], created by the Institute of the Future, in which the human race has 23 years left...

3) Participatory. Be part of the solution

We need to understand that we are part of the solution, that's why promoting healthy and sustainable habits in a friendly, competitive environment, with the chance to benefit can be a very stimulating approach. For example:
- Bike to Work Project [5], every year this project promotes the use of the bicycle as a means of transport in everyday life, to ride to work or school. As they state, the objective is to "Bring a fresh breeze to your company and promote movement, team spirit and pleasure".
- EuroNET 50/50 MAX [6], was project financed by the EU, it aims to mobilize energy savings in public buildings through the implementation of the 50/50 methodology, increasing energy awareness of a building's users and actively involves them in energy-saving actions. The financial savings achieved are shared equally between the building's users and the local authority which pays for the energy bills.
- Momo Car-Sharing Project, intending to promote a sustainable mobility culture, supporting various transport options aside from car ownership.

Teaching regenerative sustainability

To reach a state of regenerative sustainability we need to affect the community, allowing for sustainability knowledge to be available to everybody. We can use the local infrastructure of community centres. One example of this is the Fabrica del Sol [7], a community that promotes environmental education funded by the City Council of Barcelona, where the citizen is invited to participate through workshops [8]. Some of the services and resources that are offered here include: information and consultation services, a program of activities for adults and families, and material loan services.
Empowering the community through, changes to our daily tasks, energy savings and using more renewable energies, and sharing resources is a key way for us to transition to a circular economy, working with the idea of being proud to belong to a community that can regenerate for generations to come.

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5.3.3 REGENERATIVE BUILDING OPERATIONS: THE RELATIONSHIP BETWEEN BUILDING ELEMENTS, BIOPHILIA AND WELLBEING IN THE WORK ENVIRONMENT

KEY THEME OF WG 1: Wellbeing (working environment); Wellbeing (biophilia)
THEMES OF WG 3: Maintenance and operation
Author: **VIRNA MONERÓ FLORES**

Traditionally the **maintenance and operation phase** has focused on hard aspects of buildings, which continues as we transition to sustainable operations. Facility Managers have had a fragmented approach to the sustainable operations of building with separate strategies to address the sustainable integration of its core elements: people, place and processes.
Providing stimulating environments demands the integration of tangible building characteristics and intangible aspects, which still poses a challenge[1]. Researchers report on the holistic role of sustainability during the operations phase going beyond the physical building and addressing factors such as health, food consumption, biodiversity, resources utilization, indicating that in the operative phase of buildings, sustainability involves end-user related wellbeing outcomes. In addition, sustainable operations entail the synthesis of sociotechnical systems within the built environment, integrating between building, users, maintenance and operations, management processes and how these can contribute to the achievement of sustainable goals[2].
In the context of work environments, sustainable operations are defined as continuous improvement of work environments and worker wellbeing, while positively influencing the core business and while preserving the environment[3]. Although ambitious, these positions do not fully address the need for a regenerative approach to operations during the building life cycle. Industry trends point towards a more human-centric and regenerative approach to sustainability[4], end-user related outcomes should be at the core of sustainable operations, given that buildings are not an end in themselves but serve the demands of those who use them. Buildings play a key role in the development of society, as they host many of the productive activities in today's modern society.
Approaches like biophilia emerge as a solution to mediate the relationship between people and nature. Biophilia as a concept refers to the inherent human inclination for natural elements, as environmental features have been dominant in the context in which humans develop[5]. Many benefits are reported by

researchers on the positive influence of biophilic elements within indoor environments. Healing, relaxation, enhanced coping skills, sensory stimulation, higher performance and motivation are only some of the many influences the use of biophilic elements can enable [5-6]. Within the built environment these effects are associated with environmental features, natural shapes and forms, natural pattern and processes, light and space, and relationships between people, place and nature [5]. These biophilic elements can be further divided into biophilic design attributes that can be made tangible in the design and development of the indoor work environment. In addition, these biophilic elements in the work environment offer the possibility for sensorial experiences, promote relaxation, and add variety within the environment and positively influencing the wellbeing of the users [6].

Within the framework of RESTORE, wellbeing is related to ensuring that buildings and facilities promote health, happiness, salutogenesis, biophilia, mindfulness, air, light, comfort [4]. A characteristic of this definition is how these elements directly relate to the human, demonstrating the human-centric character of the regenerative approach to sustainability.

Building maintenance and operation phases can be linked to four areas of action (i) facility services, (ii) technical operations and maintenance, (iii) business support services and (iv) property management [1]. Integrating these four areas involves managing the tangible elements and the intangible effects that can influence the satisfaction of the end-users and therefore also influence wellbeing. From Sustainable Facility Management research, these intangible elements are linked to tangible building factors, ensure restorative wellbeing of the end-users [7]. Among elements to be managed the following can be considered: environmental factors such as energy consumption, waste production, expenses, emissions [8]; indoor environmental quality [9]; operative aspects [10]; technical aspects [11]; and other physical environment factors [7]. Studies demonstrate the influence of these sustainable building factors on users: openness, ambience, daylight and natural ventilation where shown to impact performance in schools' settings; access to windows, views to the outside and control over indoor environmental conditions were shown to impact productivity and reduce energy consumption; and connection to the outdoors and access to daylight where shown to increase environmental satisfaction and performance [1]. This suggests that by steering these tangible factors within a regenerative approach the wellbeing of the end users can be positively improved. Many of these tangible building factors are within the scope of FM. However, the most important aspect in ensuring the restorative wellbeing of end users would be the management of the indoor environment, in which two main sub-components come together: the indoor, built environment and the psychosocial environment. While the relationship between these two sub-components is a complex one, indoor environmental conditions have been identified as possible stressors for the end-users [7]. Temperature, air, lighting, humidity, sounds, odours, natural elements among others are important action elements.

An interesting relation comes to light in which the characteristics of both environments affecting wellbeing are linked to biophilic design elements. Research shows that the predominant environmental features affecting human development are biophilic elements and that regenerative strategies beyond aiming at a low environmental impact, should also promote the contact between humans and nature.

In addition, the wellbeing and satisfaction with the environment are dependent on contact with nature. Therefore, it is of importance to integrate biophilic elements during earlier phases of building life cycle [5]. Facility Managers should also consider integrating biophilic elements into the work environment during the maintenance and operations phase, as it has been shown they can also promote a regenerative work environment in which outcomes like productivity and absenteeism are improved [10]. For Facility Managers, the focus should not only be on buildings and associated building services, but also on improving how this socio-ecological-technical approach influences the users and the end-user related outcomes.

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5.3.4 TOWARD A RESTORED BUILT ENVIRONMENT: INNOVATIVE AND HOLISTIC APPROACHES TO ADDRESS THE MAINTENANCE WORKS AND OPERATION OF EXISTING BUILDINGS

KEY THEME OF WG 1: Resources (materials)
THEMES OF WG 3: Maintenance and operation
Author: **CRISTINA JIMÉNEZ-PULIDO**

Buildings are a major stock of materials [1]. With roughly half of all the extracted materials and energy consumption in the EU related to the built environment, it is also responsible for generating about one-third of all waste [2]. One, the major future challenge is related to the renovation phase, necessary for the sustainable refurbishment of existing buildings [3]. The robust maintenance of the building stock is key to ensure resilience and good energy performance.

Circular Economy and Sustainability principles need to be incorporated into buildings during their entire service life [4]. Where this service life is estimated, maintenance planning should be applied to ensure and exceed any estimation, to reduce early obsolescence [4]. In existing buildings, a well-designed maintenance plan will contribute to sustainable replacements and components. Promoting greater resource efficiency during building renovation works is of paramount importance for reducing consumption. Sustainable approaches will also seek to maintain components and materials that can be used repeatedly with a long life [9] at their highest value and, subsequently, recycling and re-using [2]. Likewise, an optimal energy management strategy toward energy-efficient buildings is also required to address natural resource conservation [5].

For building maintenance, operational system management should include all technical and associated administrative actions during the building service life to retain all the parts in the best possible condition [4]. New approaches to building management are an important focus, identifying a gap in research on renovation plans and quality, on how re-design against a base linear case [1]. A systematic approach for a building inspection in order to improve data collection and diagnosis accuracy would address these challenges. Diagnosis would reveal anomalies of building components, their real state of repair, and refurbishment needs [3], guiding sustainable renovation strategies.

The adoption of decisions regarding building interventions without a deep analysis of data remains too common [5]. This occurs mainly due to the complexity of interventions, with many agents are involved (e.g. users, design team, maintenance and operational teams), often with different conflicting perceptions and preferences, fragmented expertise [5], and economic constrictions. Tools that provide the technicians with the proper guidelines to assess building condition and support the decision-making process [3] are necessary to address interventions and reduce uncertainties.

Innovation and education are key questions for collaboration. A considerable number of theoretical methods have been developed [3] but the capability for proper use is needed. Sustainable refurbishment projects are often driven by energy and CO_2 efficiency [3], yet there are also many social issues that should be considered. Therefore, a holistic approach is highly recommended for decision-making in this kind of complex process.

We need to reconsider the materials chosen for existing buildings in the same way as for new building designs, also identifying their recycling potential and including information about how materials can be optimised as part of maintenance plan. These decisions have a strong influence on increasing building adaptability, durability and resiliency. In addition, it is recognised that building materials can affect the user's wellbeing, as evidenced by many studies, but there is a lack of awareness of healthy materials in construction [6]. Knowing the health impacts of construction materials used in our buildings and the alternatives available, materials that present health or ecological hazards could be avoided. A holistic maintenance plan must also address this challenge and set the goal to eliminate hazardous materials from the buildings, replacing them with non-toxic alternatives and making real progress on health regenerative sustainability [6].

It is important to take advance of the interventions carried out during operational phase to improve not only the structural condition of the buildings but also to choose materials capable of reducing a buildings environmental and human health impacts and to improve the wellbeing quality of their indoor spaces. New technologies and approaches can play a significant role in achieving these goals when we address and intervention during the operational phase, enabling a deep knowledge of the building stock. Applying innovative strategies and technologies could help to restore the damages of the existing buildings (Brown, M. et al., 2018) [8], incorporating concepts such as adaptive and regenerative sustainability.
Since building stock plays a key role in tackling Climate Change successfully, sustainable management during the buildings operation phase with sustainable materials maintenance is essential to move from obsolescence to resilience, and, to built environment regeneration.

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5.5 CASE STUDIES

5.5.1 CASE STUDY 1: SELLO

NAME
Sello

LOCATION
Lepppävaara, Espoo, Finland

CLIENT
The shopping centre draws an average of 24 million shoppers annually, and annual total sales are over EUR 400 million.

JOINT BUILDING OWNERS
The public sector pensions agency Keva, Elo Mutual Pension Insurance Company, and Etera Mutual Pension Insurance Company

PROJECT TEAM/STAKEHOLDERS
NCC Construction Ltd & Skanska Construction, partnership with Siemens

THEME / TYPOGRAPHY
Shopping centre

Figure 5.4 - Indoor view.

CONSTRUCTION / COMPLETION YEAR
I phase 2003, II phase 2005

BUILDING
The 102,000 m^2 complex houses more than 170 stores, supermarkets, restaurants, entertainment attractions, and even a concert hall and a library. Located near Helsinki, Finland. The mall has 18 million visitors per year.

STANDARDS, CERTIFICATIONS
The shopping centre was recognized in Spring 2010 as the first European shopping centre to achieve the LEED Gold-level certification.

REGENERATIVE OPERATIONS AND MAINTANENCE
This building is regenerative because it can implement consumption flexibility.
2017 the centre has managed to save 680 MWh in electricity and 800 MWh in district heating and has reduced its energy costs by around €93,000 over an eight-month period when compared to 2016. The consequences are up to 50 percent less energy consumption, which reduces operating costs. The savings guaranteed in Energy Saving Performance Contracting are used to finance the investment over the period of the agreement and amortize these costs in four years.

The goal is to have a lighting system that is controlled according to the need and not just on or off. Natural light is taken care by building design. The intention is to have quick or even automatic

Figure 5.5 - The shopping centre Sello has a photovoltaic plant with a total power of 550 kWp. Batteries can take the load if over production occurs.

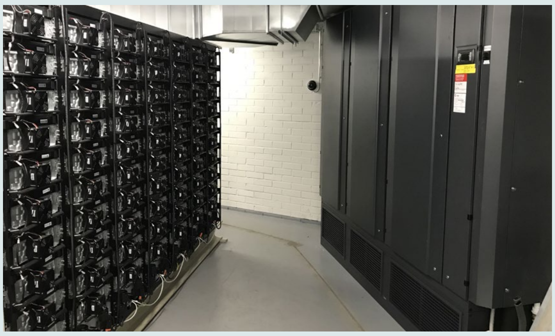

Figure 5.6 - Batteries are situated in the parking hall in ground floor. Total power of 2 MW enables flexibility of energy use.

adjustments for the number of visitors in the shops and public spaces, as well as adjustments for the change in daylight over the opening hours.

Energy Saving Performance Contracting ensures annual savings of
- 1.25 million kWh of electricity (27 %)
- 1.3 million kWh of thermal energy (15 %)
- 630 tons of CO_2 (20 %)
- € 133,000 in energy costs (25 %)

Using Navigator, a Siemens cloud-based energy and sustainability platform, to monitor and analyse the centre's ventilation units, room sensors and lighting systems in all the various spaces and shops. Navigator provides exact and specific data about energy consumption from "connected" devices, data which can then be analysed and used to immediately pinpoint inefficiencies or maintenance issues, such as a broken valve, as opposed to having to search for the source of a ventilation problem. The monitoring tools also provide new opportunities to support Sello's tenants with ways to improve their own energy efficiency, leading to both a higher level of sustainability and an economic gain for the tenants.

Monitoring, controlling and optimizing the lights, heat and ventilation will lead to economic advantages for both Sello and its tenants. The annual value in euros of the benefits gained in this way by the shopping centre is higher than the sum total of the service fees and the overall investment to be made. The smart energy solution halves the repayment period for investments in renewable energy production.

Vision is energy efficiency and perfect conditions for the 24 million customers that visit the shopping centre each year. Digitalization, data analytics and the continuing development of programs like Navigator and the shopping centre's automation and control system Design will soon make it possible for machines and systems to learn from the manual adjustments the maintenance team makes. If the machines can learn from how we've reacted to certain situations and how they've been adjusted in those situations.

In the future they will continue to concentrate on electricity usage and the continued benefits of digitalization, which is paving the way for a visionary project to install photovoltaic panels and microgrid capabilities in the centre

Siemens Osakeyhtiö and Kiinteistö Oy Kauppakeskus Sello shopping centre have signed a contract for construction of a smart energy system at the shopping centre. The solution is the first concrete step towards connecting properties to the virtual power plants of the future; then properties become operators that are comparable in function to backup power plants. The project will be completed during autumn 2018.

The centre is about "much more than just shopping. There are also coffee houses, a library, a concert hall, movie theatres, a bowling alley and other kinds of areas where people come together" Sello is more than a shopping centre. It's a big part of the community in Espoo city, which was found to be the most economically, socio-culturally and ecologically sustainable city in Europe. The climate programme steers green development in Espoo.
Sustainability in the growing city of Espoo is also supported by the grid-like structure of five urban centres which is woven together by railway lines. Plenty of effort has gone into developing business education, the circular economy and participation.

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5.5.2 CASE STUDY 2: KAMPUSAREENA

NAME
Kampusareena

LOCATION
At Tampere University campus in Hervanta, Tampere, Finland

CLIENT / BUILDING OWNER
University Properties of Finland

PROJECT TEAM/STAKEHOLDERS
University Properties of Finland, Arkkitehdit LSV Oy, SRV Rakennus Oy Pirkanmaa, A-Insinöörit Rakennuttaminen Oy

THEME / TYPOGRAPHY
Office and educational building at university campus

CONSTRUCTION / COMPLETION YEAR
2015

BUILDING
Office and university building at the Hervanta campus in Tampere Finland. 15500 brm^2. Value approximately 40 million euros.

STANDARDS /CERTIFICATIONS
BREEAM-certification with a grade of "Very Good"

PHOTOS
Ari-Pekka Lassila

REGENERATIVE OPERATIONS AND MAINTANENCE
This building is regenerative because it has a green roof and solar panels and the area was a parking lot earlier.
A hub of science, research and technology called Kampusareena is a full scale pilot project in the campus of the Tampere University of Technology in Finland. The preplanning of the building was started in 2011 and actual project planning in 2012. This over 15 000 gross square meter building was finished on August 2015. The eight floor building consists of bigger three floor base and five floor tower. 60% of the premises are used by the university and 40% is rented to an office and business premises.

Green roof and biodiversity are the external landmarks of the building in the heart of Tampere University campus in Hervanta. The area has non-smoking policy and low-emission materials are part of the indoor environment. Natural light is provided by big windows in the ceiling. The lighting is realized with 14, 57W fluorescent T5- lamps. Lighting system adapts itself according to daylight. The building is heated by district heating and cooling is provided by electricity and passive cooling by PV-panels situated above windows. Total power of PV-panels situated on the walls is 60 kWp. The percentage of renewal energy is over 50 % of total energy.
The building has lot of services and service requests can be done through internet 24/7.

Figure 5.7 - Green roof of Kampusareena increases biodiversity, comfort and has also helped to manages with surface water at university campus

Figure 5.8 - Overview of the roof landscape

Customer satisfaction is important and e.g. restaurants ask the customer feedback continuously.

Campus and building is walkable. There is no car-parking close by, however bicycle parking is close by sheltering roof and possibility to lock bike. Green roof can be accessed by foot and there are activating staircase on the floors 0-2 outside and inside the building. There is outdoor fitness centre in the front lawn. GYM inside in the next building, accessible from indoors. The concept of walking meeting has been piloted in the campus and Kampusareena building provides many possibilities to be the centre of the walking meetings.

The concept behind of Kampusareena was formed during the "Indoor Environment" research program. The leading idea was to create a service platform students, researchers and other professionals that enables their collaboratively work, study and create with the specialists of enterprises in the campus area. Kampusareena is a "test lab" for a new kind digital real estate services. University Properties of Finland Ltd (SYK) and Tampere University of Technology (from 2019 on Tampere University) were entitled to one of the finalists for EuroFM Partners for Innovation Awards 2018. The competition recognizes the most innovative service in Facility Management, which can be any service, technological or organisational innovation contributing to the added value of Facility Management. Earlier, SYK and TUT merited a final place with the Kampusareena concept. The concept got elected as one of the Good Practises of Interreg Europe's Innobridge project and was widely introduced in keynote presentation in the Interreg Europe's Urbact projects seminar.

Kampusareena consists of innovation platforms in different floors, where those using the spaces, share the ideas and goals as well. The spaces and platforms are designed to support serendipity and collaboration aiming to innovations and successful business. Kampusareena remarkably enhances the interaction between the companies and the surrounding society. A service platform is a working environment that provides the entire infrastructure to this kind of operation. Kampusareena can be considered as an innovative, a different stakeholders integrative, protean multipurpose building to support learning and businesses. In this case it is justified to talk about more a service platform rather than a building.

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5.5.3 CASE STUDY 3: EDGE OLYMPIC

NAME
Edge Olympic

LOCATION
Amsterdam, The Netherlands

CLIENT EDGE
Technologies

PROJECT TEAM/STAKEHOLDERS
J.P. van Eesteren, Architekten Cie, EDGE Technologies

THEME / TYPOGRAPHY
Office building

CONSTRUCTION / COMPLETION YEAR
2018

BUILDING
11,108 m^2 floor area

CERTIFICATES
Energy Label A, C2C certified, pursuit of BREEAM Excellent and WELL Silver certifications

PHOTOS
Mikko Östring

REGENERATIVE OPERATIONS AND MAINTANENCE

This building is regenerative because it supports well-being.
Located on the former grounds of Olympic Plaza, EDGE Olympic was designed to minimize its environmental impact by extending the lifetime of the initial construction. To implement this circularity strategy, EDGE Technologies reused existing materials where possible. Instead of demolishing the original building it was redeveloped, reusing existing materials and introducing circular products and systems. The old natural stone, for instance, now serves as flooring at ground level. All of the new materials have a natural base. Thought has also been given to the lifespan of the building. The top two floors, for example, have a wooden construction that can be disassembled relatively easily for future reuse. This part of the building is cradle-to-cradle certified as a result. EDGE Olympic provides 11,100 m^2 LFA of workspaces for innovation led and technology-based companies, ultimately accommodating up to 1000 people.
All lighting in the building is LED, which is experienced as users as comparable to daylight (90% equivalent to daylight) and less likely to cause fatigue. Compared to traditional fluorescent lighting, LED lights also use less energy and have a much longer lifespan.
From the ground up, EDGE Olympic incorporated sustainable practices and implemented VOC-free materials. More than 15000 sensors measure air quality and provide twice the amount of fresh air. Maximized natural daylight and circadian lighting, to sustain healthy sleep-wake cycle. Rich

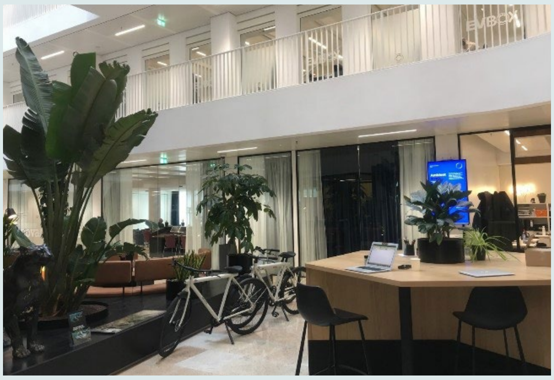

Figure 5.9 - Indoor view of Edge Olympic.

Figure 5.10 - Outside view.

biophilic design with nature-based architecture to boost nervous system activity.
Careful spatial planning and sound scaping ensuring comfortable noise levels.
EDGE Olympic is based on a digital infrastructure that connects everything and everyone within its walls to a single cloud platform. This flexible digital infrastructure allows people to plug and play with extra services, regularly update the system, and bring value for building residents and management.
Following a powerful sustainability strategy, EDGE Olympic has been designed to save energy costs, thus minimizing its environmental impact. As a result, it consumes 72 kWh/m^2, as compared to typical non-residential buildings that use 223 kWh/m^2. The building is energy neutral on city level and is saving thousands of euros and kilowatt hours. Remotely installed solar panels (photovoltaics) and 296,000 kWh of solar panels and geothermal storage play important role. The building has green roof, optimized glass and façade. Efficient atrium that distributes heat and circulates air.
EDGE Olympic is an extraordinary example of fine user centred design practices. The building keeps its residents healthy by nudging them to move and is further aimed to create an inspiring environment where real an extraordinary example of fine user centred design practices.
To further support the physical wellbeing of the residents, they measure key indoor climate parameters, such as temperature, humidity, light intensity, noise levels, then analyse these and make improvements. EDGE Olympic is largely circular and developed with respect for living environment. All information collected on the use of the building is used for future changes to and the evolution of the structure. If, for example, it becomes clear that users spend less time in certain areas, these areas can be adapted to new personal preferences. The flexible technology underlying EDGE Olympic facilitates continuous development and, consequently, guarantees user comfort and well-being.

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6. FUTURE LIFE

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CONTENT

6.1 A FUTURE CIRCULAR LIFE

11 May 2019 was the European ecological overshoot day when Europe had used all the resources than the earth can regenerate within the year. The built environment, as a significant user of resources, and as a significant waste contributor, has a substantial role in addressing a better future in the way we manage our resources. Core to the RESTORE objective is the transition towards a Regenerative Economy of which a second, future and circular life for buildings are vital, based on the concepts of the Circular Economy supported by thinking such as Doughnut Economics.

It is an unrealistic task to determine specific purpose and status for buildings and facilities about a circular economy and future life. New knowledge and paradigms are developing with creative booms of interdisciplinary innovations and searches for changes of modern human lifestyles and worldviews.

By studying themes of future life for a built environment within the circular economy, the conclusion is that we do not need to introduce new rules and knowledge - we already have them. We need to implement them by using our more profound wisdom as is illustrated by Isenhour et al. (2019) who explores the human old base rules of reuse, repair and care.

HUMAN MIND AND HABITS

To make a transition to a healthy regenerative future, an understanding of human mind patterns is essential. Kaufman& Gregoire (2016) seek to demystify creativity. Creative minds are far from transparent, step-by-step linear processes and rigid inner structures but are rather dynamic, spontaneous, chaotic and probabilistic flows. Abductive reasoning becomes a method to bring order and structure out from the chaos of ideas and impulses. The status of art for future life is characterised as creative chaos with several innovative incentives and practices. Constraints drive creativity, and obstacles boost capacity.

There is a need to revise the paradigm and concepts of waste. At an instinct level, humans have self-preservation – a desire and care to stay alive and healthy. The waste is a symbolic invisible danger to hygienic presumptions. Waste within the construction industry does not fit to the risk of anti-hygiene. Spelman (2016) discusses the personal habits of trash culture. She describes "Trash is a trail we leave in the world: Showing not what we want but precisely what we do not want."

The discourse developed by online hub Discard Studies questioning the concept of waste, "not just as an ecological problem, but as a process, category, mentality, judgment, an infrastructural and economic challenge, and as a site for producing power as well as struggles against power structures." (https://discardstudies.com/)

M. DunLany defines aesthetics of waste: "An aesthetics of waste values the leftover, the discarded, the imperfect. It is an aesthetic that highlights the need for disorder, digression and chance. It denies the idea of the 'finished' product, the perfect work, the end. It undermines concepts of authenticity and originality. It is an aesthetic of the margins and the marginalised. It fights against mainstream ideals of beauty and recuperates the beauty of waste. It resists standardisation and measures of normalcy. It engages with failure and leaves space for mistakes. It advocates for difference, messiness, hybridity. It celebrates excess. It is a gesture of inclusion." (DunLany (2017; 143)).

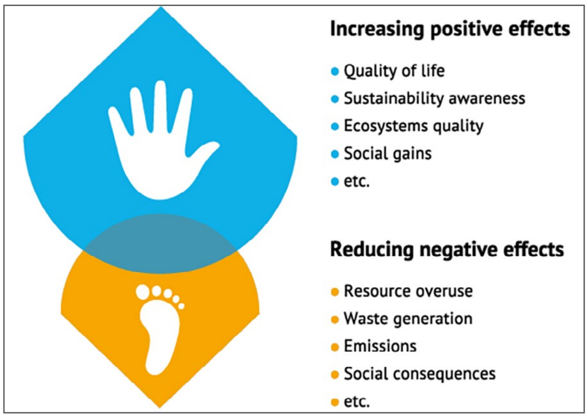

Figure 6.1 - Handprinting Source: https://www.scp-centre.org/our-work/handprint/

6.1.1 FUTURE CIRCULAR CONSTRUCTION

Regenerative thinking can be demonstrated through the Handprint approach – it presents a focus shift on positive vs negative. CSCP explains that "while the widespread footprint is used to metaphorically symbolise negative ecological impacts on individuals, organizations or countries, the handprint, on the other hand, shall determine, measure and evaluate the positive sustainability impacts including the social and economic dimension." Both methodologies are merged in a holistic approach including the handprint and the footprint" (https://www.scp-centre.org/our-work/handprint/)

With a mission to enable a systemic shift in the building sector by creating circular solutions, BAMB, Buildings As Material Banks started in September 2015 and progressed till February 2019 involving 15 partners from 7 European countries as an innovation action within the EU funded Horizon 2020 program. The project to develop and integrate tools that could enable a shift to a circular economy: Materials Passports and Reversible Building Design – supported by new business models, policy propositions and management and decision-making models.

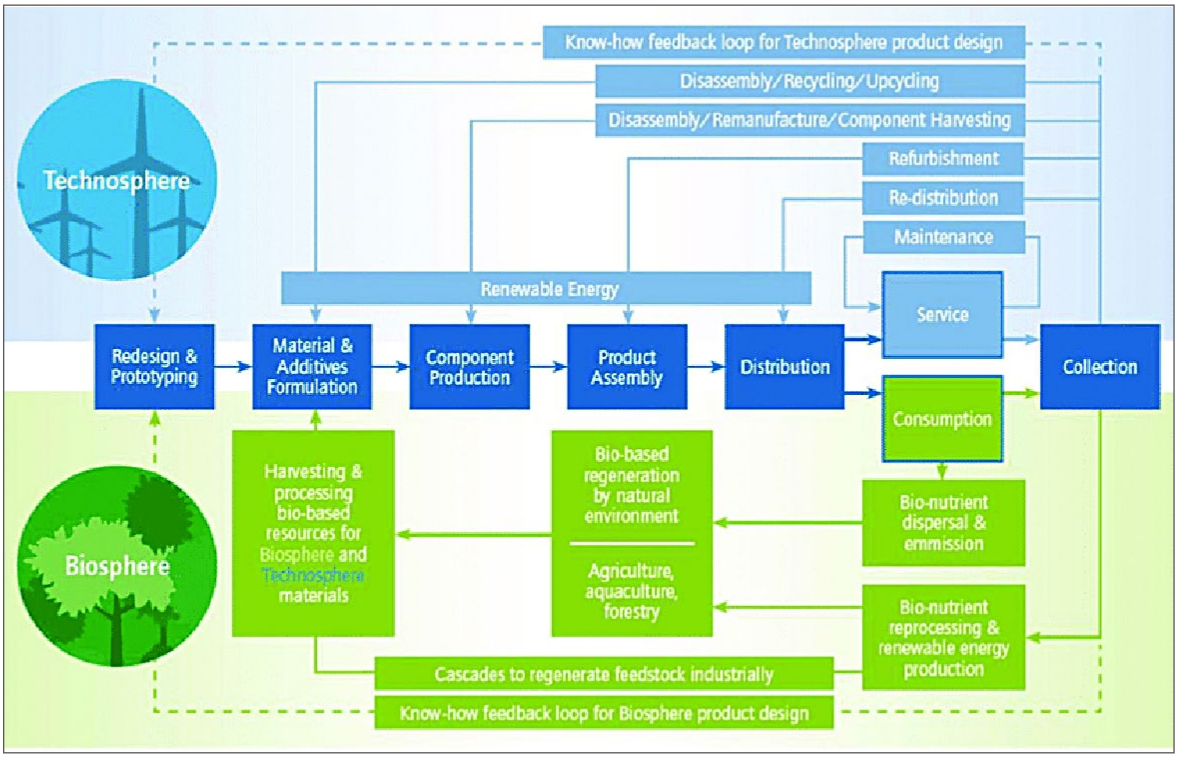

Figure 6.2 - Circular Economy: Technosphere and Biophere

6.2 SENTIENT BUILDINGS THAT LEARN

“This is the worst that this building should perform at” Kevin Hydes, (Integral (2013) at opening day on an Integral project.
The concept that building users ‘use’ buildings until they are worn out, or are no longer usable is challenged by the application of a range of innovative, regenerative initiatives including Circular Economy, Cradle to Cradle and Buildings as Material Banks.

6.2.1 BUILDINGS AS URBAN MINES

Resources constraints will continue to impact the construction and materials manufacturing sector. Access to and affordability of new primary, raw materials will increasingly become prohibitive; hence, materials locked into existing buildings will be seen as resource farms or urban mines for new buildings.
Removing carbon from the construction process, key to achieving CO2 carbon reductions by 2030, (IPCC, 2018) (UK Committee on Climate Change 2019) will also drive a move to circular economy buildings, where buildings are reused, reassembled and repurposed, or seen as mines, or material banks to supply other

buildings. We see examples of this thinking, at least in design consideration, with reassembling Primary Schools to Secondary Schools in the UK and repurposed Sporting Venues to School facilities following the Brazil Olympics.

6.2.2 ARE BUILDINGS SENTIENT?

In 2017 an inspiring think tank session at the RESTORE training school in Lancashire explored the question "Are buildings sentient" An excellent question to ask, one that should be addressed more frequently, given we now refer to Living Buildings within the zeitgeist of regenerative design and buildings. Moreover, if buildings are sentient, can they learn, what stories can they tell from the past and what learning can they share forward to a future second life?

6.2.3 CAN BUILDINGS LEARN?

In 1999 the concept of "Pace Layers" was introduced in The Clock of Long Now by Stewart Brand (2000), as a simple diagram titled: "The order of civilisation. The fast layers innovate; the slow layers stabilise. The whole combines learning with continuity."

Steward Brand was also the author of the influential Whole Earth Catalogue, described by Steve Jobs as Google in paperback and noted in FutuREstorative (Brown, M) as a key influencer that triggered many sustainability journeys in the 1970s. As a then counter-culture it focused on an ecological whole system thinking approach to resources for, amongst other sectors, Shelter and Land use,

Brand in How Buildings Learn: What Happens After They're Built, translated the layer concept to buildings, as an illustrated book on building evolution and how buildings adapt to changing requirements over long periods.

Brand maintains that the best buildings are made from low-cost, standard designs that people are familiar with, easy to construct and easy to modify. In this way, people can easy and gradually adapt their buildings to meet their needs. The inner layer of 'stuff' will be subject to change on a frequent basis, lending itself not only to circular thinking but also to the sharing economy, leasing, even the bring your own device (BOYD device, equipment, furniture) to work approaches. The outer layers of shell and structure will age and renew at a far slower pace.

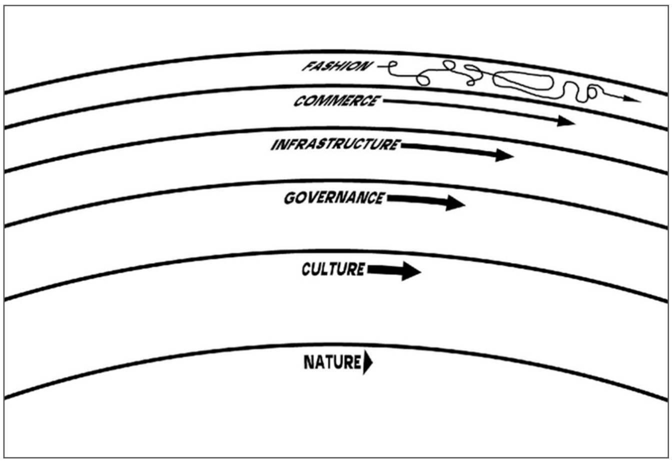

Figure 6.3 - Pace Layers

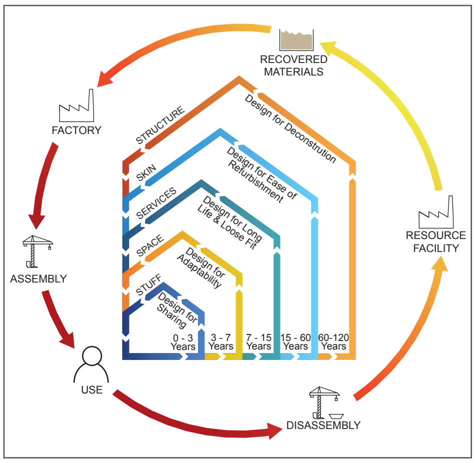

Figure 6.4 - Building layers (based on the graphic by useful project, based on S. Brand "How building learn")

6.3 THE CIRCULAR ECONOMY

Costs can be reduced in the circular built environment by reusing buildings and materials and designing for disassembly. A 2015 Ellen MacArthur case study for Denmark calculated the investment opportunity for the construction sector and found it could save 30% in material costs – amounting to €100-150m per year by 2035 – when designing buildings for disassembly and using innovative business models. (Johansson, E., 2018)

A Circular Economy is based on the three principles of the Ellen MacArthur Foundation,

- Eliminate waste, pollution, negative social & environmental impact.
- Keep products and materials in use.
- Regenerate natural systems.

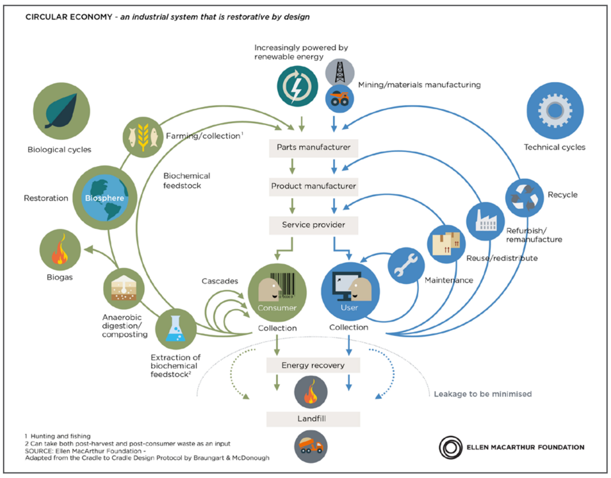

Figure 6.5 - Circular Economy 'Butterfly Diagram"

which can be implemented as follows (DNGB 2019)

1. Value finite resources and control their stocks and material flow. Dematerialise value, use renewable raw materials, replace finite resources and recover used resources
2. Improve raw material yields by closing loops while always maintaining the highest possible value of the raw materials. Close loops, share benefits, 'use rather than own', extend lifetime, repair products, reuse, refurbish, recycle materials, avoid waste
3. Ensure the effectiveness of the system through consistent consideration of externalities. Consistently include external consequences for humans (e.g. health, justice) and the environment (e.g. pollutants, emissions).

Today the concept of building layers, each ageing and renewing with different rhythms has become a very useful tool in understanding and in breaking down the perceived complexity of a circular built environment into manageable bite-sized building layers.
David Cheshire in Building Revolutions (2017) observes that "Creating buildings that are more flexible and adaptable to other uses also draws on the idea of layering the building by ensuring that the primary structure is independent of the secondary structure, allowing for more interventions, and the use of independent layers helps to enable disassembly at the end-of-life of the building by allowing each element to be removed independently".
Adopting a layer replacement structure requires a Design for Disassembly or DeConstruction approach as typified with the ten principles established in the King County DfD Design for Disassembly in the built environment: a guide to closed-loop design and building paper (King County 2005). This approach, while aimed at design has significant implications not only for the methods of construction but also for building remodelling and renovation opportunities for second life use,
Also, buildings designed for disassembly will provide greater scope for second life reuse and place a different business model on facilities management and building operations.

6.3.1 TEN KEY PRINCIPLES FOR DFD

1. Document materials and methods for deconstruction.
2. Select materials using the precautionary principle.
3. Design connections that are accessible.
4. Minimise or eliminate chemical connections.

5. Use bolted, screwed and nailed connections.
6. Separate mechanical, electrical and plumbing (MEP) systems.
7. Design to the worker and labour of separation.
8. The simplicity of structure and form.
9. Interchangeability: materials & systems that exhibit principles of modularity, independence, standardisation
10. Safe deconstruction.

6.3.2 UNDERSTANDING THE RHYTHM OF PLACE

The site layer is exciting and worthy of greater exploration. At the landscape level, it certainly has a very different ageing rhythm. In typical buildings from day one, the structure deteriorates while the landscape matures. Considering the site as a Brand fast layer, responding to seasonal and climatic change, rather than a slow layer that remains as a low maintained static layer. It should therefore innovate, inform and function to support the other layers, bring the building alive, terms of inhabitant biophilia, health and wellbeing, water ecology, heating, shading, lighting, in addition to carbon and biodiversity benefits relating to soils, planting. We can view the site layer as place. Ecology of Place is one of the seven petal imperatives of the Living Building Challenge, and perhaps in terms of regenerative buildings the most important. Reed, B in his 2006 paper Shifting our Mental Model – "Sustainability" to Regeneration puts' Understanding the Master Pattern of Place' as a critical aspect for Regenerative Buildings. A place-based approach is one way to achieve this understanding, noting that a regenerative process begins by attempting to understand how the systems of life work in each unique place.

6.4 TOWARDS RESTORATIVE CONSTRUCTION: A ROADMAP FOR CIRCULAR ECONOMY THINKING FOR THE CONSTRUCTION INDUSTRY IN ISLANDS

The growing world population puts enormous stress on the environment and natural resources. The intense activities of the construction sector in Europe have been generating massive amounts of CDW (EC, 2018). Cyprus is facing a construction boom, as seen throughout the world in large and small metropolitan areas. The considerable demolition, reconstruction and construction activities are producing a sizeable amount of building material waste which can have a high cost to manage as well as an adverse effect on the local environment due to the limited high-value land mass and local resources of these island nations. Putting things into context, the Cyprus construction sector in the first quarter of 2017 had a 36.7% increase compared with the same period in 2016, is one of the four industries (alongside professional services, tourism and maritime) that drive GDP growth (Eurostat, 2018). Statistics for construction and demolition waste in Cyprus for 2015 had a figure of 142kton which can be assumed to be rapidly increasing due to the increasing growth of the sector. Excluding excavation re-use, the recovery rate of treated waste goes down to 14%. Its relative distribution is shown in Figure 6.6.

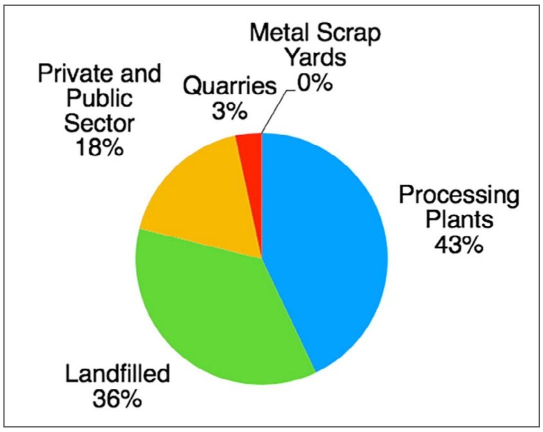

Figure 6.6 - Relative distribution of CDW in Cyprus (Cyprus Ministry of Agriculture, Rural Development & Environment, 2016).

6.4.1 THE SANDPIT WORKSHOP

A sandpit workshop was the main activity of a Climate-KIC Ideation action on the topic of Circular Economy Thinking for the Construction sector on islands (Yiatos, S. et al,). Over two days in September 2018 stakeholders from academia, engineering consulting, contractors, construction waste management, policymakers as well as architects and product designers from Cyprus and Malta participated in this facilitated workshop. The workshop started by setting the group's vision, identifying and mapping challenges, forming ideas and refining them in order to design and plan solutions. Through this workshop, we were able to pinpoint the barriers for a sustainable CDW waste management and pave the necessary steps, a roadmap, for the implementation of Circular Economy thinking in the construction sector in islands.
Workshop participants, through a long ideation process, identified barriers as
Regulations for CDW are still in a transition phase and the transposition of the Waste Framework Directive to Cyprus law generated the need for definition clarifications.
No strict control and enforcement of the environmental policy for the precautionary principle, the "polluter pays" principle and the principle of collaboration between industry, regulators and academia.
Manufacturers and distributors are, in their majority, most likely not designing their products in such a way as to minimize the amount of waste produced during manufacturing and to facilitate an ecological removal of those components of the waste which can no longer be reused.
The absence of a policy requiring designers, builders and contractors to use an appropriate percentage of recycled CDW materials.
Lack of environmental inspectors and low organizational capacity for implementation and/or enforcement of the law, causing delays in the administration of fines or non-conviction of CDW management rules violators.
The general mentality in the construction sector and of the general public in Cyprus is based on the misperception that CDW can be disposed somewhere and left there since its inert nature makes it harmless for human health and the environment.
There is a preference to avoid the cost of CDW management (fly tipping or re-use on site) even if it means paying the fine for not complying with the regulations due to the high cost of transport and disposal in collection areas and general lack of skills and knowledge to organize effective systems of CDW management.
No perceived value in construction waste due to virtually no market demand for recycled CDW
Lack of knowledge from construction industry professionals regarding the implementation of CDW legislation, including on how to prevent CDW.

After the identification, grouping and prioritization of the barriers, the participants were able to concentrate on a six-step roadmap in order to push for the implementation of Circular Economy Thinking.

1. Educating
2. Incentives
3. Technology
4. Mentality
5. Legislation
6. Minimise

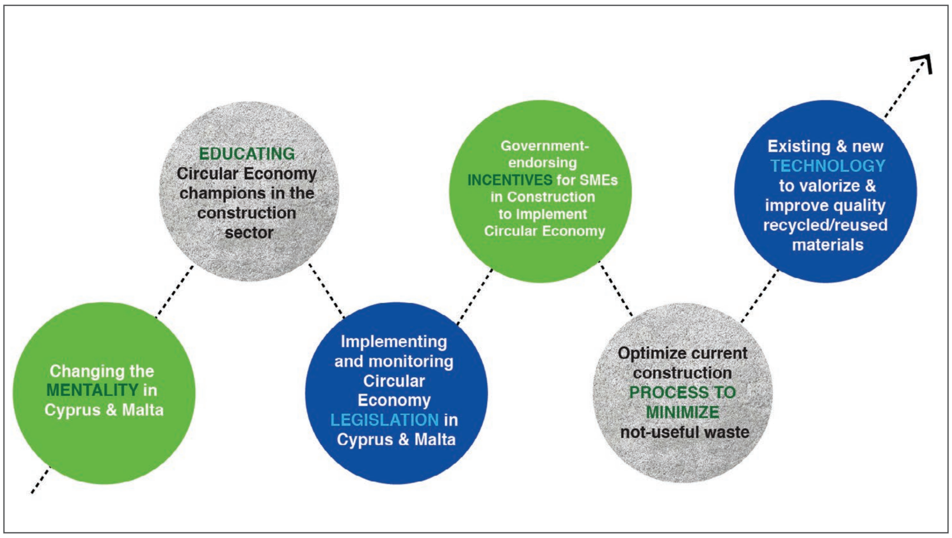

Figure 6.7 - The roadmap for the implementation of CE in the construction sector in island nations such as Cyprus and Malta.

These six steps can be broadly put in three categories: Education, Policy and Processes. With the role of education it is imperative to highlight the results of the current practice while showcasing the potential Circular Economy success stories (Mangialardo & Micelli, 2018). This includes:
Guided tours to landfill sites and CDW process centers as part of engineering and architectural curricula and CPD courses to show the cycle of waste as well as the calculation of the true cost of waste to the taxpayer, whether this is the individual or a company.
Universities and public bodies could lead the way with flagship construction projects (like Living Labs) implementing circular economy thinking such as the Arup Circular Economy Demo in Central London (Zimmann et al, 2016).
Educational institutions and Professional bodies should coordinate for a multi-point entry to Circular Economy education (vocational, higher education, professional) through agile problem based learning in order to provide a solid educational platform for the majority of actors in the construction sector, including joint activities, building on existing programs such as the “Constructionarium” (Casanova-Rubio et al, 2016) in the UK and adapting it to design for the whole lifecycle of a construction project, while also supporting training for novel business models for startups and new products/services in existing companies.
Building on the steps undertaken on education and outreach, policies should focus on setting the bar high in terms of implementing and monitoring EU and national legislation on the ground while it should act as a springboard for CE initiatives in the construction sector (Eklund et al, 2003). Especially in the case of small island nations, there should be implemented a “one-stop shop” Department for the implementation and monitoring of the CDW cycle which should include an online monitoring platform and site inspections. This will allow for the tracking CWD throughout the lifetime of materials, define by-products as secondary materials by adopting new standards and certification schemes for such products and harmonize national legislation with WFD in order to exclude naturally occurring material (such as excavation soil) from the list of CDW. The policy should support communication, awareness and education activities in order to inform stakeholders but also raise awareness and co-develop educational material for designers and construction waste managers. Other than these horizontal actions the roadmap includes the recommendation for different stakeholder categories shown in Table 1.

Table 1 - Recommendations for stakeholders

Stakeholder category	Recommendations
SME construction companies	Incentivize CE through Green Public Procurement Good Practice (EC, 2019) Incentivize entrepreneurship in circular economy for CDW Enable participation in the waste management system Apply a levy directing tax money for waste disposal towards trainings, infrastructure and rewards for sustainable waste management.
Large construction companies	Resolve the quarry tax conflict in Cyprus and implement the WFD construction hierarchy in CDW Adopt a % of materials that follow CE principles in new construction projects
Local construction material producers/manufacturers	Apply a % threshold on the use of virgin materials in new construction products Incentivize the production of materials produced with circular economy principles (%of reused or recycled materials, manufactured for dis-assembly) with subsidies and lower taxes.
Project owners and building designers/consultants	Building designers to prepare the initial waste management plan and inform the owners regarding their legal obligations. Adoption of waste management certification for designers to ensure correct implementation.
CDW Management companies (transport & processing)	Changes in the remediation law for quarries. Total coverage of the whole of the island with recycling/processing plans in order to reduce transport costs.

The final two steps under processes are looking to transform the construction sector internally, re-designing the construction process to minimize waste as well as use technology to valorize and improve the quality of CDW so that it can be used as secondary material. In order to implement the former, design-to-deconstruct criteria are necessary at the design process while the existing construction/demolition workflow should prioritise minimum waste, being informed and incentivized by the changes in policy and education. Such an approach is deemed to be the most impactful as it takes place at the primary phase of the building design. Examples of such criteria and strategies include prefabrication, pre-assembly and modular construction, efficient waste removal and separation during deconstruction, standardisation of connection details, design with reusable materials and design for flexibility and adaptability. Examples of such practices include the Serpentine Gallery pavilion in London (Serpentine Galleries, 2019) which on annual basis a building is designed with all the relevant permits and according to building standards, accepts guests for four months and then it is disassembled and sold to be reused somewhere else.

On the use of technology, improved communication between industry and research centers will lead to new research and policy revamping. Existing technologies can be utilized to enable faster launch of research and development outcomes in niche markets that are easier to test valorized materials and build market confidence. Big Data and Internet of Things strategies can support the creation of local depots for CDW collection and reuse. In fact, a significant barrier for companies trying to acquire secondary materials is the lack of access to information such as their supply location, available quantity, quality classification, frequency and price. At the same time CDW management companies are unaware of potential interested buyers. These secondary materials depots can address a market opportunity matching supply and demand in a sorted and classified manner in order to overcome lack of confidence in the availability and reuse of such materials. Combined with national (or European) quality standards and testing methods for acceptance criteria "at the gate" of these depots will support immensely the scalability of such venture and its implementation.

6.4.2 CONCLUSIONS AND FURTHER WORK

Implementation of Circular Economy thinking in a very conservative sector for a regenerative future requires a holistic approach that involves not just the direct actors of the sector but also the policymakers, standardization organisations and indirect potential users of the secondary materials. Six key areas were identified and placed in a roadmap in order to infuse Circular Economy Thinking in the construction sector. We are working already with EIT Climate-KIC partners to change the mentality and provide tools for the implementation of Circular Economy through education, while we have also contributed to the transformation of the legislative agenda in Cyprus in order to remove barriers and introduce incentives for implementation.

6.5 CONTRIBUTIONS FROM TRAINING SCHOOL TRAINEES

6.5.1 CONCRETE WASTE – FROM PROBLEM TO SOLUTION

KEY THEME OF WG 1: Resource (materials)
THEMES OF WG 3: Future Life
Author: **KATARZYNA KALINOWSKA-WICHROWSKA**

Planning the construction or designing a building in accordance with the principles of sustainable development and a closed-loop economy, in the context of the second life of resources, is not easy - as it might seem. Creating a building that considers all possible needs, e.g. economic, social, environmental, and other, providing a second life criteria for all materials (raw materials) used in the process of construction and erecting the building requires specific knowledge and actions from the designer. It is required to be

able to anticipate the future of the building, have knowledge of recycling techniques, reuse possibilities, and the regenerative potential of materials. Compiling it with other expectations of a modern building, that is to be more than nearly zero energy, requires in-depth analysis. An important issue is the awareness of the society (consumers) and people in the construction industry (e.g. producers, investors, architects, contractors) about the numbers related to waste. During designing a sustainable building it is important to remember to design for: waste-efficient procurement, material optimisation, offsite construction, reuse and recovery and for deconstruction and flexibility. This is named circular economy policy.
Looking at the material it has to consider its application in terms of recycling, remanufacture, reuse, refurbish, refit, retain. Resources after being built in and then finishing their function become a waste. This is where the problem arises, as waste is usually not needed by anyone and is generated on a mass scale. It should be emphasized why we care about the second life of resources and what is its purpose. Waste used to be a resource expensive in obtaining and processing, so is it good to throw money down the drain? What will we leave for future generations? This article investigates the state of the art regarding the legislative framework in the concrete industry and shows on the example of using the natural aggregates (resources), concrete production, and construction waste, the scale of the problem we are dealing with today. It also shows the solution/method to solve this problem- the method of comprehensive recycling of concrete.

Example

Construction industry is strongly linked to the concept of sustainable development, as its environmental impact is enormous: more than 40% of the global energy production is used in construction, about 35% of the global greenhouse gases emissions come from construction, and about 50% of the mass of recycled materials is used in construction (http://www.argox.com.pl/budownictwo_zrownowazone.php). According to the idea of sustainable construction, a building should be designed, constructed, used, and demolished in a way consistent with the requirements of sustainable development. The effect of the end of life of an object is construction rubble, which as one of the most significant waste streams generated in the European Union accounts for about 33% of all generated waste (EC, 2015). It consists of various materials such as concrete, ceramics, gypsum, wood, glass, metals, plastic, earth from excavations, and others (EC, 2015). It is difficult to clearly determine the percentage composition of construction and demolition waste, as it varies from country to country and from region to region. As statistic information show, in 2016 about 5.0 tonnes of waste was generated per EU inhabitant, 45.5 % of waste was landfilled and 37.8 % were recycled (https://ec.europa.eu/eurostat/statistics-explained/index.php/Waste_statistic.)
Concrete is nowadays the most commonly used building material, finding its application in almost every newly constructed engineering structure. It is estimated that even up to 25 billion tonnes of concrete are produced worldwide every year. The result is 510 million tonnes of construction waste generated in Europe, about 325 million tonnes in the USA, and about 77 million tonnes in Japan (Ferrari et al 2014). As concrete consumption increases, the demand for cement and aggregates increases as well. The need to protect the Earth's resources, mainly natural aggregates, and high energy intensity of the cement production process impose on the Member States the need to reuse concrete components, i.e. its recycling. It is estimated that the concrete industry absorbs about 11 million tonnes of natural aggregate per year and the cement industry is responsible for about 5-8 % of anthropogenic CO2 emission worldwide (Jin and Chen, 2015). The Framework Directive (2008/98/EC) called on the Member States to take the necessary measures to achieve a minimum target of 70% for the re-use, recycling, or recovery of non-hazardous construction and demolition waste by 2020, compared to an average of 47% at present. Recycling rates vary among the Member States - for example, in Spain it is only 14%, while in Germany it is as high as 86%. Numerous difficulties in achieving the required recycling rate may result mainly from the lack of requirements for recycled materials, inconsistencies in legislation, regional differences in landfill fees, market capacity to absorb recyclates, and technical and cultural barriers.

The need to save the natural resources has found a legal postulate in the form of new Basic Requirement No. 7: Sustainable use of natural resources, recorded in Regulation (EU) No. 305/2011 of the European Parliament and Council of 9 March 2011, which establishes harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC. According to the Regulation No. 305/2011 of European Parliament, during the design, construction, and demolition of buildings the natural resources must be used in a sustainable manner, taking into account the reuse of materials after demolition, the durability of buildings, or the use of products having low consumption of raw materials, by using environmentally friendly materials that do not lead to deterioration of the condition of the environment. In 2017 the European Commission approved the closed-loop economy package. The aim was to help the European companies and consumers in switching to the stronger closed-loop economy, i.e. one in which resources are consumed more sustainably. The proposed actions contribute to "closing the circulation" of the life cycle of products through increased recycling and reuse and will benefit the environment and economy. Implementation of those plans will increase the reuse of raw materials, products, and waste, and this will help to save energy and reduce greenhouse gases emissions. The proposals cover the entire life cycle of products: from production and consumption, to waste management, and the secondary market of raw materials (https://ec.europa.eu/commission/priorities/jobs-growth-and-investment/towards-circular-economy_en).

Due to the large scale problem with the development of concrete debris, an attempt was made to develop a comprehensive method for its recycling. The research objective of the team of scientists from the Białystok University of Technology was to find a way to effectively recycle concrete, which allows to reuse and refresh the recovered components from the processing of old concrete (PAT.229887). A new recycling method was developed in 2016 after several years of research. The invention allows comprehensive processing of concrete debris into high-quality recycling products: recycled aggregate with increased parameters and active recyclable mortar. These products, thanks to their properties, will be used in the construction industry: - recycle aggregate as a 100% replacement of the necessary natural aggregate in concrete, recyclable mortar as a partial cement substitute in cement composites or active filler in autoclaved products (Pawluczuk, Kalinowska -Wichrowska et.all,2019) The process in the future will take place in one device, which improves the work and is economically advantageous.

The full process of thermal and mechanical treatment is based on four main stages, which in laboratory conditions were carried out in the following way (Fig.2). The proposed device and method is a comprehensive way of using the accumulated and generated concrete debris. The technology is completely waste-free. The invention can be applied everywhere where the concrete production process takes place, in concrete factories, prefabrication plants, etc. The device can ensure the total use of waste from production and convert it into valuable recycling products - aggregate and mortar, which can be reconnected to the production process, without compromising the quality of new materials. I stage - the concrete rubble was crushed in a jaw crusher to <40 mm in size. II stage - the rubble obtained in such way was placed in a thermal furnace and roasted (after this stage a partial separation of cement mortar from aggregate has been observed). III stage - after being removed from the furnace, the rubble was placed

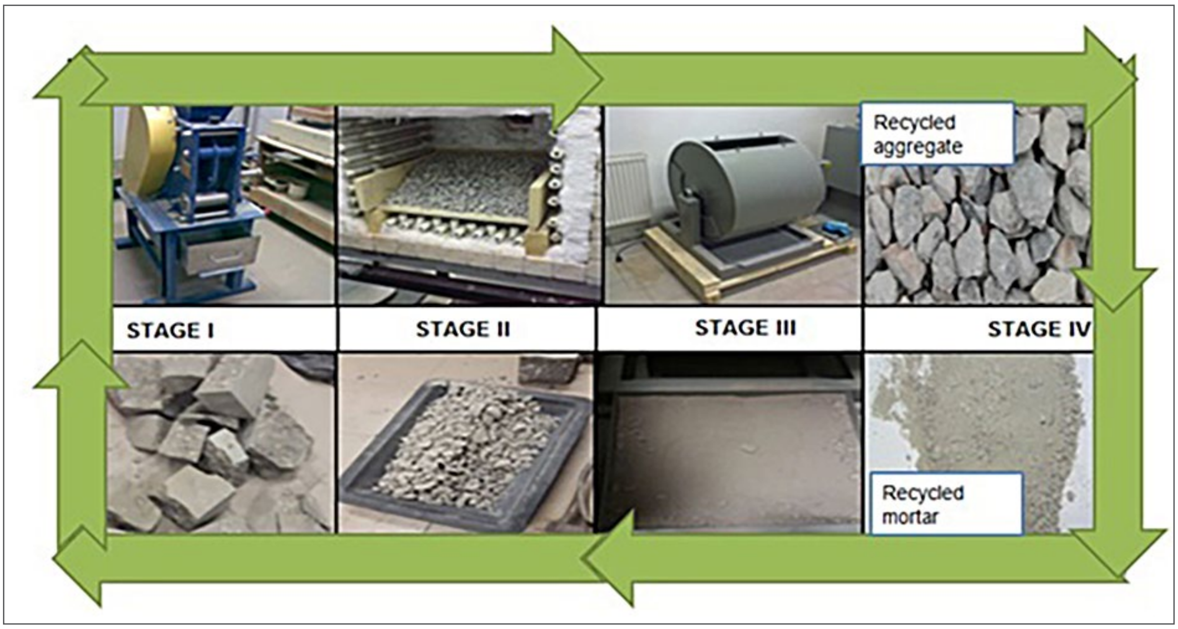

Figure 6.8 - The laboratory process of thermal-mechanical treatment of concrete rubble

in a Los Angeles drum and subjected to mechanical treatment of constant parameters in order to finally separate the cement mortar from the coarse aggregate grains. IV stage - the cooled material was sieved through a 4 mm sieve to separate the fine fraction < 4 mm from the coarse fraction (≥4 mm). The coarse aggregate of dimensions ≥ 4 mm was additionally divided into fractions of 4-8 mm, 8-16 mm, and 16-32 mm. Then the prototype of the device has been designed, which, thanks to its design, combines thermal and mechanical treatment of concrete rubble. As a result of experimentally selected parameters of the process the high quality recycled aggregate and active fine material obtained as a result of additional remilling of separated mortar (< 4 mm) were obtained. The device and the way the concrete rubble is processed have become the subject of a patent PAT.229887(„Method for separation of set cement mortar from coarse aggregate and for crushing that mortar, and the device for the application of this method”). The aim of the invention was to develop a method and device for comprehensive recycling of concrete rubble, eliminating the disadvantages of methods used so far.

The elimination of waste generation, as well as the change of waste into a product, are not only economic benefits, but also an important step towards implementing the principles of the circular economy and sustainable development. The method is currently being implemented for production in an existing production plant in Poland.

Conclusion

The use of recycled materials in the age of development of the world is an increasingly aspect but in my opinion, more scale and more accessible activities are needed. This may change with stricter legislation and introduction of significantly higher charges for the storage and disposal of rubble-cement waste. Creating the wide-range public awareness policy, as well as trainings, programmes for designers or investors or any participant in the construction process may encourage the use of good practices.

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6.5.2 THE ROLE OF WATER IN OUR PRESENT LIFE AND ITS REFLECTION IN REGENERATIVE RESTORATIVE ARCHITECTURE

KEY THEME OF WG 1: Water
THEMES OF WG 3: Future Life
Author: **Elena GUALANDI**

The importance of water in restorative architectural interventions can be easily witnessed by the beautiful 30 meters high water tower that stands right near the main entrance of NOI TECH PARK in Bolzano/Bozen. The water tower was built in 1934 and today, thanks to the project of Claudio Lucchin and Chapman Taylor it regained its original role of tank, whose water serves as thermal energy storage for the climatization of the whole building; also, it works as a fire fighting reserve, since part of the water collected in the tank can be used for this specific purpose.1

In accordance with the tool that out team proposed in the frame of the WG3 of the Cost Restore program, it's important to enlighten the strict connection among the different phases of a building process and the efforts needed by all the actors involved, first to achieve better performing buildings, and consequently to build districts that are efficient from the environmental point of view. It is central for the future of regenerative architecture to stand on those bases of collaboration and mutual listening.

This is because the expectation of use in the long term of a building, and therefore its "second life" phase has to be taken into consideration from the very early stage of the project. Future use and the possibility of reuse have been considered to be central and to play the role of coordination criteria for the whole project. Doing so the benefit in terms of maintenance and bio-climatic comfort in the long run, are evident from the start.

Water and "Second Life"

It is in such perspective that water management has been a major issue and a subject of constant research in the area of restorative and regenerative architecture.

This inevitably passes through the increase in people's awareness of the value of water: the respect of the natural hydro-graphic network of the territory, the use of the right amount of water according to the needs of the ecosystem and the collection and the purification of water for the purpose of reuse are just some of the fundamental precautions to be kept in mind.

The major challenge is how to design management systems that know how to best take advantage of rainfall and other natural phenomena in favour of a "closed" and efficient re-use from the early procurement phase of the project. It is vital, moreover, to adopt these management systems to less intrusive, economically affordable and architecturally elegant construction technologies, all within the building constraints.

The Challenge: Intervention on an existing building

It is clear that this can become a huge challenge in the case of an intervention on an already existing building, as the intervention has to forcibly pass through the awareness of the actual dwellers and users of such building and the probable update of the existing technologies and infrastructures. In contemporary times we are used to taking resources for granted, and too often we lose touch with the real needs of the ecosystem.

It is not always the case, though: the Markas Headquarters - that we had the opportunity to visit during the workshop - are an example of architecture that helps to raise awareness of water as a valuable element of the workplace. The offices, in fact, were provided of water fountains placed no further than 30 meters of distance from the workstations, making water a useful and constant presence and a value to protect.

Another useful action is to reduce losses of water due to leaks of the building's facilities, with an increase in the efficiency of water systems through a modernization of the technologies involved and the perfect maintenance of the existing ones.

It is also to be noticed, when talking about the reuse of rainwater, that not all European Countries allow them, due to different legislation on the hygienic standards to respect.

In Paris, for example, phytopurification and use of grey water for domestic use is a habitual practice and it has been broadly used as of its launch in 2001 for the design of the most modern eco-neighbourhoods and in the recovery of historical spaces such as the Boucicaut.

The eco-neighbourhood of the Boucicaut is extended over almost 3 hectares of an area that was initially used as a hospital complex, set in the west of the 15th arrondissement of Paris. the project deserves a distinction for the management and economy of water resources, involving a cut in their consumption and a reduction of 55% in the waste of rainfall water.

Water is integrated with the development and in the functioning of the eco-neighbourhood through the installation of efficient devices and tools for water conservation (such as double flush WCs)

Run-off related pollutants are also limited, thanks to reorganization and adaptation projects of public spaces that favour the natural infiltration of rainwater: drainage channels, grooves along the perimeter of the road network, semi-intensive green roofs, planted flower beds and underground collection basins.

Despite the successful and unsuccessful studies and experiments on regeneration in the most modern projects, the real challenge for the existence of a "second life" phase for the majority of buildings will be the adaptation and the organic inclusion of efficient water systems in the existing (and outdated) architectures and heritage buildings, keeping in mind the operational costs and the eventual change of destination of use of the building itself.

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6.7 CASE STUDIES

CASE STUDY 1: NEST-UNIT "URBAN MINING AND RECYCLING"

NAME
NEST-Unit "Urban Mining and Recycling"

LOCATION
Dübendorf, Switzerland

CLIENT/OWNER
Empa, Dübendorf/Switzerland

PROJECT TEAM
Architect: Werner Sobek Design GmbH, Stuttgart/Germany; Heisel/Hebel Architekten GbR, Karlsruhe/Germany
HLSK, MSR: Amstein + Walthert AG, Zürich/Switzerland

THEME/TYPOGRAPHY
New residential building, build completely with recycled or recyclable materials

CONSTRUCTION/COMPLETION YEAR
2017

BUILDING
NEST (Next Evolution in Sustainable Building Technologies) is a research building on the campus of the Swiss Federal Laboratories for Materials Science and Technology (Empa) in Dübendorf, Switzerland. The building consists of diverse units, which were individual designed as working and living environment.
The Urban Mining And Recycling (UMAR) Experimental Unit is one of the units at NEST and was created by Werner Sobek in cooperation with Dirk E. Hebel and Felix Heisel. Located on the second floor of the four-storey NEST research building is UMAR part of a modular concept.
The basis of the UMAR is the life-cycle thinking, every resource used in construction must be fully reusable, recyclable or compostable. Materials are borrowed from their technical and biological cycles for a certain amount of time before being returned into the circulation. Therefore this conceptual emphasis means that UMAR functions simultaneously as a materials laboratory and a temporary material storage.

PHOTOS

Figure 6.9, 6.10 - External view of ther NEST research building (left) and interior of the UMA module by Werner Sobek (pictures copyright Zooey Braun, Stuttgart/Germany)

Figure 6.11 - Exploded axonometric view of the UMAR module (copyright Werner Sobek, Stuttgart/Germany

REGENERATIVE SUSTAINABILITY
The UMAR-Unit is shaped in time-honored methods and modern looks at the same time. It is connecting the best aspects of past, present and future. The prefabricated module shows the latest engineering solutions in modular concept while obstructing pure resources like many generations before us. The place is a conscious reminder to a gentle and effective approach in construction. Counteracting subsequently disposal of resources, makes reusing and repurposing materials just as important as recycling and upcycling. Therefore substances are only borrowed from their technical and biological cycles. To guarantee the circular process the used materials can be separated out cleanly, melted down and recycled after use. The supporting structure consists of untreated wood. For the façade untreated wood as well as aluminum and copper are the applied materials. The materials are connected through traditional clamping profiles, so that there are no bonded joints whatsoever.

LINKS:
https://www.wernersobek.de/

CASE STUDY 2: NOI TECHPARK

NAME
NOI Techpark

LOCATION
Bolzano/Bozen, Italy

CLIENT/OWNER
Autonomous Province of Bolzano/Bozen

PROJECT TEAM
Architecture: ATI Chapman Taylor Italy (Milan) and Studio CLEAA (Lucchin and Associates, Bolzano), with A. Cattacin (Trento)
Structure: Bergmeister Engineering

THEME/TYPOGRAPHY
Historical dismissed construction regenerate to a technology park

CONSTRUCTION/COMPLETION YEAR
2017

BUILDING
The NOI Techpark is a multifunctional complex including offices, laboratories, gastronomy, research areas, seminar rooms and landscape. The acronym “NOI” stands for “Nature of Innovation” and reflects the aspiration of the Techpark of being a hub for innovative sustainable technologies and services. The Techpark is growing on a 12 hectare areal in the industrial area of Bolzano, previously used for the aluminum industry, the Montecatini, which was the largest aluminum plant in Italy up to its dismissing in the nineties. The historical constructions were built in 1937 and were declared as historic monuments in 2004. In 2007 the Province of Bolzano launched an international competition for the regeneration and second life as well as extension of the complex. The NOI Techpark and is a successful example of philological restauration and contemporary architecture.

REGENERATIVE SUSTAINABILITY
The NOI Techpark is located on a historical site in the middle of the beautiful landscape of Bolzano. By renovating the old industrial construction, in remembrance of the former production, the region is getting a new chance and meaning. The area of the actual Tech Park has been a very active place in the thirties, with huge economic relevance (production and man power). The refurbishment and extension of the complex aims to give again a strategic importance and the prestige of the historical place, as well as its key role for the local community
Given the status as historic monuments and reuse in second life, the old facades are gently renovated and the inside remodeled to fit the

Figure 6.12 - NOI Tech park

current occupants. To complement the old construction, remember the former production and symbolize the innovation the Black Monolith is developed, with an innovative aluminum foam façade.
NOI aims to be a central place for education, research and development, bringing also physically together the most innovative companies and institutes at local, national and international level. This helps the sharing and the development of knowledge and the share of know-how between research and industry.
NOI is a working and living environment, with a business incubator for start-ups, workplaces and laboratories as well as catering services and cultural offers.

LINK
https://noi.bz.it/en

CASE STUDY 3: CUERDEN VALLEY PARK VISITOR CENTRE

LOCATION
Lancashire, United Kingdom

CLIENT/OWNER
Cuerden Valley Park Trust

PROJECT TEAM
Architecture: Straw Works (Barbara Jones)

THEME/TYPOGRAPHY
Visitor Center designed to celebrate the ecology and natural landscape of the park,

CONSTRUCTION/COMPLETION YEAR
2018

BUILDING
The design and construction of the Cuerden Valley Park, through natural materials and craft skill-based construction lends itself well to Brand's layers and circular economy thinking. It provides evidence of what is possible, reinforcing Denis Hayes comment that once something exists we can no longer say it is impossible. Designing and constructing within the imperatives of the Living Building Challenge provided the framework for addressing the three circular economy principles. With a design life of 150 years, he building contains no cement, concrete or red list chemicals of concern, making a vital contribution to eliminating pollution and negative social and environmental impacts. Throughout the building the focus is on mechanical and accessible connections, rather than chemical, adhesive or sealant connections, enabling future second life adaptation.
The visitor center incorporates a number of waste products such as tyres in the foundations, straw as a waste product from the agricultural sector, and at the stuff level, reclaimed furniture, which even in the first year is replenished and refreshed through the Shabby Chic courses run at the centre, in addition the vast majority of the building can be reused for future buildings, or eventually returned to the ground and compost.

Figure 6.13 - Cuerden Valley Park, Lancashire.

7. SUSTAINABLE REGENERATIVE TOOL – SRT (TRAINING SCHOOL WG3)

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CONTENT

7.1 SUSTAINABLE REGENERATIVE TOOLS

The Sustainable Regenerative Tools presented within this publication provide a foundation for future development towards real and viable tools for regenerative construction and facilities management.

7.2 INTRODUCTION

Procurement, Construction, Facility Management and Second Life are the four steps, post design, that each building undergoes one on at least once in its lifespan. In an ideal situation, the four life cycle stages work symbiotically together to strive towards best possible regenerative performance. In practice, however, the driving factors of the involved actors are manifold and mostly driven by financial matters, which poses a challenge of implementing a lean process that integrates all actors. Showing interconnections, which actions of one contributor have to others in the project, represents a key element that requires rethinking within the industry. In order to tackle the characterised intricacies, the Cost RESTORE WG 3 Training School focused on designing a tool dedicated to enabling regenerative construction and operation. More than just promoting sustainability, the tool should help actors at all building stages to foster regenerative aspects. Following a holistic approach, regenerative construction projects can be brought closer to a circular life cycle. Figure 7.1 illustrates, how the building life stages can be delineated as a loop.

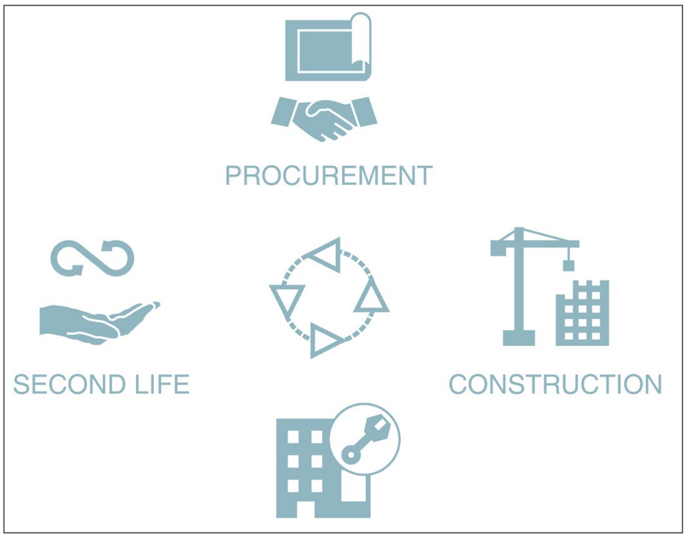

Figure 7.1 - Life stages of built environment, terminology according to WG 1

For the Training School's competition, the 24 trainees were divided into six teams, assuring a good mix of backgrounds in each group. Each team was then facing the challenge of creating a Sustainable Regenerative Tool (SRT) and a 10-minute demonstration during the RESTORE mid-term conference on 14th of March in Bolzano in front of more than 100 researchers and professionals from over 30 countries. Additionally, a written description of the developed SRT was required.

During the mid-term conference, a jury composing four professionals from RESTORE awarded a special mention to the SRT of Team 2 and the SRT of Team 3 was conferred the winner. The decision was based on pre-defined score criteria including, presented material, assessing social, economic and environmental aspects, the scalability & replicability, creativity & innovation, comprehensibility of the SRTs structure, presentation and a peer review from the audience.

The aim and the prerequisites of the SRT are explained in the following section. Following an overview of the tools, the winning and mentioned teams are provided. Then a discussion on how to proceed towards a commercial or open-source SRT is given by the authors of this chapter.

Finally, a summary of the four other SRT's developed by the other teams is briefly presented.

7.3 THE CHALLENGE – AIM AND DESCRIPTION

Regenerative and sustainable buildings throughout their whole life cycle are today one of the highest inspirations for the built environment. However, many factors compromise construction and operation. Thus, adequate guidelines and indicators to help designers, contractors, project management as well as the owners to implement and verify regenerative sustainability goals, are needed.

The challenge of this competition was to develop a tool that can be used to implement regenerative sustainability aspects throughout the building process, namely a Sustainable Regenerative Tool (SRT).

The SRT should aim to be an instrument for professionals of the construction and facility management sector, which supports and guides the delivery of regenerative aspects in construction and monitoring during the operation of the building and any future 'second life'.

The SRT should cover the entire building construction process: procurement/pre-construction, construction, operation and future life and the key themes developed in Working Group WG 1: Place, Energy, Water, Wellbeing, Carbon, Resources, Equity, and Education.

Although related to a specific project, (the NOI Tech Park in Bolzano was used as a case study) the participants were to develop a tool that is scalable to other projects.

The participants could take reference of other tools currently used in a specific stage of the building process. Examples of the such were introduced in the Training School with the Pre-Qualification-Questionnaire (PQQ) used in the procurement stage and the Sustainable Facility Management Index (SFMI). The SRT should integrate the principles of PQQ and SFMI, however, the form, contents and evidence were open and had to be developed by the trainees.

The development of the SRT in teams took place during the first three days of the Training School, combined with lectures given by the trainers with backgrounds in the four disciplines. The trainees were given a timeframe for teamwork which was accompanied by the trainers. Finally, the proposals of each team were translated into an abstract and a public presentation as the closing of the training school.

7.4 REGENERATIVE ROADMAP

WINNING SRT: TEAM 3

Team: Marco DELLI PAOLI, Jonas Manuel GREMMELSPACHER, Louise HAMOT and Virna MONERO FLORES

Team 3 comprised four group members in their mid-twenties from professional and academic backgrounds. Louise enriched the team with various inputs from her background as a Sustainability Consultant. Virna brought insights from the world of sustainable facility management. Marco introduced his knowledge in green building design and circular economy and Jonas shared his understanding of sustainable pre-construction and construction stages based on practical and academic experience.

A Regenerative Roadmap. The decision of the jury to award this proposal was because this presentation was intended to be neither critical or a new assessment system, but a way ahead to find or propose solutions for regenerative buildings. It started from vision, and then concentric circles from mission to engagement. The tree system is an original idea, very flexible and which allows further development through collaboration between different sectors of construction. The team enhanced the concept of regeneration of a building in all stages and was giving examples for a second life.

We appreciated the interactivity and interconnectivity between different components/tasks involved in all stages of design and construction, which we think is closer to what is happening in actual cases. Also, the flexibility and openness of the suggested system/network.

INTRODUCTION

THE REGENERATIVE ROADMAP as a Sustainable Regenerative Tool (SRT) is a guide for stakeholders in the built environment to benchmark the performance of their activities during the life cycle of a facility. Overall, it was envisioned for stakeholders to implement the tool at any of the building life cycle phases. Therefore, a strategy stating an overall aim for each of the phases pointing the direction towards regenerative life cycle was crafted. 12 regenerative key themes, each connecting to objectives, tactics, and indicators allowed for benchmarking to determine the regenerativity of measures taken in the four building life stages.

ABSTRACT

The REGENERATIVE ROADMAP provides a guideline towards regenerative and sustainable interventions and is therefore divided into multiple levels. The software is targeted to serve actors involved in all building life cycle stages, regardless of the intensity of the intervention. Actors are represented by Design Team, Builders, Occupants, Investors/Owners, Facility Managers, Municipality and Local Community. The mission for the REGENERATIVE ROADMAP was defined as 'Regenerative Design to Live Symbiotically within Long-lasting Ecosystems'.

In detail, the starting point of the REGENERATIVE ROADMAP are the four building phases. The overall strategy followed in the Pre-Construction stage was defined to be 'Positive and Balanced Interest Group Involvement'. In Construction, the proclaimed most significant strategy was 'Integrated Lean Intervention'. Maintenance and Operation follow the principle of 'Quality and Economic Driven Stewardship'. The Future Life stage was assigned to create a 'Continuous Life Through Adaptability'. In addition to seeing the phases as a process, the tool emphasizes and visualises the four stages as a closed loop. Further, the closed loop approach allows all interest groups/actors, to step in at any point. Thus, the REGENERATIVE ROADMAP can be employed for the analysis of new and existing buildings. Mission and strategies as the significant elements of REGENERATIVE ROADMAP are built the core of the SRT. The five remaining levels of the SRT are placed as shells around the mission and strategy, creating a six-step outline as seen in a schematic diagram in Figure 7.2.

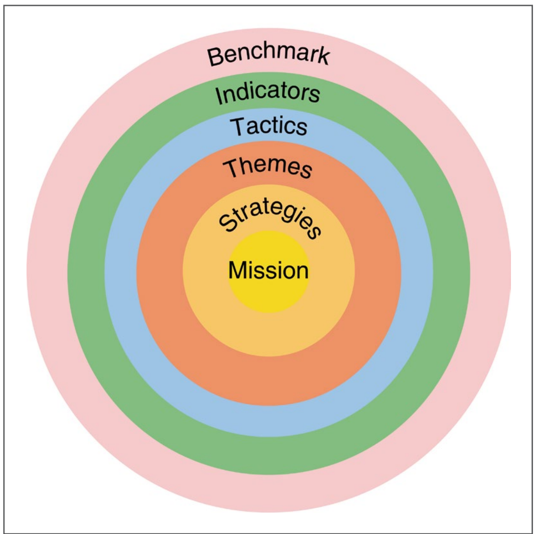

Figure 7.2 - Schematic Diagram of the REGENERATIV ROADMAP

Each of the four building stages composes 12 key themes, which are placed in the next hierarchic shell. The first nine follow the themes developed in Cost RESTORE WG1. The three remaining were added by the team to adequately address economic, social and environmental aspects, represented by Resiliency, Community and Governance.

In the next level, objectives were defined as realistic outcomes, defined for each life cycle stage and key theme. Individual tactics formed the actions, which describe the requirements for regenerative design at the next level. Indicator definitions are used as phrased questions, which help actors to reflect the performance in the respective category. Evidence as input is required in the form of surveys, figures, strategies and plans, used to benchmark. Numerical benchmark is turned into qualitative and quantitative values and further used for comparison.

Creation of the REGENERATIVE ROADMAP required the definition of outcomes to be transformative so that actors get an understanding of the best-case scenario that should be the overall objective for each project. The questions formulated under indicators are targeted to get an understanding, which measures actors must review in order to improve in respect to the underlying sustainable criteria. To highlight the relevance that interventions cause, the tool shows interconnections between indicators of all life cycle stages. This demonstrates how actions impact the competences of multiple actors and emphasise the importance of all actors to work together. Through a holistic approach, social, environmental and economic aspects can be addressed appropriately, so the key elements of sustainability are balanced. To open REGENERATIVE ROADMAP to all actors with individual preference, the roadmap provides possibilities to follow a top-down as well as an outside-in approach.

Processing the schematic diagrams in Figure 7.2 into a user-friendly interface by keeping the tree structure is shown in Figure 7.3, with the key theme 'Place' and selected objectives, tactics and indicators. Elements in the level's objectives, tactics and indicators are herein only visualised to showcase how interconnected actions in the different life stages are to others.

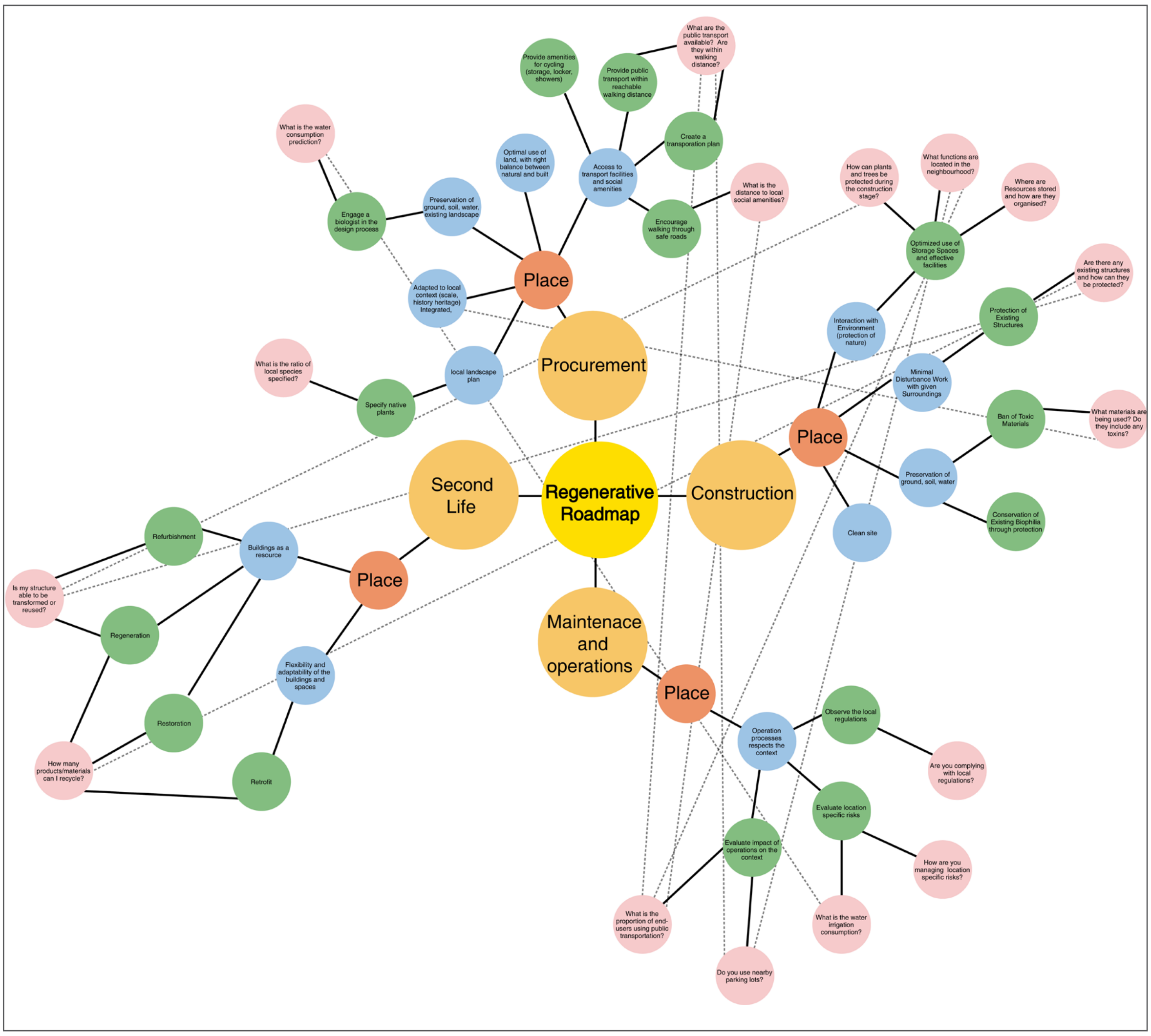

Figure 7.3 - REGENERATIVE ROADMAP outline exemplary for the key theme 'Place' (Readability only for the first three levels)

7.5 SMART – SRT

MENTIONED SRT: TEAM 2

Team: Anastasia STELLA, Rafael CAMPAMA PIZARRO, Amit ANAFI and Zvi WEINSTEIN.

Team 2 combined extensive professional experience in design and construction, a solid academic background and curiosity for new approaches. Anastasia contributed creativity and her knowledge of BIM Integration and Building Sustainability Assessment. Zvi demonstrated that people priority through his vast experience in urban development and social aspects. Rafael shared experience in the procurement of public projects and the overall understanding of the sustainable construction process. Amit brought project management skills and a passion for bioclimatic architecture.

> *We appreciated the idea of a structured knowledge framework, in the form of the proposed platform for regenerative buildings, enabling exchanges and cross-contamination among involved players from the early stage of the development process (design – procurement - construction – commissioning – O&M – future life).*

INTRODUCTION

SMART is a tool for the implementation of regenerative solutions throughout the whole building process. It is structured in two main parts. The first being the selection of different actors involved in the construction of buildings (Architects and Engineers, Contractors, Facility Management, operators, specialists and Second Life specialists) in a fair and transparent way. Secondly, it provides a working interface for interaction between the different actors. This part of the tool interconnects both the guidelines for the nine identified regenerative themes and the corresponding strategies and actions which are actively proposed by individual actors.
Contributors to design, construction and operation, are the main actors or counsellors within their assignment. Outside their main field of expertise, all actors are needed for supporting decisions taken during other lifetime stages. Regarding the Second Life stage, the tool is mainly used as a traceability database which reveals the measures taken during the previous stages.

ABSTRACT

The proposed tool seeks to enable the paradigm shift from sustainability to restoration and to regeneration. SMART is a Sustainable Regenerative Tool (SRT) embracing two complementary visions. The first being Fair and Transparent Choice and second being Regenerative Project Management.

1 Fair and Transparent Choice

Regenerative architecture is based on promoting a new building paradigm and breaking existing boundaries. It is no longer acceptable for a building to be less bad in terms of embodied energy, carbon emissions and resource exploitation; it must give back more than it takes from the environment. Implementing this approach in practice poses difficulties with the existing procurement framework and stakeholders' interaction. In the public bidding process, technical and price evaluation is often key to selecting the most suitable firm. Regenerative ideas will not find an environment conducive to their development in a context where low prices and conservative technical evaluation predominate. SMART is targeted to be a detailed database with full traceability of all projects carried out by SMART users. This database is used starting in the procurement stage to transparently and fairly select the most appropriate actors, creating the best possible team for a regenerative project.

2 Regenerative Project Management

The second vision and main capability of SMART is the function of a regenerative project management tool. The concept is to gather all the actors at the early stages of a project. This is to maximise the successful implementation of regenerative goals and to ensure that all actors participate and are involved in the process.

The definition and proposal of regenerative sustainability goals are to be open to experts from different fields, including environmentalists, psychologists, material experts, sociologists, economists, anthropologists and many other professionals, researchers and academics. Regenerative objectives will be integrated into the SMART tool and must always hold the balance between nature, human beings and buildings. The different stakeholders will be able to access their guidance concepts, defined for each project step and grouped according to the nine basic elements of sustainable regeneration developed in Cost RESTORE WG1. The basic operating principle of the tool and its data flow can be seen in Figure 7.4.

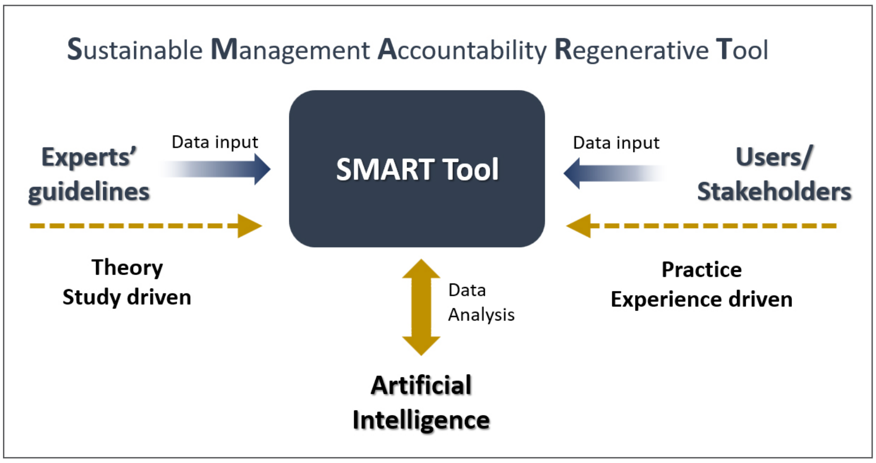

Figure 7.4 - SMART Basic working principles and data flow.

Teams work in a holistic way, according to plans, sharing information, knowledge and problems to be solved as well as the participation of all stakeholders in interdisciplinary decisions.

Figure 7.5 Summarises the SMART workflow. For each of the nine regenerative themes, the tool provides guidelines for all stakeholders. Based on this, stakeholders are required to develop strategies that result in firm actions adapted to the project and its corresponding working stage. These actions are then discussed and agreed by the rest of the team before moving on to the next step.

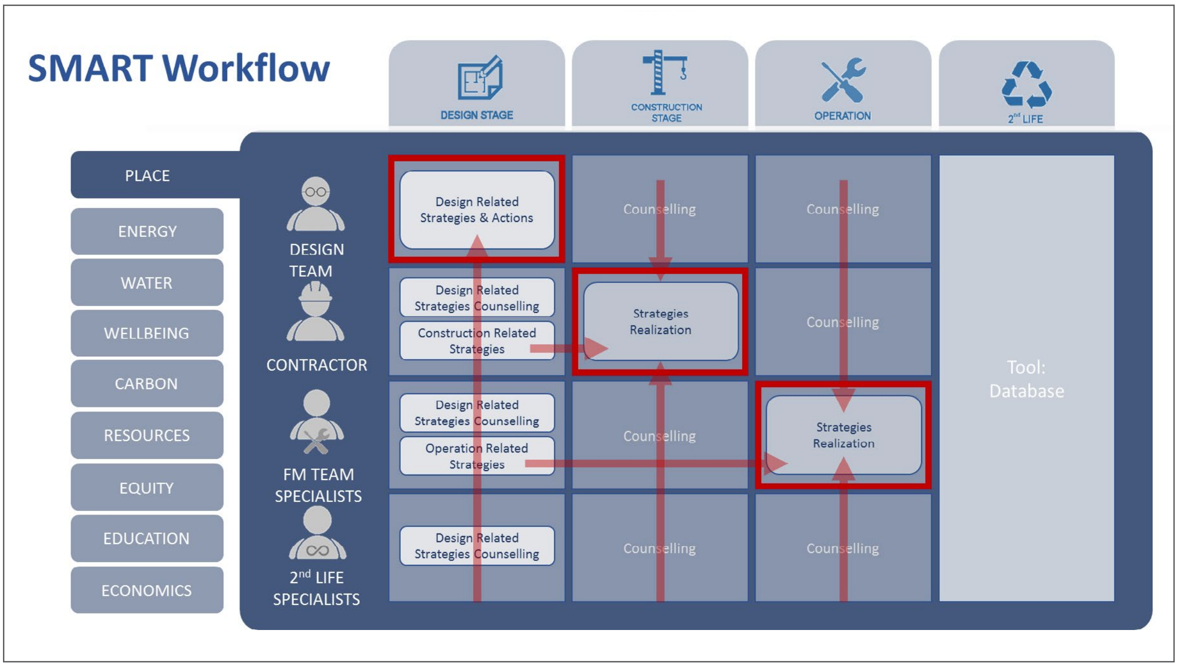

Figure 7.5 - Visualisation of the SMART workflow and how stakeholders interact at each stage.

SMART keeps track of how these regenerative proposals are effectively implemented in the project, as well as the interaction and impact of these regenerative actions on other participants throughout the process. The solutions implemented for each project will be evaluated, rated, and accessible to all SMART users. This provides valuable information for new projects as well as the enabling of innovative ideas. In order to provide each actor with the best information and proposals according to the project and phase, it is anticipated to handle all the generated data with artificial intelligence (AI) engine.

For developing a second-life strategy for a building, the company or stakeholder responsible can use the tool as a database of materials and actions performed throughout the full lifetime of the building with full traceability. The actions taken by the Second Life specialist during the construction phase will be particularly useful in this stage.

SMART Overview: Why is it a Regenerative Tool?

The current generation faces a great challenge when it comes to the climate crisis. The building sector plays an important role and responsibility in resolving climate change problems, to secure a better future for generations. To change the balance, it is necessary to think in an innovative and regenerative way. To be innovative, new processes must be invented, with the help of technology and artificial intelligence. To be regenerative, it is essential to change the mindset, from simply being sustainable to providing positive added value.

The SMART tool offers a practical and innovative tool for the construction industry, helping all stakeholders to achieve these ambitious goals. Transparency makes it an accessible and visible tool for everyone, Collaboration makes the process efficient and self-learning guarantees the Participation of all actors including end users, achieving a Regenerative Conscious Building where the human being is at the centre, while the building is in harmony with nature.

7.6 DISCUSSION

In addition to the mentioned and awarded SRT, four other groups proposed their SRT ideas for the implementation of a tool. All proposals contain valid ideas, important to adopt in the development of a real-life SRT. By picking the best ideas of all individual tools, structuring them into a logical application, translated into an easy-to-use interface and creating intuitive workflows, a valuable contribution towards a regenerative economy in the built environment would be achieved. Testing, validation and building of a final SRT would require a working environment as in the WG3 Training School, teaming trainees, trainers and jury members, as well as other specialists from the field.

Identifying highlights and best ideas contained in all SRT proposals.

To involve building surroundings, Team 1 oriented their SRT towards the integration of the local community into the design. The mentioned team highlighted a transparent and fair choice of the actors involved throughout the life stages, leaving no gap between the phases. As highlighted by the jury, the winning team was focused on an SRT that acts as a system to promote regenerative solutions, combined in a rigorous and well-structured hierarchy. Team 4 left no margin for buildings that do not exhibit regenerative principles, promoting a hard change in the mindset of all stakeholders. A user-friendly interface, allowing for interaction with the final user was suggested by Team 5. The potential for a continuous life for buildings and its materials by translating the regenerative aspects of a building into a map, proposed by Team 6 recommends a great way to manage the built stock as a future bank of materials.

The abstracts of the SRG of the Teams 1, 4, 5 and 6 are presented in the next section.

7.7 SRT'S DEVELOPED BY THE OTHER TEAMS

This section includes those SRT's developed by the teams at WG3 Training School that did not receive award or mention by the judges, yet provide insights towards real and viable tools for regenerative construction and facilities management.

TEAM 1: THE INCLUSIVE APPROACH

Pedro Silva Humbert, Alejandra Vidales Barriguete, Adrian Krezlik, Paula Hild

After intense discussions with participants and experts at the training school regarding generative approaches, we are now questioning traditional linear planning processes. We do not want to think in linear phases anymore, but rather in loops. A building life in a circular economy is not linear, but a circle. Therefore, we suggest speaking about a continuous building life instead of only a second life.

Experiencing the NOI Tech Park, our group realised that the Black Monolith (training school building), as well as the site (NOI Tech Park), are deserted. The building might be (nearly) zero energy and zero carbon, but it is zero people as well. The vital ingredient of architecture is missing and the building can be seen as an obsolete object – not connected to the local community. The building and the area are fantastic infrastructures but are so far underperforming. Thus, the aim of our Sustainable Regenerative Tool (SRT) is to give recommendations to the NOI Tech Park managers on how it could perform better. Our approach calls for inclusiveness in all phases. We want to engage with all interested parties in the process of achieving the performance of NOI Tech Park.

We recommend shaping a program for opening the NOI Tech Park to the outside and make it more accessible for people, an integral element of social patchwork and a nutritious element of the environment. This program should include different types of activities: discussions, panels, workshops, roundtables, art exhibitions and science labs for diverse groups.

In the procurement phase of a new construction project (e.g., a new building), NOI could organise workshops with all interested parties: Potential contractors and workers, local artisans, local communities, future users. The multi-directional, crossed generation knowledge transfer would improve the design program of the new building and better meet the needs of the locals. Artisans, artists, activists, designers and creatives should be invited to a competition to develop building concepts based on local expertise and culture (e.g., timber constructions, natural stones). The connection to the Bolzano is a crucial element of the design.

In the construction phase of a new building, the construction site could be opened to the public for visits. Workshops could be organised for the local community and workers on site to engage them with the new construction and provide them with better quality at their workplace (e.g. workshops about the history of the place, the architectural vision, and the technologies integrated into the future building).

In the operation phase of NOI Tech Park, we see a great potential to bring people to the place by organising, for instance, after work events (i.e. drinks), concerts and exhibitions. Another way to build up a relationship with locals is to create an open space inside the Black Monolith building, which is of interest to be regularly visited (e.g. a library, a science lab). The modern-day Facility Management concept does not include the social performance of a building, which is a purpose of it. Only a building with occupants is a true regenerative tool for the environment, local economy, and community.

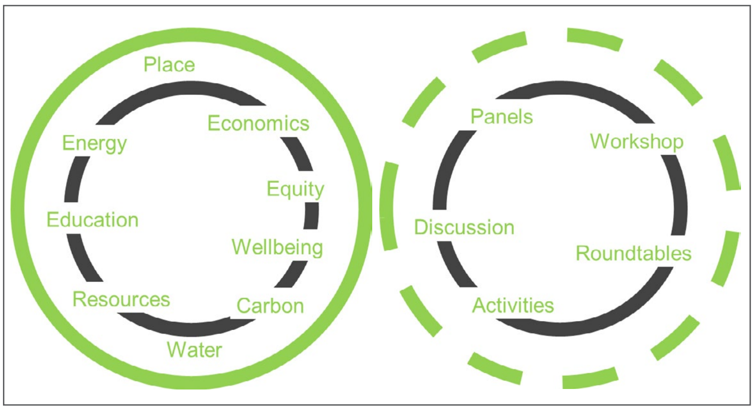

Figure 7.6 - Principles of the approach

TEAM 4: SUSTAINABLE REGENERATIVE TOOL

Dario Bottino Leone, Mahmoud Elsayed, Tudor Iuga, Marta Sabater Forteza Rey

Developing process

The starting point of this tool was the scale developed through the WG1 Publication "Sustainability: From Restorative to Regenerative" which evaluates projects from Building as Usual, to Green, to Sustainable, to Restorative and to Regenerative.

This document presented a grouping of current standards based on this mentioned scale. Given the fact that the number and quality of readily available sustainability certification systems are growing quickly, we decided not to reinvent the wheel, but to optimize it. The main idea was to extract from appropriate standards the criteria considered to be relevant for an SRT tool. All the selected criteria were regrouped to match the key themes and goals of RESTORE:

Place, Energy, Water, Well-being, Carbon, Resources, Equity, and Education, for each of the four, recommended phases: Procurement, Construction, Operational and Second Life

Even though the thresholds here were already high, we decided to go even further, pushing projects from simple sustainability towards a target of regenerativity.

Why a Sustainable Regenerative Tool?

There are many tools to evaluate the (environmental) performance of a project, but there few that focus on regenerativity that covers all the phases of a project.

What can you do with SRT?

The SRT tool was developed to be used in multiple ways. It can be used to:

- Guide developers, project managers, design teams, constructors and facility managers.
- Evaluate the sustainability performance of a building for every step of the project, for every category or any combination between these.
- Create multiple scenarios and comparisons between alternative options or use benchmarks to have an overview of the results prior to construction.

How does it work: Levels & Scoring?

The minimum level for SRT was set to represent "Sustainability". Nothing less is acceptable, but significant additional improvements are encouraged and rewarded through the other two levels: "Restorative" and "Regenerative".

Each criterion can be individually evaluated: 0 (Non-compliant), 1 (Sustainable), 2 (Restorative) or 3 (Regenerative). The internal criteria thresholds for each level need to be further developed. The minimum score/level of each criterion in a project phase or key category defines the score/level of that phase/category. In order to obtain a classification, it is necessary therefore need to obtain at least 1 for every criterion. To be regenerative scores of 3 throughout are required.

Auto-Evaluation

- Comprehensibility of SRT: The structure is designed to be easy to understand and use, being entirely based on RESTORE key themes and project phases, with only 4 options of scoring criteria. (0, 1, 2, 3)
- Scalability & replicability in other and for specific building functions: residential/industrial/commercial projects.
- Creativity/Innovation: the key creative/innovative aspect is the structure that allows a general overview of the sustainability performance of a building, covering all phases of a project. It also gathers, connects and develops the most challenging criteria of existing sustainability systems.
- Social, economic and environmental aspects are considered and covered through dedicated criteria grouped mainly as follows:
  - Social: Wellbeing, Equity, Education
  - Economic: Economics, Energy, Water, Wellbeing, Resources
  - Environmental: Place, Energy, Water, Carbon, Resources

TOPIC	TITLE	Procurement		Construction		Maintenance and operation		Second Life	
		DESCRIPTION	Score [0-3]	DESCRIPTION	Score [0-3]	DESCRIPTION	Score [0-3]	DESCRIPTION	Score [0-3]
ENERGY	Positive energy balance	Design the building to have net positive energy balance.The project's energy needs must be supplied by on-site renewable energy on a net annual basis. Surplus of energy production: no surplus (0 points), 0% (1 points), 10% (2 point), 20% (3 points)	3	Produce renewable energy on site and/or buy (the additional quantity) only from renewable sources.	0	Monitor and adapt the building in order to be net zero using renewable sources. Surplus of energy production: no surplus (0 points), 0% (1 points), 10% (2 point), 20% (3 points)	3	Assure the building remains net zero/producer after the adaptations.	3
	Local procurement	Local design team (<500km)	2	Build only local materials from <500km	0	Build only local materials from <500km	2	Recycle locally.	2
	Energy efficient equipments	Specify the equipments with the lowest consumption.	2	X		X		X	
	MINIMUM		2		0		2		2
WATER	Positive water balance	The project's water needs must be supplied by captured precipitation or other natural closed-loop water systems, fulfilling the overall of the builidng demand	2	Collect and use rain/grey water to use cleaning the worksite. Use compostable toilets	1	Monitoring and testing the water quality. Promote drinking water	2	Further use must not alterate the existing water balance	2
	Outdoor water reduction	Appropriate landscape design and plant selection / xeriscaping	2	Use construction water-less techniques	1	efficient irrigation (drip irrigation) , reduce turf grasses and monocultures and use	2	reuse of fertilizing soil	2
	Indoor water reduction	High-efficiency toilets and waterless urinals systems , rooftop rainwater	2	X		low-flow showerheads and faucets , install water meters for reduction measurements	2	X	
	MINIMUM		2		1		2		2
WELLBEING (working environment)	Light	Occupied spaces have daylight, with solar glare control and adequate uniformity (0.3). Daylighting factor: <1.7 (0 points), <1.9% (1 points), <2.1% (2 point), >2.1% (3 points)	1	Worksite office barracks to have daylight, with solar glare control and adequate uniformity (0.3). Daylighting factor: <1.7 (0 points), <1.9% (1 points), <2.1% (2 point), >2.1% (3 points).	1	Monitoring of the daylight rate to optimize the shading system depending on sun.	1	Further changes on the building must increase the existing daylight rate	2

Figure 7.7 - Overview of three topics and the evaluation categories

TEAM 5: ECOSEVA

Carolina Piña Ramírez, Katarzyna Kalinowska-Wichowska, Denisa Petrus, Cristina Jiménez Pulido

Implementing regenerative/sustainable principles is a key approach in applying circular economy criteria to a project. Assessment of buildings in terms of regeneration is difficult, however, there are solutions available to assess the needs of a building and its possibilities for a second life locally.
EcoSeva is a comprehensive application or program that will allow evaluating a building in terms of durability and regeneration.
The aim of the EcoSeva is to design/show an innovative sustainable/regenerative assessment for all types of building projects, that considers the entire building construction process, using a second life approach, and assesses social economic and environmental aspects.
EcoSeva is the application supporting the analysis, done by adopting a specific method and related graphic models. Applying this tool, the performance of the building and how it can be improved in order to extend the building's service life and guarantee its second life can be tested.
EcoSeva is a straightforward application for all project agents to design or assess the building in terms of its performance, consisting of 39 questions, divided into 10 sections. These results graphically to analyse the regenerative level of a project.

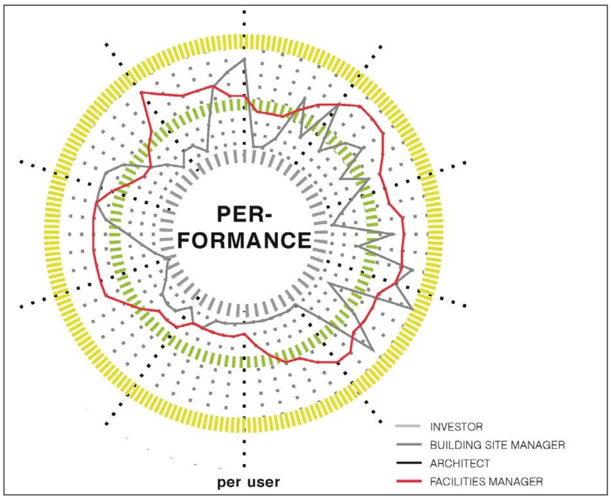

Figure 7.8 - Output graph

EcoSeva has been tested with the case study of the NOI Tech Park building.

The following lines of improvement are proposed:

- Improve the visual aspect of the application.
- Improve the checklist (include more questions and possibilities to answer).
- Add more aspects in application results.
- Develop new outputs.
- Take satisfaction surveys for the improvement of EcoSeva.

ECO-SIVA: From 2nd LIFE APPROACH toward REGENERATIVE BUILDINGS															
TOPICS		QUESTION / STATEMENT	ASSESSMENT CRITERIA EGO | ECO | SEVA ○ | ● | ●●	PROCUREMENT				CONSTRUCTION				OPERATION			
				New buliding	RATE	Existing building	RATE	New buliding	RATE	Existing building	RATE	New buliding	RATE	Existing building	RATE
1	PLACE	Treatment of pollution of the site	○ New pollutant ● No changes ●● Less polluted /decontaminated	○	0	●	0		0		0				0
		Site with no use before	○ New impacts ● Same use ●● Different use and less polluted	●●		N/A									
		Construction plan for no disturb	○ No plan ● Planned ●● Planned already applied			●									
		Environmental cooperation plan	○ No plan ● Planned in the future ●● Already planned			N/A									

Figure 7.9 - Abstract from the tool – category Place

TEAM 6: SRT COLLABORATIVE PLATFORM FOR MATURITY ASSESSMENT

Nevena Simic, Aranzazu Galan Gonzalez, Manuel de Borja Torrejon, Elena Gualandi

Climate change is a fact. We have the responsibility to take all necessary steps to reduce global warming within the next 10 years (IPCC). The construction sector is key to achieving this ambitious goal. However, our current structure is obsolete and has not been prepared to perform at the level now required.

To date, the linear sequence of **pre-construction, construction, maintenance/ operations and end of life** was working to achieve a built environment which was not designed for future thinking. An initial attempt to improve our existing building stock was to define the built environment as an element that could adapt to life changes and was capable of having several lives and functions.
Unfortunately, this is approach is not enough. A radical change is required, changing from a Top-Down approach to a **Bottom-Up approach** where the future of the product is defined at the same level as the initial project requirements. In a top-down approach, the different construction stages are conducted as information silos, where there is little or no knowledge transfer between the different involved agents.
SRT is proposing a **collaborative platform** where an advisory committee representing the four stages is established to work alongside the project from the early decision stages through construction to the operation and maintenance phase, with the second life targets as initial constraints.

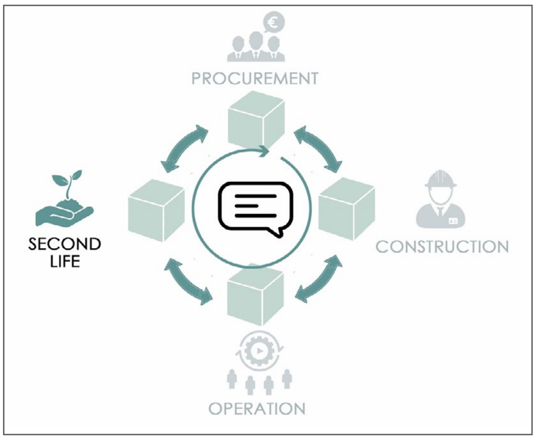

Figure 7.10 - Circular Built Environment Sequence

To achieve the goals and assure the success of the implemented strategies. Communication and common language are core to the **SRT** approach.

SRT is configured as a **matrix** to evaluate the **maturity level** of a project in respect of the nine RESTORE themes: Place, Energy, Water, Wellbeing, Carbon, Resources, Equity, Education and Economics. It is an analytical methodology that seeks to provide optimal strategies to enable the transition of buildings and the built environment from business- as-usual to regenerative.

The nine themes are divided into quantifying criterion that is evaluated regarding the descriptions provided at each level. These descriptions would be supported by the most current available data defining each criterion. The same matrix is used at each of the four stages, with different expected outcomes, with increasing maturity level in the final stages.

The matrix evaluates the current maturity stage and identifies a road map towards a regenerative level using a visual system, easily understood for discussion by all project stakeholders at different hierarchy levels.

In conclusion, SRT is created to be a tool that will allow a common language that needed across the different construction stages and all project stakeholders. The SRT tool, initially, structured as a matrix that would be continuously revised and updated with the last and more updated data of each criterion would readily transfer to a web-based open-source application. In addition, the SRT matrix would quantify the maturity level by providing a grade to be used as a rating system.

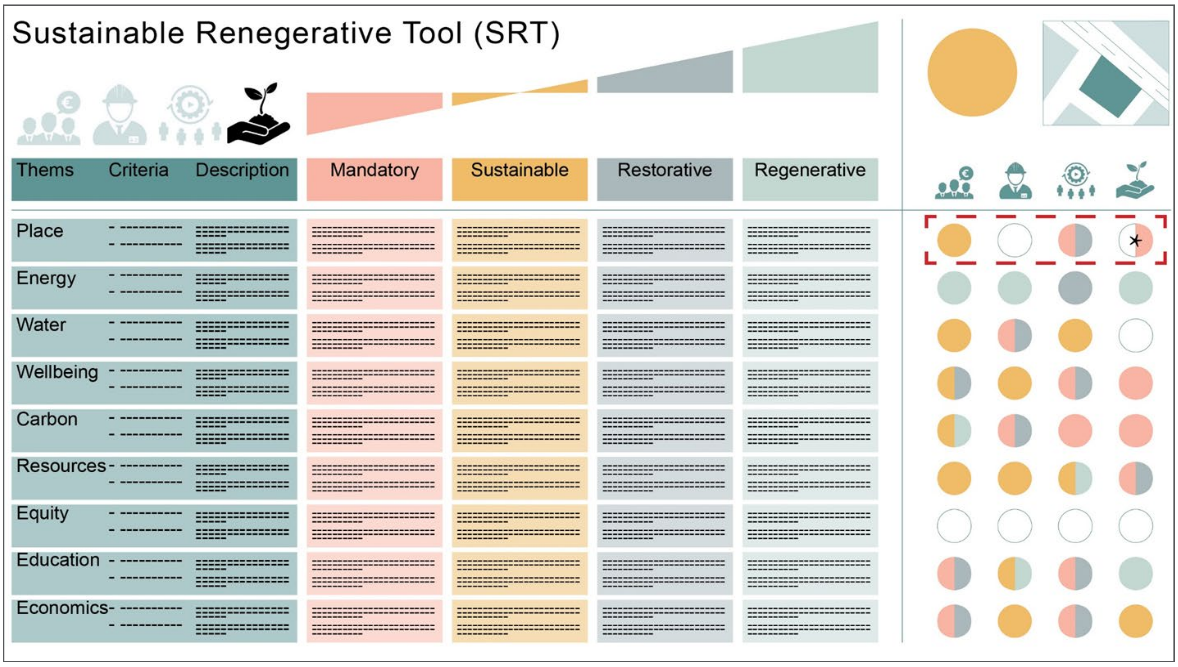

Figure 7.11 - SRT Categories - Evaluation

				Maturity Level			
				Mandatory / Business-as-usua	Sustainable	Restorative	Regenerative
	Indicators	Description	ase to be implement	1	2	3	4
Theme 1: Place	Bioclimatic Design	Design of buildings and spaces (interior – exterior – outdoor) based on local climate, aimed at providing thermal and visual comfort, making use	- Procurement - Construction - Second Life	- Design not linked with initial climate conditions - Design for demolition - Cradle to grave	- Design for disasembly - Simplicity of structure and form - Minimize or eliminate chemical connections	- Place-based design - All stakeholders engaged in the place - Continous learning and feedback	- Support the co-evolution of human and natural systems in a partnered relashionship. - Catalyst of positive change within the unique 'place' - Focused in enhancing life
	Heritage	Heritage sustainability aims for revitalization and readapting using flexible and eco-friendly materials.	- Procurement - Construction - Maintenance/Operations - Second Life	There are no mesures taken related to new materials and reversibility. No strategy adressing second life. Demolition and redevelopmnt.	- Eco-friendly materials are used - Recycling - Initial second life concept - Standarized solutions	- Adaptative Reuse - Increase accessibility and flexibility - hybridization of functions	- Revitalize surrounding - cultural integration - social and ecological systems - regenerate and evolve
	Design	Design of buildings and spaces (interior – exterior – outdoor) based on local climate, aimed at providing thermal and visual comfort, making use of solar energy and other environmental sources.	- Procurement - Construction - Maintenance/Operations - Second Life	- Strictly compliance with the technical country regulations - Compliance with minimum energy targets - Design not related to climate	- eco materials - LCA plan	- Document materials and methods for deconstruction - Material passport - Design Accessible connections - Design for simple forms	- Cradle to cradle materials - Carbon positive footprint - Material Conservation Plan - Plan for deconstruction -

Figure 7.12 - SRT Maturity Levels

8. PEOPLE

EDITORS

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is an architect working as sustainability consultant and team leader for the international engineering company Werner Sobek in Stuttgart/Germany and in particular for its sustainability and energy efficiency department WSGreenTechnologies. Her field of competence is the green building certification, indoor comfort and in particular visual comfort, and project management. With more than 10 years of experience in projects worldwide, one of her commitments is the integration of sustainable and regenerative principles and approaches into the practice, amongst others through consultancy to architects and engineers. She leads the Working Group 3 and was the scientific director of the TS3 in Bolzano.

Carsten K. Druhmann
studied Civil Engineering and Business Sciences and received his doctorate from the University of the Federal Armed Forces in Munich. After around ten years in industry he has been working for twelve years at the Institute for Facility Management (IFM) of the Zurich University of Applied Sciences (ZHAW) and is currently Head of Real Estate Management Competency Group. In numerous applied research and development projects he addresses issues relating to sustainability and digitalization in the real estate industry. He is also co-founder of the Swiss Green Building Council (www.sgni.ch). He is vice leader of Working Group 3.

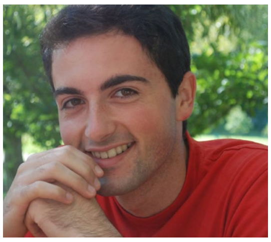
SG 1 - PROCUREMENT

Martin Brown
has over 40 years of experience within the built environment sector, in project management, business improvements and independent sustainability consultancy within the UK and internationally. Martin is a respected expert, thought leader and advocate for sustainability innovation, and his latest book, 'FutuREstorative - Working Towards a New Sustainability' furthers the debate on a new sustainability thinking within the built environment. As a 'Sustainability Provocateur' at Fairsnape, UK, he is committed to enabling success across client, design and contracting organisations with a focus on sustainability, collaborative working and corporate social responsibility. Martin is Vice Chair of RESTORE.

SG 1 - PROCUREMENT - CONTRIBUTION TRAINING SCHOOL

Louise Hamot
is a French architect engineer, currently working as a sustainability consultant & environmental designer. She has a strong understanding and experience in regenerative design, biophilic/biomimicry and integrated processes thanks to her day-to-day work in London at Elementa part of Integral Group but also for having worked on Living Buildings at McLennan Design in Seattle with Jason F. McLennan, founder of the Living Building Challenge. Her architectural and technical culture enables her to have a holistic approach to design. She has developed a passion for materials working recently on different studies about organic materials, whole life carbon and circular economy.

SG 1 - PROCUREMENT - CONTRIBUTION TRAINING SCHOOL



Tudor Iuga
is a Civil Engineer with international experience and a strong passion for sustainability. Constantly seeking better ideas, materials and technologies for proper buildings: with minimum impact on one's health, budget and environment. Currently, he manages Greengineers, a company that offers remote support (mostly focused on BREEAM) for sustainability professionals. With an experience of hundreds of studies and over 550000sqm of sustainable buildings, he helps industry leaders or pioneers through a numerous list of dedicated strategies, studies, analyses as well as sustainability certification consultancy.

Adrian Krężlik
is a trained architect who has worked on a large-scale project all around the world for the most prestigious office such as Zaha Hadid Architects or Michel Rojkind. As a founder of Berlin-based Parametric Support and Architektura Parametryczna he runs research on the application of contemporary sciences such as AI into design processes to enhance its positive impact on the environment.
He is an academic tutor at the School of Form in Poznan and an adjunct at Weißensee Kunsthochschule in Berlin. With Terytoria Kultury collective he has developed the theory of Underperforming Architecture.

Denisa Petrus
is a Rumanian MA architect and enthusiast for sustainability and the effects of design on society and the environment.She reached a complex understanding of architecture throughout various learning platforms in the past 10 years of education and working experience abroad, the specialization course in Sustainable building at Copenhagen University of Engineering has reorganized my mindset and priorities. Nowadays, her work involves a great share of passive design solutions and activism in current environmental concerns.

Anastasia Stella
is an architect-engineer with a strong interest in the integrated design process, buildings sustainability assessment and BIM (Building Information Modelling). She has studied Architectural Engineering at DTU (Technical University of Denmark) and DUTH (Democritus University of Thrace) and she has worked as an architect in Greece and sustainability consultant in Denmark, in Rambøll. In Rambøll she was involved in the development of Life Cycle Engineering, the accountable sustainability in a Life Cycle Perspective, and the development of Green BIM. She is specialized in the integration of BIM and LCA and the use of LCA as a decision-making tool.

SG 2 - CONSTRUCTION

Daniel Friedrich
holds a Bachelor degree in Economics, a Bachelor in Building Project Management, a Master in Business Administration and a Master in Civil Engineering. He has eleven years of industry experience from three manufacturers in product management, marketing, sales and research & development. For six years he is now researcher and lecturer at three Universities and Management Committee Member and Science Communication Manager of the EU COST ACTION CA16114 "RESTORE". He is also recognized reviewer for five scientific Journals and regular congress speaker in the fields of his two current doctoral studies about regenerative building materials and sustainability-driven market regulation.

Odysseas Kontovourkis
is an Assistant Professor and Director of the research laboratory for Digital Developments in Architecture and Prototyping – d2AP in the Department of Architecture of the University of Cyprus. His research aims to explore digital strategies in architectural design and construction towards sustainable growth. Particularly, his work focuses on the development of integrative computational design and fabrication mechanisms through multi-objective analysis, performance-based architectural design and robotic construction of systems according to sustainability criteria. His work has been published in several scientific journals and conference proceedings.

Mercedes del Río Merino
is a Professor at the School of Building Engineering of the Technical University of Madrid in Spain and the Director of the Building Technology and Environment Research Group (TEMA). Her research focuses on sustainable construction and recycled materials, in order to reduce its environmental impact. Her PhD thesis analysed and developed new applications of prefabricated plaster panels lightened and reinforced with E-glass fibre and other additives. She participated in over 40 scientific projects and is currently an MC member of RESTORE Cost Action (CA16114). Her research activity includes scientific articles, national and international conferences and the supervision of PhD thesis.

Blerta Vula Rizvanolli
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Themistoklis Tsalkatidis
obtained his Diploma in Structural Engineering and his PhD in Composite Structures from the Department of Civil Engineering, Aristotle University of Thessaloniki (AUTh), Greece. He is the author of several journal and conference papers and his research interests include but not limited to: Finite element analysis of structures, Contact and interface laws, Sustainability of built environment and Repair and strengthening techniques of existing buildings. He is currently working as Associate Professor of Structural Engineering at Faculty of Science and Technology, Norwegian University of Life Sciences (NMBU). Dr Tsalkatidis is a Management Committee member in COST Actions RESTORE and SARCOS.

Aránzazu Galán González
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SG 2 - CONSTRUCTION - CONTRIBUTION TRAINING SCHOOL

Amit Anafi
is an Architect with a Master degree in Architecture and Urban design from the Polytechnic of Milano. His work experience includes, tutor at the Polytechnic of Milano and Piacenza, designer at the architecture studio Attilio Terragni, a Sustainability Project Account at the Goldman & Partners studio and a Construction Manager for the Italian General Contractor firm Il Prisma. He is qualified as a LEED AP and BIM Manager. He is currently working as a Sustainable Project Manager in the international firm R2M Solution. He is involved in consultancy activity related to LEED, BIM and European Research Projects.

SG 2 - CONSTRUCTION - CONTRIBUTION TRAINING SCHOOL

Alejandra Vidales Barriguete
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Paula Hild
is a PhD candidate at the University of Luxembourg. Her work looks at sustainable practices in companies. She is particularly interested in organisational and institutional dimensions that matter for the circular economy. Before joining the University of Luxembourg, she worked at the Luxembourg Institute of Science and Technology (LIST). There, she was an R&D Engineer in the competence fields of environmental assessment and management, Footprint methodologies, and Life Cycle Assessment (LCA). She holds Master degrees in Civil Engineering from the University of Portsmouth (GB) and in Adult Education from the University of Kaiserslautern (D).

SG 3 - OPERATION

Jelena Bleiziffer
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Ari-Pekka Lassila
works as an Environmental Engineer at University Properties of Finland Ltd. Ari-Pekka is an expert of sustainable development at the perspective of a Finnish property owner. His tasks include setting, measuring and implementing company-level goals related to sustainability.

Suvi Nenonen
is an adjunct professor of real estate and facilities management in Tampere University in Finland. Her research is about people and buildings as well as usable digital and physical working and learning environments. She is especially interested in wellbeing, new ways of working and resilience. Additionally, she works in University Properties of Finland Ltd and co-ordinates the research, development and innovation projects in the company.

SG 3 - OPERATION

Asher Vaturi
is an urban planner and a lecture at Hollon Institute for Technology (HIT). Between 2009 to 2016, he was head of the Sustainability department at The Max Stern Yezreel Valley College in Israel. Dr Vaturi was involved in multidisciplinary research in Israel and Europe, focusing on analysis focal urban developments such as "Perfection" – Performance Indicators for the Built Environment or "Polis" (FP7). In addition to his academic activities on urban strategic developments, smart cities methods, green building and large urban renewable projects, his practical experience has been used to initiate feasibility studies of urban projects and create efficient master plans.

SG 3 - OPERATION - CONTRIBUTION TRAINING SCHOOL

Manuel de-Borja-Torrejon
was born in Spain in 1983. Since his graduation as an Architect in 2009 at Universidad de Sevilla (US) he has worked on several projects focussing on building renovation and energy management. He has combined his professional activity with academic and research development at US (M.Sc. Innovation in Architecture: Technology and Design, 2009-10) and Technical University of Munich (TUM), Germany (M.Sc. ClimaDesign, 2011-13). He currently works as a research and teaching associate at the TUM Chair of Building Technology and Climate Responsive Design and collaborates with the US research group TEP-130 Architecture, Heritage and Sustainability: Acoustics, Lighting and Energy.

Virna Moneró Flores
has a Bachelor's degree in Architecture and a Master of Science in Facility Management. After gaining professional experience as a Project Architect in design and construction projects, she transitioned into Facility Management, motivated by the desire to create more user-oriented buildings. She currently works as a research assistant at the Institute for Facility Management at the ZHAW in Zurich, where she researches how digitalization can add value to the holistic sustainable performance of buildings during their life cycle.

Marta Sabater Forteza-Rey
is a senior architect, working in facilities management in the public sector for the last ten years. She has created the Efficiency Energy and Maintenance Service from scratch for a regional administration in Mallorca (Spain) in which she is now working as the team leader. She recently made her debut as a trainer, trying to convince colleagues, workers, directors and politicians that living in a more sustainable and regenerative way is not just an option, but our duty.

SG 3 - OPERATION - CONTRIBUTION TRAINING SCHOOL

Cristina Jiménez-Pulido
works as a researcher in the Sustainability in Construction and Industry Research Group at Universidad Politécnica de Madrid (giSCI-UPM), where she collaborates in other different activities related to research, teaching, and dissemination. She obtained a Bachelor's Degree in Architecture from UPM in 2005 and a Master's Degree in Advanced Architecture and City Project from the Universidad de Alcalá de Henares (UAH) in 2010. After working as an Architect/Designer for over 12 years, she is currently a PhD candidate of innovation in building conservation and deep renovation management of building stock at UPM.

Marco Delli Paoli
is a young architect and a Professional Master Course's candidate in Environmental Technological Design at the Sapienza University of Rome. During his studies he developed a deep interest in the issues of sustainability and Building Information Modeling, intended both as tools and as approaches to design, experimenting their application in many projects, especially in his graduation thesis and in the international competition Solar Decathlon Middle East, in which he participated in 2018. He is going to focus his studies on these two topics, developing them in a research experience with a PhD, to define new strategies about the restorative design.

SG 4 – SECOND LIFE

Indra Purs
combines economics and finances with the creative industry of landscape architecture. She is a DrArch candidate in Landscape Architecture, holds an MSocSc in Business Administration, a professional BLArch and a BEcon in financial management. She is a board member and delegate of several international associations and groups in the Baltic sea area and the owner of Purs consulting Ltd., dealing with landscape architecture and financial and tax consulting. Her past working experience is in the Centrals Statistical Bureau of Latvia and the EY Latvia. Her research interests and publications are in climate, weather, air, water and circular and regenerative economy.

Stylianos Yiatros
is an Assistant Professor at the Cyprus University of Technology and the EIT Climate-KIC Cyprus Hub Education Lead. He holds and MEng in Civil & Environmental Engineering and a PhD from Imperial College London. He has been a Marie Curie Intra-European Fellow at the Centre of Offshore Renewable Energy Engineering at Cranfield University in the UK. He is interested in the structural integrity and stability of structures, biomimetic design and sustainable development, including Circular Economy. He is one of the Co-founders of Chrysalis LEAP, the first business idea accelerator in Cyprus for cleantech and sustainable development startups.

SG 4 - SECOND LIFE - CONTRIBUTION TRAINING SCHOOL

Elena Gualandi
Architect and PhD Researcher in Environmental technological Design. Elena Gualandi (Rome, 1992) is a European Licensed Architect and a PhD student in Environmental technological Design, based in the "Sapienza" university, in Rome. She studied also in France at "École Nationale Supérieure d'Architecture de Montpellier" and in Spain, at "E.T.S.A.M. – U.P.M." polytechnical university of Madrid, where she began her thesis investigation. In 2016, she graduated with a project of urban retraining and sustainable construction recovery. Since 2017 she has been working with different architectural firms, both in Spain and Italy, focusing on the matter of architectural rehabilitation.

Katarzyna Kalinowska
holds a master's degree from Białystok University of Technology (BUT) in the speciality of Construction and Engineering Structures. In 2018, she obtained a PhD in technical sciences. She is a lecturer at the BUT and interested in concrete technology, methods of recycling, properties of cement composites based on recycled aggregates and mortars, the second life of materials and sustainable construction. She has participated in nearly 50 scientific publications related to the above subjects, participated in several scientific conferences and co-authored a patent. She cooperates with universities in Córdoba and Madrid and works with the industry on the implementation of ecological, innovative technologies for construction.

SRT TOOL - TRAINING SCHOOL

Jonas Manuel Gremmelspacher
is a Master student at Lund University, Sweden, working on the assessment of building retrofits under future-climate scenarios as his Master thesis. He graduated in 2017 as Bachelor of Engineering from the Cooperative State University Baden-Württemberg (DHBW Mosbach), Germany. During his Bachelor studies, he combined theoretical education with his function as a project manager in a mid-sized enterprise specialised in energy-efficient retrofits. Throughout his Master education, he fostered knowledge in the field of energy-efficient and environmental building design. Focusing on building performance simulations led to part-time employment as a teaching assistant at Lund University.

Rafael Campamà Pizarro
is doing research on the assessment of daylight and electric lighting integration in retail stores, in collaboration with Lund University, IKEA and IEA-SHC (Task 61, Subtask D). He worked as a site manager and construction project manager in Spain and France for 12 years, mainly in the public sector. While finishing his master's degree in Sweden, he strengthened his expertise in building performance simulations, which allowed him to work as Assistant Lecturer.
He currently combines academic research with environmental design consultancy in Scandinavia as a specialist in Daylight and Wellbeing in Buildings.

CONTRIBUTION FROM SELECTED SPEAKER TRAINING SCHOOL

Camilla Follini
Is a researcher of the Process Engineering in Construction team at Fraunhofer Italia. Her focus is on applied research in collaboration with companies on automation and innovation of construction processes. She graduated at the Technical University of Munich with a thesis supervised by the Department of Architecture and Mechanical Engineering, while collaborating with a start-up developing a robotic system to automate the construction site. During her studies, she worked as a research assistant at the Chair of Building Realisation and Robotics, where she gained experience in international research projects on construction innovation and Ambient Assisted Living.

Paola Penna
Paola Penna studied Architecture and is a Senior Researcher at Fraunhofer Italia, where she is collaborating with the Department of Process Engineering in Construction. In the recent years Paola worked as Architect freelancer as an energy consultant for an energy refurbishment project. From 2012 to 2016 she collaborated with the Free University of Bozen-Bolzano, where she received her PhD in Sustainable Energy and Technology. She also collaborated with the Department of Architectural Engineering of the University of Colorado, Boulder (CO), USA and the Department of 'Building physics and building ecology' of the Technical University of Vienna.

Regenerative Construction and Operation
Bridging the gap between design and construction, following a Life Cycle Approach consisting of practical approaches for procurement, construction, operation and future life.

This publication is the summary of COST Action RESTORE Working Group Three activities and investigates the implementation in the building sector of the theoretical regenerative concepts and the design approaches developed by the Working Groups One and Two.

The main question Working Group Three faced, is how a building can be built, operated and maintained in a regenerative manner. Barriers can undercut a paradigm shift from the "business as usual" to a regenerative economy, making the realisation of regenerative projects difficult. The need for robust strategies to guide a transition from traditional construction process towards one which incorporates regenerative values is very clear.

This publication collates the thoughts developed by the participants of Working Group Three, investigating and proposing robust approaches helping the paradigm shift, from the procurement and construction to the operation and maintenance phases, considering also Future Life concepts.

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