BUS GoCircular

Shaping a Circular Sustainable Future

Module 1

Circular Economy and its Implementation in the Construction Sector

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Circular Economy in the Construction Industry Summary

BUS GoCircular

Through this module the learner will gain an understanding of what the Circular Economy is in a general sense and what the benefits and barriers are in order to implement this today. They will explore the current situation within Europe and internationally in relation to the Circular Economy and further explore how this relates to the construction industry. Finally the trainer will define Multi-functional Green Roofs Facades and Interiors Elements and explore what the opportunities are when pairing this with Circular Economy.

2

Objectives/Learning Outcomes

BUS GoCircular

The learning outcome for BUS-goCircular can be found here on the https://busgocircular.eu/ website. These Units of Learning Outcomes (ULO's) relate to the circular economy and the implementation of circular skills in the construction industry.

In this module, trainees will gain an understanding of the Circular Economy and Multi-functional Green Roofs Facades and Interior Elements which will then be built upon in future modules.

3

Module Content

BUS GoCircular

- The Circular Economy and its Application in the Construction Sector
  - Introduction to the Circular Economy
  - Circular Economy in the Construction Sector
  - The Key Elements Framework
- Multi-functional Green Roofs Facades and Exterior Elements and the Circular Economy
  - Introduction to Multi-functional Green Roofs Facades and Exterior Elements
  - Types of Green Roofs
  - Benefits of Multi-functional Green Roofs Facades and Exterior Elements

4

The Circular Economy and its Application in the Construction Sector

BUS GoCircular



5

What is A Circular Economy? Overview

BUS GoCircular

In our current economy, we take materials from the Earth, make products from them, and then they become waste. In a Circular Economy, we try to stop waste being produced.

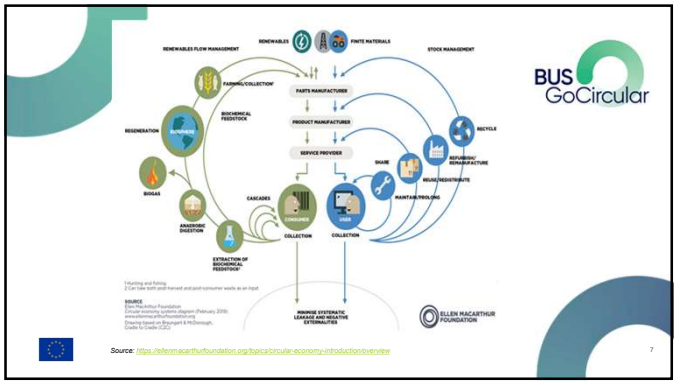
The circular economy is based on three principles, driven by design:

- Eliminate waste and pollution
- Circulate products and materials (at their highest value)
- Regenerate nature

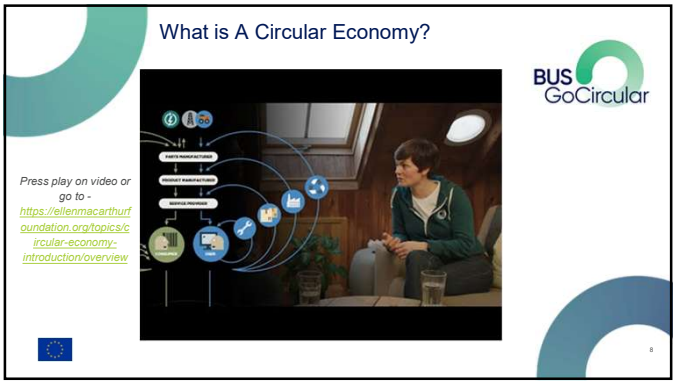
It is underpinned by a transition to renewable energy and materials. A circular economy decouples or brakes the link between economic activity and the consumption of finite resources. It is a resilient system that is good for business, people and the environment.

Source: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview

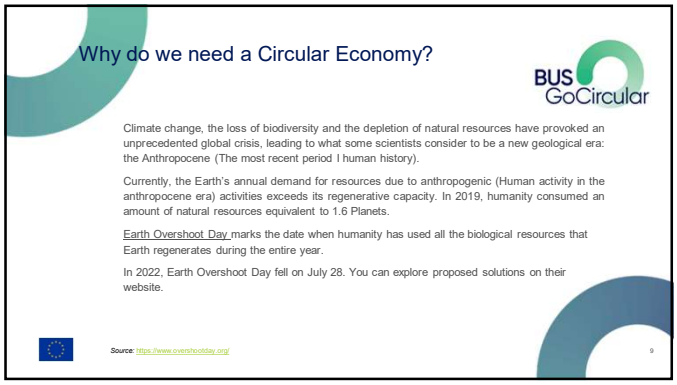
6


RENEWABLES FLOW MANAGEMENT
RENEWABLES
FINITE MATERIALS
STOCK MANAGEMENT
FARMING/COLLECTION
PARTS MANUFACTURER
BIOCHEMICAL FEEDSTOCK
REGENERATION
BIOSPHERE
PRODUCT MANUFACTURER
RECYCLE
SERVICE PROVIDER
REFURBISH/REMANUFACTURE
SHARE
BIOGAS
CASCADES
MAINTAIN/PROLONG
ANAEROBIC DIGESTION
CONSUMER
USER
COLLECTION
COLLECTION
EXTRACTION OF BIOCHEMICAL FEEDSTOCK
MINIMISE SYSTEMATIC LEAKAGE AND NEGATIVE EXTERNALITIES
ELLEN MACARTHUR FOUNDATION
BUS GoCircular
Source: https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
7

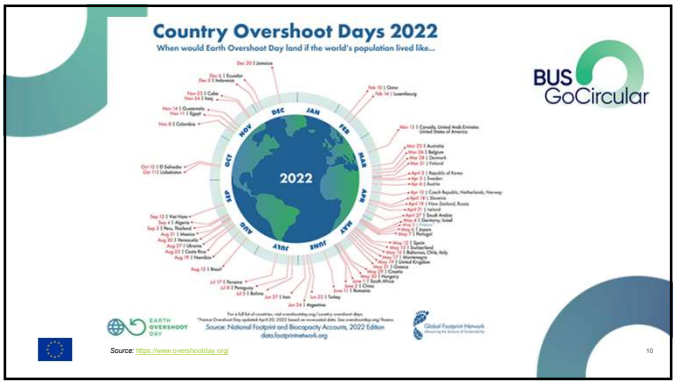
7


What is A Circular Economy?
BUS GoCircular
Press play on video or go to - https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
8

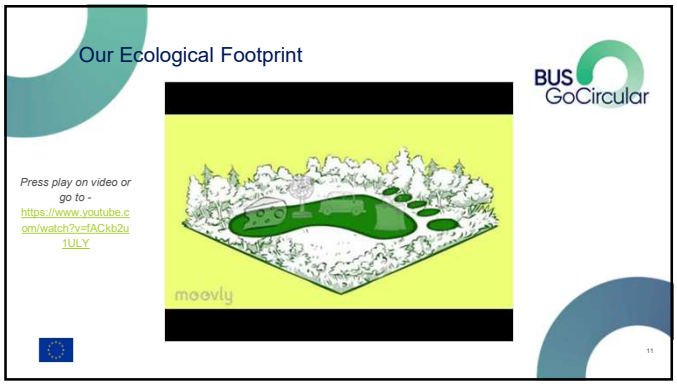
8


Why do we need a Circular Economy?
BUS GoCircular
Climate change, the loss of biodiversity and the depletion of natural resources have provoked an unprecedented global crisis, leading to what some scientists consider to be a new geological era: the Anthropocene (The most recent period I human history).
Currently, the Earth's annual demand for resources due to anthropogenic (Human activity in the anthropocene era) activities exceeds its regenerative capacity. In 2019, humanity consumed an amount of natural resources equivalent to 1.6 Planets.
Earth Overshoot Day marks the date when humanity has used all the biological resources that Earth regenerates during the entire year.
In 2022, Earth Overshoot Day fell on July 28. You can explore proposed solutions on their website.
Source: https://www.overshootday.org/
9

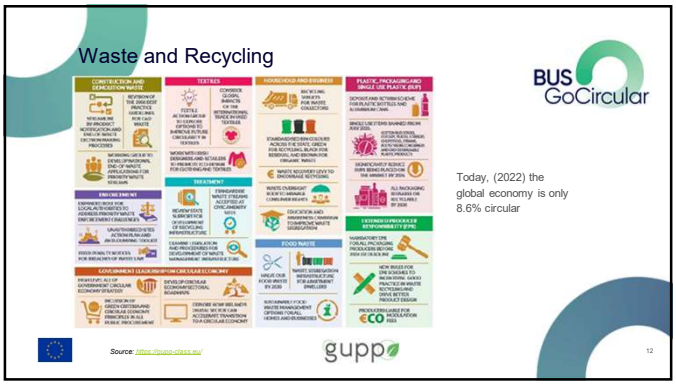
9


Country Overshoot Days 2022
When would Earth Overshoot Day land if the world's population lived like...
BUS GoCircular
2022
Source: National Footprint and Biocapacity Accounts, 2022 Edition
data.footprintnetwork.org
Source: https://www.overshootday.org/
10

10


Our Ecological Footprint
BUS GoCircular
Press play on video or go to - https://www.youtube.com/watch?v=fACkb2u1ULY
moovly
11

11


Waste and Recycling
BUS GoCircular
Today, (2022) the global economy is only 8.6% circular
Source: https://gupp-class.eu/
gupp
12

12

Linear Economy

Circular Economy application is still low which is caused in part, in large part, by the current model of production and consumption, called "linear economy".

This economic system, implemented since the first industrial revolution, is based on the pattern of "produce, use and throw away", under the assumption that natural resources are inexhaustible.

This is the modern day consumer society!

So, what is Linear Economy?



Source: https://gupp-class.eu/

13

13

Linear Economy

The linear model follows a source to grave approach where material is sourced, used to create products, distributed, consumed and then disposed of. This model means that the finite amount of materials we have on the planet are depleting, this poses a severe risk to our environment and leaves a huge amount of waste, leading to pollution across the world.



Source: https://uk.glasdon.com/images/news/linear-economy-graph.jpeg

14

14

Linear Economy

The key learnings were that our current linear economy..

1. The ecological disadvantage of the linear economy is that the production of goods is at the expense of the productivity of our ecosystems. Excessive pressure on these ecosystems jeopardises the provision of essential ecosystem services, such as water, air and soil cleaning
2. Consumes 100 billion tonnes of material annually - a number which has tripled in the last 50 years
3. Emits almost 60 gigatonnes of greenhouse gas emissions - 70% of greenhouse gasses are directly linked to the extraction, handling, and consumption of materials. In other words, our out-of-control consumption patterns and systems are directly linked to the current climate crisis.
4. And of this 100 billion tonnes, only 7.2% is kept in the loop, 92.8% is wasted every year.

Source: Circle Economy and Michelini, Moraes et al., 2017

15

15

The Current 'Linear' Economy . . .

Consumes

100 billion tonnes of materials annually

Tripled in the last 50 years

Emits over 59.1 Gt of GHGs

Expected to hit 80 Gt by 2032

Is only 7.2% circular

Wasting 92.8% of everything we use

Source: Circle Economy

16

16

Circular Economy

The circular economy, as a model of production and consumption, is a more sustainable alternative to the linear economy.

The objective of the circular economy is to achieve more efficient and resilient production and consumption systems, that minimize the use of natural resources and preserve the ones they use within continuous cycles, maintaining or improving their value.

The Circular Economy requires a new approach in the following areas:

- the design of products and services
- management and market models
- how to convert and reuse waste into resources
- national regulations
- the commitment of citizens to change their consumption habits

Source: https://gupp-class.eu/

17

17

A Circular Economy Changes the Way we Produce and Consume Materials

Enabling us to...

1. prevent climate breakdown
2. future-proof businesses
3. create decent and more sustainable jobs

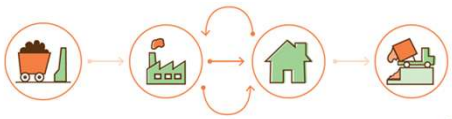
Source: Circle Economy

18

18

Decarbonizing Europe

The decarbonization of European Economy by 2050 is at the core of the European Green Deal adopted at the end of 2019. The implementation of the circular economy will be key to achieving a decarbonised Europe.



Source: GBCE. Circular economy in building 2021

19

19

Type of resources

- Materials
  - including metals, minerals, concrete and wood (timber) used in construction;
- Energy (embodied) and related GHG emissions
  - this is energy used linked to the extraction of materials, manufacturing of construction products, the construction phase itself, construction and demolition, but not energy used directly during the use-phase (see below);
- Water
  - this relates to the full cycle but primarily to water use in buildings. However, quantifications of embodied water have been excluded after thorough investigation of existing literature due to a high level of uncertainty with the figures;
- Land
  - with land we understand direct use of land (land take);
- Biodiversity impacts.

Source: https://ec.europa.eu/environment/eussd/pdf/Resource%20efficiency%20in%20the%20building%20sector.pdf

20

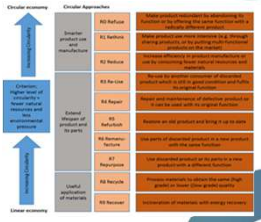
20

9 Rs of Circular Economy

Refuse, Rethink and Reduce (R0 – R2)
- Eliminating waste at the design stage. E.g. designing for disassembly.

Reuse, Repair, Refurbish, Remanufacture, and Repurpose (R3 – R7)
- Extending the lifespan of materials in a building. E.g. reuse of windows

Recycle and Recovery (R8 – R9)
- Applied to building products labelled 'waste' by the industry, requiring technical equipment and energy inputs to create a new value. E.g. recycling concrete by crushing it into rubble for road base



Source: https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FThe-9R-Framework-of-Circular-Approaches-with-the-production-chain-in-order-of-priority_fig5_328662037&psig=AOvVaw1lQEf8buDIefx1WiLrUUG&ust=1670320037396000&source=images&cd=vfe&ved=2CBAQjRqFwoTCPCrEIaIrvwCFQAAAAAdAAAAABAE

21

21

For a circular economy there are 3 principles of action which apply to the building sector

- **Avoiding the generation of waste and pollution by design**
- **Keep products and materials in use for as long as possible**
- **Regenerate natural capital**

Source: https://southernwasteregion.ie/sites/default/files/Circular%20Economy%20Checklist%20Construction%20Designers.pdf

22

22

For a circular economy there are 3 principles of action which apply to the building sector

- **Avoiding the generation of waste and pollution by design**

To achieve this, it is necessary to reduce the amount of raw materials, water and energy needed to meet the needs required at any given time, and prioritize the use of renewable energy and secondary raw materials



Source: https://southernwasteregion.ie/sites/default/files/Circular%20Economy%20Checklist%20Construction%20Designers.pdf

23

23

For a circular economy there are 3 principles of action which apply to the building sector

- **Keep products and materials in use for as long as possible**

To achieve this, efficient management of the resources that are used is essential. The aim is to keep material resources in use for as long as possible and to recirculate them in the value chain as many times as possible through reuse and recycling... Energy recovery should always be the last option and landfill is not envisaged in the framework of Circular Economy.



Source: https://southernwasteregion.ie/sites/default/files/Circular%20Economy%20Checklist%20Construction%20Designers.pdf

24

24

For a circular economy there are 3 principles of action which apply to the building sector

- **Regenerate natural capital**

This principle is essential to guarantee the supply of natural goods and services on which human survival and well-being depends.

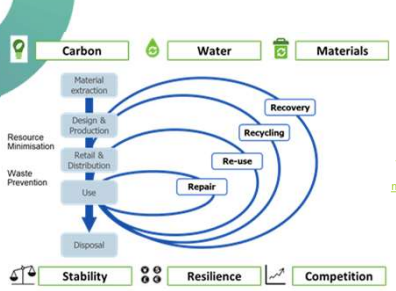
The circular economy is regenerative, and is inspired by natural cycles, where everything that is born and grows returns to its point of origin, the earth, and is born again, forming a constant dynamic balance. In nature there is no "waste", all elements have a function, and are reused and transformed to be used in different stages.



Source: https://southernwasteregion.ie/sites/default/files/Circular%20Economy%20Checklist%20Construction%20Designers.pdf

25

25



More Information: The more detailed Ellen MacArthur Foundation butterfly diagram with nutrient and technical material flows can be found by clicking this link

Source: https://gupp-class.eu/

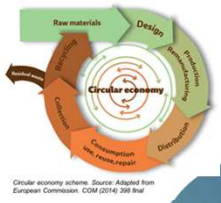
26

26

Circular Economy in the building industry

Not only does Circular Economy provide environmental benefits, it also boosts competitiveness and employment generation, with the creation of new business opportunities and innovation in products and services.

Key to achieving circularity is implementing digitalization and new technologies.



Circular economy scheme. Source: Adapted from European Commission. COM (2014) 398 final

27

27

Impacts

Raw material extraction and material processing is responsible for 90% of biodiversity loss and water stress.

We need to make sustainable products, services and business models the norm and transform consumption patterns so that no waste is produced in the first place.



Source: https://www.un.org/en/actnow/facts-and-figures#:~:text=The%20extraction%20and%20processing%20of,keep%20up%20with%20our%20demands.

28

28

Learn more!

- You can find more information about the theories on which the circular economy is based on the following website:
- In this website you will find 8 videos that explain the circular economy.
- In this link you will find the film "closing the loop", with comments from world experts, as well as innovative cases of circular economy.

29

29

The Challenge

The need for a Circular Built Environment

Construction materials are the biggest portion of the volume of materials consumed in most cities.

Despite high demands for concrete, steel, bricks and wood only 13% of these input materials originate from secondary and renewable sources.

Moreover, buildings generate nearly 40% of annual global CO2 emissions.



Source: Circle Economy

30

30

Why Care?

Why do we currently continue to mine, produce, and transport all materials from mines around the world, when there are abundant sources throughout the city to cover part of this demand?

However the most important barrier to tackle is the lack of information on what recoverable materials are present and what their value in reuse could be.



Source: Circle Economy

31

31

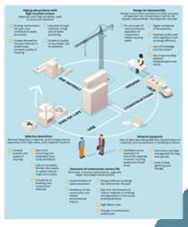
What Needs to Happen? From current state to ideal state

Against a backdrop of bold ambitions and an increasing number of policies focused on the sector

- Real on-the-ground action is limited and scattered
- Collaboration is not happening at scale
- Investments are lacking and demand needs to increase

In short, we need a holistic strategy that aims at:

- Increasing awareness and scaling of the available opportunities
- Increasing knowledge exchange and collaboration
- Strengthening demand and investment in available solutions



Source: Circle Economy

32

32

Circular Economy in the Construction Sector

The construction sector provides infrastructures, urban spaces and buildings on which all other sectors rely on, and is therefore a key sector for European economic and social development, generating 18 million direct jobs.

In the construction sector, as in the rest of the sectors, moving from a linear model of open cycles to a circular model, of closed cycles, requires a complete systemic change.

The circular model is a sustainable model which can provide important benefits for the environment, as well as new employment and business opportunities in the sector. In the long term, all this has an impact on improving the environment, the health and well-being of users, increasing productivity, and saving costs.

Source: https://gupp-iclass.eu/

33

33



Integrating the principles of the Circular Economy in the construction sector involves addressing different levels: material, component, product, system, building, city and territory.

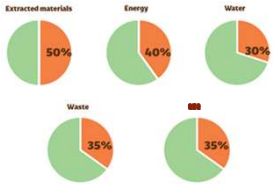
Source: https://gupp-iclass.eu/

34

34

Impact

In Europe, in recent years, the data on the impact of the construction sector are as follows:



Impacts of the construction sector in Europe. Data source: Eurostat 2016 data. Green Building Council Spain. 2021. Report on circular economy in building in Spain[TS2]

Source: https://gupp-iclass.eu/

35

35

Climate Change and Building Stock

- In 2010, the world's buildings accounted for 32% of global final energy use amd 19% of all greenhouse gas (GHG) emissions.
- If we continue as usual the projections for use of energy in buildings globally could double or even triple by 2050.
- Even if emissions are immediately stopped, temperatures will remain elevated for centuries to come, due to the effect of greenhouse gases in the atmosphere from previous human impact.



Source: Google image search

Source: Fit-to-NZEB: Ecology & Sustainability

36

36

Climate Change and Building Stock

- Limiting the rise in temperature will require substantial and sustained reductions of greenhouse gas emissions.
- Buildings face major risk of damage from the projected impacts of climate change, having already experienced a big increase in extreme weather damage in recent decades. There is likely to be significant regional variation in the intensity and nature of such impact.

Source: Fit-to-NZEB: Ecology & Sustainability

37

37

Life Cycle

The standard EN 15798:2011 (sustainability of construction works) establishes, in a generic way, the stages of the life cycle of construction.

The four stages are:

1. Product Stage
2. Construction Stage
3. Use Stage
4. End-of-Life Stage

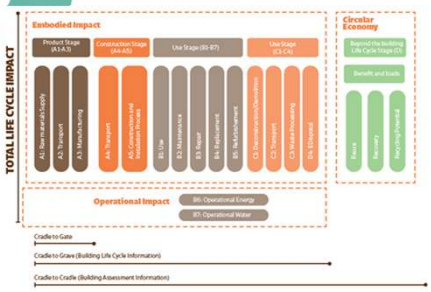
Each stage has different effects on the environment, which depend on factors such as: the characteristics of the surroundings, the materials and construction techniques used, the energy and water consumed, the waste generated, etc.



Source: https://gupp-iclass.eu/

38

38



Source: https://gupp-iclass.eu/

39

39

Production Stage

In the production stage, raw materials are extracted, transported and processed into building materials. This stage generates significant negative environmental impacts. Many minerals and rocks are extracted in open-pit quarries and gravel pits, which implies, in the area of action, the elimination of vegetation, the loss of the organic matter layer of the soil and its exposure to erosion.
For example, cement manufacturing generates approximately 8% of the world's CO2 emissions. Sixty % of these emissions are due to chemical reactions during the process.



Cement factory
Source: Green Growth Project

Source: https://gupp-iclass.eu/

40

40

Construction Stage

In the construction stage the building takes shape and many agents are involved (city council, architects, builders, etc,.).
This stage includes the transport of materials to the site and the construction and installation process, and involves the environmental impact caused by the implantation of the building in the territory, the consumption of a large amount of materials, water and energy, as well as the production of waste from discarded materials, packaging, etc,.



Image source: Google images

Source: https://gupp-iclass.eu/

41

41

Use Stage

The use and maintenance stage of the building is the longest-lived stage. It includes maintenance, repair and renovation.
It is associated with the consumption of water, operational energy, and the emission of pollutant gases as a consequence of the consumption of energy from fossil fuels. The construction of energy efficient buildings and the integration of local renewable energy systems, at building or neighbourhood level, significantly reduces the consumption of non-renewable energy. This is the case for near-zero energy buildings (NZEB).
At this stage, circular strategies such as repair and refurbishment extend the life of the building.



Image source: Google images

Source: https://gupp-iclass.eu/

42

42

End-of-life (Deconstruction) Stage

The end-of-life stage in a linear economy is the demolition process, where materials become waste. The possibility of reinsertion into the value chain of materials at the end of their useful life depends on:

- the type of materials and construction systems chosen in the design phase, and
- the way in which demolition and waste management are carried out.

In this phase, the environmental impact is related to the burning of fossil fuels from machinery and transport, as well as emissions related to landfill disposal.



Image source: Google images

Source: https://gupp-iclass.eu/

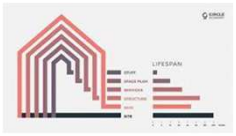
43

43

Building in layers

One technique to help envisage how to do this is to think of your project in layers and within each layer there are different opportunities:

- The site should be reused continuously.
- The structure should last as long as possible.
- The skin and services should be accessible and replaceable.
- The space plan should be flexible and adaptable.
- The stuff should be durable and reusable.



Source: https://www.circle-economy.com/resources/new-financing-needed-to-accelerate-circular-built-environment

Source: https://drive.google.com/file/d/1kO6DhVUIsmICevjrKGoDLfrQTWUBpXd/view

44

44

Tools to measure circularity in construction

"What cannot be measured cannot be improved". Therefore, a series of tools have been designed to measure and compare in a quantitative and verifiable way the environmental performance buildings and materials, and others to monitor the circular economy in the construction sector, these are:

1. Life Cycle Assessment (LCA)
2. Environmental Product Declarations (EPDs)
3. Level(s)
4. Material Passports
5. Cradle to Cradle Certification

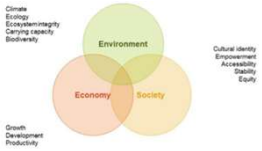
Source: Green Growth Project

45

45

National & International Building Codes

1. "[A]green economy [is] one that results in improved human well-being and social equality, while significantly reducing environmental risks and ecological scarcities", Green Jobs Report (UNEP,2008) and the Green Economics Report (UNEP, 2011a).
2. No country is the pan-European region has yet produced an assessment specifically focused on the green economy. Nonetheless, many countries are developing broad strategies for greening the economy, or have undertaken sectoral or topic-based assessments.
3. UN Environment Green Economy Initiates (GEI), a programme of global research and country-level assistance designed to motivate policymakers to support environmental investments.



Source: https://gupp-iclass.eu/

46

46

Targets and Reporting

Establishing targets and reporting structures to help achieve the client vision needs to be mandated through the procurement process in a relevant and proportionate manner. To do this, clients should embed the requirements into project-specific briefs/statements, and in the design team and contractor tendering process i.e. Pre-Qualification Questionnaire (PQQ) and Invitation to Tender (ITT) and the main construction contract (general conditions).



Source: https://www.metabolic.nl/wp-content/uploads/2019/02/roadmap_circular_land_tendering.pdf

Source: https://southernwasteregion.ie/content/circular-economy-checklists-construction

47

47

Targets and Reporting

Planned actions, metrics and targeted outcomes should be communicated between the client and contractor and passed down through the supply chain (including design and consultancy teams, sub-contractors, waste management contractors and material suppliers) and across all project phases – from option identification and preliminary/outline design through to project completion and whole-life management.

Taking this approach gives a legal standing to the targets and will create binding key performance indicators that gives the client recourse should these targets not be met. A robust monitoring and reporting process will be needed to follow progress and achievements against the targets and reported at key stages within the project.

Source: https://southernwasteregion.ie/content/circular-economy-checklists-construction

48

48

Further reading

Irish Green Building Council (IGBC) - Towards a circular economy in construction: Assessing low carbon, healthy, responsible products for the construction sector

https://www.igbc.ie/wp-content/uploads/2018/06/IGBC-Report-Web-Final-21.06.18.pdf

UK Green Building Council (UKGBC) - Circular economy guidance for construction clients: How to practically apply circular economy principles at the project brief stage

https://www.ukgbc.org/ukgbc-work/circular-economy-guidance-for-construction-clients-how-to-practically-apply-circular-economy-principles-at-the-project-brief-stage/

Circular Economy Implementation Packs for Products as a Service and Reuse

https://www.ukgbc.org/ukgbc-work/circular-economy-implementation-packs/

49

49

Further reading

Zero Waste Scotland - Construction Resources For a Circular Economy Procuring resource efficient construction projects

https://zerowastescotland.org.uk/content/procuring-resource-efficient-construction-projects

ARUP - Circular Economy in the Built Environment

https://www.arup.com/perspectives/publications/research/section/circular-economy-in-the-built-environment

50

50

Key Elements

The Key Elements framework is a conceptual framework of eight elements of circularity that can be applied at different intervention levels (for example, national, regional, sector, business, product, process, or material) towards a circular economy.

The KE framework consists of three core elements and five enabling elements. Core elements deal with physical flows directly, whilst enabling elements deal with creating the conditions or removing barriers, for a circular transition.

https://www.circle-economy.com/resources/the-key-elements-of-the-circular-economy-framework#:~:text=WHAT%20IS%20IT%3F,material)%20towards%20a%20circular%20economy.

51

51

Core Elements



Prioritise Regenerative Resources

Stretch the Lifetime

Use Waste as a Resource

Source: https://www.circle-economy.com/resources/the-key-elements-of-the-circular-economy-framework#:~:text=WHAT%20IS%20IT%3F,material)%20towards%20a%20circular%20economy.

52

52

PRIORITISE REGENERATIVE RESOURCES

Ensure renewable, reusable, non-toxic resources are utilised as materials and energy in an efficient way.



Keywords:

alternative bio-based materials ◦ reusable materials ◦ non-toxic materials ◦ non-critical materials ◦ material efficiency ◦ alternative water use ◦ water efficiency ◦ renewable energy ◦ energy efficiency electrification ◦ recyclable materials

Example on water efficiency:
Berlin (Germany) is becoming a sponge city, simply put, it promotes natural measures that allow the water system of the city to operate more naturally through green infrastructure projects. .
Find out more!

53

53

STRETCH THE LIFETIME

Maintain, repair and upgrade resources in use to maximise their lifetime and give them a second life through take-back strategies, where applicable.



Keywords:
upgradeability ◦ maintenance & (self) repair ◦ take-back systems ◦ secondary materials ◦ adaptive reuse ◦ refurbishment ◦ remanufacturing ◦ part or component recovery ◦ preservation & conservation

Example on adaptive reuse:
Four immense disused gasometers in Vienna were successfully revamped into apartment blocks and commercial space as the structures were too beautiful to be demolished.

Find out more!

54

54

USE WASTE AS A RESOURCE

Utilise waste streams as a source of secondary resources and recover waste for reuse and recycling.



Keywords:
reuse ◦ repurposing into new products ◦ using already recycled materials ◦ recovery and reuse of waste energy ◦ mechanical recycling ◦ chemical recycling ◦ open loop ◦ closed loop

Example on reuse:
The Resource Rows is using upcycled bricks and waste wood, a recycled concrete beam used as a bridge and old windows and waste wood as rooftop community gardens huts with an atmosphere of allotment gardens.
Find out more!

55

55

Enabling Elements



- Design for the Future
- Rethink the Business Model
- Incorporate Digital Technology
- Team Up to Create Joint Value
- Strengthen and Advance Knowledge

BUS GoCircular

Source: https://www.circle-economy.com/resources/the-key-elements-of-the-circular-economy-framework#:~:text=WHAT%20IS%20IT%3F,material)%20towards%20a%20circular%20economy.

56

56

DESIGN FOR THE FUTURE

Adopt a systemic perspective during the design process, to employ the right materials for appropriate lifetime and extended future use and optimal recovery.



Keywords:
modularity ◦ dis- & reassembly ◦ reuse ◦ physical durability ◦ standardization & compatibility ◦ maintenance & repair ◦ adaptability & upgradability ◦ material recycling ◦ biodegradability ◦ mono-materials ◦ emotional durability ◦ design for reverse systems

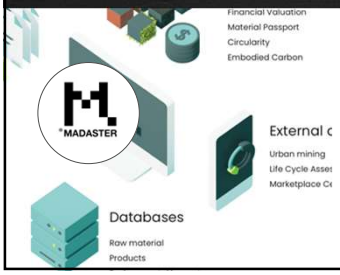
Example on design for disassembly:
The temporary courthouse building has been designed with a well adaptable configuration of parts that can be easily assembled and disassembled , to render the structure as customizable and circular as possible.
Find out more!

57

57

INCORPORATE DIGITAL TECHNOLOGIES

Track and optimise resource use and strengthen connections between supply-chain actors through digital, online platforms and technologies.



Keywords:
data analytics ◦ data modelling ◦ internet enabled, connected operations ◦ sensors, monitoring systems ◦ additive manufacturing ◦ artificial intelligence ◦ online platforms ◦ peer-to-peer online marketplaces ◦ Material passports

Example on material passport:
Madaster is the online library of information on materials and products that provides insight into the materials and products used and their location, as well as their impact on circularity and the environment.
Find out more!

58

58

RETHINK THE BUSINESS MODEL

Consider opportunities to create greater value and align incentives through business models that build on the interaction between products and services.



Keywords:
sale of durable, long-lasting goods ◦ sale of exchangeable parts ◦ peer to peer sharing or resale ◦ leasing ◦ rental ◦ pay per use ◦ crowd-based services ◦ subscription based products and services

Example on product-as-a-service:
Chainable supplies modular and circular kitchen for residential projects through a circular business model: Kitchen-as-a-service to ensure a circular supply chain.

Find out more!

59

59

TEAM UP TO CREATE JOINT VALUE

Work together throughout the supply chain, internally within organisations and with the public sector to increase transparency and create shared value.



Keywords:
Internal collaboration ◦ industry collaboration ◦ government collaboration ◦ community collaboration ◦ industrial symbiosis

Example on industrial symbiosis:
The 30 meters of plastic bike path contain recycled plastic equivalent to more than 218.000 plastic cups or 500.000 plastic bottle caps. An example of collaboration between bottle and construction supply chain.

Find out more!

60

60

STRENGTHEN AND ADVANCE KNOWLEDGE

CIRCLE ECONOMY

Develop research, encourage innovation networks, structure and disseminate information with integrity.



Keywords:
education ◦ curriculum ◦ knowledge management ◦ research and development ◦ communication and awareness ◦ co-creation ◦ living labs

Example on co-creation:
Digital solutions for smart urban mobility, energy efficiency, sustainable housing, digital public services, and civic-led governance. Through co-creation with citizens, the aim is to bring the economic and social benefits of this transformation to all local communities.
Find out more!

61

61

BUS GoCircular

MGRFIE - Multifunctional Green Roofs Facades and Interior Elements

Presentation

62

62

What are MGRFIE

BUS GoCircular

MGRFIE - Multifunctional Green Roofs Facades and Interior Elements

A green roof or living roof is a roof of a building that is partially or completely covered with vegetation and a growing medium, planted over a waterproofing membrane. MGRFIE encompasses green roofs, facades and interior elements that can involve several other uses such as, energy and water collection and storage and accessibility for public and private use.

63

63

What are Green Roofs?

BUS GoCircular

Green Roofs are made up of layers that create an environment suitable for vegetation to grow. They are becoming increasingly important as a mechanism in attenuating stormwater run-off from sites.



Examples of Extensive Green Roofs

Source: https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

64

64

Types of Green Roofs

BUS GoCircular

There are two main types of Green Roof – Intensive and Extensive.

- Intensive Green Roofs or Roof gardens provide similar benefits as a small urban park. They have a deep layer of soil, which can support a range of plants, trees and shrubs. Native species (plants which would grow naturally in the local area) can provide a rich habitat for wildlife. Intensive Green Roofs are designed to include access for people. These Roofs may require regular maintenance.



Intensive Green Roof

Source: https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

65

65

Types of Green Roofs

BUS GoCircular

- Extensive Green Roofs are more lightweight with a shallow soil layer and are not normally designed to provide access for people. They need little maintenance. There are three main types of Extensive Green Roof.
  - Extensive Green Roofs, which are made up of sedum or vegetated mats – fabric mats that are prepared before the Green Roof is built. The mats are sprinkled with sedum cuttings. These are then left in appropriate conditions to grow into the fabric mat. Once the mats are ready, they are rolled up and delivered to the construction site and laid down on to the roof.
  - Extensive Green Roofs where a soil layer is laid down and then planted directly with small plants. These plants (often sedum) will have been grown in small pots. They are often known as plug plants.
  - Extensive Green Roofs where the soil layer is laid down and then planted with seeds (which are suitable for the local environment), this type of roof is often known as biodiverse or Brown Roof.



Extensive Green Roof | Semi Intensive Green Roof

Source: https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

66

66

Green Roofs



Maintenance	Low	Periodically	High
Irrigation	No	Periodically	Regularly
Plant communities	Moss-Sedum-Herbs and Grasses	Grass-Herbs and Shrubs	Lawn or Perennials, Shrubs and Trees
System build-up height	60 - 200 mm	120 - 250 mm	150 - 400 mm on underground garages > 1000 mm
Weight	60 - 150 kg/m²	120 - 200 kg/m²	180 - 500 kg/m²
Costs	Low	Middle	High
Use	Ecological protection layer	Designed Green Roof	Park like garden

67

Green walls



68

Green roof/facades benefits

- Reduction of Urban Heat Island and improvement of urban microclimate
- Water retention
- Thermal Performance
- Air Quality
- Sound Insulation
- Biodiversity
- Amenity Space
- Urban Agriculture
- Protection of Waterproofing
- Protection of Building Stock





69

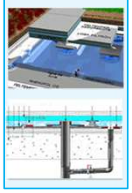
Types of Multifunctional green roofs, façades, and interior elements

FUNCTION ⇨ BY COLOUR - CODE

GREEN
Vegetation (from moss, grass to trees) and horticulture



BLUE
Water retention and harvesting



YELLOW
Generate sustainable energy (power or heat)



RED
Used for social functions



GREY
Host technical functions



70

Green + Red



Green + Grey



Blue + Green



Green + Grey + Red



Green + Red



Green roof gardens



71

Solar green roofs



Solar green facades



Rooftop and/or Facade root wastewater treatment plant





Green + Yellow + Red





72

Interior green walls (living walls)

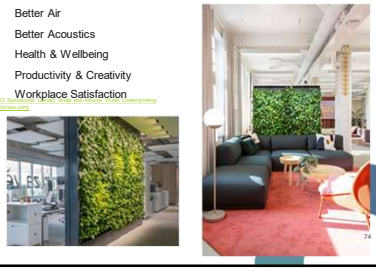


73

Benefits of interior green walls



- Better Air
- Better Acoustics
- Health & Wellbeing
- Productivity & Creativity
- Workplace Satisfaction



74

Design Considerations

- Planning Consent/Permission
- Access
- Manufacturers
- Biodiversity
- Fire Risk
- Maintenance
- Roof Pitch
- Capacity & Space

Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

75

75

Design Considerations

Planning Consent/Permission:

- Designing green roofs in a development may gain support which can help to secure planning consent.

Access:

- As with all roofs, maintenance is required and therefore access must be considered. It is important to design for ease of access to all types of green roofs, as all green roofs require some degree of maintenance. While extensive green roofs require less maintenance than intensive roofs, there are still routine cleaning and clearing that needs to be done.



Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

76

76

Design Considerations

Manufacturers:

- It's best practice to include them in the design process as industry experts can advise you on the specifics of thermal performance, drainage, loading and other factors.

Biodiversity:

- Understanding the desired biodiversity and habitat is a major factor in selecting a green roof system. A general understanding of the bioregion, species requirements and planting can help inform clients which system makes the most sense. Biodiversity is also closely tied to everything from water management to insulation. When designing for this, consider a range of elements like deeper soils, un-vegetated areas, hard surfaces, as well as varying depths and composition of substrate.

Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

77

77

Design Considerations

Fire Risk:

- Dry vegetation on green roofs has the potential to catch fire. Consider a variety of factors when selecting your system: pebble or concrete paving, vegetation barriers around roof penetrations, routine maintenance to reduce the fire hazard, and try to make sure that green roof substrate does not contain a high volume of organic content.

Maintenance:

- The maintenance schedule should be considered during the design process.



Caixa Forum Museum

Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

78

78

Structure of a Green Roof - in general

Roof Pitch:

- Any pitch can be greened, over 45 degrees is considered a living walls. A pitched roof reduces the risk of water penetrating the roof structure.

Capacity & Space:

- The roof can often be the space where major building systems are specified. As a rule of thumb, extensive green roofs usually support 10-25 pounds of vegetation per square foot, while intensive roofs support 80-150 pounds of vegetation per square foot.

Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

79

79

Structure of a Green Roof - in general

Usually, a Green Roof has a waterproof membrane at the bottom to protect the building from leaks. There is then an insulation layer and another protective layer, which will prevent damage from any penetrating roots, or other structural movement.

A drainage layer is then put down over the insulation layer and the protective layer. The drainage layer can be made of lightweight gravel or light granulated clay. It helps to keep air in the Green Roof and soaks up any extra water. The drainage layer can also help store water for the plants to use at a later time. For maintenance purposes, it is important that the drainage points can be accessed from above.

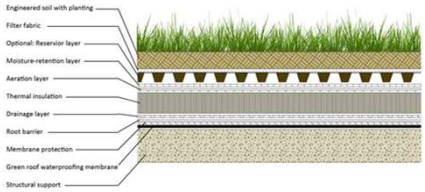
On top of the drainage layer, a filter mat may be installed to allow water to soak through. This will also prevent the fine soil from eroding. The top layers of a Green Roof system include the soil layer (or substrate), plants and a wind blanket. The soil layer is made up of a lightweight material (for example, crushed clay bricks, clay granules etc) and will help with drainage as well as providing nutrients to the plants. The wind blanket protects the soil layer until the roots of the plants take hold.

Source: https://www.dtcoco.ie/sites/default/files/atoms/files/appendix16.pdf

80

80

Structure of a Green Roof - in general



Source: https://architizer.com/blog/product-guides/product-guide/green-roofs/

81

81

The Benefits of Installing Green Roofs, facades and interior elements

Green Roofs can be designed to give a wide range of benefits. These include:

- Reducing the amount of surface water running off the Roof and so reducing the risk of flooding. Completed projects show a reduced annual run-off of at least 40% and up to 60-70%. In some cases, for Intensive Green Roofs, the water retention can be up to 90%.
- Providing habitat, shelter and feeding opportunities for wildlife(especially in built up areas).
- Contribute to sustainable drainage systems and water quality improvement.
- Helping to meet the targets of our biodiversity action plan.
- Improving the character and appearance of the building and the wider area.
- Offering an opportunity to boost the environmental credentials of a business.
- Providing extra heat and noise insulation.
- Keeping the building cool in the summer.
- Increasing the lifespan of the Roof membrane.
- Helping to reduce the amount of dust and pollutants in the air.
- Creating new open space for relaxation, providing potential for the creation of usable green spaces.

Source: https://www.dtcoco.ie/sites/default/files/atoms/files/appendix16.pdf

82

82

Further Reading

Green & Blue Roof Guide 2021, DCC - Irish Green and Blue roof guidelines for Dublin city

https://www.dublincity.ie/sites/default/files/2021-12/dcc-green-blue-roof-guide-2021.pdf

A guide to GREEN roofs, walls and facades, Victoria, Australia - Growing Green Guide, guide to green roofs, walls and facades.

https://202020vision.com.au/media/41918/growing_green_guide_ebook_130214.pdf

Regularly updated Green Roofs Database

https://www.greenroofs.com/

European Federation of Green Roof & Wall Associations

https://efb-greenroof.eu/

83

83

QUIZ/ASSIGNMENT/ACTIVITY



Assessment / Exam

84

84

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

85

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

86

BUS GoCircular

Shaping a Circular Sustainable Future

Module 2

Implementing Circular Practice in the Design, Build and Deconstruction Phase of Construction

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summary

The trainee must gain a good understanding of what opportunities for circular economy are available to them in all phases of the construction process such as reuse, adaptability, modular design and implementation. They must also be able to clearly see the benefits to their work and how this can improve the quality of buildings. They should also gain a good understanding of how this can then be implemented in Multi-functional Green Roofs Facades and Interiors Elements.

2

2

Objectives/Learning Outcomes

- 27 - Design products so they use as little material, water, energy, etc. as possible during use phase
- 28 - Design modular structures for multifunctional green roofs, façades, and interior elements, so that the components can be disassembled and reused after end of service life
- 29 - Design multifunctional green roofs, façades, and interior elements to enable reuse and recycling
- 54 - Integrate multi-functionality into buildings by making use of roofs and façades
- 60 - Assemble modular structures for multifunctional green roofs, façades, and interior elements

3

3

Objectives/Learning Outcomes

- 65 - Disassemble modular structures from multifunctional green roofs, façades, and interior elements for reuse
- 61 - Conduct a feasibility study to, if applicable, prioritise renovation, minimise used surface, and minimise the total mass of materials to be used
- 76 - Operate multifunctional roofs in a clever manner that suits the current situation best, looking further than solely the original design to optimise sustainability and circularity

4

4

Module Content

- Modular and Adaptable Design and Construction
- Design For Disassembly (DfD)
- Product-as-a-service (Paas)
- Design and build Multi-functional Green Roofs Facades and Exterior Elements

5

5

Modular and Adaptable Design and Construction

Presentation

6

6

Adaptable Design

Adaptive as the name suggests means CHANGING.

Changing according to the needs of surrounding architecture is the essence of adaptive architecture. Adaptive architecture is a framework which changes its structure, behaviour or resources according to request and need.

It is a multi-disciplinary approach concerned with buildings that are totally driven by internal data and also building those are designed to adapt to their environments, their inhabitants and objects.

Source- https://sovereignarchitects.com/2015/05/16/adaptive-architecture/

7

7

Benefits of Adaptable Design

- An adaptable home will allow people to remain in their homes throughout aging, injury, or illness, while also providing accessibility for unexpected disabilities that might occur later in life.
- An adaptably designed home that allows you to stay in your home for a longer period of time will let homeowners enjoy the savings that often come with sustainable and energy-efficient upgrades and investments. For example, a solar PV system might take about a decade to pay off through your monthly energy bill savings. Since solar systems can easily last for over 25 years, staying in your home for a longer period can enable you to enjoy extended economic benefits.
- Flexible home design can also allow homeowners to generate income later in life through rental or subletting.

Source- https://www.buildwithrise.com/stories/adaptable-design-how-to-build-a-home-for-a-lifetime

8

8

Modular Construction

- Modular construction is a way of building through the use of modular parts that are constructed in a factory and assembled on-site.
- Modular units can be used for any type of application, from entire houses to apartments to mobile site units, and more recently, home offices.



LEAN-
a way to do
"more and
more,
with
less and
less".

Source: https://gupp-class.eu/

9

9

What is modular construction

Modular construction is a process in which a building is constructed off-site, under controlled plant conditions, using the same materials and designing to the same codes and standards as conventionally built facilities – but in about half the time. Buildings are produced in "modules" that when put together on site, reflect the identical design intent and specifications of the most sophisticated site-built facility – without compromise.



Source-https://www.chapmantaylor.com/insights/what-is-modular-construction-and-why-does-chapman-taylor-embrace-it

Source- https://www.modular.org/what-is-modular-construction/

10

10

Advantages of modular constructions



Source- https://www.koma-modular.cz/en/modularity

11

11

Advantages of modular constructions

LINE QUALITY

Most production is carried out under constant climatic conditions in a production hall. Fully digitized production enables line quality to be achieved thanks to the control system.

Source- https://www.koma-modular.cz/en/modularity

12

12

Advantages of modular constructions

FIXED PRICE

The economic benefits are not only based on the speed of modular construction. Line production also means control over the price of a product. As a result, the price you agree to when awarding the contract is the price you actually pay for the construction.

Source- https://www.koma-modular.cz/en/modularity

13

13

Advantages of modular constructions

SPEED

Thanks to the preparation of modules, including the equipment in the production hall, the building will be erected on site in a matter of hours and is effectively ready for use.

Source- https://www.koma-modular.cz/en/modularity

14

14

Advantages of modular constructions

DISASSEMBILITY

A modular object can later be disassembled into individual modules and re-implemented to meet the needs of another object.

Source- https://www.koma-modular.cz/en/modularity

15

15

Advantages of modular constructions

FLEXIBILITY

Modular buildings can respond to the current needs of the owner and can be expanded. For example two additional floors could be added.

Source- https://www.koma-modular.cz/en/modularity

16

16

Advantages of modular constructions

ENVIRONMENTAL PROTECTION

One equally important feature follows from above; a modular structure is extremely environmentally friendly. Inhabitants of surrounding living spaces are not disturbed by an enduring construction process.

Source- https://www.koma-modular.cz/en/modularity

17

17

Greener

- **Greater Flexibility and Reuse:** Modular buildings can be disassembled and the modules relocated or refurbished for new use, reducing the demand for raw materials and minimizing the amount of energy expended to create a building to meet the new need.
- **Less Material Waste:** When building in a factory, waste is eliminated by recycling materials, controlling inventory and protecting building materials.
- **Improved Air Quality:** Because the modular structure is substantially completed in a factory-controlled setting using dry materials, the potential for high levels of moisture being trapped in the new construction is eliminated.

Faster

- **Reduced Construction Schedule:** Because construction of modular buildings can occur simultaneously with the site and foundation work, projects can be completed 30% to 50% sooner than traditional construction.
- **Elimination of Weather Delays:** 60 - 90% of the construction is completed inside a factory, which mitigates the risk of weather delays. Buildings are occupied sooner, creating a faster return on investment.
- **Built to Code with Quality Materials:** Modular buildings are built to meet or exceed the same building codes and standards as site-built structures, and the same architect-specified materials used in conventionally constructed buildings are used in modular construction projects – wood, concrete and steel.

Stronger

- **Safer Construction:** The indoor construction environment reduces the risks of accidents and related liabilities for workers.
- **Better Engineered Building & BIM:** PMC relies on advanced BIM for visualization to assess the energy performance and identify the most cost-effective efficiency measures. PMC is ideal for the use of this technology where the construction process is already a collaboration of systems, materials and people—much like the software itself.
- **Limitless Design Opportunities:** Modular units may be designed to fit in with external aesthetics of any existing building and modular units, once assembled, are virtually indistinguishable from their site-built counterparts.

Source- https://www.modular.org/what-is-modular-construction/

18

18

Temporary Community Centre for Refugees in Roztyly, Czech Republic

Modular community centre for refugees implemented in less than 1 month.

The assembly of the 26-module building started in March 2022 when the first half of the modules were delivered. The rest of the modules were delivered and assembled the next day. This was followed by finishing work, preparation of the modules and equipping the building. The building is scheduled to be operational less than a month after the start of assembly.



Source-https://i.ytimg.com/vi/WcyhMSQqJFQ/maxresdefault.jpg

Source-https://www.koma-modular.cz/en/references/docasne-komunitni-centrum-pro-uprchliky-v-roztylech

19

19

The Development and Innovation Centre of Modularity

The new building on the KOMA company premises breaks the stereotypes of modular construction. Thanks to cooperation with the architectural duo, Michal Krištof and Ondřej Chybík, it was possible to create a unique space with an area of 170 m2 using only 6 modules with a trapezoidal ground plan.

You can construct a building from a variety of materials – bricks, panels or whole modules. This concept is taken a step further by using and filling the space between the modules. This project also implements green roof structures.



Source-https://i.ytimg.com/vi/WcyhMSQqJFQ/maxresdefault.jpg

https://www.youtube.com/watch?time_continue=25&v=oDP7xhSPNCM&feature=emb_logo

Video available (not English)

Source-https://www.koma-modular.cz/en/references

20

20

Design For Disassembly (DfD)

Presentation

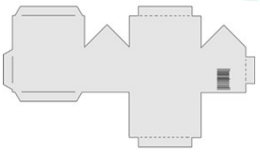
21

21

Design For Disassembly (DfD)

By definition, Design for Disassembly (DfD) is the design of buildings to facilitate future changes and dismantlement (in part or whole) for recovery of systems, components and materials, thus ensuring the building can be recycled as efficiently as possible at the end of its lifespan.

The strategy builds on an increasing acknowledgment of the fact that the majority of the built environment has a limited lifespan and that every building represents a depository of resources, which, rather than ending up in a landfill, should find their way back into the "reduce, reuse, recycle" loop.



Source-https://i.ytimg.com/vi/WcyhMSQqJFQ/maxresdefault.jpg

Source- https://www.archdaily.com/943366/a-guide-to-design-for-disassembly

22

22

Ten Key Principles for DfD

- Document materials and methods for deconstruction. To efficient disassembly and deconstruction.
- Select materials using the precautionary principle. Consideration for future impacts and high quality materials will retain value and/or be more feasible for reuse and recycling.
- Design connections that are accessible. Accessible connections will increase efficiency.
- Minimize or eliminate chemical connections. Reduce use of binders, sealers and glues on, or in materials, make them difficult to separate and recycle.
- Use bolted, screwed and nailed connections.
- Separate mechanical, electrical and plumbing systems. It is easier to separate components and materials for repair, replacement, reuse and recycling.

Source- https://www.lifecyclebuilding.org/docs/DfDseattle.pdf

23

23

Ten Key Principles for DfD

- Design to the worker and labor of separation. Human-scale components or conversely attuning to ease of removal by standard mechanical equipment will decrease labor intensity and increase the ability to incorporate a variety of skill levels.
- Simplicity of structure and form. Allow for ease of construction and deconstruction in increments.
- Interchangeability. Modularity, independence and standardization will facilitate reuse.
- Safe deconstruction. Allowing for movement and safety of workers, equipment and site access, and ease of materials flow will make renovation and disassembly more economical and reduce risk.

Source- https://www.lifecyclebuilding.org/docs/DfDseattle.pdf

24

24

Opportunities and Challenges

The construction industry is the world's largest consumer of raw materials, and most of them never return to the material loop. Incorporating the DfD strategy into the architectural process would reduce the embodied energy and carbon emissions of the construction sector, as it would significantly curtail the consumption of first-use materials.

Nonetheless, the DfD process is not without its challenges. The lack of regulation regarding recycled materials and the uncertainty around the quality and quantity of used materials are still disincentives to the DfD method. Another significant challenge, for the time being, is the cost and speed of the process, as demolition is considered cheaper and faster than taking a construction apart piece by piece.

However, research by EPA (Environmental Protection Agency) demonstrated that deconstruction could be cost-competitive with demolition if there are sufficient recoverable materials with a good market value to offset the higher labour costs.

Source- https://www.archdaily.com/943366/a-guide-to-design-for-disassembly

25

25

Material Requirements and Deconstruction

Design for Disassembly requires extensive research into construction materials for selecting the ones that are non-toxic, of high quality (to withstand assembly and disassembly) and have good recycling potential.

DfD requires generating a detailed deconstruction plan, including instructions for the disassembly of elements, as well as a review of the building components and materials and how they should be reused, recycled, or reclaimed.



Source-https://images.adsttc.com/media/images/5663c89b537655d46000029d/...

Source- https://www.archdaily.com/943366/a-guide-to-design-for-disassembly

26

26

Connections

One fundamental principle of DfD is creating accessible connections and choosing the appropriate joinery in order to ease dismantlement and avoid the use of heavy equipment, or too many tools.

The focus should be on mechanical joinery, using bolted, screwed or nailed connections, as opposed to non-removable, chemical ones such as binders, sealers, glues or welding, which would make the material difficult to separate and recycle.



Source-https://images.adsttc.com/media/images/5f00/ae95b3576f65d4600032bc/slideshow/a6.jpg?1594272401

27

27

Design for DfD Further Information

https://www.lifecyclebuilding.org/docs/DfDseattle.pdf

Design for Disassembly in the built environment: DfD a guide to closed-loop design and building

28

28

Product-as-a-Service (Design and building life)

Presentation

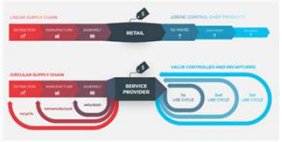
29

29

Product as a Service (PaaS)

In Product-as-a-Service (PaaS) business models, the provider retains ownership or control of the product throughout the use-phase.

As such, these businesses have a much stronger incentive to maximise product utilisation. It's also in their interests to reduce the total number of products required and their lifecycle cost (LCC).



Source- https://assets.website-files.com/5d26d80e883f6af2d12ed1269/5e4d0b66eb0887cb4ffa5e7c_PaaS-Question-Kit.pdf

30

30

Product as a service (PaaS) Strengths

Product Lifespan

- As accountability for the product is shifted from the customer to the service provider, the incentive for the service provider is to increase resource and asset productivity and to prolong the lifetime of the product.

Customer Retention

- Maintenance, repair, recycling and other services can lead to an increase in customer retention. Stable, long-term revenue, compared to traditional sales business model which it is more difficult to establish long term relationships with customers.

Sourcing

- Less exposure to pricy or material scarcity.

Source- https://assets.website-files.com/5d26d80e8636af2d12ed1269/5e4d0b66eb0887cb4ffa5e7c_PaaS-Question-Kit.pdf

31

Product as a service (PaaS) Strengths

User Data

- Predictive maintenance and other measures such as environmental impact.

Environmental Impact

- Positive impact on the environment

The Cash Flow

- In contrast to a linear business model, the incoming cash flow of the PaaS service provider is delayed as the customer pays a small service fee on a recurring basis instead of a one-off payment when buying the product.

The Customer

- The financial or creditworthiness of the customer is crucial for the robustness of the cashflow.

Source- https://assets.website-files.com/5d26d80e8636af2d12ed1269/5e4d0b66eb0887cb4ffa5e7c_PaaS-Question-Kit.pdf

32

Product as a service (PaaS) Challenges

The Service Contract

- The relationship between Client and service provider is captured in the service contract which becomes very important

The Assets

- Assets becomes less adequate as collateral

The Circular Supply Chain

- Risks to supply chain have more options to fail in comparison to one source

Source- https://assets.website-files.com/5d26d80e8636af2d12ed1269/5e4d0b66eb0887cb4ffa5e7c_PaaS-Question-Kit.pdf

33

PaaS Example Outside Construction Headphones-as-a-service

- The modular design allows 85% of components to be reused.
- Products use durable, standardised designs, meaning fewer virgin materials are used to create new headphones.
- The subscription model allows Gerrard Street to recover and recycle headphones at the end of their life.



Source- https://ellenmacarthurfoundation.org/circular-examples/gerrard-street

34

PaaS Example Outside Construction Headphones-as-a-service

How it works

- After subscribing and placing an order, Gerrard Street customers receive their headphones in a building kit box.
- If headphones become damaged in any way, Gerrard Street will immediately send out a replacement part to the customer. Customers can also return the headphones for an upgrade or complete replacement.
- New models are sent with return stickers to make the swapping process as easy as possible. This gives flexible access to people who want a high quality listening experience without a costly initial outlay.



Source- https://trapeze.audio/

Source- https://ellenmacarthurfoundation.org/circular-examples/gerrard-street

35

PaaS Example In Construction Facades-as-a-service

Instead of transferring ownership of the facade in a traditional manner, the Facade Service Company remains the owner of- and responsible for the facade, its proper functioning and the agreed quality of services.

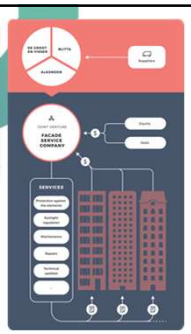
This service model stimulates the provider to develop a sustainable, future-proof facade and incentivises taking into account technological innovation and adaptability in the design phase.



Source- https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FB9780128224779000053&psig=AOvVaw2eaN7YkxoCqbeaiTOTRAAA&ust=1618559908740000&source=images&cd=vfe&ved=0CBAQjRxqFwoTCNi12Ls-vPACFQAAAAAdAAAAABAD

Source- https://www.circle-economy.com/resources/facade-as-a-service#:~:text=The%20Facade%2Das%2Da%2Dservice%20is%20a%20sustainable%20by%20remote%20control

36



- In return for paying a fixed periodic fee the customer receives the services and is unburdened: the Facade Service Company takes care of maintenance, repair and technical updates. This reinforces the 'trust' factor for the customer.
- Incentivise sustainable energy consumption. There may be a possibility for a discount on the monthly service fee when maintenance costs are lower thanks to careful use of the facade.
- Financially, this proposition is attractive if the total cost of usage of the facade does not exceed the total cost of ownership.

Source- https://www.circle-economy.com/resources/facade-as-a-service#:~:text=The%20Facades%20as%20a%20Service%20(FaaS)%20is%20adjustable%20by%20tenants%20control

37

37

Design and Build for Multi-functional Green Roofs Facades and Exterior Elements

Presentation

38

38

Multi-functional Green Roofs Facades and Exterior Elements

- Case Study
- Modular and Adaptable Design
- Green Roofs Facades and Interior Elements-as-a-Service (Green roofs-as-a-Service (GraaS))

39

39

Elementary & Middle School - Paris, France - Djuric Tardio Architectes

Djuric Tardio Architectes has completed the project for the removable and rebuildable wooden nursery in the Luxembourg Gardens, one of the most popular places in Paris for both Parisians and tourists.

The construction of the nursery is temporary since the building will be dismantled and reassembled in another part of Paris, but in another configuration that remains free thanks to interchangeable and identical modules. The site where the modular building is currently located will be restored after two years.



Source:https://www.metalocus.es/en/news/modular-and-nomadic-building-paris-wooden-nursery-luxembourg-gardens-djuric-tardio-architectes

40

40

Elementary & Middle School - Paris, France - Djuric Tardio Architectes

Architectural approach. The Jardin du Luxembourg is an exceptional site. Therefore, the building had to take into account the constraint of a short-term existence and the requirement of a harmonious insertion. This high-performing and bio-sourced building was designed with the principle of reversibility. It can be entirely reconfigured to be utilized for this program or others (emergency housing, offices, etc.), in order to serve new needs and future uses. The Luxembourg site will be identically returned to its original state in two years and the building will be erected elsewhere.



Source:https://www.archdaily.com/935476/wooden-nursery-djuric-tardio-architectes

41

41

Case Study - Noah's Ark Children's Hospice

A green roof will soon be gracing the new building at Noah's Ark Children's Hospice in Barnet, London. And it will be a green roof with a difference. With solar panels and native wildflower vegetation, this biosolar roof will bring both energy and life to the project. Bridgman & Bridgman in partnership with Bauder Ltd started construction in October 2018. We were fortunate to being able to time-lapse the construction and shall continue to film the roof as it changes over time. By spring the roof will be a flourishing wildflower meadow in the sky, helping to support native wildlife. At the same time the solar panels will be producing renewable energy.



Source- https://livingroofs.org/noahs-ark-childrens-hospice-green-roof-start/

42

42

Press play on video or go to - https://youtu.be/B0W_PVmiWjA



43

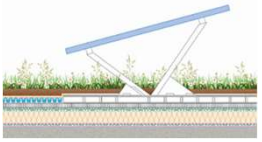
Modular and Adaptable Construction as Referenced to Case Study

Possibilities for implementing Modular Design

- Repeatable modules for reuse and easy additions
- Pre-planted modular trays

Possibilities for implementing Adaptable Design

- Easy access to services and symptoms
- Adaptable design symptoms allowing for addition of elements such as further solar panels



Source-https://www.bauder.co.uk/case-studies/post%E2%80%99e-ark-children%E2%80%99s-hospice

44

DfD and its Application to Case Study

Utilising Design for Disassembly and Modular design for green roofs, facades and interior elements means that elements of a building can easily be designed and built and reused following the end of life of the building. Allowing elements to be reused in the future.



Source-http://www.greenroofs.com/projects/uv-dept-of-environmental-protection-regional-headquarters/

45

GRaaS - Opportunities

Similarly to Facades-as-a-Service, Green Roofs-as-a-Service (GRaaS) will -

- Extend Product Lifespan
- Insure Longer Customer Retention
- Make Sourcing More Sustainable
- Utilise User Data for Maintenance and Repairs
- Environmental Impact Reduction



Source-https://www.bauder.co.uk/case-studies/post%E2%80%99e-ark-children%E2%80%99s-hospice

46

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

47

EXTRA READING/STUDY

Activity

48

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

49

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

50

BUS GoCircular

Shaping a Circular Sustainable Future

Module 3

Bio Based Material Implementation and Application in Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summary

The trainee should leave with a good understanding of biomaterials in construction regarding what exists to their profession and what needs to be done to implement these building materials successfully. They should also gain a good understanding of how this can then be implemented in Multi-functional Green Roofs Facades and Interiors Elements.

2

Objectives/Learning Outcomes

- 1 – Design roofs, façades, and interior elements with bio-based materials as an alternative for conventional construction materials
- 17 – Manage and preserve biological products on the construction site to stretch the lifetime materials
- 68 – Apply bio-based, non-critical, non-toxic, and/or reusable products on site whilst maintaining material efficacy
- 83 – Increase (access to) understanding of biobased construction materials for applications to multifunctional green roofs, façades, and interior elements

3

Content

- Bio-based Materials
- Existing Bio-based Materials and Techniques
  - Earth
  - Timber
  - Straw
  - Wool
  - Hemp
- New Bio-based Materials and Techniques
  - Bio Plastics
  - Mycelium
  - Biochar
  - Bio-based Concretes and Cement
  - 3D-Printing
- Bio Based material opportunities for Multi-functional Green Roofs Facades and Interior Elements

4

Bio-based materials

Presentation

5

Definition

Biobased materials refer to products that mainly consist of a substance (or substances) derived from living matter (biomass) and either occur naturally or are synthesized, or it may refer to products made by processes that use biomass.



Image source: Sheeps wool insulation https://www.biobasedconsultancy.com/en/database/etchimwa-lana-sheep-wool-insulation/

Source- https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NRMRL&dirEntryId=231873

6

What are biobased materials?

Biobased materials are organic resources produced by plants and animals, such as

- Timber
- Sheep's wool.
- Bio-concrete
- Hemp
- Straw
- Clay
- Earth



Image source: Cob Construction https://www.homecrux.com/cob-house-cost-why-cob-house/

7

7

Positive Impact of Biobased Materials

In the context of construction, biobased materials can have several benefits over conventional ones:

- They are renewable and can be sustainably produced long-term
- They can naturally absorb carbon from the atmosphere during cultivation, contributing to climate change mitigation
- They promise performance gains in terms of moisture absorption and breathability
- They are generally less harmful to people and the natural environment in terms of pollutant emissions
- They can be disposed of more easily and sustainably at their end of life

Source- https://www.rics.org/eu/webf/megatrends/natural-environment/are-biobased-materials-the-key-to-a-more-sustainable-construction-industry/

8

8

Existing Bio-based Materials and Techniques

Presentation

9

9

Existing Bio-based Materials and Techniques

- Earth
- Timber
- Straw
- Wool
- Hemp

10

10

Cob Construction

Cob, like adobe, is comprised of a mixture of clay, coarse sand, fine sand, silt and water; it also uses a binder of fibrous or organic material such as start, or dung.

The soil for making cob and cob bricks is usually of local material, and ideally from the property itself. Therefore, cob is also one of the most affordable types of building material, and can be built often without the use of engineers or architects, as 'non-engineered construction'.



Source- https://globalgreen.org/latest-posts-home/green-building-cob-building/

11

11

Advantages of Cob Construction

- Can easily be built up to 3 storeys
- High thermal mass is very energy efficient in both summer and winter, and ideal for passive solar heating and cooling. Indoor temperatures vary only about 5 degrees Celsius between summer and winter (17-22 degrees Celsius), making it naturally cool in summer and warm in winter.
- Environmentally friendly: Low carbon footprint and embodied energy.
- Relatively easy to build for owner builders and unskilled labour.
- Lends itself to free-form walls
- Excellent sound insulation
- Cob buildings are capable of withstanding seismic activity, but must have a ring beam
- Fireproof
- Cob can easily be recycled.

Source- https://globalgreen.org/latest-posts-home/green-building-cob-building/

12

12

Disadvantages of Cob Construction

- Labour intensive
- Relatively slow to build
- Obtaining a mortgage from lending institutions is difficult
- Cob walls cannot be laid in wet or freezing weather
- Insects, notably termites and small rodents can burrow into the walls and weaken them. The use of dung in the mud mix and lime plaster can negate this problem

Source- https://globalgreen.org/latest-posts-home/green-building-cob-building/

13

13

Timber Construction

One kind of timber construction is Timber Frame Construction.

A timber-framed house is a house where the primary load-bearing structure is made of timber. A typical design features a frame of beams and posts that make up the internal and external structure of the building and supports the entire home without the need for interior load-bearing walls.



Source- https://passivehouseplus.ie/magazine/guides/the-ph-guide-to-structural-timber

14

14

Advantages of Timber Frame Construction

- Design flexibility afforded by a fully engineered construction system
- High levels of thermal / airtightness performance
- Predictability and speed of programme
- Certification of performance and regulatory compliance
- Improved health and safety
- Considerably less impact on the environment
- Reduction of on-site wastage
- Lifetime cost savings from energy-efficient structure
- Engineered to the highest level of accuracy and quality

Source- https://www.kingspan.com/ie/en/knowledge-articles/advantages-of-timber-frame/

15

15

Timber In Construction

Press play on video or go to - https://www.youtube.com/watch?v=ieBVNgMkcpw



16

16

Straw/Typha

The Griesfwald Mire Centre, in collaboration with a company called Wetland Products, has trialled the creation of various products from Typha, including insulation materials for buildings. This has been found to be an effective material, with fungal resistant and fire resistant properties.

The video below gives a short introduction to the growing of Typha in Mecklenburg Vorpommern, Germany, and using it to manufacture wall insulation.



Source-https://craigthornerees.ie/product/typha-latifolia/

Source- https://northsearegion.eu/canape/paludiculture/typha/

17

17

Press play on video or go to - https://www.youtube.com/watch?v=DxdKl1usYe8



18

18

Press play on video or go to - https://www.youtube.com/watch?v=uFKUPEmzgT0



19

Advantages of Typha

Provides structural and insulation properties in a single layer construction

- Sustainable new buildings made by typha
  - Timber frame structures – stiffening, insulation, and passive climate control
  - 100% typha structures
  - TYPHABOARD as insulation in building structures
- Existing building retrofit: easy-to-install indoor insulation
- Resource saving installation – low material and installation time costs
- By using TYPHABOARD ventilation systems become unnecessary
- Paludiculture (the type of farming used for this process) is a regenerative process trapping carbon in the earth.



Source- https://typhaboard.com/advantages/

20

Wool in Construction

Homes need insulation to provide adequate noise absorption, to control heat levels and make a building more comfortable. Of the many insulation materials on the market, wool stands out as the ideal natural option for sustainable building insulation. Here, IWTO explains why.

Furthermore, a sustainable insulation material like wool is a key component of eco-friendly buildings, with growing environmental trends meaning every building is aiming towards becoming more sustainable overall.



Source- https://www.sheepwoolinsulation.com/about

Source- https://iwto.org/the-benefits-of-using-wool-for-natural-insulation-in-buildings/

21

Advantages of Wool in Construction

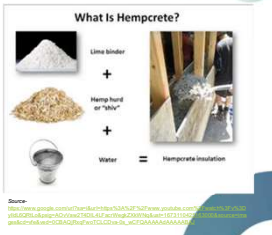
- Wool as a building and/or furnishing material can meet several sustainability criteria.
- Wool is a natural product that is less toxic than many alternatives, and fire retardant.
- Wool is an available resource that is biodegradable and easy to dispose of.
- The natural qualities that wool has allow it to dampen sound and absorb pollutants.
- Wool regulates humidity and are hypoallergenic. They perform better than synthetics in smell and staining tests. They absorb moisture when the air is moist and releasing it when the air is dry.
- Wool is a very effective insulator, suitable for thermal and acoustic building insulation. Sheep wool insulation is safe, eco friendly and energy efficient.
- Wool is ideal for structures made from wooden frames, as the wool has a natural synergy with timber.
- There are opportunities in new technological applications of wool, such as effective ways to deconstruct the fibre and reconstitute it in a range of useful forms.
- Wool is a readily available resource.

Source- https://www.procurement.govt.nz/assets/procurement-property/documents/benefits-of-wool-construction-procurement.pdf

22

Hemp in Construction

Hempcrete is a bio-composite made of the inner woody core of the hemp plant mixed with a lime-based binder. The hemp core or "Shiv" has a high silica content which allows it to bind well with lime. This property is unique to hemp among all natural fibers. The result is a lightweight cementitious insulating material weighing about a seventh or an eighth of the weight of concrete. It is not used as a structural element, only as insulating infill between the frame members though it does tend to reduce racking. Wood stud framing is most common making it suitable for low-rise construction. Hempcrete buildings ten stories high have been built in Europe.



Source-

Source- http://www.americanlimetechnology.com/what-is-hempcrete/

23

Advantages of Hempcrete

- High thermal insulation.
- CO2 sequestration.
- Passive, low energy.
- Negative carbon footprint.
- 50% – 80% energy savings.
- Healthy living environment.
- Fireproof.
- Inherently airtight.
- Termite resistant.
- High acoustic performance.
- Breathable walls.
- No waste.
- Design flexibility.
- No dry rot.
- Prevents mould.
- Low air infiltration.
- No landfill.
- Self-build friendly



Source- https://www.hempbuild.ie/

24

New Bio-based Materials and Techniques

Presentation

25

25

Bio-based Materials and Techniques

- Bio Plastics
- Mycelium
- Biochar
- Bio-based Concretes and Cement
- 3D-Printing

26

26

Bio-Plastics

Bio-based plastics refer to those materials or products that are wholly or partially derived from organic biomasses (bio-based materials), such as corn, sugarcane, and cellulose.

One of the main applications of bioplastics in the construction industry concerns their use in concrete mixtures and dry premixed mortars, as additives that optimize these products. In several applications, bio-based aggregates compete on par with those of synthetic origin; their market is, therefore, likely to expand, especially with the increasing advances achieved by technology

Source-https://www.mdpi.com/2673-8392/2/3/955/pdf?-_-text=Bioplastics%20provide%20an%20attractive%20sustainable,production%20of%20non%2Dbiodegradable%20plastic

27

27

Bioplastics – closing the loop



Source- https://www.mdpi.com/2071-1050/14/9/4855

28

28

Advantages of Bio-Plastics

- Less oil is used.
- The common bioplastics can be injection molded and shaped to take the same form as traditional thermoplastics.
- Bioplastics are more marketable, for example, their usage may improve the value-add of a product through a green marketing campaign.
- Less plastic litter is needed. In the UK, it was found that 90% of litter on beaches was plastic. Bioplastic break down naturally by composting or degrading naturally.
- Many bioplastic polymers are naturally occurring and don't have the carbon footprint of oil-based plastics because they don't require the refinement of oil to produce.
- Common bioplastics are often non-toxic and of 'no health concern'.

Source- https://qualityinspection.org/advantages-of-bioplastics-vs-disadvantages/

29

29

Disadvantages of Bio-Plastics

- First, bioplastics are generally not cost-competitive compared to their oil-based counterparts.
- There is a concern that bioplastics based on terrestrial crops could harm food supplies.
- Crop-based bioplastics require fertile land, water, fertilizers, and are reliant on weather conditions. This means that the supply of raw materials for bioplastics are at risk of natural phenomena, such as drought.
- Some bioplastics have a shorter lifetime than oil-based plastics due to weaker mechanical properties.
- Many bioplastics must follow a specific disposal procedure and require industrial composting in order to avoid being incinerated or going to landfill.

Source- https://qualityinspection.org/advantages-of-bioplastics-vs-disadvantages/

30

30

Example of Bio-Plastic in Construction

ArboSkin pavilion made from bioplastic by ITKE

The pyramidal modules are made by extruding bioplastic granules into sheets before thermoforming them to create the faceted shapes and trimming off the excess material.

Follow the link for full video - https://www.dezeen.com/2013/11/09/arboskin-spiky-pavilion-with-facademade-from-bioplastics-by-itke/



Source- https://www.dezeen.com/2013/11/09/arboskin-spiky-pavilion-with-facademade-from-bioplastics-by-itke/

31

Mycelium

Mycelium are the thin root-like fibres from fungi which run underneath the ground, when dried it can be used as a super strong, water, mould and fire resistant building material that can be grown into specific forms, thus reducing the processing requirements.

Mycelium not only out performs petrochemical/plastic based construction materials in thermal and acoustic insulation but, as a natural material, it is also safer and healthier. Mycelium does not contain the synthetic, resin-based compounds that can cause harmful toxic smoke and the quick spread of flames during a fire.



Source- https://www.dezeen.com/2021/05/25/carbon-negative-building-material-insulation-fire-proofing/

Source-https://www.certifiedenergy.com.au/emerging-materials/emerging-materials-mycelium-bricks#:~:text=Mycelium%20are%20the%20thin%20root,thus%20reducing%20the%20processing%20requirements. https://www.biohm.co.uk/mycelium#:~:text=Mycelium%20not%20only%20outperforms%20petrochemical%20flames%20during%20a%20fire

32

Advantages of Mycelium

- Thermal Capacity: Initial testing indicates that mycelium panel is a highly effective thermal insulating product.
- Fire Performance: Mycelium does not contain the synthetic resin-based materials that cause the harmful toxic smoke and quick spread of flames during a fire.
- Acoustic Performance: Mycelium provides excellent acoustic insulation and tests show an acoustic absorption of at least 75% at 1000Hz (the typical frequency of road traffic noise).
- Sustainability: Mycelium consumes organic and synthetic waste to grow into desired shapes and can achieve a range of thermal and mechanical material properties.
- Durability: Research on the long-term in situ performance of bio-based materials such as mycelium has demonstrated that they are at least as durable as conventional materials and maintain their insulative properties over the course of their life.
- Buildability: Mycelium is designed to replace carbon intensive and toxic insulation boards with a high performing natural bio-based alternative.

Source- https://www.biohm.co.uk/mycelium#:~:text=Mycelium%20not%20only%20outperforms%20petrochemical,of%20flames%20during%20a%20fire.

33

Mycelium Project

Follow Link for Video on Mycelium and Food Byproduct Construction and Image Source

http://thelivingnewyork.com/hy-fi.htm



34

Bio-Based Concrete and Cement

Mixing a new type of bacteria and calcium lactate capsules into the initial concrete mixture, *Jonkers* (http://edition.cnn.com/2015/05/14/tech/bioconcrete-delft-jonkers/index.html) created a type of concrete that can actually rebuild itself as moisture enters the inevitable cracks, gaps, and holes, a form of self-maintenance.

Bacteria is used to "grow" durable cement in ambient temperatures between loose grains of aggregate; producing building materials without emitting greenhouse gases, and without the depletion of non-renewable resources.



Source- https://www.bdcnetwork.com/dutch-teams-bioconcrete-can-heal-itself

Source- https://circle-lab.com/knowledge-hub/1629/biobased-cement https://www.generalkinematics.com/blog/what-is-bio-concrete/

35

Advantages of Bio-Concrete

- Overall maintenance cost of this concrete becomes low. The use of bioconcrete significantly enhances the strength of the concrete.
- It has lower permeability when compared to conventional concrete.
- It has also lower water absorption when compared to conventional concrete.
- It offers great resistance against freeze and thaw attacks.
- The chances of corrosion or reinforcement are reduced to negligible.
- Redressing of cracks can be done efficiently.
- It basically increases durability of the structure to a large extent.

Source- https://ghanpedia.com/blog/bioconcrete-self-healing-concrete/

36

Disadvantages of Bio-Concrete

- Cost of this concrete is comparatively higher than conventional concrete; it's about 10-30% more than conventional concrete.
- The germination of bacteria is not suitable in every possible environment.
- The investigations to observe calcite precipitation are costly.
- Bacteria that are used in concrete are not good for human health; hence its usage has to be limited to the structure.
- No design guideline for bacterial concrete are yet available in Codes of Design.

Source- https://gharpedia.com/blog/bioconcrete-self-healing-concrete/

37

37

Biochar

Biochar, a highly porous material produced from plant waste, is mostly used in agriculture as a soil conditioner, in livestock farming as a feed supplement, and in metalworking as a reducing agent. It can also be used for cleaning "grey water", as an absorber in sports clothing, in batteries and many other uses.

As well as having excellent insulating properties, improving air quality, being able to soak up moisture and protect from radiation, biochar also allows buildings to be turned into carbon sinks. Every tonne of biochar used in a building's envelope means that the equivalent of more or less one tonne of CO2 is prevented from re-entering the atmosphere.



Biochar wall paneling

Source- https://www.biochar-journal.org/en/ct/3

38

38

3D-Printing

3D printing is an industry that is already sustainable right now. The process produces a fraction of the waste of traditional construction manufacturing, because builders simply print exactly and only what they need. It only requires a small factory with minimal space for storage materials, and unlike a traditional production line, 3D printing does not require energy to move the same parts from one step to the next.



Source- https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/3d-printing-construction-and-architecture/

Source- https://www.weforum.org/agenda/2022/06/3d-printing-can-help-make-construction-carbon-neutral-heres-how/

39

39

3D-Printing Earth

Inspired by the potter wasp, since 2012, WASP (World's Advanced Saving Project) has been developing construction processes based on the principles of the circular economy and digital manufacturing. On the market since 2021, it creates 3D printed homes in the shortest possible time and in the most sustainable way with the first Crane WASP multi-printer system , the corporate pride of the construction line and the newco WASP On Site , the corporate reference point in the field of architecture.



Source- https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/3d-printing-construction-and-architecture/

Source- https://www.3dwasp.com/casa-stampata-in-3d-tecla/

40

40

Press play on video or go to - https://www.3dwasp.com/casa-stampata-in-3d-tecla/



41

41

Advantages of 3D-Printing

- Shorter supply chain and quicker design process: On-site 3D printing means that various time-consuming steps can simply be cut out from the design process.
- Fewer logistical processes and less waste: Many parts get damaged in transit, parts are over-engineered in order to withstand transportation, secure transportation and hoisting means additional features and 3D printing removes the need for wooden moulds.
- Making customised houses available to the wider market: The digitisation of a large part of the production process means that complex products can be customised at a minimal added cost.
- Simpler and more efficient installation of pipes and electrics: In conventional construction, heating systems, insulation, running water and electricity all require labour-intensive on-site installation, with 3D printing of concrete, some of these functions can become integrated in the 3D printing process.

Source- https://www.emeraldgrouppublishing.com/archived/realworldresearch/innovation/how-3D-printing-can-make-construction-better.htm

42

42

Further reading on biobased materials used in construction

Overview on Bio-based Building Material Made With Plant Aggregate

https://pureadmin.qub.ac.uk/ws/portalfiles/portal/47919763/Overview_on_bio_based_building.pdf

43

43

Bio Based Material - Multi-functional Green Roofs Facades and Interior Elements

Presentation

44

44

Bio Based Material - Multi-functional Green Roofs Facades and Interior Elements

- Case Study
- Existing Bio-based Materials and Techniques
- New Bio-based Materials and Techniques
  - Materials
  - 3D-Printing

45

45

Case Study - Senior Citizen Community Center by F451 Arquitectura, Spain

Text description provided by the architects. This proposal is based on the redefinition of ready-made components and their assembly to try to optimize the environmental performance of the building as well as the possibility of recycling used elements. The building was based on dry construction, except the ground, and formally displayed in such a way that increases its capability to interact with the surroundings-both architecturally and environmentally.



Source- https://www.archdaily.com/22310/senior-citizen-community-center-f451-arquitectura

46

46

Existing Bio-based Materials and Techniques

Bio based building materials need to be tested and experimented with further in many cases as despite years of utilising bio based materials in building we have moved away from these kind of construction recently, such as -

- Thatched roofs
- Accessible roofs on bio based buildings



Source- https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/3d-printing-in-architecture/

47

47

Existing Bio-based Materials and Techniques

For this given example - Senior Citizen Community Center by F451 Arquitectura

bio based structure and insulation could be utilised in this building. The building is located in spain meaning insolation such as sheeps wool would cool the building in summer and heat the building during winter.

What other examples could be suggested?



VISTA AÉREA DE LA COBERTA ECOLÓGICA



Source- https://karmatrendz.wordpress.com/2009/06/03/senior-citizens-community-center-by-f451-arquitectura/#s-comment-4251

Source- https://www.archdaily.com/22310/senior-citizen-community-center-f451-arquitectura

48

48

New Bio-based Materials

New bio based building materials can be utilised in many ways in buildings. One of the most obvious and easy to implement options is adding substances such as biochar to the soil used in the green roof. This will reduced the release of carbon from the plants and soil and actively sequester carbon further throughout the buildings life.

What are some other examples that can be suggested for this project.



Source- https://www.carbongold.com/biochar-bringing-soil-life/

49

49

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

50

50

EXTRA READING/STUDY

Activity

51

51

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

52

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

53

Shaping a Circular Sustainable Future

Module 4

Upgrades and Maintenance for Sustainability in the Construction Industry

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

Within this module trainees will explore the possibilities and opportunities of Retrofits, Upgrades, Repairs and Maintenance as well as the barriers that exist within these. Following this exploration of how each of these topics can be rolled out within their profession they will go on to look at how this then relates to Multi-functional Green Roofs Facades and Interiors Elements and what these models may look like in relation to this.

2

Objectives/Learning Outcomes

- 11 – Provide repair services or maintenance services for multifunctional green roofs, façades, and interior elements
- 12 - Provide upgrade programs or upgrade services for roofs and façades
- 13 - Provide DIY repair kits or spare part programs for enabling self-repair of roofs, façades or inner walls.
- 30 - Design multifunctional green roofs, façades, and interior elements that make repair accessible
- 31 - Design multifunctional green roofs, façades, and interior elements that can serve a long and useful life, as well as stay relevant to residents and users

3

Objectives/Learning Outcomes

- 42 - Provide building components (e.g. façades, technical installations on roof, partition walls) as a service instead of as a product
- 43 - Offer maintenance and repair services for multifunctional green roofs, façades, and interior elements with help of service business models
- 44 - Offer different leasing and rental models to provide access rather than ownership
- 45 - Incentivise the renovation of roofs with a potential of applying multifunctionality
- 62 - Construct multifunctional green roofs, façades, and interior elements according to service business model

4

Objectives/Learning Outcomes

- 64 - Maintain and repair multifunctional green roofs, façades, and interior elements in order to maximise lifetime
- 66 - Rebuild existing (parts of) multifunctional green roofs, façades, and interior elements for a new purpose
- 69 - Construct multifunctional green roofs, façades, or interior elements on site
- 72 - Renovate buildings with the use of multifunctional green roofs, façades, or interior elements to extend lifetime of current building stock

5

Content

- Repairs and Maintenance
- Upgrades and Retrofits
- nZEB, Passive Houses and Environmental Certification Schemes
- Sustainable Neighbourhoods
- Upgrades and Maintenance for Multi-functional Green Roofs Facades and Interior Elements

6

Repairs and Maintenance

Presentation

7

Repairs and Maintenance

Repair

- Restore (something damaged, faulty, or worn) to a good condition.

Maintenance

- The process of preserving a condition or situation or the state of being preserved.

Source: https://languages.oup.com/google-dictionary-en/

8

Types of Building Repairs and Maintenance

- Day to day repairs service facilities
- Annual repairs
- Specialist repairs



Source: https://theconstructor.org/building/building-repair-maintenance-service-types/6903/

9

Day to Day Repairs

Facilities require a certain amount of upkeep to look their best, maintain a safe environment and serve their intended function.

Day to day repairs include service repairs which arises from time to time in the services of the buildings such as in plumbing works, water supply, etc. Examples for such repairs are removing chokage of drainage pipes, manholes, restoration of water supply, replacement of blown fuses, repairs to faulty switches, watering of plants, lawn mowing, hedge cutting, sweeping of leaf falls etc.

In an industrial setting, the maintenance worker might have a set schedule of routine maintenance procedures to perform on machinery and equipment.

Source: https://theconstructor.org/building/building-repair-maintenance-service-types/6903/
https://www.remdal.com/blog/4-common-types-building-repair-maintenance-services/

10

Annual Repairs

This maintenance service is carried out to maintain the aesthetics of buildings and services as well as to preserve their life, some works like white washing, distempering, painting, cleaning of lines, tanks etc. are carried out periodically. These works are planned on year to year basis.



Image source: Google Images

Source: https://theconstructor.org/building/building-repair-maintenance-service-types/6903/

11

Specialist Repairs

- Maintenance of Electrical Installations
  - Electrical equipment must be maintained and repaired frequently for optimal operations and safety.
  - Records should be kept for all maintenance and repair work.
- Prevention Measures
  - Measures such as painting, periodic check ups and protection against flooding can all help reduce the need for repairs in the future.
  - Reduced and proper usage can also help to reduce the need for repairs in the future and can have a positive impact on a buildings lifespan.

Source: https://www.remdal.com/blog/4-common-types-building-repair-maintenance-services/

12

Specialist Repairs

- Repair and Maintenance Schemes
  - Repair and maintenance schemes are often offered by suppliers and can help to further the lifespan of a product.
  - Buying into schemes such as Product-as-a-Service schemes can also ensure the lifespan of a product is extended.

Source: https://www.remdal.com/blog/4-common-types-building-repair-maintenance-services/

13

Right to Repair

Issues with repairing products

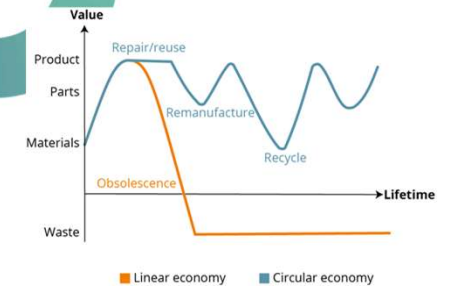
- Repairs can be costly
- Difficult to arrange for lack of spare parts
- Products tend to break down faster if pay to repair
- Consumers keep a product longer disincentivizing manufacturers

What the right to repair means

- Repair is seen as an important element of a circular economy
- Slow down the use of resources and the flow of materials
- Fewer greenhouse gas emissions and less waste
- Essential for the uptake of second-hand and refurbished products
- Can potentially generate local jobs in small and medium-sized enterprises

Source: https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698869/EPRS_BRI(2022)698869_EN.pdf

14



Illustrative indication of a circular economy versus a linear economy for electronics

Source: https://www.eea.europa.eu/publications/europe2019s-consumption-in-a-circular/benefits-of-longer-lasting-electronics

15

What is the 'right to repair'?

The Right to Repair campaign was launched in September 2019, and quickly grew since to over 100 organisations active around the cause of repair in more than 20 European countries.

The problem is simple. The products we use everyday are getting harder and harder to repair. E-waste is one of the fastest growing waste streams in the world, with phone and laptops manufacturers making their products harder to fix. And it's not just digital devices – the amount of household appliances failing within 5 years of their purchase is also skyrocketing.



Image source: Google Images

Source: https://repair.eu/about/

16

What is the 'right to repair'?

- **The right to repair during the guarantee period.** EU consumers have a right to have faulty products repaired free of charge during the legal guarantee period. Under EU law, this is two years from the moment they bought the product. However, a presumption that the product was faulty from the start (in other words, that there is no fault on the part of the consumer) is only valid during the first 12 months. Moreover, while sellers are required to repair, replace or reimburse products that break down due to non-conformity, they are not required to repair defects occurring for other reasons, e.g. if a product was dropped or used improperly.

Source: https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698869/EPRS_BRI(2022)698869_EN.pdf

17

What is the 'right to repair'?

- **The right to repair after the legal guarantee has expired.** Once the legal guarantee has expired, neither sellers nor manufacturers are required to repair the products. Consumers no longer have a right to have their products repaired, even if they want to pay for the repair themselves. They are thus often faced with a situation in which repair would cost too much (compared with buying a new product); spare parts are not available; there are no repair shops left in their vicinity; or products are made in such a way that they cannot be repaired (e.g. because parts are glued together or are inaccessible).

Source: https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698869/EPRS_BRI(2022)698869_EN.pdf

18

What is the 'right to repair'?

- **The right for consumers to repair products by themselves** (as opposed to being required to use the official repair shops). 3 Under EU law, manufacturers are not required to provide technical information (such as manuals and service handbooks) to consumers, nor are they required to provide consumers with spare parts.4 Only professional repairers have a guaranteed right to access the technical information and the spare parts, and only for some products.

Source: https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698869/EPRS_BRI(2022)698869_EN.pdf

19

Repair and Maintenance Manuals

A repair and maintenance document can be created and shared by the design and construction team for the owner and operator.

Sections can include

- General information
- Operational instructions and procedures
- Maintenance and repair procedures
- Modifications
- Project warranties and guarantees

Shown here is one example of a template to use



https://methodstatementhq.com/building-operation-maintenance-manual-template-in-word-format.html

Source: https://methodstatementhq.com/building-operation-maintenance-manual-template-in-word-format.html

20

Upgrades and Retrofits

Presentation

21

Upgrades and Retrofits

Upgrade

- Raise (something) to a higher standard, in particular improve (equipment or machinery) by adding or replacing components.

Retrofit

- Add (a component or accessory) to something that did not have it when manufactured.

22

Why Upgrade?

Incorporating the right high-performance measures into your building can drive efficiency and cost savings while also increasing occupant productivity and improving health and satisfaction. In short, it's just good business.

Focus points:

- Energy and Water Efficiency
- Indoor Environmental Quality
- Sustainable Sites and Transportation



Image source: https://www.completecommunitiesde.org/planning/sustainable/green-building/

Source: https://sftool.gov/plan/upgrades

23

Energy and CO2 Saving Potential

Individual retrofits can produce big savings versus baseline business-as-usual energy use, depending on the building types. Existing examples include:

- Detached single-family homes cutting total energy use by 50-70%
- Multi-family housing reducing space heating requirements by 80-90% and, in developing countries, cutting cooling energy use by 30% and heating energy by 60%
- Commercial building HVAC energy use reduced by 25-50% and by 30-60% for lighting

Source: *Fit-to-NZEB: Ecology & Sustainability*

24

What is a Deep Retrofit?

The Deep Retrofit of a home means carrying out multiple energy upgrades all at once to achieve a BER of A-rating.

- Firstly, you will need to reduce the level of heat loss so that you keep heat in the home for longer. This involves some or all of the following: wall insulation, roof insulation, floor insulation, window upgrades.
- The next step is to look at an efficient renewable heating system to support the transition away from fossil fuels. The typical heating system installed on a Deep Retrofit Pilot Project is an air-source heat pump.
- It also includes mechanical ventilation to maintain good indoor air quality.
- Other renewable energy technologies such as solar water heating panels and solar photovoltaic panels may be appropriate for your home.

Source: https://www.seai.ie/grants/home-energy-grants/deep-retrofit-grant/

25

Types of Retrofits

- Adaptive reuse
  - Repurposing buildings that is the sustainable way to meet new needs and purposes.
- Expansive reuse
  - Upgrade and add new space to existing buildings in creative ways, to maximise their value. Creating new basements or adding storeys to an existing building can deliver transformative outcomes.
- Proactive reuse
  - When buildings require repairs, upgrades can unlock new possibilities.



Image source: https://www.ft.com/partnercontent/lloyds-bank/building-a-sustainable-future.html

Source: https://www.arup.com/services/buildings/building-retrofit

26

Step by Step Retrofit

Types of step-by-step retrofit processes

- **Sequential retrofitting of building components:** i.e. Step 1 consist of the wall insulation; in Step 2, the windows will be replaced and a ventilation system is installed; and in Step 3, the roof insulation, the heating system and other measures are implemented.

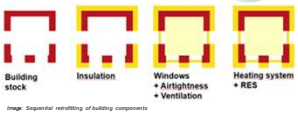


Image: Sequential retrofitting of building components

Source: https://passipedia.org/planning/refurbishment_with_passive_house_components/overall_retrofit_plan_for_step-by-step_retrofits_to_enerphit_standard

27

Step by Step Retrofit

Types of step-by-step retrofit processes

- **Sequential retrofitting of building parts or sections**: i.e. a refurbishment of single building wings, apartments, new extensions or terraced houses. Even the retrofit of single sides of a building only can be envisaged.

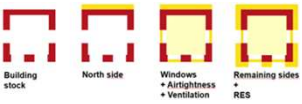


Image: Sequential retrofitting of building parts or sections

Source: https://passipedia.org/planning/refurbishment_with_passive_house_components/overall_retrofit_plan_for_step-by-step_retrofits_to_enerphit_standard

28

More Information on a Step-by-step Retrofit

https://europhit.eu/sites/europhit.eu/files/EuroPHit_Handbook_final_Optimized.pdf

Passive House Institute

29

Drive 0 Project

We want to accelerate deep renovation processes by enhancing a consumer centered circular renovation process in order to make deep renovation environmentally friendly, cost effective and more attractive for consumers and investors.

"A circular deep renovation, which contributes to a circular built environment', is based on 100% life cycle renewable energy, and all materials used within the system boundaries are part of infinite technical or biological cycles with lowest quality loss as possible."

Source: https://www.drive0.eu/

30

Drive 0 - Case Study Estonia

The aim of the project was to renovate the apartment building in the most optimal way possible, in a short period of time, and by choosing materials still reusable after the end of the building life cycle. In addition, Timbeco used as many products and materials of domestic origin as possible, and reused some of the materials generated during the renovation process.



Source: https://timbeco.ee/keskkond-jatkusuutlikkus/

Source: https://www.drive0.eu/

31

Drive 0 - Case Study Estonia

These modules can be used to fully renovate many of the typical apartment buildings constructed in Estonia before the 1990s, many of which can also be found in other countries in Scandinavia and Central Europe. All these multi-apartment buildings have quite similar problems: high energy consumption levels, poor ventilation and indoor climate, and uneven indoor temperatures. Many apartment associations have plans to renovate their buildings. The Drive 0 pilot building shows that renovations can be done conveniently and efficiently.



Source: https://www.drive0.eu/

32

nZEB, Passive Houses and Environmental Certification Schemes

Presentation

33

nZEB and Passive Houses

nZEB

- Nearly Zero Energy Buildings' means a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby



Source: https://www.bpcventilation.ie/blog/nearly-zero-energy-buildings/

Source: nZEB Fundamentals BIMzeED https://mmccarchitects.com/what-is-a-passive-house/

34

nZEB and Passive Houses

Passive House

- The Passive House or PassivHaus standard was developed in Germany as a 'fabric first' approach to minimise the energy requirements and running cost of a building.Passive House is a precise building standard and quality assurance system to ensure that there is little to no performance gap, unlike the building regulations. It is a highly flexible system that can accommodate most styles of architecture and construction methods. Ideally, it should be approached holistically within the design process at an early stage.



Source: https://passipedia.org/basics/what_is_a_passive_house

Source: nZEB Fundamentals BIMzeED https://mmccarchitects.com/what-is-a-passive-house/

35

Key Passive House Principles

- Highly insulated
- Excellent Airtightness
- Addressing thermal bridging
- High quality triple glazed windows & doors
- MHRV



Press play on video or go to https://www.youtube.com/watch?v=sWccxmQvR0o&t=2s

Source: https://mmccarchitects.com/what-is-a-passive-house/

36

Nearly Zero-Energy Buildings

Nearly zero-emission building (NZEB) means a building that has a very high energy performance, while the nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby.



Source: https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en

37

nZEB and Passive Houses

Since energy efficiency consists in reduction of consumption and reduction of greenhouse gas emissions, the Passive House standard has emerged as a key enabler for the Nearly Zero Energy Building standard. The combination of PH with renewables represents a suitable solution to move to low/zero carbon.

A passive house is designed to have an energy demand that is as low as practically achievable. With such a small amount of energy to be supplied, it is easier to meet the subsequent demand by renewable sources

Source: https://phai.ie/info/passive-house-nearly-zero-energy-buildings/

38

Environmental Certification Schemes

Considering the variety of objectives, strategies and practical approaches of sustainable development at different areas:

- LEED (Leadership in Energy and Environmental Design)
- Breeam (Building Research Establishment Environmental Assessment Method)
- DGNB (Deutsche Gesellschaft Fur Nachhaltiges Bauen)
- Green Star - Australia
- HQE (Haute Qualité Environnementale) - France, Brazil, Canada
- Ska Rating - developed by RICS
- CASBEE (Comprehensive Assessment System for Built Environment Efficiency - Urban environment) - Japan

Source: Fit-to-NZEB: Ecology & Sustainability

39

LEED

LEED (Leadership in Energy and Environmental Design) is a voluntary rating system to certify sustainable buildings and neighbourhoods. Launched by the US Green Building Council in 1998, LEED has been gaining traction around the world – in fact 1 of every 3 LEED projects is outside the United States. According to USGBC, there are more than 100 certified projects in Ireland, of which 60% achieved the certification in the past two years. (Data: USGBC, March 2020.)



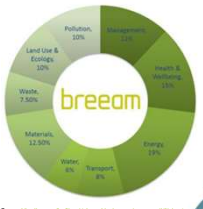
Source: https://www.igbc.ie/certification/leed/

40

BREEAM

The world's leading science-based suite of validation and certification systems for a sustainable built environment.

Since 1990, BREEAM's third-party certified standards have helped improve asset performance at every stage, from design through construction, to use and refurbishment. Millions of buildings across the world are registered to work towards BREEAM's holistic approach to achieve ESG, health, and net zero goals. It is owned by BRE – a profit-for-purpose organisation with over 100 years of building science and research background.



Source: https://www.volkerfitzpatrick.co.uk/en/corporate-responsibility/environment/breeam-capability

Source: https://bregroup.com/products/breeam/

41

Environmental Certification Schemes

- **Criterion**: states the main specifications and details of the determined objectives (i.e. objectives and aspects of sustainable urban development).
- **Indicator**: quantitative and measurable description of the criteria. Each criterion might be evaluated by a number of indicators.
- **Rating system**: shows the specific boundaries of classification and the evaluation method (quantities of qualitative) for indiatore measurement; the criteria importance factor; and the minimum level of requirement.
- **Certification process**: decides the necessary measures and the steps to award the certificate.

Source: Fit-to-NZEB: Ecology & Sustainability

42

Sustainable Neighbourhoods

Presentation

43

Sustainable Neighbourhoods

"sustainable cities and communities" start with sustainable neighbourhoods.

It is in neighbourhoods where people can easily meet their daily needs, socialize, and feel safe. This requires high-quality urban landscapes and open spaces, sustainably designed housing, shopping and recreation, access to schools, childcare facilities, and other services. At the same time, each neighbourhood needs good transport links to the places where people need to go, whether it is for work or pleasure.

United Nations Environmental Programme

INTEGRATED GUIDELINES FOR SUSTAINABLE NEIGHBOURHOOD DESIGN

https://www.neighbourhoodguidelines.org/

Source: https://www.neighbourhoodguidelines.org/

44

Sustainable Neighbourhoods - Energy Reduction

A sustainable neighbourhood is a healthy, safe and resilient place to live, work and play.
Sustainable neighbourhoods:

- Have accessible, diverse and healthy green spaces
- Encourage water and energy efficiency
- Manage rain where it falls
- Promote healthy living and active transportation
- Foster a connected community engaged in stewardship and climate action

CVC is working with municipal partners, residents, businesses, schools and community groups to develop and implement plans for environmental improvement, urban renewal, community engagement and climate change resilience.

Source: https://cvc.ca/sustainable-neighbourhoods/

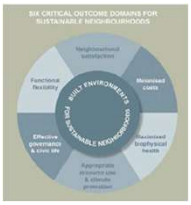


Image: https://www.researchgate.net/figure/Six-critical-outcome-domains-for-sustainable-neighbourhoods_fig1_277339703

45

Sustainable Neighbourhoods Criteria and its relation to Circular Economy and Construction

Potentialities of the location and of the project

- Transport services
- Diversity of functions
- Build density

Use of resources

- Access to sun and light
- Heating requirements and energy
- Materials

Green Spaces

- Soil sealing: Permeable surface
- Rainwater collection
- Green spaces, plants and biodiversity

Source: Criteria from the handbook "Towards sustainable neighbourhoods" by the Research Centre on Territorial, Urban and Rural Sciences (Lepur) of the University of Liège, at the request of the Walloon Minister of the Environment, Spatial Planning and Mobility (Belgium).

46

Sustainable Neighbourhoods Criteria and its relation to Circular Economy and Construction

Amenities of the neighbourhoods

- Roads and links with the surroundings
- Parking (car and bicycle)
- Architecture and image of the neighbourhood
- Collective equipment
- Waste management

Social aspects and public participation

- Diversity of uses
- Diversity of dwellings
- Social housing
- Access to handicapped people
- Community involvement

Source: Criteria from the handbook "Towards sustainable neighbourhoods" by the Research Centre on Territorial, Urban and Rural Sciences (Lepur) of the University of Liège, at the request of the Walloon Minister of the Environment, Spatial Planning and Mobility (Belgium).

47

Upgrades and Maintenance for Multi-functional Green Roofs Facades and Interior Elements

Presentation

48

Upgrades and Maintenance for Multi-functional Green Roofs Facades and Interior Elements

- Case Study
- Repairs and Maintenance
- Upgrades and Retrofits
- Impact on Other Sustainable Building Practices

49

Case Study - Munich Technology Centre, Munich

The Munich Technology Centre (MTZ) has a 2,500 m² roof it was decided to use a photovoltaic system combined with an extensive green roof. The individual frames for the solar system were each mounted on a 1 × 2 meter Solar Base Plate SB 200 and covered with substrate. Because the solar panels were set up almost to the edge of the roof the additional fixing device Fallnet® SB 200 Rail was installed which allows for safe working in the perimeter areas.



Source: https://zinco-greenroof.com/references/munich-technology-centre-munich

Source: https://zinco-greenroof.com/references/munich-technology-centre-munich

50

Maintenance on a MGRFIE

Intensive Green Roofs will require regular maintenance. Lawns will require mowing weekly or fortnightly, plant beds may require weeding on a weekly or fortnightly basis during the growing season, and wildflower meadows may require annual mowing with the cuttings removed. Extensive Green Roofs should normally only require bi-annual or annual visits to 1 As calculated by Klooster et al. (2008) 7 remove litter, check fire breaks and drains and, in some cases remove unwanted colonising plants. The highest maintenance regime is generally required in the first three years, and usually this should be made the responsibility of the Green Roof provider (Source: CIRIA C697).



Source: https://baydee.ie/news-blog/about-sedum-green-roof/

Source: https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

51

Maintenance on a MGRFIE

Intensive Green Roofs need to be watered and weeded in the same way as you would a normal garden. Larger plants, shrubs and trees should be pruned to make sure they are safe during windy conditions. Drains and gutters should also be checked and cleared to avoid blockages.



Source: https://www.urbangreenbluegrids.com/measures/green-roofs/intensive-green-roofs/

Source: https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

52

Accessibility for Maintenance

Easy access for maintenance of green roofs should be provided in the building. The maintenance staff often encounters difficulty in maintaining the roofs especially when the roofs are not designed for building occupant access. Weeds are a persistent problem, especially during the establishment period. It is a problem to dispose of the weeds if the roof does not have an easy access.



Source: https://architizer.com/blog/inspiration/collections/roof-escapes/

53

Advantages of Upgrades for MGRFIE

Manage Stormwater

- Most green roofing systems are designed to accommodate at least 1 inch of stormwater before discharging excess water to the storm drains. Instead of immediately getting rid of this valuable asset, we are able to use the stormwater to water the green roof.

Minimize the Urban Heat Island Effect

- Urban heat islands are described as the phenomenon that urban areas have a greater ambient temperature than the surrounding rural areas.

Extend Roof Membrane Lifespan

- Green roofs can also help extend the life of a roofing membrane.

54

Impact on Other Sustainable Building Practices

Green roofs can have a positive on other sustainable building practices such as passive houses and nZEB. This can benefit buildings through things such as improved insulation, space for sustainable energy and water collection and products and protect the building components such as membranes from weather damage.

What are some other benefits that align to sustainable practices you undertake?



Source: https://www.renewableenergyworld.com/baseload/copenhagens-fourfold-path-to-carbon-neutrality.html/

55

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

56

EXTRA READING/STUDY

Activity

57

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

58

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

59

BUS GoCircular

Shaping a Circular Sustainable Future

Module 5

Water and the Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

The trainer will explore multiple facets of water in construction gaining a general overview of the impact of water in construction and the opportunities that present themselves when correctly implementing water saving and collection methods. This will then be related to the many opportunities associated with water and Multi-functional Green Roofs Facades and Interiors Elements.

2

Objectives/Learning Outcomes

- 6 – Replace freshwater use with alternative water sources
- 7 – Enact measures that optimise water use for water efficiency

3

Content

- Water in Construction
  - Water and the Circular Economy
- Water and Sustainable Use in Construction
  - Sustainable Drainage Systems
  - Rainwater Harvesting
- Water Management Plan
- Application for Multi-functional Green Roofs Facades and Interior Elements

4

Water in Construction

Presentation

5

Water in Construction

Construction companies increase their contribution to environmental degradation through their current water practices. Water is a finite resource, meaning it is non-renewable. Oceans, rivers, and lakes may seem large enough to support life on Earth, but much of this water is unusable.



Builders use water for a variety of functions on the job. They utilize this resource for worker hydration, concrete batching, grouting, dust suppression, soakaway testing, pond filling, hydro-demolition, and drilling and piling. If companies mismanage this water use, they can increase their environmental impact.

Source: https://www.construction21.org/articles/h/how-construction-sites-can-minimize-water-pollution.html

6

Water in Construction

Top uses of water for constructions sites:

- Drinking water
- Supplying onsite facilities
- Concrete Batching
- Grouting
- Hydro-demolition
- Drilling and piling
- Landscaping and pond filling
- Chlorination
- Soakaway testing
- Dust suppression



Source: https://theconstructor.org/practical-guide/construction-water-quality-specification/66132/

Source: https://constructionmaguk.co.uk/the-need-for-water-on-construction-sites/

7

7

Water in Construction Manufacturing

Manufacturers of construction products rely on water for a wide variety of purposes.

Water must of course also be supplied for staff welfare purposes on any industrial or commercial site, i.e. via the provision of toilets, showers, basin taps and kitchen facilities.



Source: https://www.thomasnet.com/insights/which-industries-use-the-most-water/

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

8

8

Water in Construction Manufacturing

Water can serve as:

- a lubricant
- a cleaning agent
- a sealant
- a heat transfer medium
- a solvent
- an air pollution control medium
- plus an array of other uses depending on the material and products being produced.

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

9

9

Water in Construction Manufacturing

Different uses of water for manufacturing purposes may also have different requirements of water quality (purity, dissolved material content etc). For instance some dust suppression activities can use non-potable water, whereas there are strict requirements for drinking water which cover microorganisms, chemicals and metals as well as the way the water looks and tastes.

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

10

10

Water Sources

Mains water, supplied by a water company:

- Mains water accounts for the biggest proportion of water use overall, with alternative sources used as backup to guarantee security of supply.

Directly abstracted water from either a river or groundwater source:

- The abstraction of water directly from freshwater surface or groundwater sources requires a licence from the relevant environmental regulator (Environment Agencies). Many companies have an abstraction license, especially those in the heavy industries such as aggregates, concrete and bricks.



Source: https://www.mexichi-precia.ar/2020/05/22/ubicacion-la-manera-water-supply-as-mexico-

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

11

11

Water Sources

Harvested rainwater, collected on site, perhaps in tanks from roof runoff, in lagoons from site run-off, or from dewatering activities on site:

- Rainwater harvesting is becoming more common across the sector though tends not to be relied upon to supply significant proportions of water. This may be due to lack of constant supply, since seasonal variations in rainfall mean there is usually a reliance on mains water to 'top up' the available rainwater supply, or because of the treatment required to achieve the required water quality for wider use. Less commonly used sources of harvested water include quarry water and site lagoons which can be developed on a site by site basis.

Recycled water – where water from one process is later used in another process:

- The use of recycled water is widespread amongst construction product manufacturers; half of all respondents to a 2013 industry survey already recycle water. Whilst mains water is still the primary water source for respondents, almost a quarter indicated that recycled water is the main source of process water.

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

12

12

Water and the Circular Economy - Closing the Loop

It is vital that we not only reduce our consumption of water but that we increase the amount of reuse of this water. Closing the loop is a term used when describing the act of keeping a material in use for longer, in this case it means that once water enters a building or site it is reused as much as possible before it must be sent off site.



Source and Further Reading: https://www.chantonlabs.com/resources/importance-of-a-closed-loop-water-system-water-treatment/

13

13

Water and Sustainable Use in Construction



14

14

Sustainable Water Technologies

- Installing rainwater harvesting systems for dust suppression, vehicle cleaning, ponds, or underground tanks;
- Reusing water from groundwater or surface water drainage to dampen roads in hot weather;
- Using innovative technology, e.g. percussion taps, twin flush/low water toilets;
- Introducing recirculating systems for cleaning tools and greywater, and use for flushing toilets or irrigating plants;
- Designing ground surfaces to slope away from structures and towards garden areas and recharge zones;
- Retaining as much vegetation as possible during construction to reduce water evaporation.

Source: https://www.igbc.ie/water-conservation-guide/

15

15

Water Management in the Built Environment

Four broad groups of construction products facilitate better water management in the built environment, they are:

- Products that help reduce water use in buildings
- Products that enable building occupiers and infrastructure managers to recycle or use alternative sources of water
- Product systems that channel or soak up rainwater (runoff)
- Products that help other product manufacturers reduce water use in their processes

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

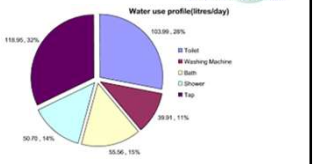
16

16

Water in Buildings

Products that help reduce water use in buildings.

A great many households are now engaging in water savings behaviour and this is assisted by innovation and new developments in the products industry



Source: Irish https://www.water.ie/about/research-and-innovation/CRU-Report-Promoting-Sustainable-Household-Water-Consumption-27th-Sept-2019-Final-Website.pdf

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

17

17

Examples

Efficient taps

Efficient baths and showers

Efficient toilets



Source: https://prestigefaucets.com/products/bathroom-faucet-water-saving-taps-chrome-finish-brass-hot-and-cold-single-tap-fully-automatic-faucet-infrared-sensor-faucet-8021

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

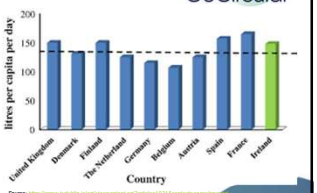
18

18

Water Infrastructure in Buildings

Products that enable building occupiers and infrastructure managers to recycle water or use alternative sources.

Much of the water used in buildings or rainwater that is not captured is lost when it can be easily utilised in many ways on a building.



Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

19

19

Examples

Greywater recycling systems

- In the domestic context, greywater systems collect the water from sources such as baths, showers and hand basins and reuse the collected water for toilet flushing, washing machines, and external use.

Rainwater harvesting goods

- For domestic purposes rainwater harvesting systems are applicable to both domestic and commercial properties, with the collected water primarily used for toilet flushing, garden irrigation and, less frequently, washing machines.



Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

20

20

SuDS

Product systems that channel or soak up rainwater (runoff).



Source: https://www.farminguk.com/sewa/reed-bed-creates-sustainable-source-of-water-for-wetlands-project_46184.html

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

21

21

SuDS

Sustainable Drainage Systems (SuDS) is the term used to describe an approach to managing rainwater falling on roofs and other surfaces that harnesses or mimics natural environmental processes. The key objectives are to manage the flow rate and volume of surface runoff to reduce the risk of flooding and water pollution. To achieve this, elements of the built environment that receive and handle rainwater are designed so that initial flows can be attenuated, runoff water channelled or stored and surface water transported at a controlled rate. SuDS also reduce pressure on the sewerage network and can offer scope for biodiversity and local amenity

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

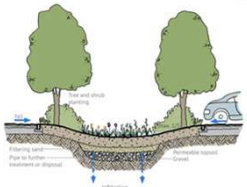
22

22

SuDS

Susdrain lists five key principles underpinning SuDS which enable the design and planning process to mimic natural drainage.

- Storing rainwater and releasing it slowly (attenuation)
- Allowing water to soak into the ground (infiltration)
- Slowly transporting (conveying) water on the surface
- Filtering out pollutants
- Allowing sediments to settle out by controlling the flow of the water



Source: https://www.susdrain.org/delivering-suds/using-suds/suds-components/suds-components-filtration.html

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

23

23

Water Reduction in Production

Products that enable other manufacturers and construction contractors to reduce water use in their processes.

These tend to be of a chemical nature and either alter a manufacturing process so that less water is required or else may be coatings that prevent the leakage of water.



Source: https://theconstructor.org/practical-guide/construction-water-quality-specification/60122/

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

24

24

Water Treatment Technologies



Disinfection

- Water disinfection means the removal, deactivation or killing of pathogenic microorganisms.

Purification

- Water purification means the process of removing undesirable chemicals, biological contaminants, suspended solids, and gases from water.

Clarification

- Clarification is an essential step in a water or wastewater treatment process to remove suspended solids through gravity settling, providing a clarified liquid effluent.

Source: https://vareoblu.com/water-treatment/

25

25

Water Treatment Technologies

De-ionization

- A deionized water system is an arrangement of DI tanks and other components that are used to produce high purity water.

Reverse Osmosis

- Reverse osmosis is a water purification process that uses a semi-permeable membrane (synthetic lining) to filter out unwanted molecules and large particles such as contaminants and sediments like chlorine, salt, and dirt from drinking water. In addition to removing contaminants and sediments, reverse osmosis can also remove microorganisms – which you certainly do not want to drink.

Source: https://vareoblu.com/water-treatment/

26

26

Water Treatment Technologies

Filtration

- Water filtration is the process of removing or reducing the concentration of particulate matter, including suspended particles, parasites, bacteria, algae, viruses, and fungi, as well as other undesirable chemical and biological contaminants from contaminated water to produce safe and clean water for a specific purpose, such as drinking, medical, and pharmaceutical applications.

Degassing

- By degassing the water, unwanted oxygen or carbonic acid is removed.

Screening

- A necessary part of all municipal and industrial wastewater treatment plants, wastewater screening retains solids found in the wastewater.

Source: https://vareoblu.com/water-treatment/

27

27

Measuring Water and Assessing Environmental Impacts

Measuring water quantities is one thing, but understanding and measuring the environmental impact of water consumption is a much more complex process and a variety of different terms have come to be used for the measurement of water consumption associated with a product, building or project. These terms have tended to become intertwined and somewhat confused. The most common terms encountered are water footprinting, water calculator and embodied water. Also, as is inevitable in a rapidly developing topic, these terms often mean different things to different groups of people and are sometimes used interchangeably. However, accepted definitions of key terms are beginning to emerge.

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

28

28

Embodied Water of Construction Products

The construction industry first developed the concept of embodied energy to distinguish the energy associated with construction materials – energy used in their extraction, manufacture, transport, installation, maintenance and disposal - from the energy associated with operating buildings known as "operational energy". As climate change became a concern, industry moved to the measurement of embodied carbon and operational carbon and as interest has grown in water, the term "embodied water" has come to be used in relation to the water associated with construction materials.

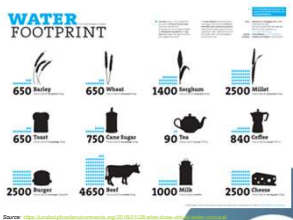
Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

29

29

Water footprinting

This relates to all products, for instance food crops such as vegetables grown in Africa and flown to European supermarkets or textile production for the global clothing industry. Water footprinting is the study of the water associated with organisations as well as products and has developed in two distinct phases.



Source: https://undisciplinedenvironments.org/2016/01/28/what-does-what-water-consumed/

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

30

30

Case Study - Culemborg

In Culemborg, a district with around 250 homes and small businesses has been realised with an extraordinary degree of integration.

Besides retaining rainwater and treating greywater at decentralised locations, the plan incorporated an ecologically designed outdoor space, use of sustainable materials and low energy consumption.

The energy consumption levels per home are exceptionally low. The houses are fitted with solar collectors and are heated using a district heating system that extracts heat from the groundwater.



Source: https://www.urbangreenbluegrids.com/projects/eva-lanxmeer-results/

31

Water in Culemborg

The design of the water system is an important foundation for the urban planning design of the residential district and the associated business locations. The district was designed around a water extraction site. The flow of clean water (rainwater runoff from roofs) is led off to the water extraction site, where it is captured in retention pools and rinse water (see below for more specifics) is added. The flow of dirty water (street water, greywater and blackwater) is led away from the vulnerable water extraction area.



Collecting rainwater from roofs to retention ponds © Copijn Utrecht

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

32

Water in Culemborg

PRECIPITATION FROM ROOFS

- Clean precipitation running off from roofs is captured in four retention pools, via a closed system of pipes

STREET WATER

- Street water is treated as it runs along wide gutters and parking spaces with scoria semi-paving.

GREYWATER

- The greywater (wastewater from dishwashers, showers and kitchens) is treated in helophyte filters at three locations along the periphery of the area covered by the plan.

Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

33

Water in Culemborg

BLACKWATER

- A separate sewer system has been realised for blackwater, which comes from toilets. The plan is to build a biogas plant to process the blackwater, together with green and garden waste and pruned branches and use it to produce energy.



Source: https://mammothmemory.net/geography/geography-vocabulary/water/sustainable.html

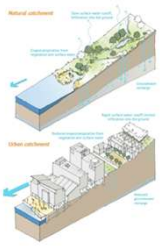
Source: https://www.constructionproducts.org.uk/media/87904/water_efficiency_report.pdf

34

Sustainable Drainage Systems (SuDS)

Approaches to manage surface water that take account of water quantity (flooding), water quality (pollution) biodiversity (wildlife and plants) and amenity are collectively referred to as Sustainable Drainage Systems (SuDS).

SuDS mimic nature and typically manage rainfall close to where it falls. SuDS can be designed to transport (convey) surface water, slow runoff down (attenuate) before it enters watercourses, they provide areas to store water in natural contours and can be used to allow water to soak (infiltrate) into the ground or evaporated from surface water and lost or transpired from vegetation (known as evapotranspiration).



Source: https://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html

35

Why are SuDS Sustainable

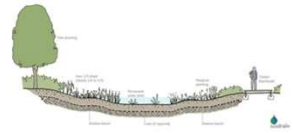
- Manage runoff volumes and flow rates from hard surfaces, reducing the impact of urbanisation on flooding
- Provide opportunities for using runoff where it falls
- Protect or enhance water quality (reducing pollution from runoff)
- Protect natural flow regimes in watercourses
- Are sympathetic to the environment and the needs of the local community
- Provide an attractive habitat for wildlife in urban watercourses
- Provide opportunities for evapotranspiration from vegetation and surface water
- Encourage natural groundwater/aquifer recharge (where appropriate)
- Create better places to live, work and play.

Source: https://www.susdrain.org/delivering-suds/using-suds/background/sustainable-drainage.html

36

SuDS - Reed Beds

Reed beds can be used for a wide range of wastewater treatment ranging from domestic use to the treatment of farm waste and even the treatment of heavy industrial contaminants. One of the advantages of sustainable urban drainage systems is that they are visually more attractive than other forms of wastewater treatment and this is certainly the case with reed beds.



Source: https://www.theikgroup.com/the-suds-balancing-act/

Source: http://www.energysavingwarehouse.co.uk/learning-portal/sustainable-urban-drainage-systems-and-reed-beds/

37

37

SuDS - Reed Beds

- Low operational costs
- No operational noise
- No electricity needed
- Do not produce sludge
- Enhance the natural environment
- Provide habitats for invertebrate such as dragonflies



Source: https://www.planningresource.co.uk/article/1311888/government-proposes-planning-changes-better-urban-drainage-space

Source: http://www.energysavingwarehouse.co.uk/learning-portal/sustainable-urban-drainage-systems-and-reed-beds/

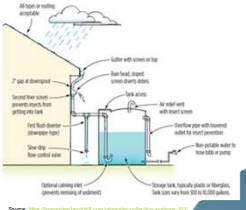
38

38

Rainwater Harvesting

The Main Components of a RWH System are:

- A catchment area such as a roof.
- Collection system such as gutters.
- A downpipe from the gutters.
- A diverter to collect water from the down-pipe.
- A water storage container such as a butt or tank.



Source: https://homesteadandchill.com/rainwater-collection-systems-101/

Source: https://www.sustainablehomes.ie/energy-insulation/rainwater-harvesting/

39

39

Rainwater Uses

- Washing clothes - You will need to put an additional storage tank in the attic area of your home and a pump located near the ground tank.
- Cleaning your car - rainwater is free from chemicals such as chlorine and fluoride which have a tendency to leave water marks on surfaces.
- Watering your garden - plants love chemical-free rainwater.



Source: https://www.jdpipes.co.uk/knowledge/rainwater-harvesting/what-are-the-advantages-of-using-rainwater-harvesting-and-do-i-need-to/

Source: https://www.sustainablehomes.ie/energy-insulation/rainwater-harvesting/

40

40

Water Management Plan



41

41

Water Management Plan

A successful water management program starts with a comprehensive strategic plan. The process for developing a strategic plan is generally the same for an individual facility or an agency. The plan provides information about current water uses and charts a course for water efficiency improvements, conservation activities, and water-reduction goals. A strategic plan establishes the priorities and helps a site or agency allocate funding for water-efficiency projects that provides the biggest impact.

Source: https://www.energy.gov/eere/femp/developing-water-management-plan

42

42

Water Management Plan Scope

- Actions during construction.
- Appliances and plumbing to be installed.
- Water reuse potential.
- Landscaping and rainwater utilisation.
- Include water conservation and water quality in all of your project tenders and contractual documents.
- Specify water efficient fittings and appliances. These should reduce drinking water use inside the home to under 80 litres per person per day. Use the Water Efficiency Calculator from European Unified Water label to calculate water use per person.

Source: https://www.water.ie/conservation/business/business-conservation-tips/construction/

43

Water Management Plan Scope

- Stay up to date with the latest design and appliances to help water conservation.
- Agree on a budget and procure funding. Check Enterprise Ireland programmes GreenPlus and Green Start for funding and grants.
- If you are designing a greenfield site, use natural drainage swales instead of costly concrete pipes.
- Install drainage systems that allow the polluted 'first flush' to be diverted into trade waste. The clean water that follows it can flow into tanks, pond systems or drainage swales.

Source: https://www.water.ie/conservation/business/business-conservation-tips/construction/

44

Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

45

Case Study - VanDusen Botanical Garden Visitor Centre

- Client: Vancouver Board of Parks and Recreation
- Size: 19,483 square feet
- Completion Date: 2011
- Sustainability: LEED Platinum, Living Building Challenge Petal Certified



Source: https://perkinswill.com/project/vandusen-botanical-garden-visitor-centre/

46

Concept

"How would a flower (orchid) do it?". A flower is rooted in its own place by harvesting all its own energy and water, by adapting to the climate and site, by operating pollution-free, and by promoting health and well-being.

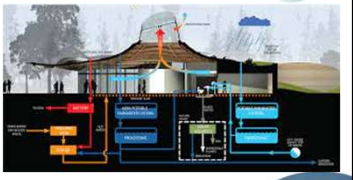


Source: https://www.archdaily.com/956788/vandusen-botanical-garden-visitor-centre-perkins-and-will

47

Sustainability

Designed to exceed LEED Platinum standards, the LEED® Canada-NC 1.0 Platinum Certified the VanDusen Botanical Garden Visitor Centre uses renewable sources found on-site to meet net-zero energy annually. The primary building material is wood which stores carbon dioxide for the life of the building. Photovoltaics on the roof create electricity for the Centre, and hot water is provided by a biomass boiler fed by dry wood waste reclaimed from the surrounding area. 100% of water use comes from captured precipitation or reused water – rainwater is filtered and used for the Centre's greywater requirements and 100% of blackwater is treated by the on-site bioreactor, the first of its kind in Vancouver, and discharged to a new percolation field in the garden.



Source: http://www.greenroofs.com/projects/vandusen-botanical-garden-visitor-centre/

48

The Green Roof

With slopes ranging from 2 degrees to 50 degrees, this project used three different green roof systems. On the low sloped land bridge roof the “ZinCo Perennial Garden” with the Floradrain FD40 and 20 cm of growing medium was installed. The sloped petals green roofs were constructed with the “ZinCo Sloping Meadow” system including the Floraset FS75 and 20 cm of growing medium. And the oculus roof with a slope of more than 45 degrees was installed with the “ZinCo Steep Sloping Meadow” system including the Georaster elements and 12 cm of growing medium. The entire green roof was hydroseeded with local grasses and planted with bulbs native to the area.

49

49

Learn More About this Project

https://perkinswill.com/project/vandusen-botanical-garden-visitor-centre/

http://www.greenroofs.com/projects/vandusen-botanical-garden-visitor-centre/

https://www.architectmagazine.com/design/buildings/vandusen-botanical-garden-visitor-centre_o

https://www.archdaily.com/956788/vandusen-botanical-garden-visitor-centre-perkins-and-will

50

50

QUIZ/ASSIGNMENT/ACTIVITY



Assessment / Exam

51

51

EXTRA READING/STUDY



Activity

52

52

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101033740

53

53

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 101033740

54

54

BUS GoCircular

Shaping a Circular Sustainable Future

Module 6

Energy and the Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

The trainer will explore multiple facets of energy in construction gaining a general overview of the impact of energy in construction and the opportunities that present themselves when correctly implementing energy saving and collection methods. This will then be related to the many opportunities associated with energy and Multi-functional Green Roofs Facades and Interiors Elements.

2

Objectives/Learning Outcomes

- 8 – Select sources with less impact to apply to operations in buildings
- 9 – Enact measures that reduce and optimise energy use through solutions on roofs and facades whilst taking into account building purpose and climate
- 10 – Generate energy or heat/cold from renewable sources in design of multifunctional green roofs, façades, and interior elements
- 24 – Enact measures to use and store energy more efficiently in buildings
- 56 – Install energy efficiency measures on roofs, façades, and interior elements

3

Objectives/Learning Outcomes

- 63 – Install renewable energy technologies in buildings to generate power or heat/cold
- 67 - Install measures to use and store energy more efficiently in buildings

4

Content

- Energy in Construction
- Energy and Sustainable Use in Construction
  - Renewable energy sources
- Application for Multi-functional Green Roofs Facades and Interior Elements

5

Energy in construction



6

Energy in Construction

In very general terms, energy is a capacity to do work that can take a number of different forms, such as; thermal (heat), radiant (light), motion (kinetic), stored (potential), secondary (e.g. electricity), chemical, mechanical, and so on.

The term 'energy consumption' refers to the amount of energy that is used by a process, system, product, community and so on.



Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

7

Energy in Construction

Today, roughly 75% of the EU building stock is energy inefficient. This means that a large part of the energy used goes to waste. Such energy loss can be minimised by improving existing buildings and striving for smart solutions and energy efficient materials when constructing new houses.

Source: https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en

8

Energy in Construction

Some of the most important elements in EU directives include

- reinforced long-term renovation strategies for EU countries
- nearly zero-energy buildings
- energy performance certificates
- consideration for health and well-being (air pollution), e-mobility (e-charging points) and smart technology (smart meters, self-regulation equipment) in new buildings

Source: https://commission.europa.eu/news/focus-energy-efficiency-buildings-2020-02-17_en

9

Energy in Construction

In a domestic context, energy consumption is often attributed to:

- Heating.
- Hot water.
- Cooling and refrigeration.
- Lighting.
- Washing and drying.
- Cooking.
- Other electric loads.



Source: https://www.thisoldhouse.com/lighting

Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

10

Whole Life Energy

The energy consumed by a building throughout its whole life comprises:

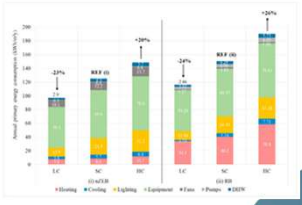
- Initial embodied energy. The energy consumed to create the building, including; extraction, processing and manufacture, transportation and assembly.
- Recurring embodied energy. That is the energy consumed in refurbishing and maintaining the building during its life.
- Operational energy. The energy consumed in heating, cooling, lighting and powering appliances in the building.
- Demolition energy: The energy consumed in the disposal of the building.

Source: https://www.designingbuildings.co.uk/wiki/Energy_consumption_in_the_construction_industry

11

Occupational Energy Use

Occupant behaviour is known to be one of the key sources of uncertainty in the prediction of building energy use.



Source: Annual primary energy consumption of the analyzed scenarios

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

12

Occupational Energy Use

'Raising User Awareness' is the most important aspect when considering occupational energy use in a building. This can span from nZEB or other energy efficient building to building that perform poorly as energy efficiency measures can be carried out by any occupant once there is a general understanding of how this can be done.

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

13

13

Energy and Sustainable Use in Construction



14

14

Energy and Sustainable Use in Construction

Renewable energies are natural resources that can be replaced or replenished with usage. When implementing energy-based sustainable construction techniques, companies should strive to use renewable resources. The construction industry has a history of nonrenewable energy usage and has seen little change in consumption in the last 20 years. As there is a finite amount of nonrenewable energy, this results in a huge strain on resources.

Source: https://www.chas.co.uk/blog/sustainable-construction-techniques/

15

15

Reduce Heating, Cooling, And Lighting Loads Through Climate-Responsive Design And Conservation Practices

Use passive solar design; orient, size, and specify windows to balance daylighting versus heat loss; and locate landscape elements with solar geometry and building load requirements in mind.

Use high-performance building envelopes; select walls, roofs, and other assemblies based on long-term insulation, air barrier performance, and durability requirements.

Consider an integrated landscape design that provides deciduous trees for summer shading, appropriate planting for windbreaks, and attractive outdoor spaces so that occupants wish to be outdoors—thereby reducing the occupant-driven additional heat loads to the building.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

16

16

Specify Efficient HVAC (Heating, ventilation, and air conditioning) And Lighting Systems

- Use energy efficient HVAC equipment and systems.
- Incorporate strategies to reduce excessive air changes and use energy recovery systems for makeup air.
- Introduce combustion air strategically into the building enclosure for mechanical equipment by using sealed combustion or ducted systems rather than simple louvered wall openings.
- Use lighting systems that consume less than 1 watt/square foot for ambient lighting.
- Use Energy Star® approved and/or FEMP-designated energy efficient products or products that meet or exceed Department of Energy standards.
- Evaluate energy recovery systems that preheat or pre-cool incoming ventilation air in commercial and institutional buildings.
- Investigate the use of integrated generation and delivery systems, such as co-generation, fuel cells, and off-peak thermal storage. See also WBDG Distributed Energy Resources (DER) and Microturbines.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

17

17

Employ Renewable Or High-Efficiency Energy Sources

- Renewable energy sources include solar water heating, photovoltaic (PV), wind, biomass, and geothermal. Use of renewable energy can increase energy security and reduce dependence on imported fuels, while reducing or eliminating greenhouse gas emissions associated with energy use. Consider solar thermal for domestic hot water and heating purposes.
- Evaluate the use of building scale to take advantage of on-site renewable energy technologies such as solar water heating, and geothermal heat pumps.
- Consider the use of larger scale, on-site renewable energy technologies such as photovoltaics, solar thermal, and wind turbines.
- Evaluate purchasing electricity generated from renewable sources or low polluting sources such as natural gas.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

18

18

Optimize Building Performance And System Control Strategies

- Employ energy modeling programs early in the design process.
- Evaluate the use of modular components such as boilers or chillers to optimize part-load efficiency and maintenance requirements.
- Use sensors to control loads based on occupancy, schedule and/or the availability of natural resources such as daylight or natural ventilation during building operations.
- Provide HVAC night and weekend setbacks where applicable to reduce heating and cooling loads when the building is unoccupied.
- Evaluate the use of Smart Controls that merge building automation systems with information technology (IT) infrastructures.
- Employ centralized remote meter reading and management to provide accurate analysis of energy use and monitor power quality.
- Use metering to confirm building energy and environmental performance through the life of the project.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

19

19

Optimize Building Performance And System Control Strategies

- Use a comprehensive, building commissioning plan throughout the life of the project.
- Employ an interactive energy management tool that allows you to track and assess energy and water consumption like the Energy Star® Portfolio Manager.
- Provide electronic interactive graphic dashboards in prominent locations to educate occupants of their building's energy and water consumption and highlight sustainable building features.
- See also WBDG Facility Performance Evaluation.

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

20

20

Deep Energy Retrofits

A deep energy retrofit is a whole-building analysis and construction process that achieves much larger energy cost savings than those of simpler energy retrofits such as upgrading lighting and HVAC equipment. In taking a whole-building approach, deep energy retrofits address many systems at once by combining energy efficient measures such as energy-efficient equipment, air sealing, moisture management, controlled ventilation, insulation, and solar control.



Source: Livingfolds.com A cable-supported vertical green wall installed on the facade of a building in Barcelona

Source: https://www.wbdg.org/design-objectives/sustainable/optimize-energy-use

21

21

Renewable energy sources

22

22

Renewable Energy

The main types of renewable energy sources include:

- Solar thermal energy: The conversion of solar radiation to thermal energy in order to heat a working fluid.
- Geothermal energy: The natural heat energy stored in the earth.
- Wind energy: Energy generated by the wind.
- Biomass: A generic term referring to organic materials that can be used as fuels.
- Hydropower: The generation of electricity from flowing water power.



Source: https://theconstructor.org/construction/renewable-energy-sources-advantages-disadvantages/8475/

Source: https://www.designingbuildings.co.uk/wiki/Energy_in_the_built_environment

23

23

What is Solar Energy

Currently, solar energy is harnessed using three primary technologies. Which are:

1. *Photovoltaic (PV)* – directly convert light to electricity;
2. *Concentrating solar power (CSP)* – heat is being used from the sun (thermal energy) to drive electric turbines, utility-scale, and
3. *Solar heating and cooling (SHC) systems* – accumulate thermal energy to supply hot water and air heating and/ or conditioning.



Source: https://www.britannica.com/science/solar-energy

Source: https://www.dexma.com/blog-en/how-efficient-are-solar-energy-technologies-for-buildings/

24

24

Advantages of Solar Panels

- Limitless Resource: Solar energy is renewable energy that never ends its supply.
- Low environmental impact: Depending on the scale of the system installed – from distributed rooftop PV arrays to large utilities – solar technologies can produce lower environmental pollution.
- Energy Independence: It makes Buildings energy independent and puts less pressure on natural sources of energy.
- Multipurpose: It can be used in various ways and for multiple applications.
- The ability for Additions: You can expand your PV systems effortlessly as they are modular.
- Portable: Can be transported easily.
- Post-Installation is Zero: Once the infrastructure has been installed no cost will be there after that (except for changing inverters and batteries).

Source: https://www.dexma.com/blog-enhow-efficient-are-solar-energy-technologies-for-buildings/

25

Photovoltaic (PV)

Solar panels that produce electricity are known as solar photovoltaic (PV) modules. These panels generate electricity when exposed to light. Solar PV is the rooftop solar you see on homes and businesses.



Source: https://energy.ie/solar-panels-cost-ireland/

Source: https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/about-solar-pv/#:~:text=Solar%20panels%20that%20produce%20electricity,or%20solar%20hot%20water%20collectors.

26

Photovoltaic (PV)

A solar electric system (PV) is typically made up of:

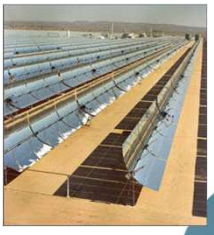
- Solar panels on the roof, which generate DC (direct current – like in a battery).
- An 'Inverter' which converts this to AC (alternating current – like the electricity in your house socket).
- Sometimes a battery on larger systems to save energy for later use.

Source: https://www.seai.ie/grants/home-energy-grants/solar-electricity-grant/about-solar-pv/#:~:text=Solar%20panels%20that%20produce%20electricity,or%20solar%20hot%20water%20collectors.

27

Concentrating solar power (CSP)

Concentrating Solar Power (CSP) technologies use mirrors to concentrate (focus) the sun's light energy and convert it into heat to create steam to drive a turbine that generates electrical power.



Source: https://solareis.anl.gov/guide/solar/csp/

28

Solar heating and cooling (SHC)

Solar heating & cooling (SHC) technologies collect the thermal energy from the sun and use this heat to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications. These technologies displace the need to use electricity or natural gas.



Source: https://www.seia.org/research-resources/solar-heating-cooling-new-study-reminds-americans

Source: https://www.seia.org/initiatives/solar-heating-cooling

29

Solar heating and cooling (SHC)

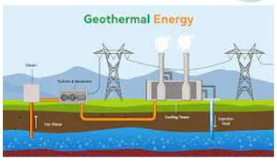
Solar water heating systems are comprised of three main elements: the solar collector, insulated piping, and a hot water storage tank. Electronic controls can also be included, as well as a freeze protection system for colder climates. The solar collector gathers the heat from solar radiation and transfers the heat to potable water. This heated water flows out of the collector to a hot water tank, and is used as necessary. Auxiliary heating can remain connected to the hot water tank for back-up if necessary.

Source: https://www.seia.org/initiatives/solar-heating-cooling

30

What is Geothermal Energy

Geothermal energy refers to energy stored in the form of heat beneath the surface of the Earth. This energy can be used for heating buildings and businesses, and even for electricity generation in some places.



Source: https://greenesa.com/blog/geothermal-energy-types-uses-advantages

Source: https://www.gsi.ie/en-ie/geoscience-topics/energy/Pages/Geothermal-Energy.aspx

31

31

What is Wind Energy

The sun heats the earth unevenly and this creates thermal air currents. In order to achieve equal temperatures around the earth, these air pockets move about as global wind. The energy that travels in the wind can be captured and converted to provide electricity.

Wind energy provides a clean, sustainable solution to our energy problems. It can be used as an alternative to fossil fuels in generating electricity, without the direct emission of greenhouse gases. And there will always be wind; it is inexhaustible and renewable.



Source: https://archinect.com/forum/thread/792251/building-integrated-wind-turbines

Source: https://www.seai.ie/technologies/wind-energy/

32

32

What is Biomass Energy

Bioenergy is a form of renewable energy generated when we burn biomass fuel. Biomass fuels come from organic material such as harvest residues, purpose-grown crops and organic waste from our homes, businesses and farms.

Source: https://www.seai.ie/technologies/bioenergy/what-is-bioenergy/#:~:text=When%20we%20use%20plants%20and,our%20homes%2C%20businesses%20and%20farms.

33

33

Biomass

Biomass such as raw wood chips and pellets are converted to energy by a variety of means. One of the most common is thermal conversion, where biomass is compressed into briquettes, and burned to produce steam, which in then powers turbines to produce electricity. Another method, pyrolysis, involves heating biomass to 200-300 degrees Celsius (390-570 Fahrenheit) to produce a dark liquid known as pyrolysis oil that can be combusted to generate energy, and in the future, may also replace petroleum.



Source: https://www.archdaily.com/933023/what-is-biomass-energy

34

34

What is Hydroelectric Energy

Hydroelectric power, also called hydropower, electricity produced from generators driven by turbines that convert the potential energy of falling or fast-flowing water into mechanical energy. In the early 21st century, hydroelectric power was the most widely utilized form of renewable energy.



Source: https://www.innovationnewsnetwork.com/hydropower-vs-wind-energy-securing-the-renewable-supply/6492/

Source: https://www.britannica.com/science/hydroelectric-power

35

35

Application for Multi-functional Green Roofs Facades and Interior Elements



Presentation

36

36

Application for Multi-functional Green Roofs Facades and Interior Elements

From the five examples of energy in construction given above what examples and benefits can these bring to Multi-functional Green Roofs Facades and Interior Elements.

- Solar thermal energy
- Geothermal energy
- Wind energy
- Biomass
- Hydropower



Source: https://architizer.com/blog/inspiration/collections/roof-scapes/

37

37

Main Opportunity

There is a perception that a roof can either have a green roof or solar power but not both. This is however not the case. Combining the two technologies is common in many countries in the world. Switzerland, Germany and Austria lead the way in the approach.



Source: https://livingroofs.org/green-roofs-solar-power/

38

38

Main Opportunity

There is substantial evidence from Germany and Switzerland that combining solar panels and vegetation can produce the following benefits:

- Solar/Photovoltaic panels can work more efficiently on a roof when installed over a green roof system. The micro-climate around the panels is important. If it is too hot, the panels can lose efficiency. The green roof element can have a cooling effect, especially in summer. Year round, green roofs can help to keep ambient temperatures around the panels at or near 250C. This is the best temperature for solar panels to work most efficiently.

Source: https://livingroofs.org/green-roofs-solar-power/

39

39

Main Opportunity

- A green roof makes the installation of A-frame panels easier. The green roof element provides the ballast to hold the A-frames and panels in place. This means there is no impact on the waterproofing layer below.



Source: https://www.sciencedirect.com/science/article/abs/pii/S0960148118308242

Source: https://livingroofs.org/green-roofs-solar-power/

40

40

Main Opportunity

- The PV panels should also increase the diversity of vegetation and therefore also fauna using the green roof. The panels can create shaded areas underneath, with rain run-off making damper areas to the front and drier areas behind. This creates a 'habitat mosaic', allowing a wider variety of vegetation to flourish, in turn attracting a wider range of butterflies, bees, beetles and other species.



Source: https://urbanstrong.com/blog/integrated-solar-green-roofs-are-the-greed/

Source: https://livingroofs.org/green-roofs-solar-power/

41

41

QUIZ/ASSIGNMENT/ACTIVITY



42

42

EXTRA READING/STUDY

Activity

43

43

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4RjsSWDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

44

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

45

BUS GoCircular

Shaping a Circular Sustainable Future

Module 7

Digitalisation and Material Passports in the Construction Industry

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summary

Within this module, trainers will explore a multitude of existing and new or emerging digitalization topics that support repairs, material reduction and training along with a number of other impacts. The trainee will also gain an understanding of material passports and why they are an important new element within the construction industry and their value. They will then relate all of this information to its application into Multi-functional Green Roofs Facades and Interiors Elements.

2

2

Objectives/Learning Outcomes

- 15 - Arrange a safe working environment and continuously consider health and safety requirements, especially for working on roofs and facades
- 46 – Apply digital tracking of materials to optimise maintenance, demolition, and recovery of multifunctional green roofs, façades, and interior elements
- 47 – Develop and apply material and building passports
- 57 – Employ BIM modelling to get insight into the effects and changes affiliated with upkeep, repair, or improvement of buildings
- 84 – Use drones and imaging technologies to collect data about roofs or facades for renovation purposes

3

3

Objectives/Learning Outcomes

- 75 – Provide documentation as guideline to use the multifunctional green roofs, façades, and interior elements properly in order to stretch its lifetime
- 26 – Design multifunctional green roofs, façades, and interior elements for prefabrication so that as little waste as possible is produced during construction
- 70 - Apply sensor technology to green roofs and façades (e.g. for predicting maintenance, to facilitate water flow from roof when needed)

4

4

Content

- Digitalization in Design and Construction
- BIM
- Drones
- 3D Modelling
  - VR (Virtual Reality)Headsets
- Exoskeleton Suits
- Digital Twins
- Material Passports
- 3D Printing and Prefabrication
- Application for Multi-functional Green Roofs Facades and Interior Elements

5

5

Digitalization in design and construction



Presentation

6

6

What is Digitalization

Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.



Source: https://www.gartner.com/en/information-technology/glossary/digitalization

7

7

Digitalization in Construction

While the pace of digitalisation across the built and natural environments continues to gather momentum, there remains a significant opportunity for the construction sector to invest more widely in adopting model-centric and data-driven work processes and practices. The benefits of digitalisation (the adoption of digital technologies, such as as BIM and digital twins) are well understood by many market participants. Still, many barriers to adoption remain across a sector that is fragmented, under continual cost and time pressures, and frequently criticised for spending less on research and development than comparable industries. In addition, to support traditional construction processes such as cost estimation, prediction, planning and control; progress monitoring; and health, safety and well-being, the sector is now having to address other practices with some urgency. These include incorporating environmental, social and governance (ESG) principles; designing and measuring social value; implementing whole-life and whole-asset thinking; and carbon footprint calculation, benchmarking and reporting across projects.

Source: https://www.rics.org/globalassets/rics-website/media/knowledge/research/research-reports/rics0112-digitalisation-in-construction-report-2022-web.pdf

8

8

Reasons for Digitalization

- Evolving client needs
- Increased technological capabilities
- Next-generation of workers and professionals
- Booming start-up environment
- Supportive policies and legal frameworks
- Increased market needs
- Up to the neck competition
- Launch of large infrastructure projects
- Need for integrated processes
- Better quality standards



Source: https://www.turnhappold.com/articles/digitisation-is-revolutionising-the-construction-industry/

Source: https://www.digigc.com/blog/digitalization-in-construction-industry

9

9

Opportunities with Digitalization

- New Channels: A broader network of contacts.
- Better Visualization: Virtual tours and visits and 2D and 3D modeling.
- 3D Simulation Tool: Eliminating errors and risks via 3D simulation
- Simplified administrative work: Easy documentation and reactive workflow.
- Tracking feedback and improvement: Better and digital interaction with clients and evolving key performance indices.
- Enhances products: Smart and better buildings with improved infrastructure. Smart cities.
- New partnership models: Flexibility between builders, partners, and promoters.
- New financing options: Customized and tailored financing models.
- Multiple performance tracking: Transparent performance tracking and enhanced value in data.

Source: https://www.digigc.com/blog/digitalization-in-construction-industry

10

10

Benefits of Digitalization

1. Safer operations
   a. With digital design and construction, the need for crews to enter dangerous situations and locations to get hard-to-reach information has reduced drastically.
2. More innovation
   a. As a result of the rapid adoption of digital technologies on the construction project site, a virtuous cycle has begun, whereby innovation is becoming a core differentiator, fueling further adoption and investment.
3. A new focus
   a. This digital transformation has enabled a renewed focus within the entire construction industry on what's most important – high-quality work safely done.
4. Relevant communication
   a. The use of cloud-connected mobile apps has become the norm and is accepted on most projects in the field.
5. Timely Intervention
   a. With digitalization, the exchange of information has become quicker and more effective.

Source: https://www.digigc.com/blog/digitalization-in-construction-industry

11

11

BIM (Building Information Modeling)



12

12

BIM Fundamentals

BACKGROUND

It's impossible to build in a perfect way, so it's impossible to resolve all the specific solutions that a project requires during the project stage or the construction one. There are a lot of issues to take into account and technology can help us to detect some issues that can compromise the quality of the project.



Source: https://bimzeed.eu/

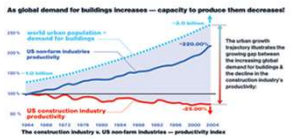
13

13

BIM Fundamentals

BACKGROUND

This graphic shows us the evolution of productivity in different industries in United States since 1964. It can be interpreted as the productivity evolution in industries in a developed country.
All industries but farm rose their productivity index from 1960s to 2000s.
In only 40 years world urban population increased 2 billion people.
US construction industry productivity falls a 25%.



Source: https://bimzeed.eu/

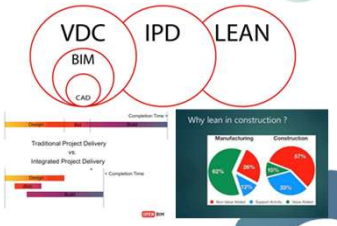
14

14

BIM Fundamentals

SOLUTION

To increase collaboration, the usage of new technologies in the construction industry and the implementing of new approaches such as Lean Construction methodology, it's supposed to be the point of inflection of the construction industry productivity.



Source: https://bimzeed.eu/

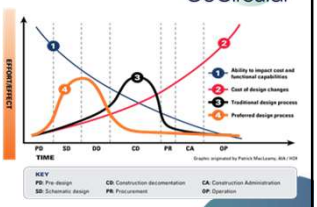
15

15

BIM Fundamentals

BIM APPROACH

The use of the BIM methodology requires that we anticipate certain decisions at an early stage.
We need to further define the documentation that will be used to build as we are building it digitally at 1:1 scale. That is, at real size.
This allows us to analyze the build, without leaving room for error of interpretation in the documentation. Because we have a 3D model, we are able to analyze it from different aspects.



Source: https://bimzeed.eu/

16

16

BIM Fundamentals

BIM APPROACH

BIM is a methodology that allows us to implement a process of creating and managing the information (graphic and non-graphic) of a project throughout all the phases of the life cycle of an asset.



Source: https://bimzeed.eu/

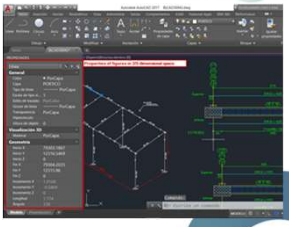
17

17

BIM Fundamentals

CAD vs BIM

CAD (Computer Alied Design)
Computer Aided Design (CAD) is based on the graphic representation of vectorial geometric entities (such as: lines, points, arcs and polygons).
The software does not interpret what is being represented, the information has to be managed by the user through support tools such as layers, line styles, etc.
CAD programs:
AutoCAD, MicroStation, Catia, Sketch Up, etc



Source: https://bimzeed.eu/

18

18

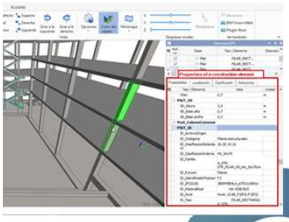
BIM Fundamentals

CAD vs BIM

While CAD is based on geometric vector entities, BIM is based on Parameterizable Objects.

The digitization of assets in BIM Objects, allows us to create parameterizable objects in which we can embed any type of information and benefit from it once the project is completed.

In addition, BIM software interprets that a wall and a pillar are different elements (CAD interprets that they are two rectangles) thus allowing the association of specific parameters according to the construction family to which each element belongs.



Source: https://bimzeed.eu/

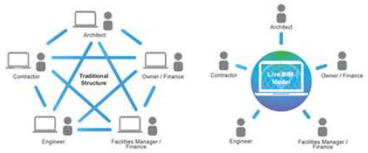
19

19

BIM Fundamentals

CAD vs BIM

Other key difference between CAD and BIM is the fact of using a centralized model data that you share with your project partners. There is only a model, a single source of information that is shared with all partners at the same time, so they all have access to the last model version.



Source: https://bimzeed.eu/

20

20

BIM Fundamentals

BIM Model exploitation: BIM Uses

Each of the actions we perform through a model are BIM Uses.

The first BIM Uses were defined in "The Uses of BIM" by PENN State University.

This document defines BIM uses, primarily by the purpose that they fulfil on a project, along with additional attributes for each BIM Use, e.g., the scope of work includes, the phase within the lifecycle, the level of development of the model, and the discipline to perform the modelling.



Source: https://bimzeed.eu/

21

21

BIM Fundamentals

BIM Uses: Programming

Process in which a spatial program is used to efficiently and accurately assess design performance regarding spatial requirements.

Potential Value

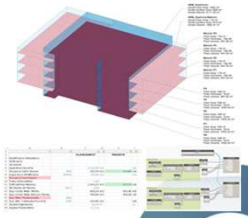
- Efficient and accurate assessment of design performance regarding spatial requirements by the owner.

Resources Required

- Design Authoring Software
- Programming Software

Team Competencies Required

- Ability to manipulate, navigate, and review a 3D model.
- Knowledge of regulations and spatial requirements.



Source: https://bimzeed.eu/

22

22

BIM Fundamentals

BIM Uses: Design Review

A process in which stakeholders view a 3D model and provide their feedbacks to validate multiple design aspects.

Potential Value

- Eliminate costly and timely traditional construction mock-ups
- Different design options can be changed in real-time during meetings based on owner feedbacks
- Create shorter and more efficient design and design review process
- Get instant feedbacks on owner's needs.
- Increases coordination and communication between different parties.

Resources Required

- Design Review Software
- Hardware which is capable of processing potential large model files

Source: https://bimzeed.eu/

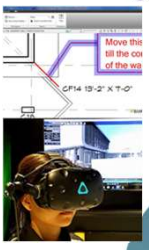
23

23

BIM Fundamentals

Team Competencies Required

- Ability to manipulate, navigate, and review a 3D model
- Ability to model photo realistically including textures.
- Strong sense of coordination. Understanding roles and responsibilities of team members and understanding how building systems integrate with one other.



Source: https://bimzeed.eu/

24

24

BIM Fundamentals

BIM Uses: Cost Estimation

This process allows the project team to see the cost effects of their changes during all phases of the project.

Potential Value

- Precisely quantify modelled materials
- Quickly generate quantities to assist in the decision-making process and generate more cost estimates at a faster rate
- Provide cost information to the owner during the early decision-making phase of design and throughout the lifecycle, including changes during construction
- Easier exploration of different design options and concepts within the owner's budget

Resources Required

- Model-based estimating software
- Design authoring software and accurately built design model
- Cost data (classification systems used in cost estimation workflows)

Source: https://bimzeed.eu/

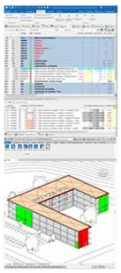
25

25

BIM Fundamentals

Team Competencies Required

- Ability to define specific design modelling procedures which yield accurate quantity take-off
- Ability to identify quantities for the appropriate estimating level
- Ability to manipulate models to acquire usable quantities



Source: https://bimzeed.eu/

26

26

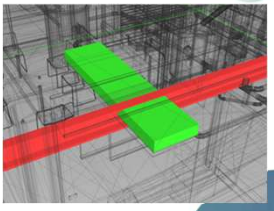
BIM Fundamentals

BIM Uses: 3D Coordination also known as Clash Detection

The 3D coordination allows the professionals involved to assimilate the complexity of the design which translates into greater efficiency in its resolution.

Potential Value

- Coordinate building project through a model
- Reduce and eliminate field conflicts.
- Reduced construction cost; potentially less cost growth (i.e. less change orders) and decrease construction time and increase productivity on site
- More accurate as built drawings



Source: https://bimzeed.eu/

27

27

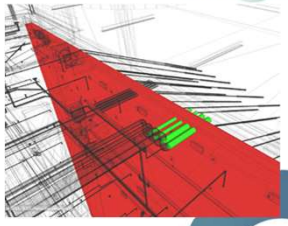
BIM Fundamentals

Resources Required

- Design Authoring Software
- Model Review Software

Team Competencies Required

- Ability to deal with people and project challenges
- Ability to manipulate, navigate, and review a 3D model
- Knowledge of building systems



Source: https://bimzeed.eu/

28

28

BIM Fundamentals

BIM Uses: Design Authoring

A process in which 3D software is used to develop a Building Information Model based on criteria that is important to the translation of the building's design.

Potential Value

- Transparency of design for all stakeholders
- Better control and quality control of design, cost and schedule
- Powerful design visualization
- True collaboration between project stakeholders and BIM users
- Improved quality control and assurance



Source: https://bimzeed.eu/

29

29

BIM Fundamentals

Resources Required

- Design Authoring Software

Team Competencies Required

- Ability to manipulate, navigate, and review a 3D model
- Knowledge of construction means and methods
- Design and construction experience



Source: https://bimzeed.eu/

30

30

BIM Fundamentals

BIM Uses: Energy Analysis

A process in the design phase which one or more building energy simulation programs use a properly adjusted BIM model to conduct energy assessments for the current building design.

Potential Value

- Save time and costs by obtaining building and system information automatically from BIM model instead of inputting data manually twice. For example: geometries, volumes precisely from BIM model
- Help with building energy code verification
- Optimize building design for better building performance efficiency and reduce building life-cycle cost

Resources Required

- Building Energy Simulation and Analysis Software(s)
- Well-adjusted Building 3D-BIM Model
- Detailed Local Weather Data
- National/Local Building Energy Standards

Source: https://bimzeed.eu/

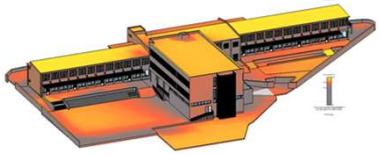
31

31

BIM Fundamentals

Team Competencies Required

- Knowledge of basic building energy systems
- Knowledge of compatible building energy standard
- Knowledge and experience of building system design
- Ability to assess a model through engineering analysis tools



Source: https://bimzeed.eu/

32

32

BIM Fundamentals

BIM Uses: Phase Planning

A process in which a 4D model (3D models with the added dimension of time) is utilized to effectively plan the phased occupancy in a renovation, retrofit, addition, or to show the construction sequence and space requirements on a building site.

Potential Value

- Better understanding of the phasing schedule by the owner and project participants and showing the critical path of the project
- Space and workspace conflicts identified and resolved
- Identification of schedule, sequencing or phasing issues
- Increased productivity and decreased waste on job sites

Resources Required

- Design Authoring Software
- Scheduling software
- 4D Modelling Software

Source: https://bimzeed.eu/

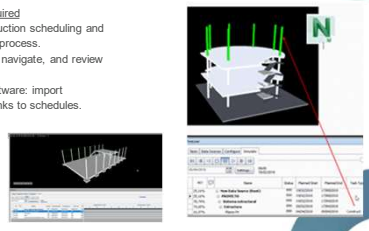
33

33

BIM Fundamentals

Team Competencies Required

- Knowledge of construction scheduling and general construction process.
- Ability to manipulate, navigate, and review a 3D model.
- Knowledge of 4D software: import geometry, manage links to schedules.



Source: https://bimzeed.eu/

34

34

BIM Fundamentals

BIM Software

Authoring tools create models while audit and analysis tools study or add to the richness of information in a model.

We can have a huge amount of analysis tools depending on the type of analysis that they do. It can be:

- Structural Analysis
- Energetic Analysis
- Clash detection analysis
- Virtual Reality and Visualization analysis
- Etc



Source: Parametric monkey

Source: https://bimzeed.eu/

35

35

BIM Fundamentals

BIM Authoring tools

There are a lot of design authoring tools, some of them are:

- Autodesk Revit
- Archicad
- Allplan
- AECOsim Building Designer
- Tekla Structures



Source: Google trends. Graphics: 3dbyggeri Danmark ApS

Source: https://bimzeed.eu/

36

36

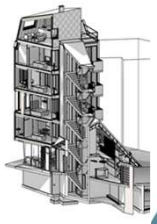
BIM Fundamentals

Considerations in the use of Design Authoring Tools

The use of these design authoring tools is critical for the BIM project, because you will condition the usability of the models for other purposes.

When we are creating building models, we need to do it in a proper and planned way and:

- Use the correct tool that fits with the purpose of the project.
- Use the correct modelling strategy
- Define the scope of the model and don't waste time with useless information



Source: https://bimzeed.eu/

37

37

BIM Fundamentals

LOD

It is used to define information delivery a reference library of definitions is required. These levels of "definition" may be either described in terms of geometry or information requirements.

Geometric also is described as graphic data and information as non-graphic data.



Source: https://bimzeed.eu/

38

38

BIM Fundamentals

LOD: GEOMETRY

Geometrical accuracy of the element that will be installed on site.



Source: https://bimzeed.eu/

39

39

BIM Fundamentals

LOD: INFORMATION

Information levels of the product that will be installed on site.

Concept (Presentation)	Design Development	Documentation	Construction	Facilities Management
DESCRIPTION: Office Chair Arms, Wheels WIDTH: DEPTH: HEIGHT: MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: 100	DESCRIPTION: Office Chair Arms, Wheels WIDTH: 700 DEPTH: 450 HEIGHT: 1100 MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: 200	DESCRIPTION: Office Chair Arms, Wheels WIDTH: 700 DEPTH: 450 HEIGHT: 1100 MANUFACTURER: Herman Miller, Inc. MODEL: Mirra LOD: 300	DESCRIPTION: Office Chair Arms, Wheels WIDTH: 685 DEPTH: 430 HEIGHT: 1085 MANUFACTURER: Herman Miller, Inc MODEL: Mirra LOD: 400	DESCRIPTION: Office Chair Arms, Wheels WIDTH: 685 DEPTH: 430 HEIGHT: 1085 MANUFACTURER: Herman Miller, Inc MODEL: Mirra PURCHASE DATE: 01/02/2013

(Only data in red is useable)

practicalBIM.net © 2013

Source: https://bimzeed.eu/

40

40

BIM Fundamentals

LOD PROGRESSION AND LOD MATRIX

To establish the information (graphic and non-graphic information from now on) requirements in every phase commonly use a resource or tool called LOD Matrix.

Here we define the different levels of information in different phases according with the BIM project strategy.



Source: https://bimzeed.eu/

41

41

BIM Fundamentals

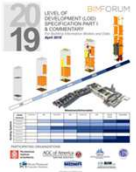
LOD VS LOD

There are two principle standards for this concept. Level of Development (AIA+BIM FORUM - USA) and Level of Definition (NBS – UK).

LEVEL OF DEFINITION – NBS



LEVEL OF DEVELOPMENT – BIM FORUM



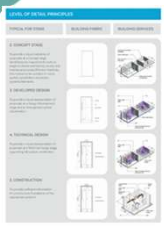
Source: https://bimzeed.eu/

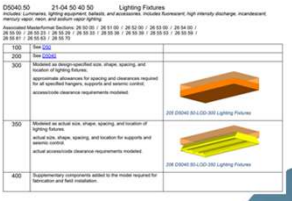
42

42

BIM Fundamentals

LOD VS LOD





Source: https://bimzeed.eu/

43

43

BIM Fundamentals

BIM Classification

Classification is fundamental to achieving effective information management and has been identified as one of seven components required for Level 2 building information modelling (BIM).
This process of deciding what 'things' are called is causing some issues in the BIM world. If you have a vast quantity of data or information, that can be a very powerful resource.

Classification can be defined as, 'The act or process of dividing things into groups according to their type.'

UNICLASS

OMNICLASS™
A Strategy for Classifying the Built Environment

Source: https://bimzeed.eu/

44

44

BIM Fundamentals

BIM ROLES

Carrying out a project in BIM implies having to take care of the models we make. Because if they are not made with the right strategy, they can be useless and the effort dedicated to make them would be in vain.
That is why new responsibilities must be acquired in order to guarantee the success of the application of the BIM methodology.
These new roles are:

- BIM Manager
- BIM Coordinator
- BIM Modeler

	Strategic						Management				Production	
Role	Corporate Objectives	Research	Process + Workflow	Standards	Implementation	Training	Execution Plan	Model Audit	Model Coordination	Content Creation	Modelling	Drawing Production
BIM Manager	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N
BIM Coordinator	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N
BIM Modeler	N	N	N	N	N	N	N	N	N	Y	Y	Y

Source: https://bimzeed.eu/

45

45

BIM Fundamentals

BIM ROLES

BIM Manager responsibilities

- To define the BIM Uses and Objectives of the project.
- To create the project standards, define the workflows and reflect them in the BIM Execution Plan (BEP) according to the phase of the project.
- To create and manage the CDE.
- To establish audit and control processes to ensure compliance with customer BIM requirements.
- Technical support in the detection of interference or Clash Detection.
- To ensure interoperability and communication.

BIM Coordinator responsibilities

- To assist the BIM Manager in drafting the BEP.
- To ensure compliance with the BEP or BIM Implementation Plan.
- To coordinate the work within his own discipline (or phase).
- To carry out the processes of checking the quality of the BIM model at a geometric and non-geometric level.
- To upload models in the CDE when appropriate.

Source: https://bimzeed.eu/

46

46

BIM Fundamentals

BIM ROLES

BIM modeler responsibilities

- To model the project within your own discipline.
- To embed and extract information from the model in the specified formats. PDF, DWG, IFC, NWC
- To solve detected conflicts in clash detection reports.
- To read the BEP and model it according to your requirements.

Source: https://bimzeed.eu/

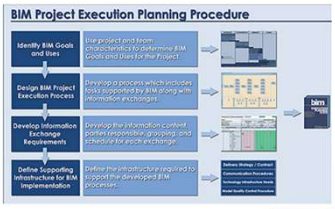
47

47

BIM Fundamentals

BIM EXECUTION PLAN

All these responsibilities, decisions, etc... must be agreed upon by all members of the Project team. Once agreed it is necessary to write them all in a contractual document where each individual agent can find their responsibilities and information requirements to ensure interoperability (and other workflows) and to achieve the Project BIM objectives.



Source: BIM Project Execution Planning Guide (PSU)

Source: https://bimzeed.eu/

48

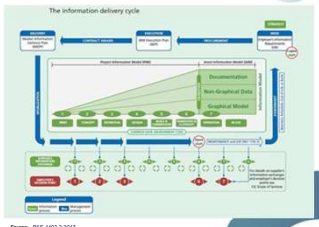
48

BIM Fundamentals

BIM EXECUTION PLAN

At tender stage, before a contract is agreed, a prospective supplier will develop a BEP with the aim of demonstrating their proposed approach, capability, capacity and competence to meet the EIR in general terms.

Once a contract has been awarded then the winning supplier is required to submit a further BIM Execution Plan. The focus of this post-contract document is to confirm the supply chain's capabilities.



Source: PAS 1192-2:2013

Source: https://bimzeed.eu/

49

Drones

Presentation

50

Drones

In 2018, this sector saw a 239% increase in the adoption of drone technology. In its report on the impact of drones, PwC states that the use of drones throughout a construction project provides an unparalleled record of all activities; cuts planning and survey costs; increases efficiency and accuracy, and eliminates disputes over the status of a project at a given point in time.



Source: 27 Advisory and Aerial Ascent

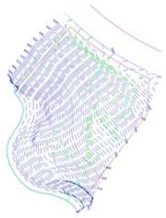
Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

51

Drones Used in Construction

Topographic Mapping and Land Surveys

Due to their ability to map vast quantities of land, drones can exponentially cut down on time spent visualizing a site's topography. This helps to keep the project on schedule and on budget and ensures accuracy before the project is initiated. Gathering this information can help determine feasibility and assist with design.



Source: https://landsurveyorsunited.com/elmerachtopographic-survey

Source: https://www.bigrentz.com/blog/drones-construction

52

Drones Used in Construction

Equipment Tracking

With a drone, you can do a flyover and quickly assess whether the equipment is where it needs to be. They can quickly recognize if a piece of equipment that should be terminated is still on-site.

Equipment malfunctions are a common issue. Drones' recording functionality could be used to identify issues remotely and provide visual representations that aid in communicating those issues.



Source: https://tracksen.com.au/asset-tracking-from-the-sky/

Source: https://www.bigrentz.com/blog/drones-construction

53

Drones Used in Construction

Remote Monitoring and Progress Reports

Another valuable feature of construction drones is the visibility they can provide for clients. Drones can produce impressive aerial views and give clients a grasp of the project's progression, especially when they cannot be physically present on a site. This helps assure clients that their spend is being utilized efficiently.



Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

Source: https://www.bigrentz.com/blog/drones-construction

54

Drones Used in Construction

Security Surveillance
A drone operator can conduct a flyover to quickly see if a piece of equipment is in a secure enough location. They can also use the surveillance camera to see if unauthorized individuals are on the site. This can help prevent damage or theft and identify any trespassers.



Source: https://www.bigrentz.com/blog/drones-construction

55

55

Drones Used in Construction

Personnel Safety
Construction managers can also use drone video cameras to monitor the job site for safety concerns, ensuring workers are properly balanced and that no structures or equipment are loose or unstable.



Source: https://www.forconstructionpros.com/construction-technology/article/21295661/six-factors-to-consider-when-adding-drones-to-your-construction-business

Source: https://www.bigrentz.com/blog/drones-construction

56

56

Drones Used in Construction

Structure Inspection and Photography
Drones can also be used for planned maintenance of larger-scale structures like bridges, towers, roofs, and scaffolding. A task that would take an entire team of surveyors to do would only take a few hours with a drone operator.



Source: https://www.geospatialworld.net/blogs/drones-to-propel-new-technological-innovations-in-the-construction-industry/

Source: https://www.bigrentz.com/blog/drones-construction

57

57

Drone Applications Throughout the Construction Cycle

1. Bidding and pre-planning

DTMs and DSMs of a site generated with drone data can show possible drainage points, changes in elevation and other factors that can assist in selecting the best locations for building, digging or storing materials.

2. Planning and design

With drone orthophotos and 3D models, you can overlay buildings onto their environment to get a clear sense of how a new building might look next to an existing one.

3. Execution

Earthworks

- From drone images, you can generate a point cloud consisting of thousands of points, each containing geospatial (X, Y, Z) and color information. Then, with a photogrammetry software, you can get precise volume measurements and run a cut/fill analysis.

Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

58

58

Drone Applications Throughout the Construction Cycle

As-built vs. as-design

- One of the most striking advantages of accurate site visualization is the ability to overlay the CAD on the orthophoto. This allows you to compare what was actually built with the plan and make sure that they fit together.

Site progress monitoring

- During the construction phase, site managers have to control and validate completed work in order to permit continued work.

Communication tool

- The visual data from regular drone surveys assists in on-demand (could be daily, weekly) operational planning.

Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

59

59

Drone Applications Throughout the Construction Cycle

Minimize rework and litigation documentation

- Having up-to-date visual data can help you catch a mistake before it takes shape and avoids demolition and the waste of time and materials related to it.

Handover

- The owner can look carefully through the documentation before agreeing to the handover, and contractors can prove that the work has been conducted as per requirements, including details on who did what.

4. Maintenance and asset inspection

- By sending drones in the air, companies can visually inspect large assets or those located in hard-to-reach areas more quickly and cost-effectively.

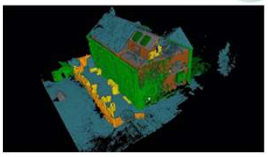
Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

60

60

Types of Drone Outputs

- Orthophotos and orthomosaics
- Point clouds
- Digital surface models (DSMs) and digital terrain model (DTMs)
- 3D models
- Raw images



Source: https://towerslidescience.com/the-future-of-3d-point-clouds-a-new-perspective-1255203535b9

Source: https://wingtra.com/drone-mapping-applications/drones-in-construction-and-infrastructure/

61

61

3D Modeling



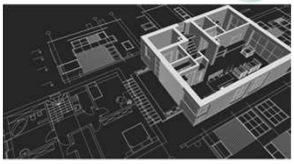
Presentation

62

62

3D Modelling

3D modeling refers to the process of creating a mathematical representation of a 3-dimensional object or shape. This is done using software. 3D models are now widely used in a variety of industries. Motion pictures, video games, architecture, construction, product development, medical, all these industries are using 3D models for visualizing, simulating and rendering graphic designs. 3D modeling in construction is widely gaining popularity due to the plethora of benefits it offers.



Source: https://www.shutterstock.com/search/3d-modeling-building

Source: https://www.geospatialworld.net/blogs/3d-modeling-construction-benefiting/

63

63

3D Modelling

1 Enable more realistic visualisations

2 Enable collaboration with easy-to-review designs

3 Ensure projects are completed on time

4 Greater control of machinery

5. Help to communicate site layout

6. Enhanced designs

7 Promotion of team synergy

8 Reduced lead time, errors and costs



Source: https://www.thecadroom.com/what-is-3d-modelling-in-architecture/#:~:text=Adopting%203D%20modelling%20has%20enabled,that%20entail%20multiple%20moving%20parts.

64

64

VR (Virtual Reality)

Virtual Reality (VR) in relation to construction is the ability to take a computer-generated 3-dimensional model and provide the ability to view, walkaround and interact with the model prior to construction.

Virtual Reality is an extension of the BIM process and whilst we all know BIM can optimise the delivery of buildings by providing greater efficiencies at all stages of the building lifecycle, BIM does not encourage exploration of form, space and aesthetics as VR can.

VR can also play an important role at all stages of the design-to-construction process, from evaluating design options and showcasing proposals, to designing out errors and ironing out construction and serviceability issues before breaking ground on site.



Source: https://www.ietvbuild.com/blog/vr-in-construction-management

Source: https://www.symetri.co.uk/insights/blog/virtual-reality-in-construction/#:~:text=Virtual%20Reality%20(VR)%20in%20relation,the%20model%20prior%20to%20construction

65

65

How VR Technology is Being Used in the Construction Industry

Design and 3D modelling

Virtual reality takes the design process to the next level. By creating a realistic digital twin of a proposed construction project, plans can be rigorously examined at the design stage. Being able to walk around a virtual site means that issues can be flagged and addressed at an earlier stage. This can help to significantly minimise costly and time-consuming alterations further down the line.



Source: https://www.capterra.com/resources/popular-free-3d-modeling-software-options/

Source: https://www.futurevisual.com/blog/construction-vr-training/

66

66

How VR Technology is Being Used in the Construction Industry

VR tours – improving communication with clients

Client relationships can also benefit from visiting finished constructions in the virtual world at the design stage, and has been adopted by leading innovators in the built environment, such as Arup. By creating a virtual completed site before it's been built allows clients to not only visualise, but tour, experience and scrutinise it from the very start of the project. This will help to realise their vision more accurately, as virtual reality helps to remove any ambiguities around their expectations and allows adjustments to be made before construction begins.



Source: https://www.futurevisual.com/blog/construction-vr-training/

67

How VR Technology is Being Used in the Construction Industry

Supporting collaborative working

One thing that all constructions projects have in common is that they rely on collaborative working for completion of interdependent tasks. But often these relationships are challenged by fragmented working practices; for example, with workers being on site at different times, or consultants working remotely. Virtual reality can help to improve communications throughout the project's lifespan, from sharing the finished vision in minute detail, through to providing site updates to those unable to visit the site regularly.



Source: https://www.futurevisual.com/blog/construction-vr-training/

68

How VR Technology is Being Used in the Construction Industry

Training

One of the key areas where immersive technology is making a real impact is in construction VR training. Immersive learning experiences give employees the chance to get hands-on and practical experience in a safe, risk-free environment. From health & safety training through to training in intricate technical tasks, virtual reality can help to hone skills, boost performance and improve collaborative working practices.



Source: https://www.futurevisual.com/blog/construction-vr-training/

69

VR (Headset)

Virtual Reality Training is the digital simulation of lifelike scenarios for training purposes. Trainees enter a 360°, active learning environment, experiencing sights and sounds that dissolve the barrier between virtual and actual reality. Using the headset and controllers, trainees look, speak, and move about freely in a 3D virtual setting, interacting with simulated real-world tools, machinery, and other trainees and instructors.



Source: https://pixovr.com/what-is-virtual-reality-training/#:~:text=PIXO%20VR%20Training-,What%20is%20Virtual%20Reality%20Training%3F,between%20virtual%20and%20actual%20reality.

70

Benefits of VR Training

- Improvements in job performance of 70+%
- Dramatic reductions in on-the-job human errors
- Increases in learning retention of up to 80%
- 40-60% reductions in time needed to train compared to traditional training methods
- Elimination of the cost and risk of unnecessary travel
- Enhanced team decision-making, workplace safety, and collaboration
- Inclusive of all four major learning styles, (Visual, Auditory, Reading/Writing, and Kinesthetic)

Source: https://pixovr.com/what-is-virtual-reality-training/#:~:text=PIXO%20VR%20Training-,What%20is%20Virtual%20Reality%20Training%3F,between%20virtual%20and%20actual%20reality.

71

Exoskeleton Suits

A robotic exoskeleton is a mechanical device worn by a human being for certain purposes or applications. An exoskeleton is generally considered to be a hard mechanical frame with joints that allow movement of the human operator.



Source: https://www.iberdrola.com/innovation/what-are-exoskeletons

72

Exoskeleton Benefits

1. ***Injury and Strain Prevention***

Exoskeletons cut down on overexertion by supporting workers' upper limbs when performing monotonous activities.

2. ***Withstanding Repetitive Tasks***

Reduces strain for repetitive activities such as painting ceilings.

3. ***Increased Productivity***

Exoskeletons have been proven to increase workers' endurance by reducing the amount of energy exerted on repetitive tasks.

4. ***More Work Accuracy***

You can practically maintain most of your attention and focus on the task at hand without the distraction of strain and fatigue.

5. **More Opportunities For Aged Contractors**

With a construction exoskeleton, all workers are able to handle more strenuous work effectively.

Source: https://ekso bionics.com/5-amazing-ways-to-use-exoskeletons-for-construction/#:~:text=You%20can%20enjoy%20many%20benefits,joints%2C%20and%20increasing%20work%20efficiency.&text=Exoskeletons%20cut%20down%20on%20overexertion,limbs%20when%20performing%20monotonous%20activities.

73

73

Benefits of VR for Circular Economy

Utilising Virtual Reality headsets and exoskeletons, waste can be reduced throughout training and building.

During training less materials must be used for Virtual on site training which can add value to the training that is provided. This can also reduce the number of mistakes or mishaps on site as the worker will have added training and added efficiency, leading again to a reduction in material use and waste.



Source: https://www.theengineer.co.uk/content/opinion/comment-how-ar-vr-is-helping-construction-go-green/

74

74

Digital Twins

Presentation

75

75

What is a Digital Twin

A Digital twin is the creation of an online model that will act as a pair with the physical building through tools such as BIM and CAD. These models will allow the user to explore and test the buildings usability, track the building life (can be paired with material passports and increase the sustainability of the building). This can be done by insuring that material use is optimised, tracking materials for repair and service and allowing for material passports and other such documents to be completed.



Source: https://www.ezot.com/en-us/digital-twin/overview

76

76

What are the Levels of Digital Twins

DESCRIPTIVE TWIN

- A live, editable version of design and construction data

INFORMATIVE TWIN

- Additional operational and sensory data

PREDICTIVE TWIN

- Leverage operational data for insights

COMPREHENSIVE TWIN

- Simulation for future what-if scenarios

AUTONOMOUS TWIN

- Ability to learn and act on behalf of users



Source: https://www.datacenterknowledge.com/security/how-secure-digital-twin-technology-your-data-center

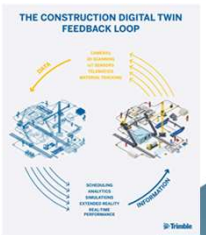
Source: https://damassets.autodesk.net/content/dam/autodesk/www/solutions/digital-twin/architecture-engineering-construction/pdf/adsk-aec-digital-twin-ebook.pdf

77

77

Benefits of Digital Twins

Resource Management: Digital twins make it possible to create an information pipeline between the office and the field. With the aid of automatic data delivery, project stakeholders can predict allocation issues and help balance labor costs with budgets. This helps the jobsite run more efficiently and affordably.



Source: https://constructible.trimble.com/construction-industry/what-are-digital-twins

78

78

Benefits of Digital Twins

Connectivity: Digital twins deliver information in a centralized platform. This technology takes BIM a bit further by automatically updating 3D models with constructible data. Component dimensions, model details, working conditions, and more can be added to content-enabled models. This way, no details get lost as a model evolves with the building over the years.

The benefits of digital twins don't end when the initial construction is complete. They continue to offer smart solutions to everyday asset use.

Source:https://constructible.trimble.com/construction-industry/what-are-digital-twins

79

79

Benefits of Digital Twins

Value-added deliverable: Digital twins can be handed over to the project owner to help support ongoing structural enhancements. The insight they provide can help inform future decision making and offer invaluable insight into day-to-day operations. A digital twin can also be a value-added asset for clients looking to leverage data in future optimization projects.



Source:https://www.cadmatic.com/en/solutions/digital-twin/digital-twins-driving-the-ultimate-customer-value/

Source:https://constructible.trimble.com/construction-industry/what-are-digital-twins

80

80

Benefits of Digital Twins

Streamlined facility management: Digital twins can offload much of the burden of asset management. For example, when a repair is needed, a digital twin can pinpoint problem areas and share necessary specs with techs. It can even keep track of who to bill for the work.

Source:https://constructible.trimble.com/construction-industry/what-are-digital-twins

81

81

Benefits of Digital Twins

Ongoing improved efficiencies: To truly increase efficiency, you need to know how the facility is being used. KONE recently used digital twins to analyze how people are using elevators. Sensors were used to track how people moved through buildings. The goal: cut down elevator wait times, especially during busy mornings.



Source:https://www.reutersevents.com/supplychain/technology/digital-twins-are-making-supply-chains-more-efficient-by-logistics

Source:https://constructible.trimble.com/construction-industry/what-are-digital-twins

82

82

Disadvantages of Digital Twins

Lack of connectivity: Digital twin methods help elevate BIM to something more than CAD display. Unfortunately, BIM models are often created without use of as-built data. This results in a digital representation that isn't a true twin — one that can't be connected to the internet of things (IoT).

Outdated information: Too often, contractors don't update design models with change orders. Without accurate, real-time data, a digital twin can't work as intended.

Source:https://constructible.trimble.com/construction-industry/what-are-digital-twins

83

83

Digital Twins and BIM

The BIM process incorporates data created during the planning and design phases. Digital twin extends data capture to the construction and operational phases of the asset—and can also inform planning and design for future projects.

Realizing the full promise of digital twin requires multidisciplinary models at the core and an integration of systems and data across workflows and between organizations. BIM is the most efficient path to the creation of an accurate, high-value digital twin.

Source:https://www.autodesk.com/solutions/digital-twin/architecture-engineering-construction

84

84

Material Passports



Presentation

85

85

Material Passports - The Aim

- Increase the value or keep the value of materials, products and components over time
- Create incentives for suppliers to produce healthy, sustainable and circular materials/building products
- Support materials choices in Reversible Building Design projects
- Make it easier for developers, managers and renovators to choose healthy, sustainable and circular building materials
- Facilitate reversed logistics and take back of products, materials and components

Source:https://www.bamb2020.eu/topics/materials-passports/

86

86

Orms - Material Passport

Orms created a material passport guideline which walks users through the creation one.

https://orms.co.uk/insights/materialpassports/



Source:https://www.bamb2020.eu/topics/materials-passports/

Source:https://www.bamb2020.eu/topics/materials-passports/

87

87

Barriers to Material Reuse

Cost

It's typically cheaper to demolish and buy new, rather than deconstruct and refurbish

Design

Contemporary construction favours chemical fixing over mechanical. Making it time consuming to remove materials and often damages them in the process.

Risk

There is often a lack of knowledge about an existing material, and therefore a lack of confidence in it. How can we trust the material will perform as we need it to?

Source:https://www.bamb2020.eu/topics/materials-passports/

88

88

What is a Material Passports

Waste is a material without an identity

Thomas Rau

A passport gives that material an identity. Knowledge about a material gives us confidence in it, enabling successful reuse



Source:https://www.bamb2020.eu/topics/materials-passports/

89

89

Material Passports - Steps

Material Identification

For most existing Buildings as Material Banks, it is unlikely that we will have sufficient data records to assess the reuse potential of the existing materials.

We recommend that a series of comprehensive surveys are carried out at an early stage, to identify the existing materials within the Material Bank. This allows for informed design decisions to be made.

Source:https://www.bamb2020.eu/topics/materials-passports/

90

90

Material Passports - Steps

The Material Database

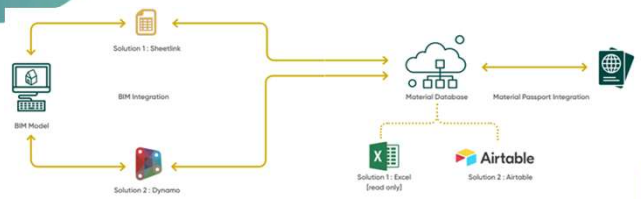
We recommend that Material Passporting is carried out along with the implementation of BIM, to ISO Standard 19650-1/2. BIM offers a standardised process to manage large quantities of data. It also ensures a higher quality 3D model and potential for a digital twin.

Source: https://www.bamb2020.eu/topics/materials-passports/

91

91

Material Passports - Overview



Source: https://www.bamb2020.eu/topics/materials-passports/

92

92

Material Passports - The Tools Available

Tool 1 - Implementation Guide
This guide provides step by step instructions on how to get started.
Tool 2 - Naming Conventions
To facilitate cross referencing between the database, revit file and physical tags on built assets, we have implemented a human friendly naming format.
Tool 3 - Shared Parameters for Revit
A Shared Parameters file contains the parameters included in the sample excel database.
Tool 4 - Dynamo Script for Revit
This is provided as a starting point for teams capable of implementing the Dynamo scripting for creating a bidirectional link between the Material Database and Revit.
Tool 5 - Sample Excel Database
For teams using Revit, this is a reference file only. The actual database file must be generated by Revit using either Sheetlink or Dynamo, as this sets up the bidirectional link.

Source: https://www.bamb2020.eu/topics/materials-passports/

93

93

Material Passports - Future opportunities

Interface with BIM Model
This is the area of greatest opportunity. We imagine the creation of a Revit plug in to replace the Dynamo script. This would give greater control over the fields that are imported for each element category, and increase automation.
Material Warehouse
A technical challenge of phasing within Revit could be addressed by creating a virtual Material Warehouse. Deconstructed elements in the 'Existing Phase' are temporarily stored and reused in the 'New Construction Phase'.
Material Database
We are in the process of creating a cloud based database system. This will improve functionality, allow for some automations and deliver an interactive Material Passport which can be accessed by scanning the physical tag in the building.
Interface with Wider Portfolio
Digital Twins have the potential to unlock greater information sharing across a portfolio. Linking or consolidating Material Databases of projects will support future material reuse and insight into real time value of each Material Bank.

Source: https://www.bamb2020.eu/topics/materials-passports/

94

94

Material Passports - Summary

Our goal was to develop an open source methodology to Material Passporting for existing buildings, that would be accessible to design teams of all sizes and capabilities.

As an industry, we must do better, and the fastest way to achieve this is by sharing our knowledge and collaborating on meaningful solutions.

Therefore we invite you to implement Material Passporting on your project, please get in touch to join our network. In return, all we ask is that you share your experience, findings and solutions back with us, so that the research can continue to evolve.

This is an exciting time, and we look forward to collaborating with partners as we advance towards a Circular Economy.

Source: https://www.bamb2020.eu/topics/materials-passports/

95

95

Material passports - Learn More

Orms -
https://orms.co.uk/insights/materialpassports/
BAMB -
https://www.bamb2020.eu/topics/materials-passports/
https://www.youtube.com/watch?v=9pB6axd7gQk&t=1s
Madaster -
https://madaster.com/platform/
Metabolic -
https://www.metabolic.nl/publications/materials-passports/

96

96

3D Printing and Prefabrication

Presentation

97

97

3D Printing

3D printing in construction has some limitations due to the scale of both the aspects that need to be printed and the scale of the printer. The opportunities in construction can be identified when pairing 3D printing with concepts such as Design for Disassembly and Product-as-a-service. This can allow for easy replacements of minor elements of products or slight alterations to original designs by printing these pieces when necessary.



Source: https://www.ibeworldllc.com/3d-printed-replacement-parts/

98

98

Benefits of 3D Printing

Flexible Design

3D printing allows for the design and print of more complex designs than traditional manufacturing processes.

Rapid Prototyping

3D printing can manufacture parts within hours, which speeds up the prototyping process.

Print on Demand

Print on demand is another advantage as it doesn't need a lot of space to stock inventory, unlike traditional manufacturing processes.

Fast Design and Production

3D printing can print objects within hours, which is much faster than moulded or machined parts.

Source: https://www.twi-global.com/technical-knowledge/faqs/what-is-3d-printing/pros-and-cons

99

99

Benefits of 3D Printing

Minimising Waste

Little or no wastage as compared to alternative methods which are cut from large chunks of non-recyclable materials.

Cost Effective

3D printing saves time and therefore costs associated with using different machines for manufacture.

Ease of Access

3D printers are becoming more and more accessible with more local service providers offering outsourcing services for manufacturing work.

Environmentally Friendly

This technology reduces the amount of material wastage.

Source: https://www.twi-global.com/technical-knowledge/faqs/what-is-3d-printing/pros-and-cons

100

100

Types of 3D Printing in Construction

Robotic arm extruders

The rails are arranged to let the robotic arm move, and within the limits of the rails, the arm will build the house layer by layer by extruding concrete material from the nozzle. This is the most popular 3D printing technology used to build XL structures.



Source: https://www.3dnatives.com/en/robotic-arms-3d-printing-141020206/

Source: https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/construction-and-architecture/

101

101

Types of 3D Printing in Construction

Sand 3D printing

The pioneer who tested it was the Italian architect Enrico Dini, who built his D-Shape 3D printer. The machine spreads a layer of sand powder, then hardens the structure's shape with a binder.



Source: https://blog.dupps.com/en/pioneers-in-3d-printing-eth-zurich-uses-3d-concrete-printing-for-new-scale-architectural-project-2/

Source: https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/construction-and-architecture/

102

102

Types of 3D Printing in Construction

Metal technology

For structures such as bridges, which have to withstand more stress, Dutch company MX3D developed Wire Arc Additive Manufacturing (WAAM). The team described the technology: "we combined an industrial robot with a welding machine to turn it into a 3D printer that works with our software". The robot allows for 3D printing metal structures in 6-axes.



Source: https://www.sculpteo.com/en/3d-learning-hub/applications-of-3d-printing/construction-and-architecture/

103

Prefabrication

prefabrication, the assembly of buildings or their components at a location other than the building site. The method controls construction costs by economizing on time, wages, and materials. Prefabricated units may include doors, stairs, window walls, wall panels, floor panels, roof trusses, room-sized components, and even entire buildings.

Source: https://www.britannica.com/technology/prefabrication

104

Benefits of Prefabrication

1. Impacts Technology Trends with Advanced Design Tools

The construction industry has reinvented prefabrication and modularization due to the innovations in construction technology. BIM (Building Information Modeling) technology is a useful tool that is making the construction industry more environmentally sustainable and economical.

2. Better Safety & Security

Construction is a hazardous industry to work in, so companies want to implement safer processes. With prefabrication, there is less risk for problems with dirt, moisture, and other environmental hazards because workers create subassemblies in factory-controlled environments

3. Cost-effectiveness

Prefabrication reduces the cost of labor, further offsetting the rising costs of materials.

Source: https://esub.com/blog/7-benefits-prefabrication-construction/

105

Benefits of Prefabrication

4. Consistency & Quality Control

Factory tools used in prefabrication offer additional quality assurance compared to repeated construction on-site. Sub-assemblies in prefabricated construction are produced in a controlled manufacturing environment and follow specified standards, therefore built to a uniform quality.

5. Flexibility

Without difficulty, workers disassemble and relocate sub-assemblies to different sites.

6. Green Construction

Compared to traditional construction, prefabricated and modular buildings are more eco-friendly in both the short-term and long-term. Traditional construction processes require more materials that lead to more waste. Prefabrication has a lower environmental impact because extra materials are recyclable. Whereas, on a traditional site, waste goes directly to a landfill. A factory's controlled environment allows for better air filtration for better wall insulation, which directly increases efficiency for energy.

Source: https://esub.com/blog/7-benefits-prefabrication-construction/

106

Benefits of Prefabrication

7. Saving Time and Accelerating Construction Process

With prefabrication, it takes a significantly less amount of time to build compared to on-site construction. In fact, it takes less than half the time compared to traditional on-site construction.



Source: https://esub.com/blog/7-benefits-prefabrication-construction/

107

Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

108

Application for Multi-functional Green Roofs Facades and Interior Elements

All of the above applications can be applied to MGRFIE to allow for easy implementation, reduced waste , increased speed and digital tracking.

What other opportunities are possible with Digitalization of MGRFIE?



Source: https://www.mvrdv.nl/projects/309/the-couch
THE COUCH, Amsterdam, Netherlands, MVRDV

109

109

Example -Digital Twins for Multi-functional Green Roofs Facades and Interior Elements

Digital twins can be a major positive for MGRFIE as it can allow for digital tracking of the building from less easy to access areas. i.e. green walls can be monitored and it can be very straight forward to monitor what must be updated or replaced or if there are leeks or damages.



Source: https://smartfields.com/decoding-digital-twin-for-solar-plants/
Digital Tracking of Solar Panels

110

110

QUIZ/ASSIGNMENT/ACTIVITY



111

111

EXTRA READING/STUDY



112

112

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

113

113

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

114

114

BUS GoCircular

Shaping a Circular Sustainable Future

Module 8

Material Impact in Relation to the Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

BUS GoCircular

The trainee will cover several topics associated with material impact reduction in the construction industry. They will gain knowledge of Green Public Procurement, Life Cycle Analysis, Life Cycle Costing and Level(s) to a level fitting the trainees profession. These should all be illustrated practically where possible to allow the trainees to gain an understanding of how to apply these practices to their own work and future MGRFIE within their industry.

2

2

Objectives/Learning Outcomes

BUS GoCircular

- 2 – Enact measures that optimise material use to strive for material efficacy
- 3 – Design with non-critical raw materials as defined by EU
- 4 – Design with non-toxic materials as defined by EU
- 25 – Evaluate and assess life cycle impacts of buildings, construction products and materials on the environment (emissions, soils, water, biodiversity, etc.)
- 36 – Make choice of materials between different tender options for multifunctional green roofs, façades, and interior elements
- 74 - Source local and lightweight materials for multifunctional green roofs, façades, and interior elements if possible

3

3

Content

BUS GoCircular

- Material Impact Reduction
- Green Public Procurement
- Life Cycle Analysis
- Life Cycle Costing
- Level(s)
- MGRFIE

4

4

BUS GoCircular

Material Impact Reduction - Embodied Carbon

Presentation

5

5

Material Impact on Indoor Climate

BUS GoCircular

Materials have impact on the indoor climate, and should mainly be oriented towards comfort. They can be:

- Temperature Regulation
- Air Regulation
- Moisture Regulating
- Noise Regulating

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

6

6

Material Impact on Energy Use

Temperature Regulation

Include thermal insulation materials built into the outer walls and roof, and materials that reflect heat radiation or stabilize room temperature through high thermal capacity. They increase thermal comfort and reduce energy use for space acclimatization (heating and/or cooling). The technical demands of an insulating material usually are:

- High thermal insulation properties
- Stability and long lifespan
- Fire resistance
- Lack of odour
- Low chemical activities
- Ability to cope with moisture

Air Regulation

Usually composed of thin barriers covering the complete building envelope to resist air flows through the construction. The three major motives are to increase the thermal comfort for the inhabitants, reduce the risk of moisture problems and reduce the energy needed for space acclimatization. Air barriers are also used in internal walls between cold and warm rooms, where there is a chance of a draught being caused in the warm room.

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

7

7

Material Impact on Energy Use

Noise Regulating

Necessary to reduce transfer of sound of different types both in and between rooms, as well as between inside and outside, and to provide a good acoustic climate.

Moisture Regulating

Using for waterproofing, and to prevent vapour produced from people and processes inside the building from penetrating walls and roof and creating moisture problems, especially through condensation. They also include materials that can regulate and stabilizing moisture both within the construction and in the indoor air.

Source: https://www.sciencedirect.com/science/article/pii/S1876610217355376

8

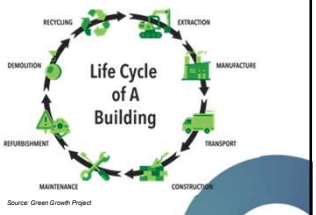
8

Material Impact Reduction

"What cannot be measured, cannot be improved"

Therefore, a series of tools have been designed to measure and compare in a verifiable way the environmental performance buildings and materials, and to monitor the circular economy in the construction sector.

Life Cycle Assessment (LCA) is a methodology that calculates the potential environmental impacts of any type of product or building throughout its entire life cycle, or parts of it.



Source: Green Growth Project

Source: https://gupp-class.eu/

9

9

What is Embodied Carbon?

Upfront embodied carbon refers to the emissions associated with all the activities of:

- procuring, mining, harvesting raw materials,
- transforming these materials into construction products,
- transporting them to site and incorporating them into a building, and
- maintaining, replacing and removing and disposing at the end of their life.



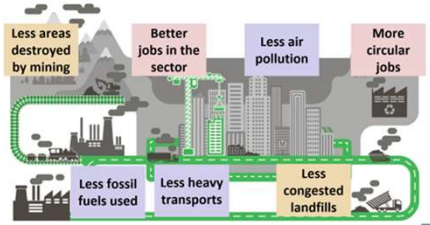
Source: https://gupp-class.eu/

10

10

Embodied Carbon Reductions Benefits

Embodied carbon reductions benefit the broader society in many ways.



Source: https://gupp-class.eu/

11

11

Reducing our building's embodied carbon

Reducing embodied carbon in buildings is critical to achieving net zero and carbon neutral construction targets. Yet there is much uncertainty about how to reduce embodied carbon. We will discuss some of the most effective approaches in these 10 easy-to-follow design rules or commandments.



Source: https://www.oneclickca.com/embodied-carbon-reduction-in-construction/

12

12

Reducing Our Building's Embodied Carbon

- When reusing a product or a building, you are also saving on embodied carbon.
- This is the carbon dioxide emitted during the manufacture, transport and construction of new building materials, together with end of life emissions.
- Our carbon footprint has a negative impact on the environment in multiple ways: It is the main cause of human-induced climate change, it contributes to urban air pollution, it leads to toxic acid rain, it adds to coastal and ocean acidification, and it worsens the melting of glaciers and polar ice.

Source: https://gupp-class.eu/

13

13

Baseline building

With a focus on practical solutions, a **baseline building design** helps to quantify the potential impact of adopting these practices.

Baseline building design

- **7000** m2 (75,350 ft2) office building
- **7** above-ground floors of each 1000 m2 (10,760 ft2)
- **2** underground parking levels
- **Precast concrete frame**
- **60**-year assessment period, assuming that the building would be kept in a condition for leasing to third parties.

Source: https://gupp-class.eu/

14

14

Reducing embodied carbon: Before we start.....

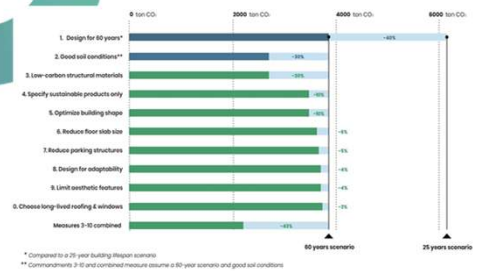
When you begin working on embodied carbon, make sure that your building has a decent energy performance and whatever low carbon energy supply options your locality can offer.

Avoid sites where transport relies on private cars or with long transport distances for users. These provide a solid basis for further decarbonization.

Source: https://gupp-class.eu/

15

15



Source: https://gupp-class.eu/

16

16

Commandment 1 - Do not build for short term

Ensure demands support a permanent building. **Optimizing the life-cycle impacts for anything less than a 60-year span is not worthwhile.** If the need for the building is not sustainable, for example, due to ongoing demographic change or zoning changes elsewhere. This may be addressed by designing either a building that's highly adaptable or with a modular transportable building that satisfies the demand for a shorter period of time.

Potential carbon savings in the baseline building

40-50% If the service life is limited to 25 years, the annualized materials-driven carbon impacts are 120% higher. If the building can be converted to another use, the impact is reduced even further.

Source: https://gupp-class.eu/

17

17

Longer lasting materials

Materials and transport | Maintenance and material replacement | Demolition

Example 1: Material that will last over 60 years building life time

Manufacturing | A4 | C3-C4

Example 2: Material that will last 40 year
Replacement after 40 years

Manufacturing | A4 | Manufacturing | A4 | 4

Source: https://gupp-class.eu/

18

18

Commandment 2 - Avoid sites requiring soil stabilization

Deep foundations can mean high emissions

Soil conditions greatly impact the stabilization and foundations your project will require. If your site requires massive foundations to support the building, reconsider the site. If you are committed to the site, see if you can place the building mass on the site to optimize the distance to bedrock as it likely varies within the site, and also consider opting for a less heavy structural solution, for example, timber or steel. Finally, avoid cast-in-place concrete, which tends to result in the heaviest of all structural solutions.

Source: https://gupp-class.eu/

19

19

Avoid sites requiring soil stabilization

Potential carbon savings in the baseline building

30% The foundations share of embodied carbon impacts is 40% when also considering replacements during life-cycle (not needed for foundations).

NOTE: for commandments 2-10, we have used a 60-year building lifespan scenario to more accurately depict the impact of each measure.

Source: https://gupp-class.eu/

20

20

Commandment 3 - Consider structural options

Could a lighter or timber framework?

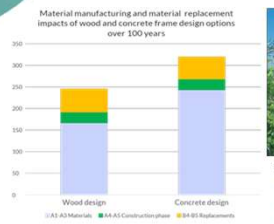
Choosing wood structures, when the requirements allow for it, can reduce embodied impacts substantially in most projects. In our example building, this embodied carbon reduction – when measured over the whole life-cycle – would lead to a reduction of around 30%.

Source: https://gupp-class.eu/

21

21

Wood versus Concrete structure





Also notify smaller scale changes such as:

- Wood based insulation vs. mineral or plastic based option
- Wood cladding (interior or exterior)
- Wooden doors and windows

Source: https://gupp-class.eu/

22

22

Consider structural options

Potential carbon savings in the baseline building

30% The share of embodied carbon impacts for structural materials is always substantial, and in our example building, nearly three quarters.

NOTE: for commandments 3 - 10, we have assumed good soil conditions and used a 60-year building lifespan scenario to more accurately depict the impact of each measure.
One Click LCA's Carbon Designer tool allows users to quickly evaluate the impacts of common structural materials using building geometry.

Source: https://gupp-class.eu/

23

23

Set clear requirements and select the right suppliers

- Setting environmental performance requirements for materials and products is an effective way of reducing impact while achieving exactly the same design and performance.
- The requirements could specify minimum carbon performance targets or other measures such as stipulating the use of recycled binders for concrete, for example.
- This strategy works effectively for all materials where supply is competitive and some suppliers are willing to supply products with improved environmental performance.

Source: https://gupp-class.eu/

24

24

Greener manufacturers

Some manufacturers may have improved their process efficiency

- Better efficiency of processes, less energy, waste and water
- Choosing renewable energy options

Rebar steel emissions, One Click LCA comparison of European and Asian manufacturers based on EPD's, secondary route (over 90% recycled content), kg CO2/kg of steel.

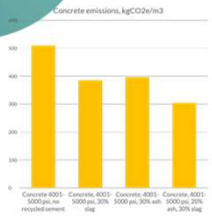


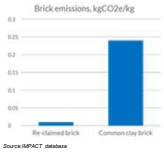
Source: https://gupp-class.eu/

25

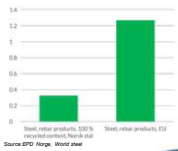
25

Recycled materials





Source:IMPACT database



Source:EPD Norge, World steel

Source:EPDs from National concrete association, US https://gupp-class.eu/

26

26

Commandment 4 - Choose low-carbon products

Potential carbon savings in the baseline building

10% In the example building, when structural concretes and steels were changed to lower impact products, the whole building materials life-cycle impacts were reduced by 10%. Looking carefully at what you source can make substantially greater reductions.

One Click LCA's materials database contains over 100,000 different construction materials environmental impact profiles for different products, technologies, suppliers and products.

Source: https://gupp-class.eu/

27

27

Commandment 5 - Optimize the building shape

Achieve a mass reduction with a compact shape

- As a general rule, a simple shape is more materials- and energy-efficient.
- Building in a square shape is not always possible due to daylighting, zoning, functional, or space distribution requirements.
- A more complex building shape drives external walls demands, and also requires additional access corridors.
- If the building requires additional staircase and elevator shafts in different locations, this also creates demand without additional corresponding available room area.

Source: https://gupp-class.eu/

28

28

Optimize the building shape

Potential carbon savings in the baseline building

10% If the example building were built as a three-storey elongated building, the embodied carbon impacts would be approximately 10% higher. Also, this increases the envelope area, and, as a result, the energy loss via the building envelope.

One Click LCA's Carbon Designer allows users to consider the impacts of the number of floors, building shape, floor height and additional parameters for the materials demand as well as resulting embodied carbon impacts.

Source: https://gupp-class.eu/

29

29

Commandment 6 - Design thinner floor slabs

Reduce both slab and envelope use

- Slabs are a major contributor to the embodied carbon of a building. Unlike the envelope area, the amount of slabs scales linearly with the internal area required.
- Slabs provide structural, acoustic and fire resistance capabilities for the building, among others, and may embed piping or other installations.
- Reducing the net thickness of slabs by 10 cm reduces the building envelope height correspondingly, thus saving materials from slabs and walls, and energy via reduced conductive loss.
- Some good practices include using innovative technologies, including Deltabeam, Bubbledeck, and hollow core slabs in concrete construction. This kind of change can reduce building life-cycle embodied impacts by approximately 6%.

Source: https://gupp-class.eu/

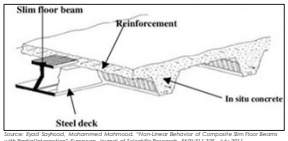
30

30

Design thinner floor slabs

It is also worth noting that having shorter grid spans for columns makes it possible to use **lighter and less steel- and cement-intensive slabs**.

This will have to be balanced against the impact it has on the materials used in the columns and the potential impact on the future adaptability of the spaces. Some types of slab systems also have higher impacts, and care should be paid to the overall design and choice of the floor slabs used.



Source: Ryad Seghaod, Mohammed Mahmoud. "Non-Linear Behavior of Composite Slim Floor Beams with Partial Interaction". European Journal of Scientific Research, 56(3):311-325, July 2011.

Source: https://gupp-class.eu/

31

31

Design thinner floor slabs

Potential carbon savings in the baseline building

6% In the example building the share of embodied carbon impacts for all slabs is around 45%. Reducing the net thickness of slabs leads to potential carbon savings of around 6%.

One Click LCA's database includes 50+ pre-built slabs as well as ready-to-use solutions for most innovative beam and deck technologies. A module for creating and calculating your own constructions / groups is also available.

Source: https://gupp-class.eu/

32

32

Commandment 7 - Do not built separate parking structures

Apply parking policies to shift demand

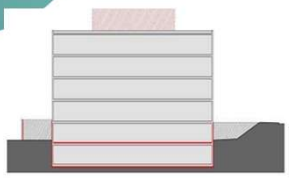
- If your zoning laws allow it, try to reduce the number of parking spots, in particular, underground parking spots and places in parking towers.
- If you have to have parking spaces below the building, consider raising the building so that the building stands on pillars with an open area for parking below the building.
- **This will save a substantial amount of materials in needless walls around the parking spaces.**

Source: https://gupp-class.eu/

33

33

Do not built separate parking structures



Conventional: retaining walls and floor slab in contact with the ground



Demand reduction: no retaining walls or floor slabs in contact with the ground

Source: https://gupp-class.eu/

34

34

Do not built separate parking structures

Potential carbon savings in the baseline building

4.8% The share of embodied carbon impacts for parking structures is 7% (in the initial case with the parking mix heavily dependent on private cars). If the initial mix of underground and above-ground parking could be shifted to only above-ground parking places, these impacts would be approximately 69% lower, so an overall potential carbon saving of 4.8%.

One Click LCA's Carbon Designer module includes an optional calculation for underground parking floors. Further, operational transport carbon impacts can be accounted for using One Click LCA's Site Designer.

Source: https://gupp-class.eu/

35

35

Commandment 8 - Use movable or refurbish-able wall elements

To solve space redistribution issues

- As floorplan configurations may often change, it is good practice to use reusable and possibly movable internal walls to the extent that they work for the building function.
- Similarly, electrification that tracks seating arrangements in office buildings.
- If this practice is not applicable to your project, consider applying construction methods that make it possible to remove the boards intact. (Design for Disassembly)

Source: https://gupp-class.eu/

36

36

Use movable or refurbish-able wall elements

Potential carbon savings in the baseline building

4%

We have assumed that half of the internal walls in our example building are load-bearing, but that the rest would require rebuilding every decade to fit changing floorplan demands. In this case, the material life-cycle impacts would be around 4% higher, compared to a scenario where wall configuration could remain in place until the material reaches the end of its service life.

One Click LCA allows you to set the service life for each material to reflect their actually foreseen replacement frequency as well as eventual reuse.

Source: https://gupp-class.eu/

37

37

Commandment 9 - Avoid elements with limited value

E.g. flooring, ceiling or facades

- If your cladding or façade material provides mainly an aesthetic function, consider omitting the layer.
- If your internal ceilings are not providing e.g. acoustic or fire protection, the entire element could be removed.
- This will also allow better maintenance access to installations and cabling.
- The same considerations apply to flooring: a simple polished concrete floor could be a good option for some types of spaces (while not all).

Potential carbon savings in the baseline building

4%

The share of embodied carbon impacts for internal ceilings is circa 1%. Furthermore, the building is cladded with an aesthetic steel facing, which has life cycle impacts of around 2%. Avoiding the flooring altogether would achieve impact reductions of around 4%.

Source: https://gupp-class.eu/

38

38

Early stage LCA

LCA performed early in the design process results in the highest carbon reductions and lowest costs. As the project progresses, the ability to reduce carbon decreases drastically

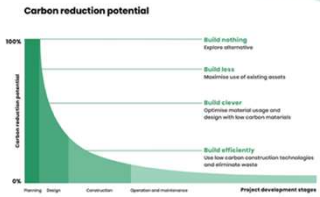


Fig 6. Opportunities to reduce embodied carbon reduces as the project progresses (Decarbonizing construction, 2021, WBCSD)

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6IBkhJTRzeViQlFsIOsOETd4HPgPtspcjBUM1HdSVRkIgaAq6wEALw_wcB

39

39

Commandment 10 - Choose long lived solutions for windows & roofing

- Investing in durable materials means fewer replacements over time, which means fewer carbon emissions, less waste generated, lower life-cycle costs and less tenant disruption.
- What is a durable and suitable material for your market varies depending on the conditions, however, the principle remains the same.

Potential carbon savings in the baseline building

3%

Depending on your project conditions, specifying longer-lived systems can save both carbon and money. This will be dependent on conditions but can achieve several percentage points of life-cycle embodied carbon reductions – in our example project between extreme cases the difference would be in the order of 3%.

Source: https://gupp-class.eu/

40

40

10 Commandments

These are our top **10 Commandments**, but there are many more. Including many innovative designs and products or applying some of the following practices:

- Incorporate design for disassembly and other circular economy principles into your design.
- Buy local materials wherever possible to reduce transport impacts.
- Ensure structural material strengths are not generalized but optimized for different uses.
- Reduce waste through careful specification and buying with takeback agreements.
- Consider the longevity of the materials that you use – if it needs to be replaced frequently its impact will be greater.

Source: https://gupp-class.eu/

41

41

Further Information

If you are interested in refurbishment, you can look at 10 ways to reduce embodied carbon emissions in refurbishment: https://www.oneclicklca.com/low-carbon-refurbishment/



Source: https://gupp-class.eu/

42

42

Green Public Procurement

Presentation

43

43

Green Purchasing

Green Public Procurement
(GPP) or Green Purchasing.
€1.8 trillion
is spent by EU public authorities each year (14% of EU GDP)
GPP aims to use this power to drive the market for more sustainable goods and services choosing environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production



Source: https://gupp-class.eu/

44

44

Key choices about building design to reduce impacts

- Construction products (recycled materials such as aggregates from construction and demolition waste)
- Transportation of aggregates to production sites by rail or shipping
- Environmental management of construction and demolition waste

Construction and use of buildings in the EU:

- Uses approx. half of all materials extracted
- Consumes 40% of energy
- Consumes 1/3 of water
- Generates 1/3 of all waste

Source: https://gupp-class.eu/

45

45

GPP Impact

GPP can affect environmental impact:

- **Directly** – through improved environmental performance of goods, services and works bought
- **Indirectly** – through using this market leverage to encourage companies to invest in cleaner products and services

How can GPP help?

- Require extended product lifetimes, and guarantee of spare parts
- Demand reduced or reusable packaging
- Encourage the use of recycled materials in construction



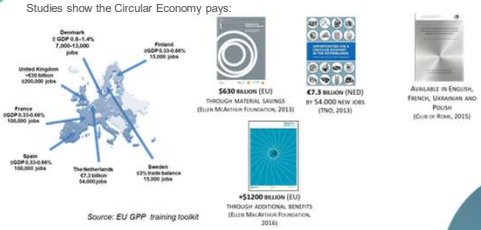
Source: https://gupp-class.eu/

46

46

Circular Benefits

Studies show the Circular Economy pays:



Source: EU GPP training toolkit

Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

47

47

What is Circular Procurement?

Circular procurement definition:

Circular procurement can be defined as the process by which public authorities purchase works, goods or services that seek to contribute to closed energy and material loops within supply chains, whilst minimising, and in the best case avoiding, negative environmental impacts and waste creation across their whole life-cycle.

Public procurement for a circular economy. European Commission, 2017 (p.5)

Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

48

48

Construction

Opportunities:

- Design for deconstruction
- Recycled content
- Multiple REBMs
- CO_2 reduction
- End of Life - closing material loops
- Refurb & maintenance
- Cost savings





- Brummen, Netherlands - circular Town Hall
- Netherlands – DBFM, Rapid circular contracting
- BAR HQ, Portsmouth, UK – Whole Life Costing & BIM
- Viaduc de Millau, France- build, fund & operate (BFOT)

Source: https://gupp-class.eu/

49

49

Procurement Cycle



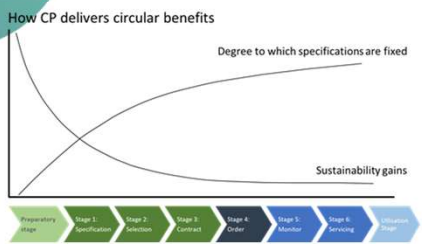
Circular procurement opportunities

Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

50

50

Procurement Cycle Impact



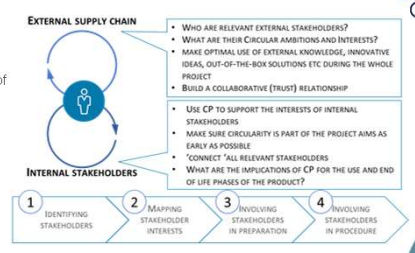
Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

51

51

Stakeholder Engagement

The importance of collaboration



Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

52

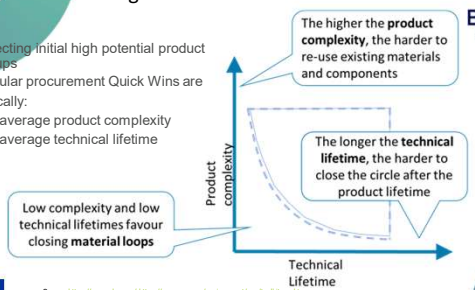
52

Product Categories

Selecting initial high potential product groups

Circular procurement Quick Wins are typically:

- average product complexity
- average technical lifetime

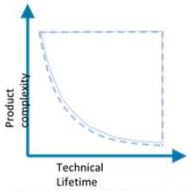


Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

53

53

Exercise



What are your organisations high-potential product groups?

Spend

- How big is the category spend?

Risk

- What level of risk does this category pose?

Scope

- What scope have you to improve sustainability?

Influence

- What influence have over this market and supply chain?

Use the knowledge you have to assess your own high potential product groups on the chart above

Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

54

54

Common examples

Product complexity vs technical lifetime

Construction projects (infrastructure and buildings) are highly complex with multiple products but also create the opportunities for large scale impact through circular procurement.

Construction procurement can also help create markets for recycled materials by specifying requirements for recycled content.



Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

55

55

Conclusions

Three key points:

- **Process** – challenge the need, consider circularity early and collaborate
- **Technical** – market engagement to understand what is possible as well as what is available
- **Finance** – circular business models help facilitate circular procurement

GPP Helpdesk

For further support on GPP, contact the EU's free

Helpdesk

Source: https://gupp-class.eu/ https://ec.europa.eu/environment/gpp/toolkit_en.htm

56

56

Life Cycle Analysis

Presentation

57

57

Life Cycle Analysis

https://www.decarbonizedesign.com/carbon-field-guide

https://www.decarbonizedesign.com/teaching-materials

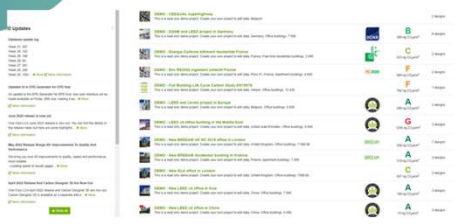
Calculating Carbon Fines

Case Study

58

58

Workshop



IGBC IRISH GREEN BUILDING COUNCIL

One Click LCA

https://www.youtube.com/watch?v=rBmfNYJJpzY&t=2s&ab_channel=OneClickLCA

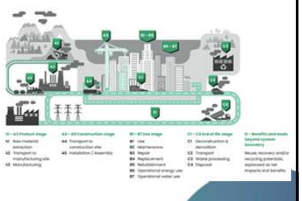
59

59

Introduction to LCA

The different periods of a building's life are known as its **life-cycle stages**. They are referred to as **product, construction, use, end-of-life and benefits beyond the system boundary.**

The processes involved in the life-cycle stages of a building releasing gaseous, solid, and liquid emissions into the air, water, or soil can negatively impact the environment and humans.



Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2e8hCIARIsAGLQ2RnUpa2E6BkhJTRzaViQiFsIOdOETg4HPgPtspc6UM1Hd5VRkIgaAq6wEALw_wcB

60

60

What cannot be measured cannot be improved

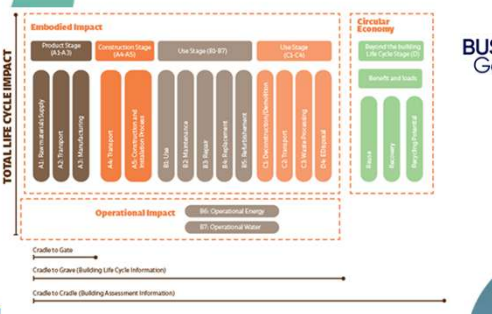
Life Cycle Assessment (LCA) is a methodology that quantitatively analyses and evaluates the potential environmental impacts of any type of product, process or service throughout its entire life cycle, or parts of it.
The environmental impacts of a building, system or construction product can be measured in certain sections of its life cycle, these sections are:

- **"From the cradle to the door".** This is the "product stage", comprising the extraction and processing of raw materials, transport to the factory and manufacturing.
- **"From cradle to site":** Comprises the "product stage" plus the "construction stage".
- **"From the cradle to the grave".** It covers the complete life cycle, including demolition and valuation as waste.
- **"From cradle to cradle"** is the life cycle of the complete product taking into account its reinsertion in the production chain if it is reused or recycled.

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

61

61



Source: https://growgreenproject.eu/

62

62

LCA in Construction

In the field of construction, the LCA is applicable to a **material, a construction system, a building or an infrastructure.**
The reference documents for the development of an LCA are the international standards
ISO 14040:2016:2006 (LCA: principles and framework for LCA)
and
ISO 14044:2006 (LCA: requirements and guidelines).



Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

63

63

LCA at different Design Phases

A building goes through several design phases: **concept design, detailed design, construction and procurement, and use phase**. The level of detail required for carrying out LCA depends on the data available at each stage.
A **screening LCA** is usually performed in the concept design phase to identify material and building element hotspots, using available data.
A **comparative LCA** can be performed at the detailed design stage and uses more accurate and relevant data to choose the best design alternatives. The most accurate LCA is performed after the construction and procurement stage using the actual material quantities and information about the exact materials.



One Click LCA solutions for each project stage

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

64

64

Business case for LCA

By far, the most common goal for the use of building LCA is **decarbonizing the construction sector and ensuring competitiveness in an increasingly carbon-aware market**.
With the growing focus on sustainability, investors, end-users, and tenants are increasingly looking for ways to assess and reduce the lifetime environmental impact of their projects. **Conducting a building LCA demonstrates a commitment to measuring and reducing the environmental impact of construction projects.** It also provides sound market advantages for actors across the supply chain.

Depending on your role within the construction supply chain –

- investor,
- designer,
- engineer or consultant

the business drivers for performing LCAs may vary.

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

65

65

Business case for LCA

Decarbonise construction projects
Incorporating a life-cycle perspective in projects can help project owners attain **carbon reductions and transparency, regulatory compliance and certifications**. Moreover, it is needed to meet the net-zero and low carbon targets which end-users, investors and tenants value. Various stakeholders across the construction supply chain are working towards decarbonizing their projects.
Regulatory compliance
Governments are increasingly recognizing the need to legislate and reduce whole-life carbon in construction. As a result, building **LCAs are now a mandatory part** of several existing and future regulations in various countries. To read more, refer to this article.



Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

66

66

Business case for LCA

Certifications	Requirements
BREEAM International (Similar to BREEAM Sweden, Norway and Spain)	Perform a high-quality whole building LCA analysis.
LEED	Complete a whole building LCA. Additional credits are awarded based on the demonstrated impact reductions and by incorporating building reuse and/or salvage materials into the project's scope of work.
DGNB DE, DGNB International and DK	Perform a whole building LCA and demonstrate impact reductions.
Energie Carbone	Undertake a whole life-cycle assessment for the building permit and post construction. The assessment accounts for materials, construction site, energy, and water impacts. The results are then benchmarked against carbon level thresholds.
Level(s)	Measure GHG across a building's life cycle, demonstrate resource-efficient and circular material life-cycles, optimize life-cycle cost and value.

List of green building certifications

Achieve certification
For a building LCA to contribute toward achieving BREEAM, LEED, HQE, E+C- or other green building certifications, its results must be tailored to the relevant scheme, including life-cycle stages, impact indicators, benchmarking, and more.

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

67

67

Summary of Business benefits of building LCA

1. Quantifying All Carbon-emitting And Carbon-reducing Options
2. Achieving Green Building Certifications
3. Complying With Regulations
4. Supporting Carbon-informed Decision Making
5. Reducing Project Costs Through Increased Material Efficiency And Waste Reduction
6. Quantifying Corporate Level Emissions With A Science-based Approach

Read more about the business case for building LCA here

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

68

68

How to perform a building LCA

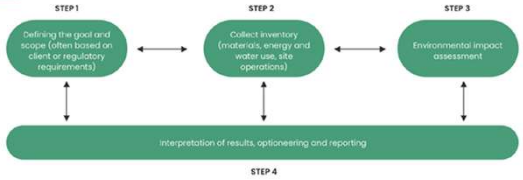


Fig. 7. Steps involved in conducting a building LCA

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

69

69

Step 1: Define goal and scope

Several reasons for conducting a building LCA include quantifying emissions, achieving certifications, and complying with regulations.
They often define the goal and scope of the analysis as described below:

Defining goal
The general goal is to measure and reduce a building's environmental impact, but specific goals can be identified based on your requirements (mentioned previously in the business case section).

Defining scope
The LCA scope defines the areas to be included or excluded from the LCA analysis and is usually defined by the overall goal. For example, if the goal does not require the evaluation of whole-life carbon, you can limit the extent of your analysis.

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

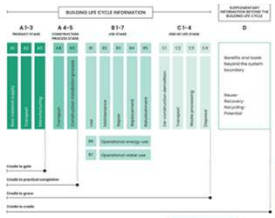
70

70

Step 1: Define goal and scope

System boundary
For building LCA, the **life-cycle scope** is specified according to the standardised module designations (A1, A2, A3... through D) as defined in EN 15804 and ISO 21930.

Right: Life-cycle scope specified according to the standardized module designations



Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

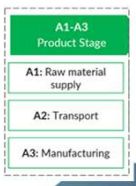
71

71

Scope

A1-A3 (Product Stage)
Reporting of different life-cycle stages depend on the certification or scheme, A1-A3 is **mandatory in most cases**.
- Calculated by including material quantities which are linked to **EPDs** (explained later in this presentation)

A4 & A5 (Construction process)
Stages A4 & A5 include all impacts and aspects related to any **losses during the construction process stage** (e.g. production, transport, waste processing and the disposal of lost products and materials).
- A4 emissions include the transport to the construction site
- A5 emissions include the installation / assembly of the building



Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BBkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

72

72

Scope

B1 – B7 (Use Stage)

- Use stage emissions include the use or application of installed products(e.g. refrigerants), maintenance, repair, replacement, refurbishment (often grouped with B4), operational energy usage (heating, services) and operational water use

C1 – C4 (End of life stage)

- End of life stages are emissions which happen after and during the building or asset is demolished. The emissions of these stages depend heavily on how materials are handled during this phase.

D – (Benefits and loads beyond the system boundary)

- Module D includes the reuse, recovery and or recycling potentials. Module D allows supplementary information beyond the building lifecycle to be considered and is consistent with a Cradle-to-Cradle (C2C) approach

Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

73

73

Step 2: Collect inventory

The information needed to perform building LCA is known as the life-cycle inventory (LCI).

The inventory can be broadly classified into building **materials and operations.**

Building Materials: Includes information about the type, quantity, lifespan, and life-cycle stage of the building in which the material is used. This information can be generally

obtained from cost plans, drawings, **and BIM models**. Design tools such as Revit, Tekla, Rhino and Grasshopper can be used for material quantities related information.

Building operations: Includes transportation details, material replacements, energy and water consumption, and end-of-life scenarios. This information can be obtained from designers, contractors, and project owners. The energy consumption can be tracked separately using energy tools such as IES, Design Builder, IDA ICE, etc.

LCA tools, such as One Click LCA, can simplify the inventory collection process by **importing materials**, providing ready-to use scenarios and database. One Click LCA can support integration with **design data from BIM**, IES-VE, Excel and more.

Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

74

74

Scope

Scope	Cradle-to-gate	Cradle-to-grave	Cradle-to-cradle
Life-cycle stages	A1-A3	A1-C4	A1-D
Examples	Product LCA	LEED	BREEAM, RICS, GLA

The scope can be restricted to meet the requirements (of certifications or regulations), as shown below.
The building area
Gross Internal Floor Area (GIFA) is used in most popular certifications (LEED, BREEAM). It is used to calculate the LCA impacts per floor area and for the purpose of benchmarking. To read more on building area, refer to this article.
The service life of the building
The environmental impacts are calculated over this time frame. It is typically dependent on the LCA methodology and standards or can be set based on the property owner's requirements.

Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

75

75

Details of inventory analysis in One Click LCA

Inventory	Source of inventory (varies by module used)	Required for
A1 - raw material extraction/supply **A2** - transport to the manufacturing site **A3** - manufacturing	Bill of materials (BOM) are manually inputted, imported from BIM models or cost schedules or created with Carbon Designer, possibly completed with One Click LCA default structures.	Level(s), LEED, BREEAM, RICS, GLA
A4 - transportation scenarios **A5** - construction installation process	One Click LCA provides appropriate default values for transport distances, which can be used when a specific source is not known.	Level(s), LEED-only A4, BREEAM, RICS, GLA.
B1 - installed products **B2** - maintenance **B3** - replacement **B4** - repair **B5** - refurbishment	B1-B5 are based on user input of quantities. B4 and B5 are based on default material service life settings and the asset calculation period.	Level(s)- except B2, LEED (only B3, B4-B5), BREEAM, RICS, GLA, (only B4, B5)
B6 - details of annual electricity, fuel, and energy consumptionincludes district heating and cooling	Based on user input of consumption quantities. In One Click LCA database, the impacts of electricity and district heat are based on the energy production fuel mixes provided for each country by IEA, or local and regulatory sources.	Level(s), BREEAM, RICS, GLA.
B7 - estimated annual water consumption during the operational stage of the building	Based on user input of consumption quantities.	Level(s), BREEAM, RICS, GLA
C1-C4 - details of processes that occur during and after the building or asset is demolished	Based on options such as Material-locked and End of life (EOL) scenarios. EOL processes are based on regulatory scenarios. For non regulatory tools, One Click LCA provides its own end of life default processing methods for various materials.	Level(s), BREEAM, RICS, GLA.
D - includes reuse and recovery of materials and energy, based on their recycling potential **D2** - is the exported energy	Based on the material and on the end-of-life process that is chosen.	Level(s), BREEAM, RICS, GLA.

76

76

LCA Data

Once the building information-related queries are filled in, **mapping each material to its respective environmental profile** is the next step.

This process is simplified by using **LCA data** which contains information about the environmental impacts of each material of interest.

An **Environmental Product Declaration (EPD)** provides an independently verified summary of the environmental impact of a product throughout its life-cycle, calculated via LCA.

Single product EPDs are the most common type, but group and industry average EPD are available.

- **Single product and manufacturer EPD:** One product and manufacturer.
- **Product group EPD:** Average of very similar products, one manufacturer.
- **Industry average EPD:** One product and several manufacturers.



Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

77

77

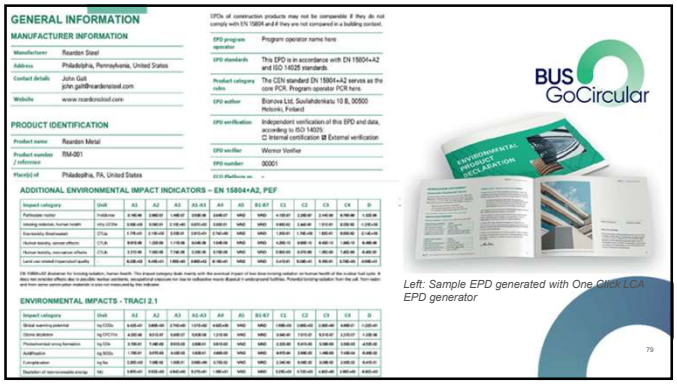
LCA Data- EPDs

- EPDs are based on **internationally-accepted** and valid methods for life cycle assessment (LCA)
- They are **credible and Neutral-** critically reviewed, approved, and maintained by an independent verifier and absent of claims of environmental preference
- **Open:** It has the widest range of applicability to all products and services, and easily accessible to all interested parties
- EPDs are based on Life-cycle assessment calculations according to **ISO 14040 and ISO 14044**
- An EPD is created and verified in accordance with the International **Standard ISO 14025.**
- In Europe, the European Committee for Standardization has published common Product Category Rules (PCR) for EPD development in the construction sector, **EN 15804.**

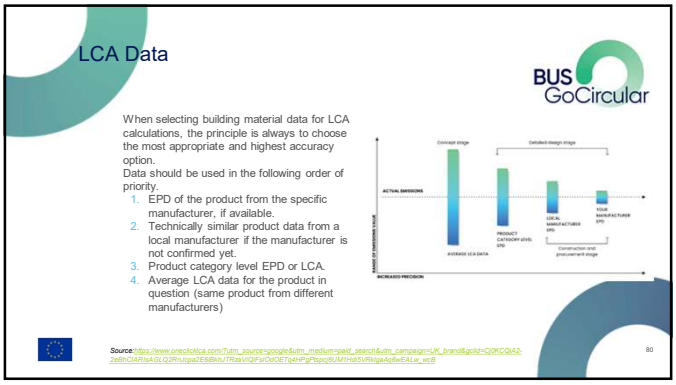
Source:https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

78

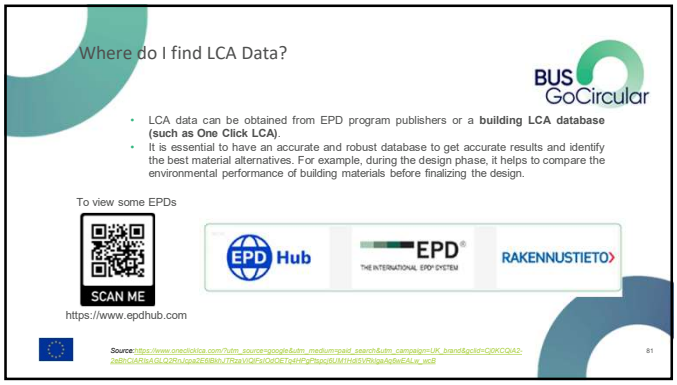
78



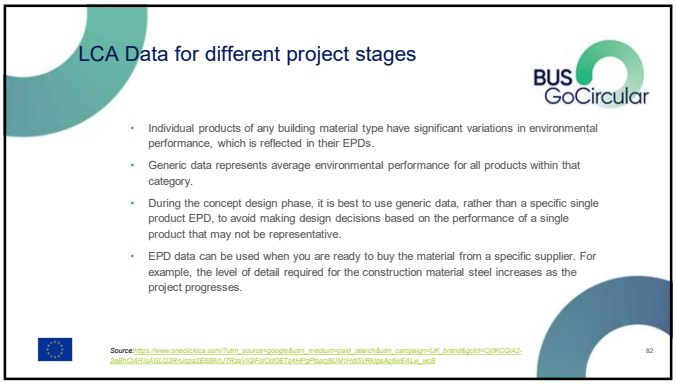
79



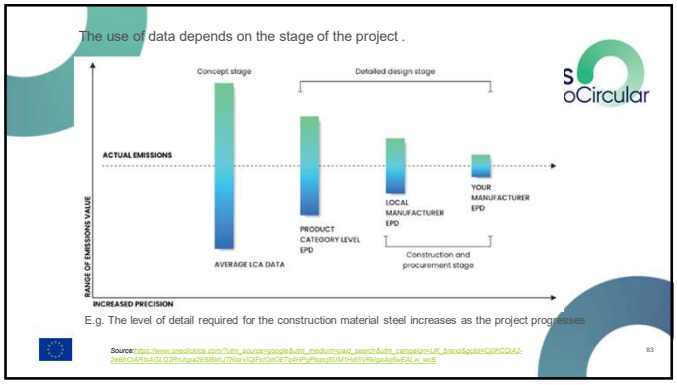
80



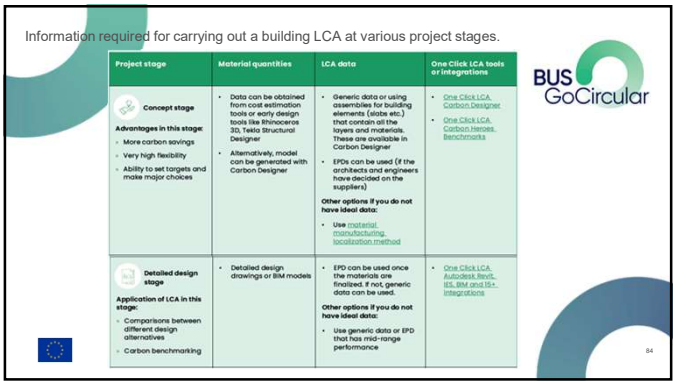
81



82



83



84

Summary: Information required for carrying out a building LCA at various project stages.

Project stage	Material quantities	LCA data	One Click LCA tools or integrations
Construction and procurement stage **Purpose of LCA in this stage:** • Detailed LCA for certifications • Comply with regulations	• Construction drawings, BIM models and cost plans of final materials	• Specific supplier EPDs can be used as the suppliers will be finalized **Other options if you do not have ideal data:** • Use private EPDs using private data feature • Model the product yourself • Use most similar data, otherwise	• One Click LCA for buildings • One Click LCA global LCA database • One Click LCA Carbon Heroes Benchmarks

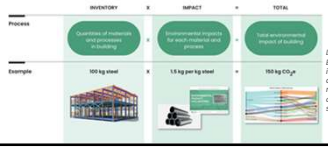
Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BIkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hdd5VRkIgaAq6wEALw_wcB

85

85

Step 3: Impact Assessment

- The overall environmental impact of a building is calculated by performing an Impact assessment.
- The results are expressed as impact categories based on the scope of your LCA.
- For example, the **Level(s)** assessment requires you to report GWP, AP, EP, ODP, POCP, and biogenic carbon.



Left: Example of impact assessment calculations

Impact assessment is carried out by **multiplying the life-cycle inventory (LCI) with the appropriate impacts for each material or process** during the life-cycle impact assessment step. The environmental profile of the inventory is obtained from the respective EPDs or generic data.

LCA tools such as One Click LCA can fully **automate the calculation of impacts** from building materials, scenarios and can **give results by life-cycle stage and building component**.

86

86

Step 4: Results and Analysis

- Once you have the building LCA results, it is useful to **break down the environmental impacts** by building component, material type, and life-cycle stages and then visualize the results.
- This helps to identify hotspots and **reduce impacts where it matters most.**
- After conducting a building LCA analysis, you **must verify the completeness and plausibility** of your data to ensure it complies with your required scope.
- In One Click LCA, this process can be simplified using the LCA Checker feature. It indicates the completeness of the project and identifies weak areas in the analysis.

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BIkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hdd5VRkIgaAq6wEALw_wcB

87

87

Summary: Simplified steps for how LCA is performed

After scope is defined…

1. Find out the type of building, life cycle (60 years) and size as well as geometry (optional)
2. Collect the **material information.**
3. Import details from models, cost plans, Carbon Designer or add manually per material layer or constructions.
4. Add energy use (SBEM, SAPs), water use (water calculations for BC or BREEAM), construction site operations (actual data or scenarios), repair
5. in % and withdrawals
6. Check the results, do optioneering, report

88

88

Visualising building LCA

- By performing a building LCA, you can identify and analyse the environmental **impacts distributed across life-cycle stage, materials, and structural elements**.
- Once the environmental impacts and hotspots have been identified, you can optimise your designs and make informed decisions to lower the impacts of your project.

To understand how this works in practice, we will look at the results of an example building LCA project carried out according to the EN 15978 standard using One Click LCA software.

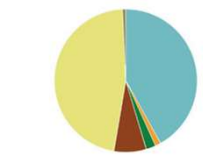
Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BIkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hdd5VRkIgaAq6wEALw_wcB

89

89

Impacts from life cycle stages

- This chart illustrates an example of how Green Warming Potential (GWP) is distributed among the different life-cycle stages of a building.
- The results imply that efforts must be focused on the product stage of the building to reduce the GWP.
- Other environmental impacts measured per life-cycle stage are shown on the following slides.
- Construction materials (product stage) contribute to most of the impacts irrespective of the environmental impact category.

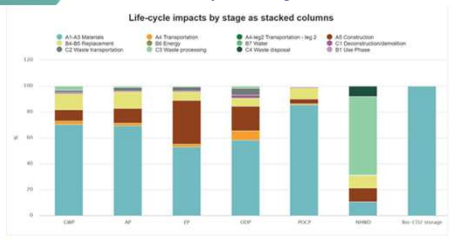


Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BIkhJTRzaViQiFsIOdOETq4HPgPtspcj6UM1Hdd5VRkIgaAq6wEALw_wcB

90

90

Distribution of environmental impacts across different life-cycle stages



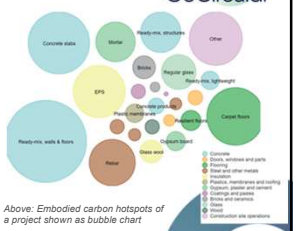
Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

91

91

Impacts from building materials

- Building materials are significant sources of emissions.
- Carbon emissions released before using a building (**upfront carbon**) are of great concern as they are irrevocably released before construction.
- Building LCA results can show which materials have high environmental impact



Above: Embodied carbon hotspots of a project shown as bubble chart

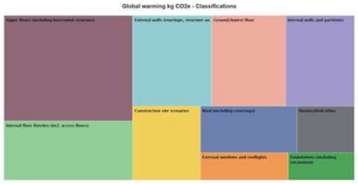
Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

92

92

Impacts from building elements

A Building LCA also identifies which building elements are significant environmental concerns. For example, the results shown below indicate that the upper floors are the major contributor to global warming.

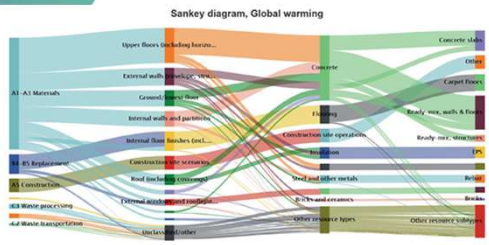


Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

93

93

Impacts from building elements



Embodied carbon breakdown by key building elements

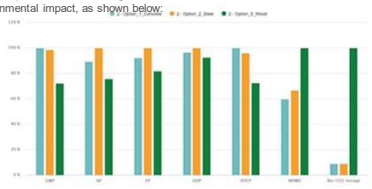
Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

94

94

Design Alternatives

- Comparing the **impacts of different design alternatives** is helpful for decision-making.
- For example, the same building constructed with concrete, steel, or wood will differ in environmental impact, as shown below:



Design optioneering can help in reducing emissions

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

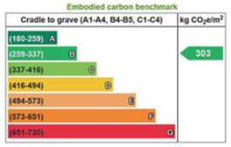
95

95

Benchmarking your project

The Carbon Heroes Benchmarks feature in One Click LCA can benchmark your project's embodied carbon with thousands of buildings across different countries

OneClick LCA's research on Embodied Carbon Benchmarks for European buildings provides benchmark data for buildings across Europe



One Click LCA Carbon Heroes Benchmarks

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjDKCQiA2-2eBhCIARIsAGLQ2RnJcpa2E6BkhJTRzaViQlFsIOdOETq4HPgPtspcj6UM1Hd5VRkIgaAq6wEALw_wcB

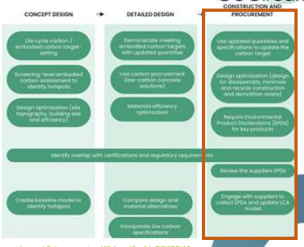
96

96

The role of various stakeholders

Alignment and collaboration between various stakeholders in the construction industry is crucial to decarbonization since **no stakeholder can achieve this alone.**

Right: Measures to reduce embodied carbon at each project stage



Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJopa2E6BBkhJTRzaViQlFsIOdOETq4HPgPbpqI6UMYHdSVRkIgaAq8wEALw_wcB

97

Standards governing building LCA

- Building LCA is performed according to international standards **(ISO 14040, 14044, or EN 15978).**
- These standards (below) ensure transparency and consistency, meaning that the results obtained from an LCA are robust and widely respected.

Cornerstone standards	Construction works specific standards	EPD standards
ISO 14040 (fundamentals for LCA)	EN 15978 – LCA standard for construction projects (European standard, basis for all EU regulations)	ISO 14025 – cornerstone standard for all kinds of EPDs
ISO 14044 (fundamentals for LCA)	ISO 21929-1 and ISO 21931-1 (less used LCA standards)	EN 15804 (EPD data) and EN 15942 (EPD format) (European standard, basis for all EU regulations) ISO 21930

Source: https://www.oneclicklca.com/?utm_source=google&utm_medium=paid_search&utm_campaign=UK_brand&gclid=CjOKCQiA2-2eBhCIARIsAGLQ2RnJopa2E6BBkhJTRzaViQlFsIOdOETq4HPgPbpqI6UMYHdSVRkIgaAq8wEALw_wcB

98

Conclusion

- The adoption of LCA by building professionals came as a result of increasing awareness of the environmental impact of buildings and followed a backlash against greenwashing and vague eco-labelling. In short, performing a building LCA is **the only reliable way to evaluate the sustainability of a building**.



Image source: Blue North

99

Learn More!

OneClick LCA - World's fastest Building Life Cycle Assessment software - One Click LCA

IGBC LCA Tools - Life Cycle Assessment tools and other useful links - Irish Green Building Council (igbc.ie)

LETI embodied carbon primer - Embodied Carbon Primer | LETI

UN Sustainable Development Goals - Home - United Nations Sustainable Development

Building Life Cycle Assessment Case Studies with One Click LCA

Emissions Gap Report 2021 (unep.org)

Embodied carbon review- wc_am-embodiedcarbonreview2018pdf.pdf (divio-media.com)

100

Life Cycle Costing



Presentation

101

Introduction to Life Cycle Costing

- Technique for evaluating the total cost of ownership or real cost of goods, services and works
- Can be applied at pre-procurement (cost estimation) stage, during tender evaluation (MEAT) and as part of contract monitoring
- Most often used for purchases where a significant part of the cost is not reflected in the purchase price, e.g. energy-using products, vehicles, buildings, civil engineering works, lighting systems



Source: Greenville Academy

102

Role of LCC in green public procurement

While LCC may be used for strictly financial reasons, it also allows the environmental costs of purchases to be evaluated. For example:

- Emissions or other environmental impacts associated with raw materials or production process;
- Energy, water consumption and emissions during use phase;
- Other consumables
- Environmental impact of maintenance activities;
- Durability/time-to-replacement
- Recoverability or recyclability of materials at end-of-life

Some environmentally preferable goods/services have a higher initial purchase price, LCC allows purchasers to analyse whether this will be compensated for by lower operational costs.

Source: Greenville Academy

103

103

Role of LCC in green public procurement

Life-cycle costing (LCC) means considering all the costs that will be incurred during the lifetime of the product, work or service:

- **Purchase price** and all associated costs (delivery, installation, insurance, etc.)
- **Operating costs**, including energy, fuel and water use, spares, and maintenance
- **End-of-life costs** (such as decommissioning or disposal) or residual value (i.e. revenue from sale of product)

LCC may also include the cost of externalities (such as greenhouse gas emissions) under specific conditions laid out in the directives. The current (2014) directives require that where LCC is used, **the calculation method and the data to be provided by tenderers are set out in the procurement documents**. Specific rules also apply regarding methods for assigning costs to environmental externalities, which aim to ensure that these methods are **fair and transparent**.

Source: Greenville Academy

104

104

Article 68 – LCC methods

Must indicate method to be applied and data required from tenderers in the procurement documents. Method must be:

- Based on objectively verifiable & non-discriminatory criteria;
- Accessible to all interested parties;
- Data required can be provided with reasonable effort by normally diligent economic operators, including operators from third countries.

Transparency principle applies: bidders need to understand what data is required and how the costs will be calculated.

In most cases, the authority can choose its own methodology, but must make this clear in the tender documents (e.g. by including a spreadsheet with detailed instructions).

Mandatory common EU methods may be developed

Source: Greenville Academy

105

105

Including LCC in award criteria - Example

AC1. Life-cycle costs
The cost of each valid and responsive tender will be evaluated on the basis of total life-cycle costs (LCC). Tenderers are required to complete the spreadsheet included in the tender documents with the requested data regarding their products. This information will be used to calculate LCC and the tender with the lowest life-cycle cost will be awarded [X] marks, with other tenders being scored according the following formula:

Score TENDER A= [X] * Lowest LCC / LCC TENDER A

Verification: The completed spreadsheet must be submitted with the tender and where indicated, supporting documentation verifying the data must be provided. The data entered in the spreadsheet regarding costs, energy consumption, time to replacement and other parameters will become binding under the contract.

Source: Greenville Academy

106

106

LCA & LCC

- Building Life Cycle Costing provides a credit in many green building certification credits and is often calculated alongside a building LCA.
- Similarly, to Building LCA, the earlier in the design process you calculate a building LCC, the more savings you can achieve. In both cases, you can compare design alternatives to find out which is better over the whole life cycle of the building. For example, if you perform LCC calculations you might find out that a product that has a cheaper initial cost might end up being much more expensive in the long run because it will need to be replaced more times during the building use phase, which is usually around 60 years.
- LCC provides reliable metrics on costs and savings over the whole lifetime of the building and there is a strong business case for building LCC. When paired with LCA, it can help design buildings that are more sustainable both from an environmental and financial perspective.

107

107

LCC Conclusion

LCC makes good sense regardless of a public authority's environmental objectives. By applying LCC public purchasers take into account the costs of resource use, maintenance and disposal which are not reflected in the purchase price. Often this will lead to 'win-win' situations whereby a greener product, work or service is also cheaper overall.

The main potential for savings over the life-cycle of a good, work or service are:

- Savings on use of energy, water and fuel
- Savings on maintenance and replacement
- Savings on disposal costs



Image source: Wikimedia Commons

108

108

Tools for Life Cycle Costing

There are two possible ways of assessing lifecycle costs in building planning services:

1. Calculation of the life cycle costs of the submitted architectural contests by **independent experts appointed by the client.** […].
2. Calculation of the life-cycle costs of the building design **by the bidders themselves**. For this purpose, the client must provide normative specifications for the calculation methodology as well as provide the predefined normatively determined data for the calculation to all bidders.

Source:SCSI Guide to LCC

109

109

Tools for Life Cycle Costing

While manual methods of calculations are still defined in relevant standards they are no longer being used in the production of LCC estimates.

Most examples of LCC are now calculated and presented in computer software.

There are two categories of computer-based LCC programs, which can be described as glass box or black box systems.

- A **glass box** computer-based LCC program is characterised by the visibility of the process, such that each step in the LCC process can be seen by the operator. Conversely, a **black box** computer-based LCC program is characterised by the input of data and the output of results with each step in the process being invisible to the operator.
- The most common glass box systems are based on **spreadsheets** and are developed within an organisation for their specific needs and on specific projects. Black box systems are usually proprietary software bought from a software company.

Source:SCSI Guide to LCC

110

110

LCC and BIM

A Building Information Modelling/Management (BIM) approach to construction procurement is being increasingly utilised as a collaborative set of procedures and associated technologies that assist design and construction professions in conceiving, designing, constructing and operating the built environment. (See LU 11)

Although **5D BIM (Cost Modelling**) is currently being used in Quantity Surveying practice, BIM is not extensively used in the application of LCC and there has been limited research in this area to date.

5D automated measurement can still be utilised in 5D application, but currently it is recommended to **export these quantities to MS Excel and then carry out the LCC estimate.**

Source:SCSI Guide to LCC

111

111

Learn more!

The following section provides links to a number of videos, workbooks and solutions to get started on carrying out LCC estimates. The intention is that the user will develop the building blocks of proficiency in LCC calculations and start applying them to an LCC estimate.

Life Cycle Costing in Excel 1 – Video
LCC Excel Template - 1
LCC Excel Solution - 1

Life Cycle Costing in Excel 2 – Video
LCC Excel Template - 2
LCC Excel Solution - 2

The exercises shown in these 4 videos, outline a number of scenarios where the calculations demonstrated in the previous videos (left) are used in some simple LCC models.

Life Cycle Costing Exercise 1 - Video
LCC Excel Template - 1
LCC Excel Solution - 1

Life Cycle Costing Exercise 2 - Video
LCC Excel Template - 2
LCC Excel Solution - 2

Life Cycle Costing Exercise 3 - Video
LCC Excel Template - 3
LCC Excel Solution - 3

Life Cycle Costing Exercise 4 - Video
LCC Excel Template - 4
LCC Excel Solution - 4

Source:SCSI Guide to LCC

112

112

Case Study 1

Case Study 1: Berlin Police cars

Technical specifications:

- Must meet Euro 5 European Emission Standard (the most demanding standard at the time of tendering)
- Carbon particulate filter (for diesel engines)
- Must meet or exceed German 4 standard or equivalent for particle emissions –this allows the vehicle to be driven in inner-city environmental zones



Award criteria: Technical performance (40%) and Life-cycle costs (60%)

Life-cycle costing: Maintenance costs calculated based on projected future maintenance and repair work of the vehicles (e.g. tyres, window replacement). Environmental costs calculated based on a) fuel consumption, b) energy consumption, c) CO2 emissions, d) NOx, e) non-methane hydrocarbons and f) particulate matter.

113

113

Case Study 2

Case Study 2: Lighting in Syddjurs, Denmark

- LCC/TCO included purchase price, replacement (including labour costs) and operational costs
- Product sheet listing a range of lighting solutions in different technology categories which may be required over the course of the framework
- 15-year evaluation period

Results: For a standard bulb with a E27 socket, 405-470 lumen

Halogen –2,354 krone kr (**€316**)

Low energy bulbs -581 kr (**€78**)

LED -362 kr (**€49**)

Link to full case study here

114

114

Level(s)



115

115

Level(s) is a common framework for sustainable buildings across Europe.

- **Greenhouse gas emissions along a buildings life cycle**

Use stage energy performance (kWh/ M² /yr)
Life cycle Global Warming Potential (CO2 eq./M² /yr)

- **Resource efficient and circular material life cycles**
- **Efficient use of water resources**

Use stage water consumption (M3 /occupant/yr)

- **Healthy and comfortable spaces**
- **Adaptation and resilience to climate change**
- **Optimised life cycle cost and value**

Life cycle costs (€/m²/yr)

Level(s)

https://environment.ec.europa.eu/topics/circular-economy/levels/lets-meet-levels/how-does-levels-work_en

116

116

Introduction to EU Level(s)

- EU Level(s) is a common framework for sustainable buildings across Europe.
- It is an assessment and reporting tool for sustainability performance of buildings, firmly based on circularity.
- As we respond to the Paris Agreement's demand that the building and construction sector **decarbonise by 2050**, Level(s) supports the essential **assessment over the full lifecycle** through design, construction, use, and end of life.
- Building upon the objectives of both the EU Green Deal and the EU Circular Economy Action Plan, Level(s) supports the efforts of the building sector **in improving energy and material efficiency**, thereby reducing overall carbon emissions

Level(s)

Source: https://gupp-class.eu/

117

117

Introduction to EU Level(s)

EU Level(s) uses core sustainability indicators to measure carbon, materials, water, health, comfort and climate change impacts throughout a building's full life cycle.

It is a flexible solution for identifying sustainability hotspots and for future-proofing your project or portfolio.

By using EU Level(s) you are contributing to EU policy goals to strengthen the sustainability of Europe's buildings, which are responsible for:

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

Level(s) is open source and freely available to all

Level(s)

Source: https://gupp-class.eu/

118

118

Benefits of Level(s)

With a limited number of indicators, Level(s) helps you by:

- ✓ Providing a **simple entry point to circularity** and lifecycle thinking;
- ✓ Identifying hotspots and **future-proofing buildings** by making them more sustainable and carbon efficient.
- ✓ Supporting **initial discussions between contractors and clients** regarding what to focus on to **make the project more sustainable**, and perhaps taking it further to detailed design and construction.
- ✓ **Greening buildings/portfolios** and discussing between designers and clients how to best align with European or other policy;
- ✓ **Demonstrating how policy initiatives can align with a European framework** that has been developed, tried, and tested by a large number of building professionals across the EU.
- ✓ Providing flexibility to the users during implementation, adapting it to their needs, pace, and understanding of the framework.
- ✓ Being a **valuable framework for all those committed to improving environmental performance** and resource use.

Source: https://gupp-class.eu/

119

119

Level(s) and GPP

- Level(s) will be the basis for the revision of the EU GPP Criteria for office buildings. These criteria will be expanded to cover schools and social housing, and will pay particular attention to renovation
- Level(s) guides part of the technical screening criteria used to identify new buildings for sustainable finance
- International sustainability certification tools are aligning their schemes to Level(s), ensuring common EU policy objectives are integrated.

Source: https://gupp-class.eu/

120

120

How Level(s) can support you

- Level(s) helps built environment and sustainability professionals, investors and policy makers in their efforts to transform the built environment into a sustainable and circular one.

Built Environment and Sustainability professionals

Level(s):

- Uses consistent indicators for all project stages, based on best practice industry standards.
- Brings together building professionals to discuss sustainable objectives.
- Supports comparison of design options and encourages monitoring of real performance.



Source: EU Academy

121

121

How Level(s) can support you

Policy makers / Procurers / Public authorities

Level(s):

- Is based on a method tried and tested across the EU and underpins future EU policy.
- Allows public authorities to develop and implement policies and actions.
- Brings minimum numbers of indicators with maximum leverage to deliver sustainability.



122

122

How Level(s) can support you

Investors / Building Owners / Landlords

Level(s):

- Ensures future proofing of buildings as it tracks performance throughout the full life cycle.
- Brings consistency, accountability and, thus, investor confidence.
- Supports communication on value based on Environmental, Social and Governance factors (ESG).



Source: EU Academy

123

123

How does Level(s) work?

- Level(s) is based on six **macro-objectives.** These can be tracked through 16 **indicators.**
- The **6 macro-objectives** address key sustainability aspects over the building life cycle.
- The sustainability **indicators** within each macro-objective describe how the building performance can be aligned with the strategic EU policy objectives in areas such as energy, material use and waste, water, indoor air quality and resilience to climate change. The following slides will explain what each entails.



Source: EU Academy

124

124

1. Greenhouse gas emissions along a building's life-cycle

Macro Objective 1: **Greenhouse gas emissions along a building's life-cycle**

Intention: to minimise whole life cycle carbon emissions, taking into account both energy consumption during the use stage of the building and embodied energy in building materials and construction products.
Indicators:

1.1 Use stage energy performance.
1.2 Life cycle Global Warming Potential.



Source: EU Academy

125

125

2. Resource efficient and circular material life cycles

Macro Objective 2: **Resource efficient and circular material life cycles**
Intention: to optimise the building design to support lean and circular product and material flows, including:

- Quantification of construction products and materials used.
- Planning, estimation and monitoring of circular outcomes for construction and demolition waste generated.
- Assessment and scoring of the adaptability of building designs.
- Assessment and scoring of the potential for deconstruction in building designs as opposed to demolition.

Indicators:
2.1 Bill of quantities, materials, and lifespans.
2.2 Construction & demolition waste and materials.
2.3 Design for adaptability and renovation.
2.4 Design for deconstruction.



Source: EU Academy

126

126

3. Efficient use of water resources

Macro Objective 3. **Efficient use of water resources**

Intention: to use water efficiently, particularly in areas with identified long-term or projected water stress.

Indicator:

3.1 Use stage water consumption.



Source: EU Academy

127

127

4. Healthy and comfortable spaces

Macro Objective 4. **Healthy and comfortable spaces**

Intention: to create building spaces that are comfortable, attractive, and productive. This includes four aspects regarding the quality of the indoor environment:

- The quality of indoor air for specific parameters and pollutants.
- The degree of thermal comfort.
- The quality of artificial and natural light and associated visual comfort.
- The capacity of the building fabric to provide a comfortable acoustic environment for its occupants.

Indicators:

4.1 Indoor air quality.
4.2 Time outside of thermal comfort range.
4.3 Lighting and visual comfort.
4.4 Acoustics and protection against noise.



Source: EU Academy

128

128

5. Adaptation and resilience to climate change

Macro Objective 5. **Adaptation and resilience to climate change**

Intention: to future proof building performance:

- Adapt to future climate changes that will impact thermal comfort.
- Make the building more resilient and resistant to extreme weather events (including flooding: fluvial, pluvial and coastal).
- Improve the building design to reduce the chances of pluvial/fluvial flood events in the local and downstream area (i.e. incorporating sustainable drainage features).

Indicators:

5.1 Protection of occupier health and thermal comfort.
5.2 Increased risk of extreme weather events.
5.3 Sustainable drainage.



Source: EU Academy

129

129

6. Optimised life cycle cost and value

Macro Objective 6. **Optimised life cycle cost and value**

Intention: to gain a long term view of the whole-life costs and market value of more sustainable buildings, including:

- Life cycle costs (construction, operation, maintenance, refurbishment, and disposal).
- Encourage the integration of sustainability aspects into market value assessment and risk rating processes and ensure that this is done in as informed and transparent a way as possible.

Indicators:

6.1 Life cycle costs.
6.2 Value creation and risk exposure.



Source: EU Academy

130

130

Establish a Level(s) project plan

To set up a project to use the Level(s) common framework, you must establish a Level(s) project plan.

- Once you have selected the macro-objectives and indicators to address, you next decide at which 'level' the project performance will be assessed.
- A design team could use different levels for the different indicators, use one or several levels for each indicator to follow the development of performance throughout the project.
- The more levels that can be addressed, the more complete the picture of the project's sustainability performance.

Source: EU Academy

131

131

Level 1: Conceptual Design Assessment

- Early-stage qualitative assessments and reporting on the concepts that will be considered during the initial project definition and conceptual design phases.
- It provides a simple structure that can be presented to clients to focus attention on the most relevant sustainability aspects for each indicator.
  - *L1a. Project definition and brief.*
  - *L1b. Concept design.*



Source: EU Academy

132

132

Level 2: Detailed Design and Construction Assessment

- Quantitative assessment of the performance of the design.
- Allowing comparison of estimates for different design options and monitoring of the construction according to standardized measurements and methods.
  - *L2a. Outline design (Spatial planning and permits).*
  - *L2b. Detailed design (Tendering).*
  - *L2c. Technical design (Construction).*



Source: EU Academy

133

133

Level 3: As-Built and In-Use Assessment

- Monitoring and surveying of activity on the construction site and of the completed building and its first occupants.
- Level 3 helps the entire team understand actual building performance and identify lessons learned from the design to inform and improve future projects.
  - *L3a. As-built design.*
  - *L3b. Commissioning and testing.*
  - *L3c. Completion and handover.*
  - *L3d. Occupation and use.*



Source: EU Academy

134

134

Setting up a Project- An overview of the levels

The next sequence of slides will provide an outline of how you would use the different indicators at the three levels.



Source: EU Academy

135

135

1.1 Use stage energy performance

Level 1
For users who would like to:
- ✓ Understand the energy uses associated with the type of building they are working on.
- ✓ Know where they can focus attention to reduce the use of non-renewable primary energy associated with the building's use of the delivered energy during the use stage.

This includes a checklist with information on design energy concepts.

Level 2
For those users who are at the stage where they need to
- ✓ estimate the delivered and primary energy use of a building for the purposes of design comparisons, building permits or tendering.

This could include, for example, an energy simulation.

Level 3
For those users who would like to:
- ✓ Collect metered data to understand the energy use associated with the building.
- ✓ Carry out testing of the building in use to identify any performance issues with the building fabric and technical services.

This could include an energy meter that measures real-time energy consumption.

Source: EU Academy

136

136

1.2 Life cycle Global Warming Potential

Level 1
For those users who would like to:
- ✓ Incorporate some important life cycle concepts into the design and, later, into the detailed designs.
- ✓ Interpret and use the results from life cycle Global Warming Potential assessments and Life Cycle Assessments carried out previously, which were based on the analysis of similar building types.

This includes a checklist to integrate life cycle concepts.

Level 2
For those users who would like to:
- ✓ Calculate the life cycle Global Warming Potential emissions of their project and select software tools and databases in accordance with to the standard EN 15978.
- ✓ Interpret and use the results from a 'hot spot' analysis.

Level 3
This is the same procedure as defined in Level 2 but supported by the final materials procured, technical building systems installed, and the energy consumed.

Source: EU Academy

137

137

2.1 Bill of quantities, materials and lifespans

Level 1
For those users who would like to:
- ✓ Find out about the six highly relevant aspects for optimising the consumption of construction materials and products.
- ✓ Describe how these aspects were considered (or not) during discussions and decision-making at the concept design stage.

Level 2
For those users who would like to:
- ✓ Make an estimate of the Bill of Quantities during the design stage that ensures budgetary limits are respected.
- ✓ Use an inventory template to insert and manage the Bill of Quantities data. Furthermore, by entering optional cost data and lifespans, the Bill of Quantities template can generate outputs that are useful for other Level(s) indicators.

Level 3
For those users who would like to:
- ✓ Register and log Bill of Quantities data as materials and products are procured and delivered to the site based on actual quotations and purchases.
- ✓ Use an inventory template to centralise purchasing records and track spending in line with project budgets and schedules.
- ✓ Compare with estimates during the design stage.

Source: EU Academy

138

138

2.2 Construction & Demolition Waste (CDW) and materials

Level 1

For those users who would like to:

- ✓ Find out about highly relevant aspects for reducing Construction & Demolition Waste and optimising its management.
- ✓ Describe how these aspects were considered (or not) during discussions and decision-making at the concept design stage.

Level 2

For those users who would like to:

- ✓ Report on and to make reliable quantitative estimates of Construction & Demolition Waste.
- ✓ Use inventory template(s) for Construction Waste and /or Demolition Waste estimations.

Level 3

For those users who would like to:

- ✓ Measure the quantities of Construction & Demolition Waste in their project, using the Level(s) Excel templates for Construction Waste and Demolition Waste reporting to collate data.
- ✓ Compare estimates with actual data.

Source: EU Academy

139

139

2.3 Design for adaptability and renovation

Level 1

For those users who would like to:

- ✓ Understand how the design of a building could facilitate future adaptation to changing occupant needs and market conditions.
- ✓ How these design aspects could extend the service life of the building as a whole, either by ensuring it can continue to be used as intended or through possible future changes in use.

Level 2

This level is for those users who wish to set design objectives or who are at the stage of making design decisions and wish to compare design options to determine their relative adaptability.

Level 3

This level is for those users who wish to compare the final as-built design with the earlier detailed designs.
It can also form the starting point for long-term monitoring of the building and how it performs in the local property market.

Source: EU Academy

140

140

2.4 Design for deconstruction

Level 1

For those users who would like to:

- ✓ Understand how the design of a building could facilitate future deconstruction to access, dismantle and disassemble parts and materials.
- ✓ Determine the extent to which these building parts may be recovered for reuse and/or recycling.

Level 2

This level is for those users who wish to set design targets or who are at the stage of making design decisions and wish to compare design options to determine their deconstruction potential.

Level 3

This level is for those users who wish to compare the final as-built design with the earlier detailed designs.

It can also form the starting point for preparing the technical content of a building passport or building material bank record.

Source: EU Academy

141

141

3.1 Use stage water consumption

Level 1

For those users who would like to:

- ✓ Find out about five highly relevant aspects for reducing and optimising water consumption in the use stage.
- ✓ Describe how these aspects were considered (or not) during discussions and decision-making at the concept design stage.

This includes a checklist with information on water efficient design concepts.

Level 2

This level is for those users who wish to

- ✓ Estimate the water consumption per person in the building through the use of water-consuming devices, appliances and irrigated areas via an Excel-based calculator.
- ✓ Minimise potable water consumption by specifying more efficient devices and appliances and by collecting rainwater and/or reusing greywater.

Level 3

This level is for those users who would like to:

- ✓ Measure of actual water consumption over the course of one year considering an estimation of building occupation rates.
- ✓ Compare estimates with measures.

Source: EU Academy

142

142

4.1 Indoor Air Quality

Level 1

For those users who would like to:

- ✓ Find out about three highly relevant design aspects that represent the main factors that influence Indoor Air Quality and contribute to optimising the ventilation strategy for a building.
- ✓ Describe how these aspects were considered (or not) during discussions and decision-making at the concept design stage.

Level 2

For those users who wish to:

- ✓ Design the ventilation system, specify indoor fit-out materials and, in the case of major renovations, design insulation and make other design improvements to the air tightness and integrity of the building fabric.
- ✓ Quantify the ventilation rates needed in different zones of the building.
- ✓ Factor into the design the potential influences on the quality of outdoor air (e.g. proximity of roads, traffic volume etc.) and on the quality of indoor air (e.g. emissions from materials, bio-effluents, point sources of humidity, etc.).
- ✓ Inform the design team to specify the ventilation system. The difference in quality between outdoor air entering the system and the desired quality of the air to be supplied indoors will directly influence the filter specification, which in turn will influence the sizing of the system and its energy performance.

Level 3

For those users who wish to:
Assess Indoor Air Quality in an objective manner based on the performance of a completed building.

Source: EU Academy

143

143

4.2 Time outside of thermal comfort range

Level 1

For those users who would like to:

- ✓ Assess the risks of occupant thermal discomfort during the heating and cooling seasons for the building type being assessed.
- ✓ Understand measures that can be taken to create a comfortable thermal environment in the building types being assessed.

Level 2

This level is for those users who wish to

- ✓ Assess the energy requirements of a building.
- ✓ Make a quantitative assessment of the indoor thermal conditions according to the Category II temperature ranges outlined in EN 16798-1:2019 (or national equivalent).
- ✓ Perform an overheating assessment of a building for the purpose of obtaining a building permit.

Level 3

This level is for those users who would like to:

- ✓ Collect monitoring data on the thermal conditions in a building to compare the performance with design simulations.
- ✓ Carry out a post-occupancy survey of occupants to determine the level of dissatisfaction with the thermal comfort conditions and compare the results with the design estimates.

Source: EU Academy

144

144

4.3 Lighting and Visual comfort

Level 3

Level 1

This indicator is currently only specified for Level 1

For those users who would like to:

- ✓ Get support to learn how to understand and prioritise the most important lighting and visual comfort aspects to focus attention on.
- ✓ Get support to establish requirements and specifications that enable the production of a detailed design that ensures the health and comfort of occupants during visual tasks and activities.

Level 2

Source: EU Academy

145

145

4.4 Acoustics and protection against noise

Level 3

Level 1

This indicator is currently only specified for Level 1

For those users who would like to:

- ✓ Understand and prioritize the most important design aspects to focus on, taking into consideration five acoustic and noise protection design aspects at the concept stage of a project.
- ✓ Make the right decisions when setting requirements and specifications.

This level also provides initial suggestions for how calculations and field measurements can be made.

Level 2

Source: EU Academy

146

146

5.1 Protection of occupier health and thermal comfort

Level 3

Level 1

This indicator is currently only specified for Levels 1 and 2

For those users who would like to:

- ✓ Assess the risks of occupant thermal discomfort during the cooling seasons for the building type being assessed.
- ✓ Understand and identify measures that can be taken to future-proof a building's thermal environment and/or incorporate adaptation measures.

Level 2

This level is for those users who are at the stage where they need to assess the energy requirements of a building and wish to make a quantitative assessment of the indoor thermal conditions under projected future climate conditions.

Source: EU Academy

147

147

5.2 Increased risk of extreme weather

Level 3

Level 1

This indicator is currently only specified for Level 1.

For those users who would like to:

- ✓ Learn about the steps to take during the conceptual design stage (and even earlier) to ensure maximal awareness of extreme weather events at the building location.
- ✓ Optimise the design of the building and any surrounding plot area to adapt to extreme weather events.

Level 2

Source: EU Academy

148

148

5.3 Sustainable drainage

Level 3

Level 1

This indicator is currently only specified for Level 1.

For those users who would like to:

- ✓ Set out the steps to take during the conceptual design stage in order to embrace sustainable drainage options as much as possible.
- ✓ Be aware of both the risk of flooding at the building and the possible effect of the building itself on flood risk in surrounding and downstream areas.

Level 2

Source: EU Academy

149

149

6.1 Life cycle costs

Level 1

For those users who would like to:

- ✓ Calculate the life cycle cost of their building project but want to understand how to achieve a longer-term understanding on the costs associated with a building project.
- ✓ Incorporate some important life cycle cost concepts into conceptual designs and, later, detailed designs.

Level 2

This level is for those users who wish to

- ✓ Calculate the life cycle costs of their building project.
- ✓ Select software tools and databases.
- ✓ Understand the basic elements of the calculation and the calculation steps in line with the Cost Optimal method, EN 15459 and the ISO 15686-5 standard, including assumptions and default parameters that shall be used and data gap filling.

Level 3

This level is for those users who would like to:

- ✓ Revise the life cycle costs of their building project based on the as-built initial costs and any associated revisions in the projected annual and periodic costs.
- ✓ Report on the life cycle costs for a completed building.

Source: EU Academy

150

150

6.2 Value creation and risk factors

Level 3

Level 1	Level 2
This indicator is currently only specified for Level 1 For those users who would like to: ✓ Understand how sustainability aspects addressed by Level(s) can have an influence on property financial value and risk appraisals. ✓ Have a starting point for dialogue between the design team, the client and their property market specialists. ✓ Ensure that improved sustainability performance, which can be reported on and verified using Level(s), is amongst the factors taken into account when making a property market valuation.	

Source: EU Academy

151

151

Establishing a Level(s) project plan

- Finally, having decided at which level project performance will be assessed, ensure your planning is associated with key workflow requirements.
- As such, sustainability will become a key priority for the building project alongside factors such as cost and yield.
- In the following slides you will see which questions the team needs to consider when establishing the workflow from the outset. This will enable effective planning and integration into the project Level(s) assessment.

Source: EU Academy

152

152

Establishing workflow

Level(s) performance assessments

✓ Does the team have the training and expertise to make an assessment at all levels? If not, how will the gaps be bridged?

✓ Has the team read the introduction material on Level(s) such as the European Commission website, fact sheets, flyers and introduction manuals?

✓ Have milestones been established by the team for each indicator assessment?

✓ Who will be assigned the responsibility for performing each indicator assessment?

✓ Who will coordinate the Level(s) indicator assessments?

Source: EU Academy

153

153

Establishing workflow

Information and data management

✓ How will the flow of information and data required to make each indicator assessment be managed?

✓ Will Building Information Modelling be used and, if so, how could it support Level(s) assessments?

Renovation baseline

✓ Will it be a major renovation project?

✓ If so, how comprehensive is it planned to be?

✓ How will the baseline survey of the building and its fabric be carried out?

✓ What information will be needed from the baseline survey to perform the indicator assessment?

Source: EU Academy

154

154

Establishing workflow

Property market valuation

✓ How will Level(s) indicator performance aspects be considered in the buildings market valuation?

✓ How and at what points in the project will dialogue be established between the project team and the valuer?

External verification

✓ Will third party verification of the Level(s) assessment results be required?

✓ If so, by whom and at what point in the project?

Source: EU Academy

155

155

Completing the building description

An important part of working at Levels 2 and 3 is the completion of the building description. Its role is to provide a transparent basis for comparing the performance of different buildings.

The following topics must be included and the required information associated with each one.

Location and Climate-	1.1 The country and region where the building is located. 1.2 Heating and cooling degree days. 1.3 The climate zone where the building is located.
Building Type and age-	2.1 The project type. 2.2 The year of construction. 2.3 The market segment
How building will be used-	3.1 The intended conditions of use. 3.2 Building occupation and usage patterns. 3.3 The intended (or required) service life.
The building model and characteristics-	4.1 The building form. 4.2 The total useful floor area within the building and measurement standard used. 4.3 The scope of building elements to be assessed and categorisation system used.

Source: EU Academy

156

156

Learn more!

EU Level(s) User manuals:

- **User Manual 1** - introduction guide to Level(s). It provides detailed information on who Level(s) is for and how to use it.
- **User Manual 2** shows you how to set up a project according to the Level(s) methodology.

All the user manuals and accompanying Level(s) documentation are available to download on the Level(s) website

For more courses on Level(s).

- EU Level(s) academy
- Level(s) Building Sustainability Performance - Irish Green Building Council (igbc.ie)

157

157

Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

158

158

Application for Multi-functional Green Roofs Facades and Interior Elements

Have you worked on a project containing a green roof?

Can you attempt to utilise all of the above topics on a Multi-functional Green Roofs Facades or Interior Element. What comparison can you draw with other projects and what improvements can you notice?



Source:

159

159

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

160

160

EXTRA READING/STUDY

Activity

161

161

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

162


Colophon
Copyright © 2021 by BUSGoCircular consortium
Use of any knowledge, information or data contained in this document shall be at the user's sole risk. Neither the BUSGoCircular Consortium nor any of its members, their officers, employees or agents shall be liable or responsible, in negligence or otherwise, for any loss, damage or expense whatever sustained by any person as a result of the use, in any manner or form, of any knowledge, information or data contained in this document, or due to any inaccuracy, omission or error therein contained. If you notice information in this publication that you believe should be corrected or updated, please get in contact with the project coordinator.
The authors intended not to use any copyrighted material for the publication or, if not possible, to indicate the copyright of the respective object. The copyright for any material created by the authors is reserved. Any duplication or use of objects such as diagrams, sounds or texts in other electronic or printed publications is not permitted without the author's agreement
BUS GoCircular
Partners
ISSO
BUILDING CHANGES
IVE
CIRCLE ECONOMY
TUS
ICLEI
ace-cae.eu
CTU
ĚMI
EnEffect
INSTITUT OBĚHOVÉ EKONOMIKY
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

163

BUS GoCircular

Shaping a Circular Sustainable Future

Module 9

Waste as a Resource in Circular Economy

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

Within this module the trainee will gain an understanding of what the opportunities associated with material reuse are and how this can be applied to their industry. they will also recognise some of the barriers that exist within a national context. They will also become familiar with some material digital marketspaces as well as becoming familiar with the concept of buildings as material banks. This will all then be related to MGRFIE.

2

2

Objectives/Learning Outcomes

- 5 – Design with products and materials that can be easily reused or recycled after use
- 16 – Enable second hand sale of multifunctional roof/façade products through marketplaces or services
- 19 – Transform waste products and materials from multifunctional roofs, façades or interior elements for reuse, or as a last resort into lower value products in the same industry
- 20 – Use waste products and materials from construction demolition projects that have been processed and recycled
- 21 – Collect products and materials for reuse or recycling in roofs, façades or interior elements from outside construction

3

3

Objectives/Learning Outcomes

- 22 – Transform waste products and materials from multifunctional roofs, façades or interior elements for reuse outside construction, or as a last resort into lower value products outside construction
- 23 – Use waste products and materials from outside construction that have been processed and recycled
- 48 – Employ a regional construction digital marketplace for construction resources
- 58 - Reduce waste as much as possible during production
- 73 – Organise logistics and storage of secondary materials, whilst aiming to reduce waste

4

4

Objectives/Learning Outcomes

- 78 – Assess quality of materials to be reused from multifunctional green roofs, façades, and interior elements (audit of waste)
- 79 – Trade secondary materials and products on digital marketplaces

5

5

Content

- Waste as a Resource
  - Implementing material reuse
- Digital marketspace
- Material Banks
- Application for Multi-functional Green Roofs Facades and Interior Elements

6

6

Waste as a Resource

Presentation

7

7

Waste as a Resource

The EU Data Centre on Waste compiles waste data at European level. According to data for 2010 for 29 European countries (i.e. EU-28 and Norway), around 60 % of the waste generated consisted of mineral waste and soil, largely from construction and demolition activities and mining. For metal, paper and cardboard, wood, chemical and medical waste and animal and vegetal wastes, each waste type ranged from 2 % to 4 % of the total.

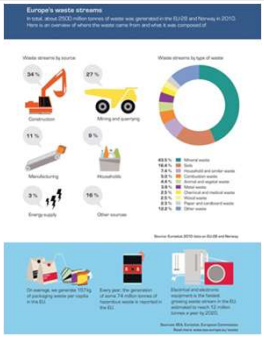
Around 10 % of the total waste generated in Europe consists of what is known as 'municipal waste' — waste generated mainly by households, and to a lesser extent by small businesses, and by public buildings such as schools and hospitals.

In 2012, 481 kg of municipal solid waste was generated per person in the 33 member countries of the European Environment Agency (EEA). There is a slight downward trend from 2007 onwards, which can be explained partly by the economic crisis affecting Europe since 2008.

Source:https://www.eea.europa.eu/publications/signals-2014/articles/waste-a-problem-or-a-resource

8

8



Source:https://www.eea.europa.eu/publications/signals-2014/articles/waste-a-problem-or-a-resource

9

9

Irish Context

The construction industry accounts for approximately 50% of materials used on the planet, and 48% of all waste generated in Ireland. Very little of this waste is currently reused, or even recycled. Where recycling does take place, it is often in the form of downcycling, creating aggregates and backfill at best. The objective of the pilot is to demonstrate a feasible, transparent, fair, and user-friendly system for the reuse of construction materials that would otherwise enter the waste stream.

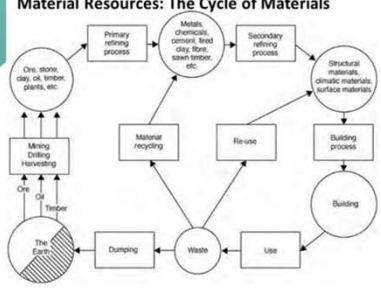


Source:https://www.igbc.ie/the-irish-green-building-council-launches-a-pilot-scheme-to-increase-reuse-of-construction-materials/

10

10

Material Resources: The Cycle of Materials



Source:BERGE, B., (2009) the ecology of building materials 2nd ed

11

11

Circular Economy & Waste

- The construction sector consumes 42 billion tonnes of resources annually, making it the most material-intensive sector.
- The construction sector also produces about one-third of all global waste, most of which is not recycled or reused, but ends up in landfills.



12

12

Circular Economy & Waste

Construction and Demolition (C&D) waste is waste from any building works, demolition and development (including transport infrastructure).

- The remainder includes concrete, brick, tiles, metal, glass, wood, plastic and metal.
- Excavated soil and stone is the largest element of construction and demolition waste at approximately 85%
- The quantity of C&D waste generated and collected in Ireland increased to 8.8 million tonnes in 2019



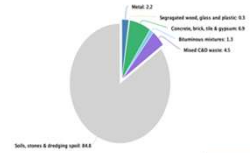
13

13

Circular Economy & Waste

- Most of the C&D waste collected in Ireland in 2019 was backfilled (82 %), while 10 per cent went for disposal and only 7% per cent was recycled. This reflects the large proportion of soil and stones in C&D waste.
- Recycling was the main treatment operation for metals (100%) and waste bituminous mixtures (64%).
- It is notable that only 39% of segregated wood, glass and plastic waste was recycled in 2019 while 54% went for energy recovery (incineration)

Figure 2. Composition of C&D waste material collected in Ireland, 2019



14

14

Circular Economy & Waste - Example

Plasterboard Recycling Service (PRS)



15

15

Circular Economy & Waste - Example
Expanded polystyrene (EPS)

Used for packaging and insulation
Offcuts and waste are shredded, then heated and compressed which into a solid mass, reduced to 10% of its' original size, for resale and re-use.
It is exported to manufacture insulation to Spain, Portugal and Germany.
12% of EPS currently recycled globally
Waste Matters (Ireland) Ltd
https://www.youtube.com/watch?v=zDfdya7iUVY&ab_channel=WasteMatters



Recycling system at (LOETB) National Construction Training Centre at Mount Lucas, Ireland

16

16

Lendager Group - Resource Rows Project
Oerestad, Copenhagen

The Resource Rows is using upcycled bricks and waste wood, a recycled concrete beam used as a bridge and old windows and waste wood as rooftop community gardens huts with an atmosphere of allotment gardens.

A significant and innovative concept is to reuse brick facades from abandoned structures in the new building, saving as much as 29% CO_2 by upcycling only 10% of all building materials.



Source: https://lendager.com/project/resource-rows/

17

17

Limerick 2020 - OPERA SQUARE
Limerick, Ireland

It's one of the country's biggest projects involving the recycling and reuse of construction rubble in which over 1,000 tonnes of stone, brick, cobblestone, old doorways and gates have been salvaged.
Sixteen old buildings, many of them Georgian, and of important historical significance, are being retained for use as living accommodation, but huge volumes of material which would otherwise go to landfill, are also being harvested for reuse in other building projects.
Further information and image source - https://limerick2030.ie/opera-site/



Source: https://www.rte.ie/news/regional/2022/0414/1292354-limerick-opera-recycling/

18

18

Digital Marketspace

Presentation

19

19

What is a Digital Marketspace

In simple terms, digital marketplaces connect multiple sellers with multiple buyers via an online platform. They exist across a wide range of operating models, including price comparison sites, affiliates, online auction platforms, lead generators, cashback sites, sales platforms and classifieds. Some marketplaces adopt multiple models to serve multiple needs.



Source: https://www.pwc.co.uk/industries/technology-media-and-telecommunications/insights/digital-marketplaces.html

20

20

Types of a Digital Marketspace

1. Business-to-consumer (B2C) marketplaces
2. Business-to-business (B2B) marketplaces
3. Peer-to-peer (P2P) or consumer-to-consumer (C2C) marketplaces
4. Consumer-to-manufacturer (C2M) or consumer-to-business (C2B) marketplaces
5. Service-to-consumer (S2C) marketplaces



Source: https://www.the-future-of-commerce.com/2021/05/12/digital-marketplaces/

21

21

Benefits of a Digital Marketspace

Easy to use. Online platforms are usually user friendly and human focused.

Access to a ready customer base. Supports connections with target audience and can remove barriers that may exist outside of these platforms.

Fulfillment, payment, and logistics. Payment and supply is easy and straightforward. It can also support buying local removing waiting times.

Innovation. Allows for new products, concepts or material used to be shared easily in one place with other professionals.

Marketing, analytics, and personalization. Easy to tailor your search or direct you towards a target audience from one place.

Global reach. Can allow for connections and sales to happen internationally where necessary, however, it is often better and more sustainable to purchase locally.

Source: https://www.the-future-of-commerce.com/2021/05/12/digital-marketplaces/

22

22

Examples of Digital Marketspaces in Construction

Digital marketplaces have a place in the construction industry going forward. They not only allow for easy access to expert knowledge and reusable and more sustainable materials they also help to guide consumers to local business and suppliers. The benefits of employing digital market spaces are similar to the benefits that can be seen in the second hand clothing market already such as reduced material loss and longer lifetimes of products. This can lead us to a more sustainable future and circular future for the construction industry.



Source: https://cobuilder.com/en/digitising-construction-data-classification-system-cmx-data-templates/

23

23

Ireland CMEx Project

The CMEx project is a pilot scheme to demonstrate a feasible, transparent, fair, user-friendly system for the reuse of construction materials that would otherwise enter the waste stream. The project will identify and track resources through the supply chain; identify the potential value of matching materials; and apply these insights to steer organisational processes towards supporting a circular economy. It will identify materials from the waste stream with the potential for diversion to reuse and develop mechanisms to enable reuse through an online platform that generates materials passports, facilitates material matches, and utilises blockchain technology to document transactions.



Source: https://www.igbc.ie/wp-content/uploads/2021/12/CMEx-One-page-Flyer.pdf

24

24

Excess Materials Exchange Platform

Excess Materials Exchange (EME) is a young and innovative technology company. On our digital matching platform, we find new high-value reuse options for materials or (waste) products for companies. Far too many valuable resources and materials are wasted or ill-designed in the current paradigm, for which the planet must pay a heavy price. Isn't that a waste?

EME is determined to accelerate the global transition to a circular economy – and play a part in creating a more viable planet. By showing the financial and ecological value of materials. By challenging companies to design and produce their goods in a more efficient and circular manner. And by making matches. A whole lot of matches.

Source: https://excessmaterialsexchange.com/en_us/

25

25

Excess Materials Exchange Platform

The digital platform unlocks the maximum potential of your company's materials, products and waste streams by matching them to their highest value uses. The best part about that? It's better for your profits as well as the planet. In our experience, material flows increase by 110% on average in financial value, and the ecological footprint reduces by 60% on average. Four tools are instrumental to our method of working:

1. Resources Passport
2. Tracking and Tracing
3. Valuation
4. Matchmaking

Source: https://excessmaterialsexchange.com/en_us/

26

26

Material Banks

Presentation

27

27

Material Banks

A material bank is essentially a stockpile or store of materials for future use.

In construction this can take the form of a building, this change in the way we think about a building can help us to view a building as something that can continue its life after the initial use is complete.

This can pair with Material Passports or Design for Disassembly for added value.



Source: https://www.youtube.com/watch?v=3EKddd_dAA0
Follow link to watch video

28

28

BAMB

In the Project BAMB – Buildings As Material Banks 15 partners from 7 European countries were working together with one mission – enabling a systemic shift in the building sector by creating circular solutions.

Today, building materials end up as waste when no longer needed, with effects like destroying ecosystems, increasing environmental costs, and creating risks of resource scarcity. To create a sustainable future, the building sector needs to move towards a circular economy.

Whether an industry goes circular or not depends on the value of the materials within it – worthless materials are waste, while valuable materials are recycled. Increased value equals less waste, and that is what BAMB is creating – ways to increase the values of building materials.

Source: https://excessmaterialsexchange.com/en_us/

29

29

BAMB

BAMB will enable a systemic shift where dynamically and flexibly designed buildings can be incorporated into a circular economy. Through design and circular value chains, materials in buildings sustain their value – in a sector producing less waste and using less virgin resources. Instead of being to-be waste, buildings will function as banks of valuable materials – slowing down the usage of resources to a rate that meets the capacity of the planet.

BAMB
BUILDINGS AS MATERIAL BANKS

Source: https://excessmaterialsexchange.com/en_us/

30

30

Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

31

31

Caixa Foundation - Madrid, Spain - Herzog & De Meuron

Situated in the heart of Madrid's cultural district, the Caixa Forum Museum vertical garden was designed and created by Patrick Blanc using his Le Mur Végétal system. The adjacent square is accessible to the public who can walk up, touch, and explore over 15,000 plantings on the hydroponic living wall. Nearly 300 different species were chosen by Patrick Blanc who had to keep in mind Madrid's very demanding seasons – very hot in the summer and cold in the winter.



Source:https://www.greenroofs.com/projects/caixa-forum-museum-vertical-garden/

32

32

Caixa Foundation - Madrid, Spain - Herzog & De Meuron

Taking into account all parts of the building here, what are some examples of reuse of waste that could have been utilised in the construction of this building.

Consider how the plants are attached, the materials used and the demolition of the building that may have stood here previously.



Source:https://www.esmadrid.com/en/tourist-information/caixaforum-vertical-garden

33

33

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

34

34

EXTRA READING/STUDY

Activity

35

35

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4Rjs5WDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

36

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

37

BUS GoCircular

Shaping a Circular Sustainable Future

Module 10

Deconstruction as an Element of a Building Life

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

Within this module trainees will see deconstruction as a continuation of a building's life cycle. They will delve into different elements within the deconstruction phase such as Pre-demolition surveys, Urban mining and Designing for deconstruction. They will see the value in deconstruction and relate this to MGRFIE.

2

Objectives/Learning Outcomes

- 14 – Extract and reuse parts from end-of-life roofs, façades, or interior elements for use in new buildings
- 18 – Collect products and materials for reuse or recycling in roofs, façades or interior elements from the construction industry
- 59 – Compile demolition specifications for multifunctional green roofs, façades, and interior elements and provide them at final commissioning of the building
- 77 - Conduct post occupancy survey and analysis for building with multifunctional green roof, façades, or interior element

3

Content

- Pre-demolition survey
- Circular Deconstruction
- Urban mining
- Application for Multi-functional Green Roofs Facades and Interior Elements

4

Pre-demolition survey

Presentation

5

Pre-demolition survey

When a building is to be demolished the (non-domestic) client (usually the property owner) has a duty to provide pre-demolition information to the designer and contractor. This will involve a pre-demolition investigation and survey.

Before any work commences, a full site investigation must be made by a competent person to determine the hazards and associated risks which may affect the demolition team and members of the community who may pass close to the demolition site.



Source:https://www.totaldemolition.co.uk/pre-demolition-survey/

6

The Purpose of Pre-demolition survey

The main purpose of a pre demolition survey is to -

- Map the services on site
- Determine if there are any hazardous materials on site
- Carry out a soil and foundations survey



Source-https://www.sumoservices.com/blog/2018/10/1/are-you-willing-to-hit-buried-utilities

7

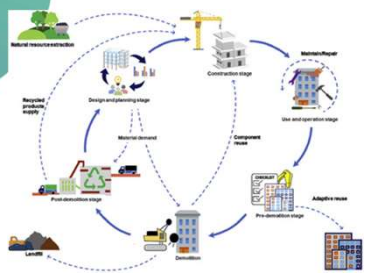
7

Pre-demolition survey for Circular Economy

Pre-Demolition surveys can be utilised for the circular economy by not only mapping out the the three areas identified above but also looking at the materials within the building. Fittings furniture and appliances are often removed prior to the demolition process, however, other materials such as concrete, timber and steel can all be reused within the construction sector.

8

8



Source:https://www.sciencedirect.com/science/article/abs/pii/S036013232200645X

9

9

Circular Deconstruction



10

10

Circular Deconstruction

Circular Demolition is is the demolition, dismantling, disassembly and removal of materials that are released becoming available again for high-value reuse in other projects. This makes circular demolition a vital link in the circular economy.

Source:https://www.metabolic.nl/publications/circular-demolition/

11

11

The Importance of Circular Demolition

Out of the 6,000,000 tons of materials released in the Netherlands in 2014 through demolition of residential and non-residential buildings, the majority was recycled (88%). However, this material is mostly reused in a low-value form, such as filling under buildings or in civil and hydraulic engineering projects. Only 0.2% was in fact reused at product-level. Low value recycling means that the value accrued during original manufacturing and assembly is lost, as shown graphically in the figure below.

Source:https://www.metabolic.nl/publications/circular-demolition/

12

12

Obstacles to Circular Demolition

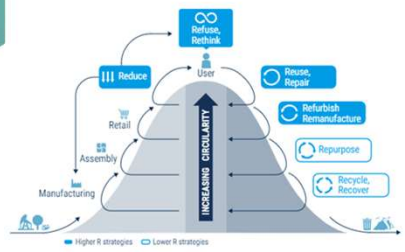
The use of secondary materials is still insufficient for a number of reasons. For example, the demand for secondary materials is still relatively limited, the price of circular building materials is often higher than their linear alternatives, the physical facilities for storage and reprocessing are not always adequate, and the quantity and quality of materials from demolition projects offered for reuse are still unsatisfactory.

In addition, there is still a lack of incentives or obligations for circular demolition, resulting in a market that has not yet fully embraced circular demolition. Take practical obstacles: there is no time devoted to planning for inventories and disassembly, and opportunities for repurposing materials are not yet clear enough for many demolition workers and builders. It is vital to promote the demand for secondary materials from demolition in order to combat these issues.

Source: https://www.metabolic.nl/publications/circular-demolition/

13

Figure 1: Adapted from 'Circle Economy - Master Circular Business with the Value Hill (2016).[3]



Source: https://www.metabolic.nl/publications/circular-demolition/

14

Circular Demolition Process in 5 Steps

- The timely signaling of demolition projects and making details about them available;
- Making an inventory of products and materials;
- Valuing and prioritizing inventoried products and materials
- Offering and repurposing
- Disassembly of the products and materials

Source: https://www.metabolic.nl/publications/circular-demolition/

15

Urban mining

Presentation

16

What does urban mining mean?

Urban mining is the process of reclaiming raw materials from waste products sent to landfill. On a conceptual level, it looks towards the waste generated by cities and urban environments as a valuable resource, using anthropogenic stocks rather than geological to meet the demands of manufacturing.

Source: https://www.rts.com/blog/what-is-urban-mining/#:~:text=Urban%20mining%20is%20the%20process,meet%20the%20demands%20of%20manufacturing.

17

What does urban mining mean?

It commonly refers to the recovery of metals from e-waste but has been used more generally for the recovery and monetization of any materials from any waste stream, including:

- **Construction and Demolition Waste**: the recovery of wood, paper, card, rubber, metals, and more.
- **Municipal Solid Waste**: General recovery which could include everything from redirecting metals and plastics to commercial composting for resale.
- **Tires**: Specifically, the recovery of rubber and metal from tires and other rubber products.

Source: https://www.rts.com/blog/what-is-urban-mining/#:~:text=Urban%20mining%20is%20the%20process,meet%20the%20demands%20of%20manufacturing.

18



Source: https://www.holcim.com/who-we-are/our-stories/what-is-urban-mining

19

19

Why is Urban Mining Useful

1. The age of cheap, abundant raw materials is over
2. Raw material recuperation from e-waste can be done increasingly cost-efficiently
3. In cities all over the world there are still millions of appliances waiting to be recovered
4. For some rare metals, urban mining is gradually becoming the *only* source
5. Urban mining avoids a substantial amount of pernicious effects on human beings and the environment
6. Classic mining alone cannot meet the rising demand for electrical and electronic appliances
7. The business community *and* investors are jumping on board the urban mining train

Source: https://www.recupel.be/en/blog/7-reasons-why-urban-mining-is-overtaking-classical-mining/

20

20

Application for Multi-functional Green Roofs Facades and Interior Elements

Presentation

21

21

Walk the Line - The Scarcity and Creativity Studio - Ritoque, Chile

This project is located in Ritoque, Chile, in the site of the Open City, run by the Corporación Amereida and the School of Architecture and Design of the Catholic University of Valparaiso, which for fifty years has been constructing a town which now houses many of the school's staff and contains a church, cemetery and many public spaces and facilities. Walk the Line departed from a study of Le Corbusier's 'house for an artisan' and consists of a small room in which to sleep and work and an elevated gangway for observation of the Pacific ocean and the nearby nature reserve.



Source: https://www.archdaily.com/779712/walk-the-line-the-scarcity-and-creativity-by-studio

Source: http://scs.aho.no/walk%20the%20line.htm

22

22

The Opportunity

The reason I selected this building as the example for deconstruction is due to the fact that this building would be relatively easy to identify in terms of what can be saved and reused from this building.

Take a few minutes to note down what can be reused and repurposed from this project.



Source: http://scs.aho.no/walk%20the%20line.htm

23

23

QUIZ/ASSIGNMENT/ACTIVITY

Assessment / Exam

24

24

EXTRA READING/STUDY

Activity

25

25

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4RjsSWDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

26

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

27

BUS GoCircular

Shaping a Circular Sustainable Future

Module 11

Circular Economy Across the Value Chain

Circular Economy in the Construction Industry

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

1

Summery

The trainee should gain an understanding of what is available to them in order to implement circular practices into both their company and their community. This should include Communication, Knowledge sharing, Integration, implementation, national and European guidelines. This module should also highlight the importance of each of these topics in MGRFIE

2

Objectives/Learning Outcomes

- 32 - Facilitate discussions and meetings between internal team members to identify circular opportunities multifunctional roofs and façades
- 33 - Integrate circular economy thinking into employee evaluations that are linked to professional compensation
- 34 - Collaborate to apply and improve circular procurement processes of multifunctional green roofs, façades, and interior elements
- 35 - Collaborate with industry stakeholders to share best practices in circular multifunctional roofs and façades, and act together
- 37 - Work together with residents and users to jointly create multifunctional green roofs, façades, and interior elements fit for them

3

3

Objectives/Learning Outcomes

- 38 - Engage in discussions with construction customers to raise awareness of the circular economy and explore circular opportunities for multifunctional green roofs, façades, and interior elements together
- 39 - Engage in discussions with government bodies and policy makers to push for regulations that support the application of circular multifunctional green roofs, façades, and interior elements
- 40 - Participate in government programs that support and advance circular multifunctional green roofs, façades, and interior elements
- 41 - Work together with the (local) community and engaging them in the company operations

4

4

Objectives/Learning Outcomes

- 49 - Incorporate circular strategies, archetypal circular interventions and case studies into educational programs (in the construction value chain)
- 50 - Provide internal training about navigating in the value chain for circular multifunctional green roofs, façades, and interior elements
- 51 - Solidify definitions of circular construction by being consistent and using circularity frameworks
- 52 - Conduct research about circular construction strategies applied to multifunctional green roofs, façades, and interior elements
- 53 - Follow developments in the field of environmental costing models and CO_2 taxes

5

5

Objectives/Learning Outcomes

- 55 - Raise awareness about recycled construction materials and reconstructed buildings
- 71 - Explain the benefits of green and/or multifunctional green roofs, façades, and interior elements in different contexts and situations (e.g. public/private, to building users, industry, or local community)
- 80 - Redefine building regulations to incentivise circular approaches to multifunctional green roofs, façades, and interior elements
- 81 - Comply design of multifunctional green roofs, façades, and interior elements with applicable (national/local/EU) legal requirements
- 82 - Organise and provide insurance and guarantees for reused materials to buyers

6

6

Content

- Collaboration and Knowledge sharing
- Integration and implementation of Circular Economy in the workplace
- Regulation and Definition
- Multi-functional Green Roofs Facades and Exterior Elements

7

7

Collaboration and Knowledge sharing



8

8

Collaboration and Knowledge sharing

At its core, "collaboration in construction" simply means that teams are working together towards one project goal. Everyone can access the main plans and goals of a project at any time, without having to rely on gatekeepers or slog to faraway offices in order to get the information they need.

When collaboration is strong, team members pool their resources and knowledge and prioritize meeting shared goals dictated by the timeline and budget of the entire process rather than their own goals. This, of course, is the ideal way to conduct projects.

Source: https://constructionblog.autodesk.com/collaboration-construction/#:~:text=At%20its%20core%2C%20%E2%80%9Ccollaboration%20in,get%20the%20information%20they%20need.

9

9

Key Takeaways

- Collaboration in construction requires teams to work together toward a common goal.
- With collaborative construction, all stakeholders can access the main goals and plans at any time.
- Around 43% of the highest trust construction firms place collaboration as a central goal when working on a project.
- Collaboration can have challenges such as trouble with growing pains when getting used to a new system, changing job site and workplace culture, and the potential for higher upfront costs.
- The benefits of collaboration may include fewer changes and rework, a higher likelihood of an on-time delivery, higher profits, fewer wasted materials, and other important positives.

Source: https://constructionblog.autodesk.com/collaboration-construction/#:~:text=At%20its%20core%2C%20%E2%80%9Ccollaboration%20in,get%20the%20information%20they%20need.

10

10

Key Takeaways

- Successful collaboration in construction builds trust, is seamless, is inclusive, defines clear roles and responsibilities, and prioritizes high-quality communication.
- Emphasizing collaborative communication between the key players in the design and preconstruction phases of a project has a positive impact on long-term results.
- Developing a more collaborative culture is possible by changing project delivery methods, starting with collaboration with the original contract, embracing diversity, using collaboration tools, encouraging accountability, and focusing on human interaction.
- Trust and collaboration go hand-in-hand. High-trust firms are half as likely to have problems linked to slow data exchanges and twice as confident about meeting their budgets and project schedules.

Source: https://constructionblog.autodesk.com/collaboration-construction/#:~:text=At%20its%20core%2C%20%E2%80%9Ccollaboration%20in,get%20the%20information%20they%20need.

11

11

Collaboration and Knowledge sharing

https://drive.google.com/file/d/1XKTqhfOypYgGWAl0tnMHiNGacsAYEKX1/view

Importance of networking

12

12

Integration and Implementation of Circular Economy in the Workplace

Presentation

13

13

How to Implement Circular Economy

To implement circular economy in the construction industry the gaps existing within your company must be mapped and education and upskilling must then follow in order to implement this.

It is not necessary for the every person to be an expert in every element of the circular economy, however, it is vital that every team has an expert on each element of the circular economy.



Source: https://www.circle-economy.com/circular-economy/key-elements

14

14

Useful Tools

Circularity Academy

"CAMY"
Closing the green skills gap* is crucial to enable a circular economy. Our gamified e-learning platform boosts mass adoption of these skills.
*Linkedin's Green Skills Gap report

Ganbatte powered by CIRCLE ECONOMY

15

15

What is Circularity Academy?
Left and right menu

For playing Tracks
From the left menu on the left you can find all features for the players:
Account
change e-mail and other account settings
Tracks
Tracks are series of Games. Unless it is an open track, all tracks are invite only. As a player you'll receive an invite from a Change Agent.
Games
Games are the central entity on the platform. They can be part of a track or can be played standalone. You can be invited for Teamplay sessions by Quizmasters.



There are 4 roles on the platform
Players (a.k.a. learners)
Play games and tracks, can be certified after finishing tracks
Quizmasters (a.k.a. Game Guides)
Can guide the games in Teamplay modus. It works like Kahoot or Mentimeter. You generate a teamplay with a QR code which the players can scan. Now you can play the games as a group and discuss the outcomes
Change Agents (a.k.a. Educators)
Can setup and guide tracks, which are more in depth learning experiences distributed over several learning session. With the data dashboards you can measure progress over time
Company Managers (a.k.a. Mission Manager)
The Company Manager has all rights + the overview of progress on the entire cohort of organisation. It can boost progress by notifying other roles to take action.

16

16

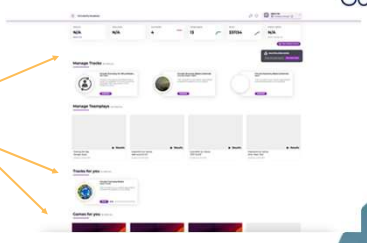
What is Circularity Academy?
Dashboard based on role

Dashboard

The dashboard is the landingpage of the academy once you are logged in.

Depending on your role (player, quizmaster, change agent or company manager) you will have a **different dashboard.**

As any role can also **just play** games and tracks, you will always find games and track for you on the bottom or in the left menu.



17

17

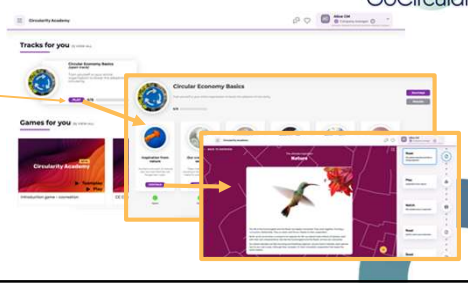
What is Circularity Academy?
Playing games and tracks

Showcase a track (player perspective)

Scroll down to Tracks for you or click on play tracks in the left menu.

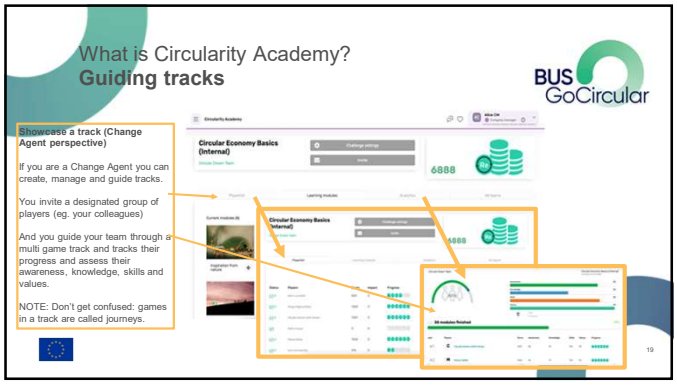
Now click play and the track will open and shows the games in the track.

NOTE: Don't get confused: games in a track are called journeys.



18

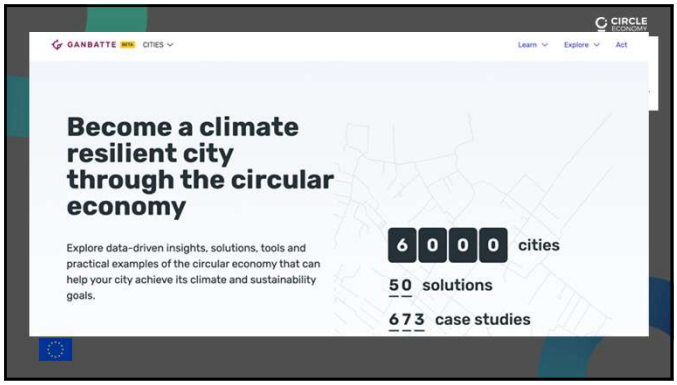
18



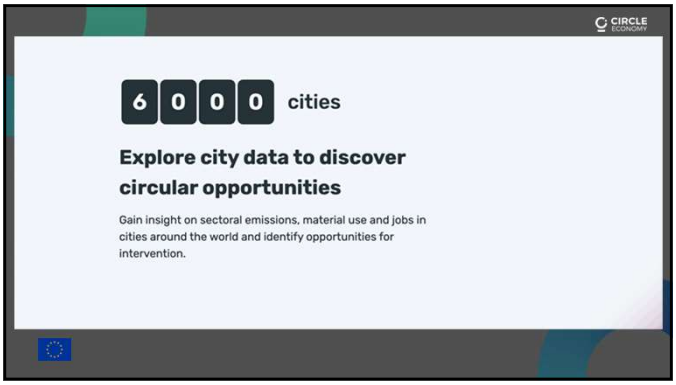
19



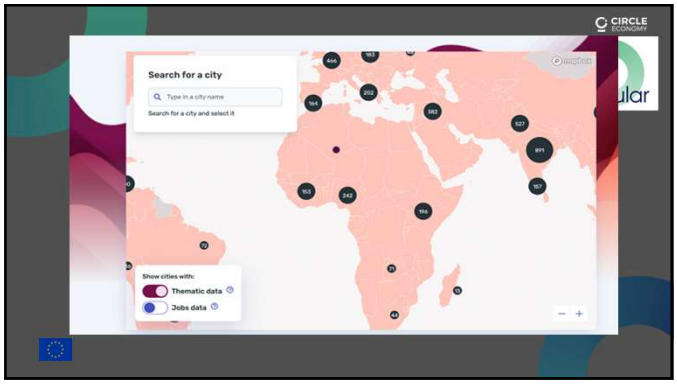
20



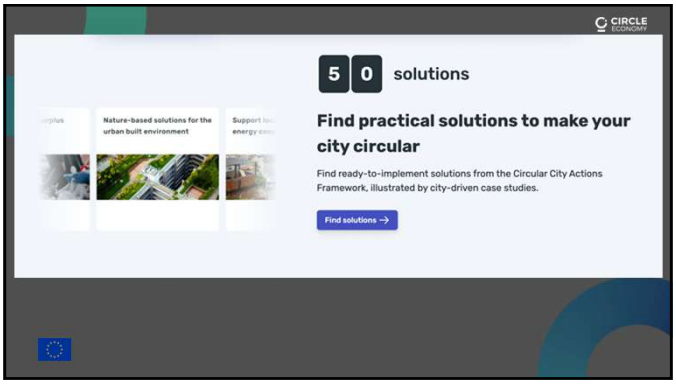
21



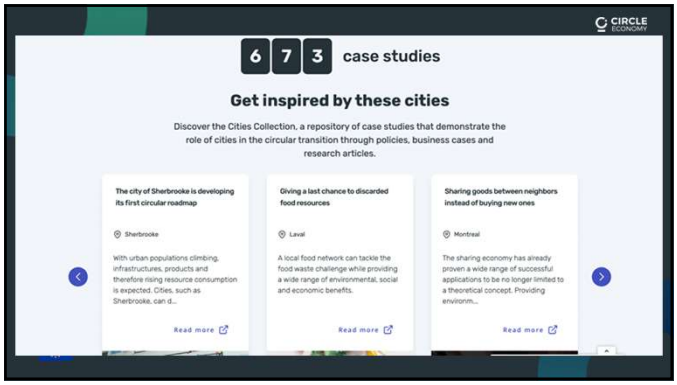
22



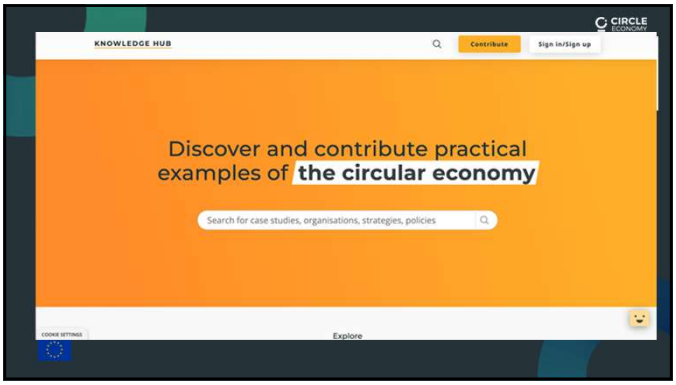
23



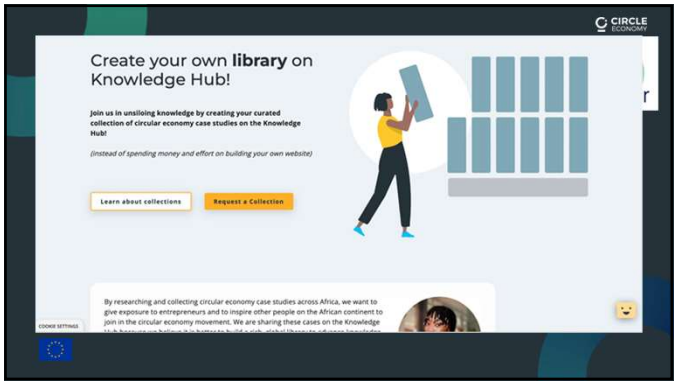
24



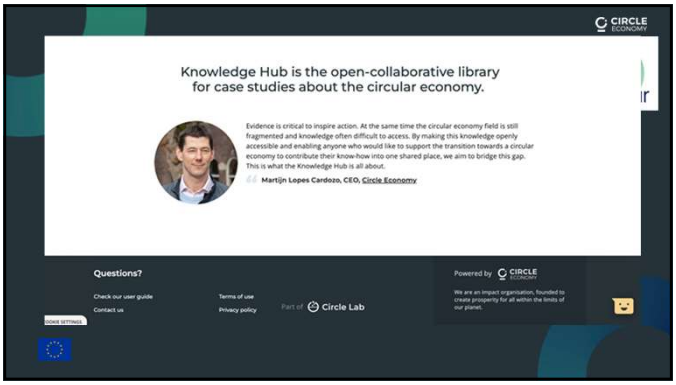
25



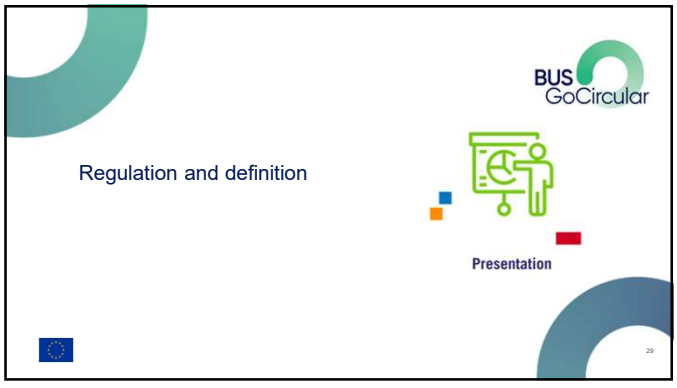
26



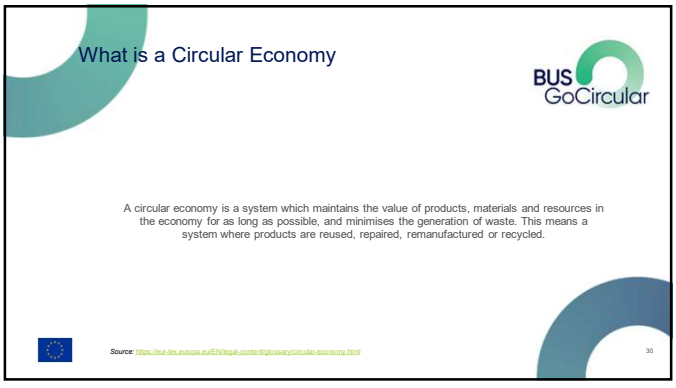
27



28



29



30

Value & Governance Video

https://drive.google.com/file/d/1keRvTmdEZRRvOA-m8hb2jlQaj7psD2P5/view

31

31

Current Guidance Document Examples

The EU Green Deal - Circular economy action plan

https://environment.ec.europa.eu/strategy/circular-economy-action-plan_en

Public Procurement for a Circular Economy

https://ec.europa.eu/environment/gpp/pdf/Public_procurement_circular_economy_brochure.pdf

Circular Economy for the built environment: a summary

https://drive.google.com/file/d/1miNS6IYTeFNteZoil_vC0e8XtjGXwKDH/view

Roadmap Circular Land Tendering

https://www.metabolic.nl/wp-content/uploads/2019/02/roadmap_circular_land_tendering.pdf

Circular Economy Checklist Construction Designers

https://southernwasteregion.ie/sites/default/files/Circular%20Economy%20Checklist%20Construction%20Designers.pdf

32

32

Current Guidance Document Examples

LEVEL(S): A GUIDE TO EUROPE'S NEW REPORTING FRAMEWORK FOR SUSTAINABLE BUILDINGS

https://ec.europa.eu/environment/eussd/pdf/Level_publication_EN.pdf

EU Taxonomy

https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/eu-taxonomy-sustainable-activities_en

A Holistic Sustainability Framework for Waste Management in European Cities: Concept Development

https://drive.google.com/file/d/1Q9eluKr4bI8YWLByPuAoq5Kh3nMRsfv_/view

33

33

Overview of Policies for Circular Economy Video

https://drive.google.com/file/d/15BeaLUm-U15OonovpzPlF17s7NhOHOyB/view

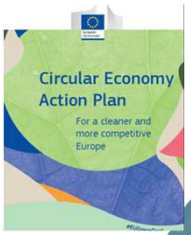
34

34

EU Green Deal

The Green Deal is a roadmap for achieving a sustainable, carbon-neutral, competitive and resource-efficient economy. Its objectives are:

- reduce net greenhouse gas emissions to zero by 2050
- Disconnecting idea of economic growth from resource consumption by promoting the circular economy
- improve the quality of life of all
- restore biodiversity and reduce pollution.



35

35

EU Green Deal- Action Plan for the Circular Economy

An initiative of the Green Deal Aims to modernise the European economy through a green and digital transformation

The Plan proposes measures to achieve:

1. That the products marketed in the European Union are sustainable
2. That consumers receive information on the durability and repairability of the products they purchase
3. Avoiding the production of waste, and converting the waste produced into secondary raw materials.

36

36

Irish Examples

Waste Action Plan for a Circular Economy

https://www.gov.ie/en/publication/4221c-waste-action-plan-for-a-circular-economy/

Circular Economy and Miscellaneous Provisions Act 2022

https://www.oireachtas.ie/en/bills/bill/2022/35/

Whole of Government Circular Economy Strategy 2022 – 2023 'Living More, Using Less'

https://www.gov.ie/en/publication/b542d-whole-of-government-circular-economy-strategy-2022-2023-living-more-using-less/

37

37

Circular Economy in Ireland

On the measure of circularity, Ireland currently lags behind its EU peers.

- In 2019, Ireland's circular material use rate (material recovered and fed back into the economy -saving extraction of primary raw materials) was the second worst in the EU according to Eurostat figures.
- Ireland's rate was 1.6%, compared to an EU average of 11.9%. The best performing EU Member State, the Netherlands, achieved a rate of 28.5%.
- Countries which have been most successful in moving towards circularity appear to benefit from having overarching national circular economy policies



38

38

Ireland: Circular Economy and Miscellaneous Provisions Act 2022

- Shifts Ireland away from a "take-make-waste" economy
- Incentivises the use of recycled and reusable alternatives to wasteful, single-use disposable packaging
- Moves Ireland closer to being among the first in the world to eliminate disposable drinks cups
- Tackles illegal fly-tipping and littering
- Signed into Law in July 2022



39

39

Multi-functional Green Roofs Facades and Exterior Elements



40

40

Multi-functional Green Roofs Facades and Exterior Elements

Green & Blue Roof Guide 2021

https://www.dublincity.ie/sites/default/files/2021-12/dcc-green-blue-roof-guide-2021.pdf

Green Roofs Guidance Document

https://www.dlrcoco.ie/sites/default/files/atoms/files/appendix16.pdf

A guide to GREEN roofs, walls and facades

https://202020vision.com.au/media/41918/growing_green_guide_ebook_130214.pdf

41

41

QUIZ/ASSIGNMENT/ACTIVITY



42

42

EXTRA READING/STUDY

Activity

43

43

https://busgocircular.eu/

Follow us

https://twitter.com/BusGoCircular

https://www.linkedin.com/company/busgocircular

https://www.youtube.com/channel/UCXu4RjsSWDXBE-yqda5kt5A

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

44

Colophon

Copyright © 2021 by BUSGoCircular consortium

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

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

Partners

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101033740

45