Construction and Demolition Waste Management

understanding the phenomenon with a case study in Turin

Tesi di Laurea Magistrale

A.CAN AKTOLUĞ

MASTER OF SCIENCE IN ARCHITECTURE FOR THE SUSTAINABILITY DESIGN

Corso di Laurea Magistrale in Architettura per il Progetto Sostenibile

A.a. 2021/2022

Sessione di June 2022

Construction and Demolition Waste Management

understanding the phenomenon with a case study in Turin

Candidate: A.Can Aktoluğ

Supervisor: Riccardo Pollo

Co-Supervisor: Matteo Trane

Vorrei sfruttare questa opportunità per esprimere la mia gratitudine a tutti coloro che mi hanno assistito e supportato durante questa esperienza.
Sono grato alla mia famiglia e ai miei amici per aver creduto in me.

Al mio bisnonno...

Un ringraziamento speciale ai miei nonni; Esin e Ferdin Hoyi e mio zio Dr. Kaan Aktoluğ.

I would like to use this opportunity to express my gratitude to everyone who have assisted and supported me during this experience.
I am grateful to my family and friends for trusting in me.

To my great grandfather...

Special thanks to my grandparents; Esin&Ferdin Hoyi and my uncle Dr. Kaan Aktoluğ.

GLOSSARY of waste mangement terms

A glossary of terms and definitions often used in the waste management sector.

Aerobic Composting

Composting biological wastes is done with oxygen-requiring bacteria. This biological waste must be exposed to the elements.

Agricultural Waste

Organic by-products from a variety of sources, including fruits, vegetables, livestock, and poultry. It's available in both solid and liquid forms.

Air Pollution

Air pollutants that are harmful to humans, animals, and/or plants are present in the atmosphere. It may also cause property damage.

Anaerobic digestion

Anaerobic composting, unlike aerobic composting, does not require oxygen. During the fermentation process, methane is created.

Backfilling

Any reclamation activity in which acceptable trash is used for reclamation in excavated areas or for engineering purposes in landscaping or building instead of nonwaste resources that would have been used otherwise.[1]

Basel Convention

Over 100 nations have signed an international agreement on the control of transboundary movements of hazardous wastes and their disposal, which was drafted in March 1989 in Basel, Switzerland.

Biodegradable material

When microorganisms break down organic materials into simpler compounds, biodegradable materials are created. Some of the most common household examples are: food waste, paper, clothing and towels.

[1] 0 COM(2015) 595 final, Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC
on waste, Article 3(f), http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098

Bulky waste

Household items such as ovens and refrigerators, as well as unwanted furniture and other large waste that can't be handled by the unregulated Municipal Solid Waste (MSW).

Chemical Waste

Hazardous garbage that contains or is made up of toxic chemicals. Chemical waste is not collected by most waste disposal firms in the UK for safety reasons.

Clinical waste

Healthcare facilities, such as laboratories and hospitals, are the most common sources of medical waste. Clinical trash does not belong in the "general waste" category.

Collection

Residential and/or business waste is placed onto a specialized van, which delivers it to a nearby disposal facility.

Co-disposal

Different forms of rubbish are disposed of in one section of a landfill or dump. Sewage sludges, for example, can be disposed of with other solid wastes.

Commercial Waste

Materials from factories, markets, restaurants, pubs, offices, warehouses, hotels and other wholesale or retail establishments.

Compost

Compostable materials are those that are created as a result of the composting process. It's called humus, and it's commonly used as a fertilizer.

Composting

The natural decomposition of organic elements such as food waste and grass into compost or humus, a soil improvement.

Cogeneration

Production of both electricity and steam from the same fuel source in a plant.

GLOSSARY

Construction and demolition debris
Cement, concrete, debris, lumber, and steel are examples of waste generated during building and deconstruction.

Co-processing
The phrase used when alternative fuels and raw materials are introduced into a typical manufacturing process instead of conventional fuels and raw materials.

Controlled dump
A planned dump that includes some of the characteristics of a sanitary landfill: Grading, compaction in some circumstances, leachate control, partial gas management, regular (but usually daily) cover, access control, basic record-keeping, and controlled garbage picking are all things to consider when it comes to hydrogeological compatibility.

Curbside Collection
A household garbage collection service is sometimes known as kerbside collection. Garbage containers and residential rubbish are collected using special vehicles.

Debris
Waste strewn about with the intention of being disposed of. It is made up of solid materials that are usually greater than 62mm in diameter.

Disposal
The waste removal staff collects and transports rubbish to the nearest landfill or dump.

Drop-off center
A location or facility where trash generators can drop off compostables and recyclables.

Duty of care
For health and safety reasons, anyone who generates, stores, transports, or disposes of residential and/or commercial garbage must treat the public with regard and respect.

Electronic waste
E-waste refers to electronic gadgets such as computers, televisions, microwaves, and other electrical appliances that have been abandoned. Garbage Electrical and Electronic Equipment is another name for this type of waste. (WEEE)

Emissions
Gases released into the atmosphere.

Energy recovery
The process of collecting useable energy from garbage, usually by using the heat generated by incineration or landfill methane gas.

Environmental impact assessment (EIA)
An assessment aimed at determining and forecasting the impact of a policy or project on the environment, human health, and well-being. Risk assessment, as well as economic and land use assessments, are all possible components.

Environmental risk assessment (EnRA)
A study of the interactions between agents, humans, and natural resources Typically examining the possibilities and magnitudes of harm that could be caused by environmental toxins, it is made up of human health risk assessment and ecological risk assessment.

Extremely Hazardous Waste
A hazardous waste that can cause major injury or even death to humans and pets. It could also be damaging to the environment.

Final recycling process
When no further mechanical sorting is required, waste materials enter a production process and are effectively reprocessed into products, materials, or substances, the recycling process begins.

Fly-tipping
Illegal trash disposal on land that has not been certified to store and/or accept it.

Food Waste
This is leftover food from both home and commercial kitchens. Fruit and vegetable peelings, meat scraps, and wasted meals are the most typical sources of food waste.

Fungus (Fungi)
Yeast, mushrooms, toadstools, and mould are examples of syncytial, unicellular, or multicellular microbes that feed on organic matter. Some of the spores produced by these organisms are pathogens, while the rest are stabilized sewage digesting composted trash.

GLOSSARY

Garbage

Garbage is a colloquial term for waste, garbage, junk, and trash. They're undesired items that must be discarded.

Hazardous Waste

A potentially hazardous and dangerous sort of waste that is hazardous to both humans and the environment. When it's disposed of, extra caution should be exercised.

House Clearence

A form of domestic service that (usually) involves a portion of the house. When many items (typically bulky) need to be removed from the house, basement, shed, or garage, people turn to a house clearance service.

Household hazardous waste

A hazardous waste present in most homes. It contains paint as well as abrasive cleaning agents.

Humus

This is the end product of the composting process, often known as compost. Soil microbes break down leaves and other organic elements into humus.

Inert waste

Indicates waste that has not been subjected to major physical, chemical, or biological modifications (for ex. concrete, bricks, masonry, tiles). Inert trash will not dissolve, burn, or otherwise react physically or chemically, biodegrade, or have a detrimental effect on other matter with which it comes into contact in a way that will pollute the environment or harm human health.

Incineration

Industries utilize this approach to break down trash and disperse it into the environment via ash, water, and air.

Industrial Water Waste Treatment

The procedures for dealing with tainted water. When the project is finished, the water can be reused and released back into the environment.

Inorganic waste

Sand, dust, glass, and a variety of synthetics are examples of waste that are not formed of plant or animal matter.

Integrated Waste Management

The word refers to the application of numerous strategies in tandem to effectively and properly manage municipal solid waste.

Landfill

A typical location for garbage and trash disposal. Excavated pits are used to bury waste, which are normally filled with soil or a particular cloth cover. This procedure is thought to be environmentally friendly.

Landfill gases

Methane, carbon dioxide, and hydrogen sulfide are the main gases produced by the breakdown of organic wastes. Landfills may have explosions as a result of these gases.

Litter

Any type of misplaced rubbish left in an inconvenient open or public location.

Materials recovery facility (MRF)

A specific facility for automatically or manually separating recyclable materials. Glass, plastic, paper, and metal waste are separated into several categories.

Mixed waste

A collection of waste materials that have been discarded in the trash.

Municipal solid waste (MSW)

Except for industrial and agricultural trash, all solid waste created in a certain area. Construction and demolition debris, as well as other special wastes, may occasionally enter the municipal trash stream. Hazardous wastes are generally excluded, except to the extent that they enter the municipal waste stream. Occasionally, the term is used to refer to all solid wastes for which a city government accepts responsibility in some form.

Municipal solid waste management

The design, development, and implementation of systems to handle municipal solid waste is known as MSWM.

Open dump

An unplanned "landfill" with few, if any, of the features of a managed landfill. Typically, there is no leachate control, no access control, no cover, no management, and a large number of waste pickers.

GLOSSARY

Organic waste
Paper, plastics, wood, food wastes, and yard wastes are all examples of carbon-containing trash. In MSWM practice, the word is frequently used in a more limited sense to refer to material that is derived more directly from plant or animal sources and can be digested by microbes.

Pollution
The release of waste or other undesirable items into the soil, water, or atmosphere, resulting in contamination of the soil, water, or atmosphere.

Processing
Using techniques such as baling, magnetic separation, crushing, and shredding, MSW materials are prepared for future use or management. Separation of recyclables from mixed MSW is another word for the same thing.

Recyclables
Products or items that can be reprocessed to make new products. Paper, aluminum, glass, and plastic containers are the most frequent recyclable materials.

Recycled content
The percentage of a product manufactured from recycled materials.

Recycling
Reprocessing of previously used materials into new products in order to reduce raw material consumption. Its goal is to reduce resource waste, reduce air and water pollution, and reduce greenhouse gas emissions.

Recovery
denotes any process in the plant or in the larger economy that results in waste serving a beneficial use by replacing other materials that would otherwise have been used to fulfill a certain function, or waste being prepared to fulfill that function.

Refuse
Garbage accumulated in homes, retail stores, and offices. It consists of discarded food, paper, and green garbage.

Refuse-derived fuel (RDF)
MSW that has been processed is used to make fuel. Separation of recyclables and non-combustible materials, shredding, size reduction, and pelletizing are all examples of processing.

Renovation
Work that involves the structural alteration of buildings, the considerable replacement of main services or finishes, and/or the substantial changed use of floor space, as well as connected redecorating and repair works on the one hand and related new building on the other. Renovation encompasses all work done on existing structures and is divided into four categories: renovation, rehabilitation, restoration, and remodelling. Residential, historical, and commercial structures owned and maintained by private/public companies or authorities are all treated from an international perspective.

Reuse
Unlike recycling where the waste is broke down into raw materials, reusing is a process in which products that are not categorized as waste are used again for their initial purpose.

Rubbish
Waste, trash, or litter

Sanitary landfill
An engineering technique of disposing of solid waste on land that meets most of the conventional standards, such as adequate siting, thorough site preparation, proper leachate and gas management and monitoring, compaction, daily and final cover, complete access control, and record-keeping.

Scavenging
Is the process of identifying useable materials following demolition, with a focus on re-usable and recyclable resources in this case.

Scrubber
In an incinerator, an emission control device is utilized to control acid gases as well as remove some heavy metals.

Secondary material
A post-consumer waste-derived material that can be used in place of a primary material in the production of a product.

Secure landfill
A waste disposal facility that is designed to keep wastes out of the environment indefinitely. This involves burying the wastes in a landfill with clay and/or synthetic liners, liquid collection, gas collection (if gas is produced), and an impermeable cover.

GLOSSARY

Selective demolition
Entails timing demolition actions so that building components can be separated and sorted.

Separated collection
Collection in which waste streams are separated by kind and nature in order to enable treatment.

Sewage sludge
A semi-liquid residue found at the bottom of canals and pipes conveying sewage or industrial wastewaters, as well as the bottom of effluent treatment tanks.

Site remediation
Removing polluted solids or liquids from a contaminated site or treating them on-site

Solid Waste
Garbage from homes, restaurants, and shopping malls accumulated

Stockpiling location
Is a platform for transportable trash storage.

Stripping
The process of removing precious components from a construction site, installation, or building prior to demolition.

Special wastes
Wastes that are ideally kept out of the MSW stream, but which occasionally find their way in and must be dealt with by local governments. Household hazardous waste, medical waste, building and demolition debris, war and earthquake debris, tires, lubricants, wet batteries, sewage sludge, human waste, slaughterhouse waste, and industrial trash are all examples of these.

Sustainability
Meeting the requirements of the current generation without compromising future generations' ability to meet their own.

Virgin materials
Materials such as wood and metal that are taken from the environment in their natural, unprocessed state.

Waste collector
A person hired by a commercial corporation or a municipal government to remove rubbish from homes, businesses, and containers.

Waste holder
The waste creator or the person in possession of the waste, whether natural or legal.

Waste management plan
Establishes the demolition strategy, as well as the handling and logistics of the materials discovered during the pre-demolition audit.

Waste management hierarchy
A ranking of waste management operations based on the environmental or energy advantages they provide The waste management hierarchy was created with the goal of making waste management procedures as ecologically friendly as feasible.

Waste producer
Any natural or legal person whose activities generate waste (original waste producer) or anyone who performs pre-processing, mixing, or other procedures on this waste that alters its nature or composition.

Waste reduction
All methods of minimizing the amount of waste produced at the outset and collected by solid waste authority. This includes everything from law and product design to community-based initiatives aimed at keeping recyclables and compostables out of the final waste stream.

GLOSSARY

Waste stream

The entire waste flow from residential or industrial locations to final disposal.

Waste-to-energy (WTE) plant

A facility that generates electricity from solid waste products (processed or unprocessed). Incinerators that create steam for district heating or industrial usage, as well as facilities that convert landfill gas to power, are examples of WTE plants.

Wetland

For at least portion of the year, an area that is regularly wet or flooded and has a water table that is at or above the land surface.

Zero Waste

A philosophy that promotes resource life cycle redesign so that all products can be reused.

The following sources are primarily referenced in this glossary:

- Ahmed, R., A. van de Klundert, and 1. Lardinois. Rubber Waste, Urban Solid Waste Series, Vol. 3. Amsterdam and Gouda: Tool, Transfer of Technology for Development and WASTE Consultants, 1996.

- Beede, David N., and David E. Bloom, "The Economics of Municipal Solid Waste." The World Bank Research Observer, Vol. 10, No. 2, August, 1995, pp. 113-150.

- Kreith, Frank, ed. Handbook of Solid Waste Management. New York: McGraw-Hill, 1994.

- Tchobanoglous George, Hilary Theisen, and Samuel Vigil. Integrated Solid Waste Management. Engi-neering Principles and Management Issues. New York: McGraw-Hill, 1993.

- UNEP-IETC, International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management. Technical Publication Series no. 6. Osaka/Shiga: UNEP International Environmental Technology Centre, 1996 (pp. 421-427)

- United States, Government of, Environmental Protection Agency. Decision Makers Guide to Solid Waste Management. Washington: US Environmental Protection Agency, 1989.

- United States, Government of, Office of Technology Assessment (OTA). Facing America's Trash: What Next for Municipal Solid Waste? Washington: OTA, 1989.

- Directive 2008/98/EC on waste (Waste Framework Directive), Article 3(17), http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:32008L0098

- Recyclingportal.eu, Report: Waste transfer stations in different EU regions, 2009, http://www.recyclingportal.eu/artikel/22506.shtml

- Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, Article 2(e), http://eur-lex.europa.eu/legalcontent/EN/ALL/?uri=celex%3A31999L0031

- COM(2015) 595 final, Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC
on waste, Article 2(e), http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32008L0098

- Directive 2008/98/EC on waste (Waste Framework Directive), Article 3(13), http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:32008L0098

- ANSI accreditation, https://www.ansi.org/accreditation/faqs.aspx#2

- Regulation (EU) No 305/2011 CPR, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex-:32011R0305

- ISO, 1996, http://certifications.thomasnet.com/certifications/glossary/quality-certifications/iso/iso-14001-1996/

INDEX

INDEX

Abstract:

The first focus is to outline the context of "waste" on a global level: as a fact, there are minimal reports which analyze the concept of construction and demolition of waste. Governments and institutions research the issue, but questions have been raised regarding the research's reliability. The World Bank published the most updated global waste recycling data in 2020. At the most conservative estimate, 33 percent of the 2.01 billion tonnes of municipal solid waste produced annually throughout the world is not managed in an environmentally friendly manner. The average quantity of trash created worldwide daily is 0.74 kilograms; however, there is a wide range, ranging from 0.11 to 4.54 kilograms. Despite making up only 16 percent of the world's population, high-income countries create about 34 percent, or 683 million tonnes, of the waste generated worldwide. It is anticipated that worldwide garbage will increase to 3.40 billion tonnes by 2050, more than double the population growth. The generation of waste and income level are generally positively correlated. In contrast to low- and middle-income countries, which are anticipated to rise by roughly 40%, daily per capita trash creation in high-income countries is projected to increase by 19% by 2050. When income levels fluctuate incrementally, waste creation declines at the lowest and rises more quickly than at higher income levels. By 2050, it is anticipated that the overall amount of waste produced in low-income nations will have increased by more than three times. The Middle East and North Africa regions make the least amount of waste globally, at 6%, whereas East Asia and the Pacific account for 23% of global waste production. The fastest increasing regions, however, are Sub-Saharan Africa, South Asia, the Middle East, and North Africa, whereby in 2050, the total amount of garbage will be doubled. More than half of the waste in these areas is disposed of openly, and the trajectory of waste increase will have significant adverse effects on the environment, human health, and economic growth, necessitating immediate action. Regarding these pieces of information, the research has been conducted to understand the definition and management issues.

First, 6 case scenarios have been analyzed to understand the waste management practices in different regions and countries. Understanding the initial precautions municipalities took into account while considering the environmental aspects and health issues. During this step, policies, directives, and regulations have been researched and acknowledged based on the municipalities' data and trying to differentiate the total waste generation by category. On the other hand, these debris generations' climate issues and environmental impacts have been investigated. According to the World Bank, 1.6 billion tonnes of carbon dioxide (CO_2) equivalent greenhouse gas emissions, or 5% of world emissions, were produced through the treatment and disposal of solid waste in 2016.

Waste disposal in open dumps and landfills without landfill gas collecting equipment is the maximum negative effect. Nearly 50% of emissions come from food waste. If no changes are made in the sector, solid waste-related emissions will rise to 2.38 billion tonnes CO_2-equivalent year by 2050.

Furthermore, the initial layout of the main sub-topics has focused on Europe, Italy, Piedmont, and the Metropolitan City of Turin. The thesis investigates an area in Turin, which is a part of the northern area of Turin, the Regio Parco district near the Po river. The focused spot is Villaggio Rurale (Via bologna and Via Gottardo). This area is characterized by a widespread presence of public residential buildings with various types of settlement development. After examining the literature and experiences in the European context, the thesis research is divided into distinct methodological phases that are interconnected. The first step corresponds to the "scientific background," which studies literature as theoretical research on the thesis's chosen theme. The study uses a data-based perspective on treating waste, specifically construction and demolition waste management. Yet, to have an ideal view on this topic, it is crucial to understand the waste hierarchy and treatment practices correctly applied throughout the study. Another aim of this study is to show each milestone considered before and after construction. Understanding the importance and benefits of on and off-site waste management for multiple stakeholders; community, users, and especially the environmental aspects is essential. This study aimed to give a to-do list of the objectives that should be analyzed for the construction sector. Through the study, it was necessary to embark on the concept of reuse-recycle and recovery. These topics have been fundamental points in each decision-making process. Research findings are then presented, together with a final consideration and conclusion.

The study has been accumulated by reviewing the current urban structure in Villaggio Rurale. Materials used in those buildings have been analyzed to investigate the current waste production and future waste projection. The goal was to try all initial steps mentioned throughout the research and implement these acknowledgments by drawing, creating, and designing the given area. In the design process, the main goal was to filter the whole study by Waste Management on an urban scale and apply these concepts and precautions to the buildings on an urban scale. The perspective of scaling and reproducing the design solutions to the whole plot. The plot's demographic, topological, morphological, quantitative, and accessibility analysis has been made. The topic's perspective has been faced from a systemic perspective for waste management, prevention/reuse, and neighborhood self-sufficiency.

As a final step, four different case scenarios have been made in the plot regarding the roof structures of the plot's current buildings. Each one has a different perspective; 1st one focuses on preserving the existing roof and trying to renovate the roof structure with the old materials, combining it with the materials that could be recycled and reused as the roof structural element again. The 2nd scenario focuses on the total amount of C&D waste generation if the roof structure has been demolished and constructed similarly with new materials. Between these two scenarios, the total waste production, total reusable materials, and the total amount of recyclability ratio have been calculated. The third and the fourth case scenarios focus on changing the roof's current structure and adding new elements to understand the correlation between preserving and renewing a system. It has been seen that there is a significant conflict between these two actions in terms of c&d waste. As a result, there is no consistent correlation between developing and incorporating more features that will be advantageous in the short and long periods and leaving the roof structure precisely as it is. The fundamental issue with this equation is that the system must continually regenerate itself. It needs to be changing for its users while still having a good environmental impact. Therefore, adding solar panels to the roof, which is wholly advantageous in generating green energy and self-sufficiency, does not have a positive side impact when taking C&D waste into account.

Keywords: waste management, construction and demolition, waste treatment,
architectural refurbishment, sustainable consumption and production

INTRODUCTION

Writers note:

The world we live in is constantly evolving, changing in the way we want it to be, and it has been going on in this direction since the boosting effect of the industrial revolution. We want to improve the life standards we had to produce, eliminate, create, change, extract, and as a matter of fact, we are taking these steps; we are in a linear model of mass production, using and finally creating wastes.
Over the years, scientific data has clearly shown us that we are doing something wrong[1] , and if we don't take some precautions and change the way we live on this planet, the situation will be worse than ever. As humans, one of our crucial basic needs is sheltering ourselves from natural hazards and feeling secure. Unfortunately, as our population is growing, the needs for humanitarian shelter and settlements are dramatically increasing, so that we cannot provide enough solutions right away.

As mentioned by the European Commission[2], civil protection and humanitarian aid operations: «In 2019, conflict and violence triggered 8.5 million new displacements in 50 countries, whereas around 1,900 natural hazards provoked 24.9 million new displacements across 140 countries and territories the highest figure registered since 2012 and 3 times the number of displacements caused by conflict and violence.» (European Civil Protection and Humanitarian Aid Operations - B-1049 Brussels, Belgium.)

In the light of this information, it is clear that the provocative need for shelter and the right choices that we must make and take directives according to the situation that we have globally and trying to find the best solution correlated with the phenomenon of waste. Therefore, it is crucial to understand the relationship between shelter, the need for raw materials that we are using to provide these shelters, and the urge that we must keep our planet clean for future generations.

[1] United nations / Before The Next Disaster Strikes: The Humanitarian Impact Of Climate Change

[2] European Commission Humanitarian Aid & Civil Protection Report Brussels (2018). http://dgecho-partners-helpdesk.eu/partnership/start, 18.12.2018.

It's clear that we see improvements and innovations throughout solid waste management globally , but it seems that these changes won't make any difference if it's not spread globally. [1]

Waste management is a delicate issue to work upon, especially in the desperate need of humanitarian aid. Therefore, we need cities, municipalities, countries, stakeholders to take the proper directives and plan a waste management scenario for our shared future.

"What a waste 2.0: A global snapshot of solid waste management to 2050."
In 2016, the world generated 242 million tons of plastic waste- 12 percent of municipal solid waste. Plastic waste is choking our oceans, yet our consumption of plastics is only increasing. Cities and countries are rapidly developing without adequate systems in place to manage the changing waste composition of citizens."
"The world is on a trajectory where waste generation will drastically outpace population growth by more than double by 2050" (what a waste 2.0: A global snapshot of solid waste management to 2050.)

In this study, the availability and reliability of data have been the main obstacle according to this subject.

The World Bank's Social, Urban, Rural, and Resilience studies prepared and exploited the study.

The starting point of this study is directly linked with the waste phenomenon and its relationship with the construction industry. Therefore, this study can be summarized by the following questions:

Are there any borderlines between producing and wasting materials, resources?

How can we reduce construction and demolition wastes?

Is it possible to create a building with zero waste?

[1] The World bank_understanding poverty_solid waste management. September 23 2019. / What a Waste 2.0: A global snapshot of solid waste management to 2050.

practice example/**case study 1**

c&d waste management

The history of C&D waste recycling in the Netherlands

C&D waste recycling began in the Netherlands in the 1980s. The main driver was the problem of contaminated soil from landfills. The Netherlands established the Waste Hierarchy in response. Landfill bans and recycling targets were part of the new policy's implementation. All parties collaborated on a national plan for C&D waste, allocating duties and obligations to each. The establishment of quality assurance programs was a specific task for the recycling industry. Crushing harmless C&D trash into recycled aggregates was the first step in recycling. These were employed for various purposes, including what is today known as "backfilling." For many years, the primary operation has been crushing inert C&D waste. As landfilling of mixed C&D trash became illegal, new factories for sorting this waste were established. Wood, metals, polymers, and inerts are all recovered at these factories. The leftover fraction is used to make a secondary fuel in part.

Over time, the quality of recycled aggregates has improved. Quality control and processes are both enhanced. The Ministry of Transportation has prescribed recycled aggregates solely based on their superior technical properties for many years. Certification programs that include the standards of the Soil Quality Decree ensure that environmental quality is adequately assured. Recycled aggregates are increasingly being used in concrete manufacturing. Asphalt recycling has gone through a similar procedure. Almost all asphalt is recycled nowadays and used to make fresh asphalt.
Wood recycling is also standard, while biomass for power generation remains the most common choice (energy recovery).

Other materials have proven to be more challenging to recycle. These materials make up a smaller portion of C&D waste, and recycling them usually necessitates more effort. Other materials that are gradually being recycled include:

- Flat glass: The glass business has started a collection program for flat glass, and the glass can be transported to collection stations for free. PVC windows: PVC windows have a collection mechanism in place, and they can also be delivered for free to collection stations.

- Gypsum: A few years ago, the government and business reached an agreement to make the Netherlands a leader in gypsum recycling. Gypsum is maintained separate primarily to avoid affecting the quality of inert C&D waste recycling.

- PVC pipes: One recycler has devised a PVC pipe recycling technique. To meet the standards for usage in new PVC pipes, PVC is micronized.

- Roofing supplies Bitumen roofing material may be recovered and treated, and it can be used in new roofing structures as well as asphalt.

official CDW generation data	2006	2007	2008	2009	2010	2011	2012
hazardous CDW (mt)	3.13	1.44	1.58	1.57	1.47	1.33	1.48
non-hazardous CDW (mt)	21.33	22.71	23.72	23.60	23.06	23.07	24.22
total (mt)	24.46	24.15	25.30	25.18	24.53	24.41	25.71

Figure1 (case study) adapted from: Screening template for Construction and Demolition Waste management in The Netherlands V2 – September 2015

Construction and Demolition Waste (CDW) management national performance

In 2012, the Netherlands officially recorded producing 25.71 million tonnes of construction and demolition waste (CDW). In comparison to 2010, it represents a 4.8 percent increase. This statistic ignores dredging spoils and the vast bulk of soil when compared to Eurostat data. The official trash generation data in the Netherlands excludes soils and dredging spoils, mostly because the amounts of these waste types fluctuate dramatically depending on annual policy on governmental projects. When compared to Eurostat statistics, 6,254 Ktonnes of soil waste are eliminated, leaving 241 Ktonnes. The remaining soils are made up of stony waste kinds, as shown by waste types 170503 and 170504. A total of 49,150 Ktonnes of dredge soil was excluded.
The source of the data in these tables of both the waste generation and treatment of CDW is the data provided by the Rijkswaterstaat, which is part of the Ministry of Infrastructure and Environment. This data was directly obtained from the waste helpdesk of Rijkswaterstaat.[1]

---

1 Screening template for Construction and Demolition Waste management in The Netherlands V2 – September 2015

The legislative framework for waste management in general, and CDW management in particular, is well established in the Netherlands. The following are the most important decisions and laws: It is mandatory to construct a National Waste Plan. A landfill prohibition applies to the bulk of garbage. Landfilling is taxed at €13 per tonne. Import and export of trash are severely controlled, and an incineration fee is currently in place to reduce the quantity of waste that is burned. Waste management and, more specifically, CDW management are well developed in the Netherlands. There is an advanced waste management plan as well as a waste avoidance plan. As previously stated, over 98 percent of CDW is recovered, and CDW landfilling is virtually non-existent.

Sustainable CDW management involves many governmental bodies, building designers, clients, contractors, and recyclers. Several best practices are being implemented: so called Greendeals are being implemented with the help of the government and several industry organizations and sector associations. Greendeal cirkel city, Greendeal circular buildings, Greendeal sustainable ground, roads and water construction, and Greendeal sustainable concrete are some of the products available.

Many industry efforts exist in which CDW is used to construct buildings or entire districts. Various R&D initiatives for recycling mono streams from CDW are available. Finding and implementing circular economy solutions for various waste kinds, including concrete, is becoming more common. CDW prevention measures are becoming more common.

Main barriers to long-term CDW management[1]

MARKET CONDITIONS

- The availability of secondary materials is currently insufficient.

- For recycled materials, there are no apparent quality gradations.

- The market continues to place a premium on individual unit pricing, such as the cost of a container, rather than the whole cost of garbage recycling.

- The market is still struggling with novel ideas, such as a business model in which a building is owned by the builder (producer) rather than the consumer.

BUREAUCRACY

- Because the government is made up of multiple parties (RWS, municipalities, and provinces), communication can be difficult. Furthermore, many municipalities are currently struggling due to a lack of people, hours, and knowledge.

- Local governments and municipalities do not have a lot of information. The national government should supply her with more information.

- The workload for the project-level to provide feedback on how well it was done in terms of sustainability.

LACK OF MATURITY OF INITIATIVES

There has been a lot of learning, but the genuine commitment to each other on how to tackle CDW requires commitments from clients and contractors. All of the projects are still in their early stages.

CULTURE

The conventional character of the building sector, according to interviewed stakeholders, limits the full potential of recycling CDW. People do not consider how to improve garbage recycling operations.

The most important factors in ensuring long-term CDW management

The Netherlands has a strong legislative and regulatory framework for CDW management (and waste management in general). There is an advanced waste management plan as well as a waste avoidance plan. CDW recycling is aided greatly by landfill and incinerator charges. The following drivers outline the most important current drivers and proposals from the stakeholders who were questioned in order to maximize CDW management's potential:

MARKET CONDITIONS & LEGISLATION

Builders are enthusiastic about purchasing secondary materials because the quality is excellent for the price. Builders are willing to use materials if the quality of the materials can be assured by a quality label. Cost-cutting is a major motivator for effective CDW management. For example, in order to reduce logistics, constructors focus on waste separation at the source. The imposition of a fee on landfilling and garbage burning is a key factor in increasing the amount of recycled CDW.
Waste burning prohibition would be a strong driver for waste recycling in general.

8 DECENT WORK AND ECONOMIC GROWTH

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

practice example/**case study 2**
(Australia) c&d waste management

1. Regional Victoria manufactures with recycled materials.

Integrated Recycling, based in Mildura, Victoria, creates durable items such as grape vine supports, landscape products, boardwalks, and railway sleepers from recycled plastic mostly from local agricultural sources. Duratrack, a recycled plastic railway foundation that lasts more than three times longer than timber platforms and uses less energy to produce than concrete or steel sleepers, is another product made by the company. This allows waste plastic that would otherwise end up in landfill to be reused for a longer period of time, which is a crucial component of the circular economy. Rounds 2 and 3 of the Victorian Government's Resource Recovery Infrastructure Fund helped Integrated Recycling expand its production capacity.

2. Local infrastructure made on recycled materials (Victoria)

Sustainability Victoria's Research, Development and Demonstration funding program has helped local company Close the Loop produce TonerPlas, a new asphalt additive made from materials that would otherwise end up in garbage. 530,000 plastic bags, 168 glass bottles, toner from 12,500 used printer cartridges, and 134 tonnes of reclaimed road asphalt are used for every 300 meters of road. In some cases, tests have shown that asphalt created from recovered materials outperforms normal VicRoads-specified asphalt in terms of wear and deformation resistance.

3. Waverley Council is putting recycled glass on the roads (NSW)

Waverley Council, in collaboration with the NSW Department of Planning, Industry and Environment, NSW Roads and Traffic Authority, Institute of Public Works Engineering Australia, and the Packaging Stewardship Forum, provided the first site in NSW to demonstrate the alternate use of crushed glass in pavement construction as an accepted product on NSW roads in 2010. Waverley Council used 15 tonnes of glass cullet in road construction, 7.5 tonnes of asphalt, and 7.5 tonnes of concrete.

4. 100 Hutt Street, Adelaide, South Australia (South Australia)

100 Hutt Street is a commercial office building and the headquarters of Built Environs, McConnell Dowell's national building brand. To illustrate best practice, 100 Hutt Street was renovated between 2007 and 2008 utilizing the Green Building Council of Australia's (GBCA) Green Star building rating mechanism. The renovation received a total score of five green stars. During construction, 100 Hutt Street adopted a waste management plan that resulted in the recycling or re-use of 95.1 percent of construction waste (by weight), considerably exceeding the Green Star credit threshold.

5. Kwinana Freeway Northbound Widening: Roads to Reuse Pilot Project (Western Australia)

The Kwinana Freeway Northbound Widening project, which was finished in 2019, uses 25,000 tonnes of recycled construction and demolition (C&D) waste or crushed recycled concrete as a sub-base under full depth asphalt. In addition, the project team has donated surplus site material to smaller local projects and sold 56,783 tonnes of reusable waste sand.

A circular economy for Victoria Creating more value and less waste / issued paper july 2019 / victoria state government

image1: A circular economy for Victoria Creating more value and less waste / issued paper july 2019

6. Unsealed residential pavement made from reclaimed asphalt (South Australia)

The City of Gawler's works engineering department took on the reconstruction of Cooper Street Kudla, choosing Bitumate as the best material for an unsealed surface. Cooper Street serves five residential properties as a regional access road. Regular floods necessitated the reconstruction of the road pavement as well as the installation of side drainage. Patrol grading is limited on an unsealed surface, and remaining bitumen provides some cohesiveness to reduce ravelling (especially at the intersection), as well as some "re-healing" of the surface under traffic in hot weather. C&D recycling plants mostly accept reclaimed asphalt in the form of slab asphalt removed from old pavements.

case study 3

practice example/**case study 3**

urban waste management

The Yamuna River Project: An Essential Future

image 2 (study case 3): THE YAMUNA RIVER PROJECT ©RANDHIR SINGH

The Yamuna River Project (YRP) seeks to assist New Delhi and its residents in reimagining and transforming the filthy Yamuna River as it passes through India's capital. New Delhi, as one of the world's fastest growing megacities, faces issues in planning, urban design, and social equality. These constraints are arising at a time when the economy is unstable and the environment is vulnerable. As a result, inhabitants of the world's greatest democracy live in an unprecedented state of environmental deterioration.[1]

Existing governance institutions have struggled to keep up with the speed at which climate change dynamics are changing. Toxic air and septic water are simple side effects in this situation. As more residents are exposed to the negative impacts of environmental issues in everyday life, overburdened public health systems are straining. Millions of people continue to suffer, sometimes in silence, as they live in impoverished cities with no remedy.

[1]: roca gallery sharing knowledge on architecture and design / books / connection in a material world / sustainable world by pankaj vir gupta

With an analytical, multi-disciplinary, research based methodology, the Yamuna River Project faces the difficulties of Delhi's urban reality. This strategy allows for a dynamic collaboration between academic ideas and their practical implementation for a variety of knowledge partners involved in city governance, such as municipal authorities, political leaders, and non-governmental groups. The Yamuna River, a living ecological entity with its own seasonal flow cycle, complicated hydraulics, and altering floodplain region, has long been a prominent geographical presence in northern India. The Yamuna has been immortalized as a primal Goddess in myth and religion, in prose and poetry, and as the agricultural lifeline of the various villages that preceded present day Delhi.

image 3 (study case 3): THE YAMUNA RIVER PROJECT ©RANDHIR SINGH

The Yamuna and Delhi were once connected. Even now, watermarks of the Yamuna can be seen on the sandstone walls of Mughal era monuments that abut the floodplain.

The Yamuna's water is diverted at the Wazirabad barrage to satiate the capital city's ravenous thirst. The Najafgarh Drain formerly the perennial Sahibi River provides the Yamuna's only flow after this Barrage, carrying 60 percent of the river's entire pollution burden. The flow of the Najafgarh drain, which contains untreated sewerage, solid waste, industrial and chemical effluent, and urban debris, depletes the water's oxygen level, rendering it incapable of supporting any kind of life.[1] Without relocating waste and chemical absorption to other places, the site cannot be recovered to its natural form. As a result, the site must consider alternative options that account for the human disruption created by the depot's construction while restoring the ecosystem's functionality and value.

practice example/**case study 4**
urban waste management

Battery Park City, NYC

Type
Shared compactor

Best Practice Strategies
3.01 Provide loading area at base of a building that can also be used by other buildings
3.09 Incorporate community into collection operations

ref: Hugh L. Carey Battery Park City Authority Residential Environmental Guidelines

"The original Hugh L. Carey Battery Park City Authority Residential
Environmental Guidelines were written in 1999 and published in January 2000. They were sponsored by the Hugh L. Carey Battery
Park City Authority, the New York State Energy Research and Development Authority, and the Carrier Corporation and written by
Fox & Fowle Architects, Flack + Kurtz, Green October, the Rocky Mountain Institute, the Carrier Corporation, Barney Skanska USA,
the Hugh L. Carey Battery Park City Authority, and the New York State Energy Research and Development "Authority. The current version incorporates what we have learned from The Solaire, the first building developed under these guidelines, and is a response to the evolving technology, philosophy, and feasibility of green development."

Battery Park City – Residential Environmental Guidelines
May 2005

image 4 &5 (case study 4):
https://www.zerowastedesign.org/03-collection-and-urban-design/c-collection-urban-design-case-studies/

Battery Park City, a proposed high rise town along the Hudson River at Manhattan's southern tip, is home to 14,000 people, office buildings, and public parks. The Battery Park City Authority (BPCA) rents land to developers that must meet strict architectural, sustainability, and community amenity requirements.

The development of the new World Trade Center site in 2006 resulted in a rat population increase. Developers of specific sites were obligated to host compactor containers overseen by the Battery Park City Authority, just as they were required to provide open space, schools, and other facilities. Porters may now deliver bags to a communal compactor every day instead of dumping them on the pavement two days a week for pickup the next morning. Roll-on/roll-off vehicles collect compacted containers from only four locations, rather than a compactor truck stopping to load bags from every school and residential building in the neighborhood. Compactors can contain the equivalent of 150 carts of material. Each compactor handles around 2,000 units of material every day and takes about 90 minutes to load. Not only did the method solve the rat problem, but it was also well received by porters. Only waste is collected in communal compactor bins at Battery Park City. Metal, glass, plastic, paper, and cardboard, as well as organics from buildings participating in the city's organics collection pilot, are still collected door to door with rear load compactors. To include these source separated streams in the consolidated collection system, more loading area space or separate time windows allotted to each waste fraction would be necessary.

The fact that BPCA is in charge of the entire development's leasing arrangements made the transition from door to door collection to centralised collection much easier. Because new projects were in the planning phases, it was simple to install curb cuts in places where trucks could access the shared compactors.

image 6 (case study 4):
https://www.zerowastedesign.org/03-collection-and-urban-design/c-collection-urban-design-case-studies/

case study 5

practice example/**case study 5**

urban waste management

Roosevelt Island, NYC

Type

Pneumatic collection

Best Practice Strategies

3.03 Provide a system of pneumatic tubes connecting buildings to a central terminal

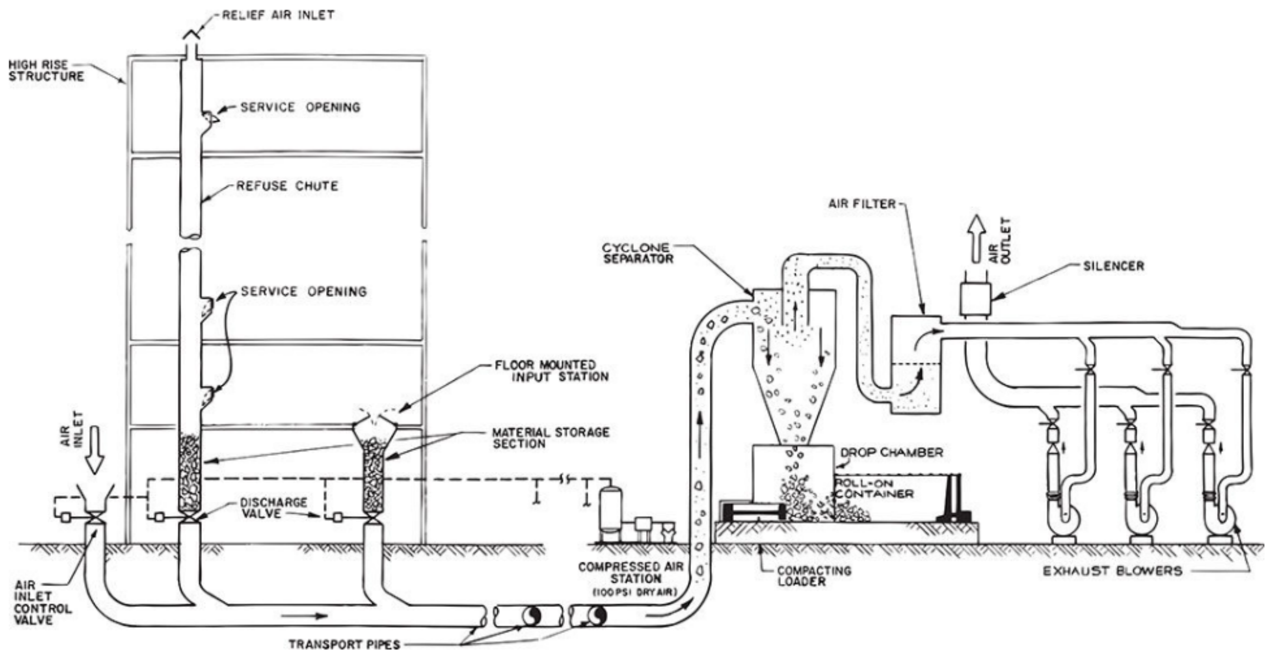


image 7 (case study 5): https://www.zerowastedesign.org/03-collection-and-urban-design/c-collection-urban-design-case-studies/

"Operations diagram by Gibbs and Hill engineers showing how waste flows from chutes in individual buildings through a pneumatic tube to a shared compactor container, 197."

Roosevelt Island, located between Manhattan and Queens in the East River, is a planned city of 14,000 people. Philip Johnson and John Burgee's master plan from 1969 envisioned a full-service community devoid of automobiles. Engineers established the first pneumatic tube network for municipal solid waste in the United States after being tasked with finding a solution to transfer trash without trucks. Trash chutes in the island's 16 residential complexes are connected to a terminal on the island's north end by a pneumatic tube. Turbines at the collection station are turned on several times a day, creating a vacuum. Trash flows at 50 mph to the terminal, where it is compacted into containers and collected by roll-on/roll-off vehicles once valves at the bottom of the chutes are opened.

The system, which has been in place since 1975 when the first inhabitants arrived, has been enlarged three times to accommodate new construction. The Roosevelt Island Operating Corporation (RIOC), a New York State public benefit corporation, manages the island. All developers that rent land from RIOC are required to link their structures to the pneumatic system. As a result, building porters on the island are unable to manage waste, and buildings lack waste storage places. Residents are typically only aware of the network when it is shut down and bags are stacked on the curb, as is the case in most New York City areas. Roosevelt Island was the only neighborhood in the city whose DSNY service was maintained during Hurricane Sandy and the blizzard of 2012. This is because collection takes place off the street and without vehicles.

http://fasttrash.org/ Roosevelt Island's Pneumatic Tube and the Future of Cities (2010)

"What if we significantly altered the way rubbish is transported across the city? Garbage collection is often considered as a technical issue for engineers and sanitation departments to tackle, despite its vital role in urban settings. As you can see, establishing pneumatic collection networks necessitates close collaboration among designers, engineers, municipalities, and private developers, as well as political will and a long-term strategy. Fast Trash applauds this holistic approach and wonders what we might learn about infrastructure from a community built on progressive policies and technologies."

The pneumatic tube below is connected to a valve in the building cellar at the base of a gravity chute. View inside the terminal, which includes container moving machinery for 30 cu yd containers (pneumatic tubes are painted red).

image 8&9 (case study 5): https://www.zerowastedesign.org/03-collection-and-urban-design

case study 6

practice example/**case study 6**

urban waste management

Punt Verd, Barcelona

Type

Neighborhood-scale recycling center in public realm

Best practices

3.07 Staffed drop-off locations

3.09 Incorporate community into collection operations

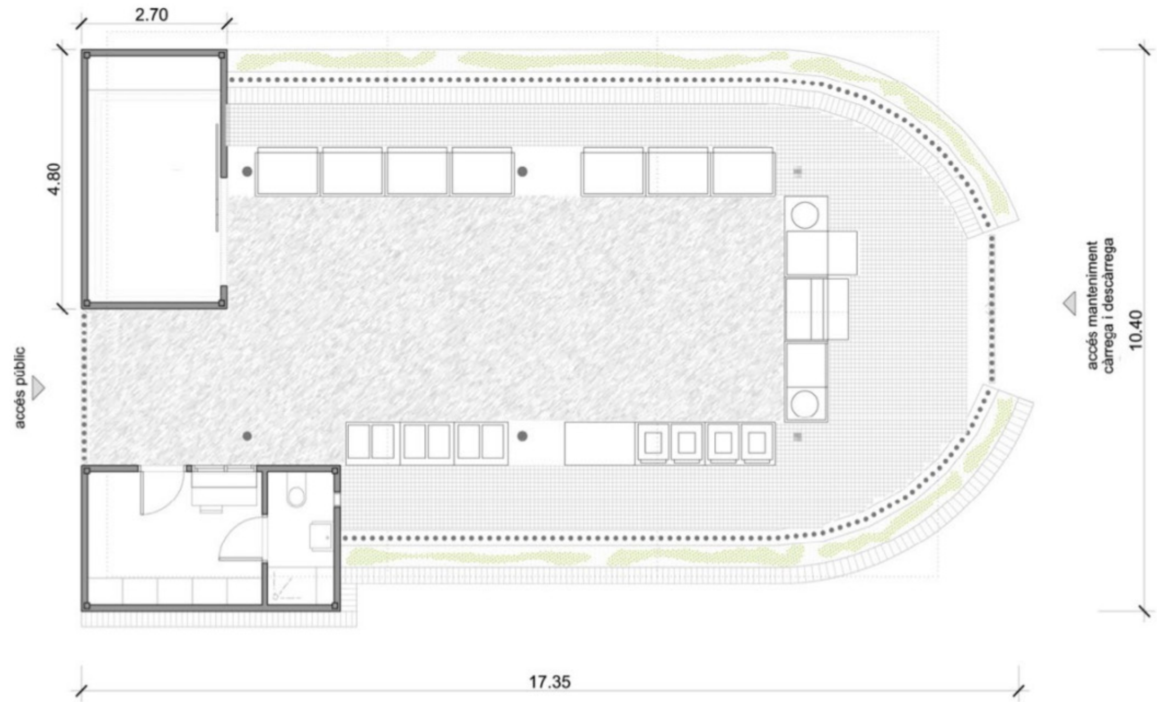
image 10 (case study 6): https://www.zerowastedesign.org/03-collection-and-urban-design/c-collection-urban-design-case-studies/

Punts verds (Catalan meaning "green points") are small recycling stations that can be seen in plazas and parks. Residents in Barcelona can drop off household hazardous garbage, recyclables, and smaller bulk items at the semi-permanent staffed facilities, which are located within walking distance of their homes. Punts verds are a complement to larger recycling centers on the outskirts of town that have car access. Over 2,000 tons of material were managed by the city's 23 neighborhood-scale punts verds in 2016.

The facility's layout is straightforward: containers are organized in such a way that they are available for public deposits on one side and staff emptying on the other. The facility is surrounded by fencing and is sheltered from the weather. A small office with a staff restroom and a small visitor's center are the sole inside spaces. Punt verds are made to stand out in order to encourage people to use them and to provide visual interest to the surrounding area. They also provide you the chance to show off your sustainable design skills. Picharchitects erected a modular building in Barceloneta Park in 2013 that has a landscaped enclosure and uses little energy to operate: Solar panels and passive systems create power and hot water, while roofs shielding the drop-off area collect rainfall and fill cisterns used to irrigate planters.

This is not a typical project, according to architect Felipe Pich-Aguilera Baurier. To avoid the stereotype of a trash plant, every detail had to be created from scratch. A trash project is always constrained by "industrial" restrictions, such as accommodating truck logistics and providing the site's contamination protection. To maintain coexistence within the urban fabric, highly tight safety and sanitary procedures were also required for this project. As a result, developments are often isolated, resembling "bunkers," and are threatening to passersby and neighbors. Our project aims to produce a domestic scale product that can serve as a community gathering spot while also completing all of the program's objectives.

Note from architect, Felipe Pich-Aguilera Baurier, 9/2017. Translated and edited by Juliette Spertus.



Containers are situated around a public drop-off location, with service access around the perimeter, according to the plan.

image 11 (case study 6): https://www.zerowastedesign.org/03-collection-and-urban-design

1

What is considered as waste?

-defining the global situation

1

what is considered as waste: defining the global situation

1.1 introduction

As a result of the industrial revolution, people began to migrate from rural to urban regions in the sixteenth century, resulting in a significant increase in waste output (Wilson, 2007). This influx of people to cities resulted in a population explosion, increasing the volume and diversity of waste generated in cities. Metals and glass began to appear in substantial amounts in municipal waste streams. (Williams, 2005).

Littering and open dumps arose because of the increased number of people in cities and villages. These landfills, in turn, became breeding grounds for rats and other vermin, creating severe health dangers.
Several pandemic outbreaks with large mortality tolls came from poor waste management techniques (Tchobanoglous et al., 1993).
As a result, public officials began to dispose of waste in a controlled manner in the nineteenth century to protect public health (Tchobanoglous et al., 1993).
Many developed countries went through a period of environmental development. Most of these countries, on the other hand, have effectively addressed many of the health and environmental pollution challenges related to garbage generation today. In contrast, the rising rate of urbanization and growth in emerging countries is causing a recurrence of the same historical issues that developed countries have had to deal with in the past (Wilson, 2007).
The rate and volume of garbage produced have both increased in recent years. As the amount of waste produced grows, so does the variety of waste products (Vergara and Tchobanoglous, 2012). Unlike in the prehistoric age when wastes were simply an annoyance that needed to be eliminated. Because the population was tiny and a large amount of land was accessible at the time, proper management was not a severe issue. Those were the days when the ecosystem could simply absorb the amount of waste created without any damage (Tchobanoglous et al., 1993).

1.2 what is waste?

Waste, defined by Directive 2008/98/EC[1] as "any substance or object which the holder discards or intends or is required to discard, potentially represents an enormous loss of resources in the form of both materials and energy." Another Waste definition is: "an unusable by-product of human operations that physically contains the same substances as the valuable product" (White et al., 1995).

According to Brunner and Rechberger (2014), most human activities generate waste. A waste is legally considered waste; if it's not required by the one who used it, even if the article is given to somebody else to be reused or recycled.

In basic terms, waste is anything you decide to throw away or are required to throw away. "Even if the substance or article is given to someone else to be reused or recycled, it is still legally considered to be waste if it is no longer required by the person who produced it. / Used it."
Waste is also defined as any product or substance that is no longer useful to the maker (Basu, 2009). According to Dijkema et al. (2000), Wastes are materials that people would wish to dispose of even if money is required for disposal.
Although waste is an inevitable byproduct of human activities, it is also the result of inefficient manufacturing processes, resulting in a loss of critical resources (Cheremisinoff, 2003).

[1] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

The Environmental Association for Universities and Colleges (EAUC)[1] defines waste with these sentences in 2021: "There are certain exceptions to this definition of waste. It does not, for example, include gaseous emissions, radioactive waste, certain natural, non-dangerous agricultural wastes, wastewaters, and decommissioned explosives; this does not mean that these items are not waste, but simply that they fall under different legal definitions."

The European Garbage Catalogue reveals a hierarchical list of waste; each waste has a unique code that distinguishes it from the others. A "waste" can be divided into three categories: The first subgroup looked at problematic wastes, which aren't defined by law. The hazardous wastes were considered in the second, legally specified type, and the controlled/non-controlled wastes were considered in the third subgroup. «There are certain exceptions to this definition of waste. For example, include gaseous emissions, radioactive waste, certain natural, non-dangerous agricultural wastes, wastewaters, and decommissioned explosives; this does not mean that these items are not waste, but simply that they fall under different legal definitions. » (Community Strategy for Waste Management (1996) / "European Commission's Sixth Environmental Action Program).

-Difficult (complex) wastes (have no legal definition)

ex: Scrap metal, timber, building or construction materials, white goods, mattresses, furniture, large bundles of tree and shrub prunings, tires, batteries, E-Trash, and other materials as defined by Council from time to time are all examples of hard waste.

[1] EAUC (2021), The Alliance for Sustainability Leadership in Education, what is waste? - https://www.eauc.org.uk/waste1

-Hazardous wastes[1] (legally defined)

- Spent solvent wastes,
- Electroplating and other metal finishing wastes,
- Dioxin-bearing wastes,
- Chlorinated aliphatic hydrocarbons production,
- Wood preserving wastes,
- Petroleum refinery wastewater treatment sludges
- Wood preservation,
- Organic chemicals manufacturing,
- Pesticides manufacturing,
- Petroleum refining,
- Veterinary pharmaceuticals manufacturing,
- Inorganic pigment manufacturing,
- Inorganic chemicals manufacturing,
- Explosives manufacturing,
- Iron and steel production,
- Primary aluminum production,
- Secondary lead processing,
- Ink formulation, and
- Coking (processing of coal to produce coke).

-Controlled wastes[2] ex; asbestos, clinical or related waste, tyres and waste that has been immobilized or encapsulated./non- controlled wastes[3] ex; hazardous wastes, mining wastes, agricultural wastes.

[1] A waste is determined to be a hazardous waste if it is specifically listed on one of four lists (the F, K, P and U lists) found in title 40 of the Code of Federal Regulations (CFR) in part 261.

[2] The definition of controlled waste is clarified in the Controlled Waste (England and Wales) Regulations 2012. Controlled waste is the term used for waste that is subject to regulation under the Environmental Protection Act. It does not cover certain wastes that have their own legislative regimes, such as radioactive wastes and animal by-products.

[3] Uncontrolled waste is a group of waste products that fall outside of the controlled, special, or hazardous waste categories. Hazardous wastes can be in the form of solids, liquids, sludges, or contained gases and they are are typically by-products of chemical production, manufacturing, construction, and other industrial activities.

1.3 what is waste management?

It is crucial that waste management should not be overlooked in today's world. When it comes to changing the Waste Management methods that we already have and in rural and urban areas, it should be viewed as a global issue that must be addressed.

These changes should be thoroughly investigated so that waste management policy, education, and economic and environmental evaluations, as well as data on solid waste creation, characterization, minimization, collection, separation, treatment, and disposal processes done properly.

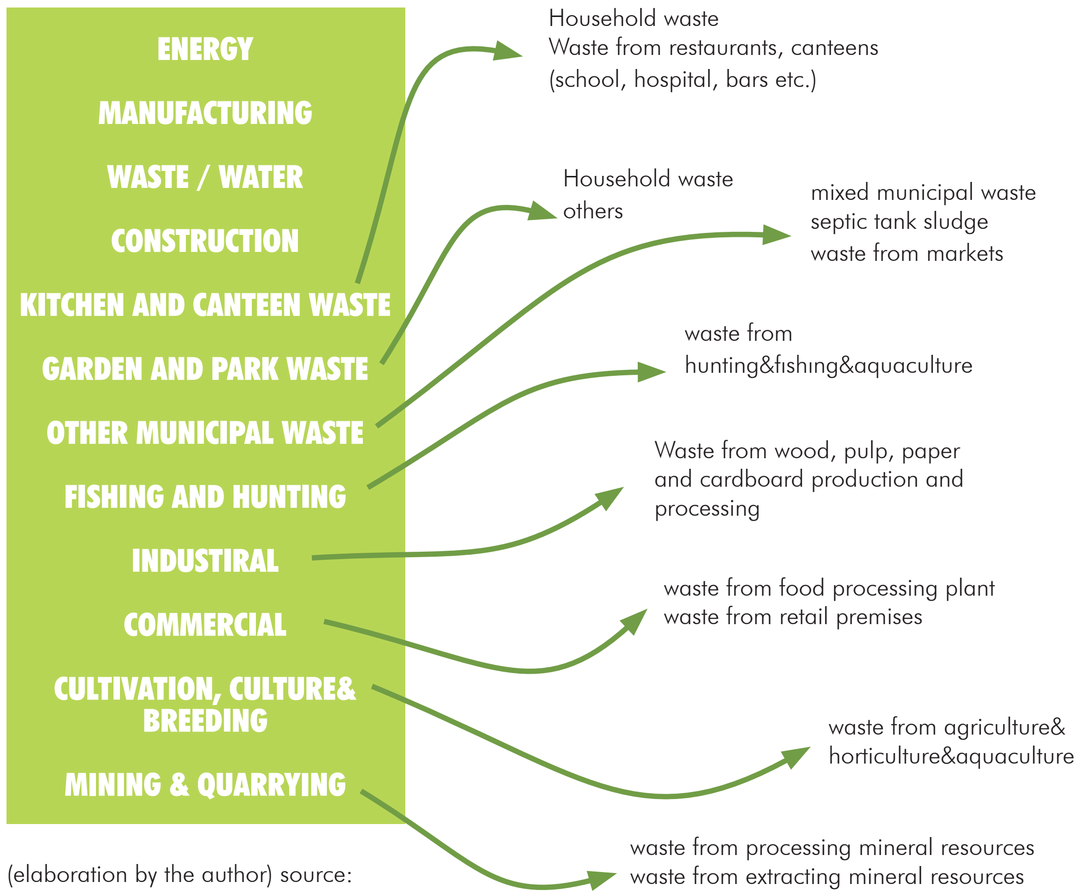
The necessity of educating all the citizens is crucial, without understanding the importance of these issues, it would be a hard period to pass through.
One of the most significant aspects to address while describing this phenomenon is the various sorts of solid wastes, including municipal garbage.
Construction and demolition, household hazardous, sewage sludge, and non-hazardous industrial wastes are examples of common (e.g., residential, institutional, and commercial), agricultural, and special (e.g., construction and demolition, household hazardous, sewage sludge, and non-hazardous industrial) wastes. (Waste Management International Journal of Integrated Waste Management, Science and Technology).

Main topics that must be considered in Waste Management:
• Generation and characterization • Minimization
• Storage, collection transport & transfer
• Recycling and reuse • Treatment (thermal, chemical, biological, mechanical)
• Landfill disposal • Environmental Assessments
• Economic analysis • Policy and regulations
• Education and trainig • Planing

1.4 main waste categories & components

It is critical to recognize that we all make waste; we must all bear responsibility for it; waste is not solely the duty of someone who transports, manages, or disposes of it for us. Waste management legislation assigns responsibilities to waste producers; thus, it's critical to understand whether your organization is functioning as a waste producer. Guidance is given in "Waste Management: The Duty of Care - A Code of Practice". This defines a producer as Source: (Manfredi & Pant, 2011)
• the person who made the substance become waste (by breaking or contaminating it).
• the person who decided that a substance was unwanted and therefore waste.

When construction work is being done, for example, the waste producer is the person who is doing the work that produces the waste, not the person who issued the contract or gave the work orders. You can, of course, define waste that will be handled in the agreement, such as if it will be reused or recycled.
(Figure 1: Main waste categories and their components.) Source:(Manfredi Pant,2011)



(elaboration by the author) source:
Municipal Solid Waste Figure 2

1.4.1 municipal solid waste (MSW)

In the first place, Municipal Solid Waste (MSW) is a critical waste, also one of the most studied. Many writers argued about municipal solid wastes and described them differently.

Kaseva & Gupta (1996) describe municipal solid waste as the waste collected by the city authorities, including refusing from the household, non-hazardous solids from industrial, commercial, institutional, and non-pathogenic hospital waste.
Buah et al. (2007) describe MSW as only a tiny fraction of the total waste arisings collected for local authorities from domestic and commercial sources. White et al. (1995) portrayed municipal solid waste (MSW) as waste produced from household and commercial premises.
Vergara & Tchobanoglous (2012) observed that municipal solid waste reflects the lifestyles and customs of the people that produce it. Also, they mentioned that if not adequately managed, MSW might negatively impact the well being and health of the public and the environment.

1.4.2 construction waste

In many countries, the main waste comes from the construction industry. Reports show that in Hong Kong, construction waste amounted to about 29,674.013 tons per day. Also, according to studies, across the EU, the volume of construction waste is increasing, and the wastes produced are significantly high compared to the total waste generated. To define with numbers, Eurostat (2014) revealed that in 2008, construction waste in the UK was about 100.999,493 tons, while in 2010, the sector contributed about 105.560,291 tons of garbage.

photograph no:1 by author (Can Aktoluğ)


photograph no:2 by author (Can Aktoluğ)

1.5 EU waste policy and the directives and regulations

Context

Waste management regulations in the EU aim to reduce waste's environmental and health implications while also increasing Europe's resource efficiency. The longterm goal is for Europe to become a recycling society, with waste avoided whenever possible and scrap used as a resource whenever viable.

The goal is to obtain substantially better recycling rates while reducing new natural resources. Therefore, waste management is a critical component of resource efficiency and longterm economic growth in Europe.

"Community Strategy for Waste Management (1996)"
"European Commission's Sixth Environmental Action Program"

• The need to make producers responsible for their waste products.
• The need to encourage consumers to reduce waste by the product and services selections that they make.
• To develop and promote an EU wide recycling strategy and promote markets for recycled materials.
• To develop an approach to Integrated Product Policy that promotes a reduction in the environmental impacts of products throughout their lifecycle.

The European Commission initiated a consultation campaign on future waste management policies in 2003. In 2003, a consultation document titled "Towards a Thematic Strategy on Waste Prevention and Recycling" was released in anticipation of adopting a new waste management policy in 2005.

• Framework legislation (defining waste, permitting requirements, and infrastructure)
• Technical standards for operating waste facilities to ensure a high environmental protection standard.
• Requirements for specific waste streams (measures to increase recycling or reduce hazard).

As a result, EU waste management regulations aim to reduce waste's environmental and health implications while also increasing the EU's resource efficiency. The longterm goal of these policies is to limit the quantity of waste produced, and where waste generation is unavoidable, to promote destruction as a resource and increase recycling and garbage disposal safety.

1.5.1 total waste generation

In 2018, the EU-27 generated 2.317 million tons of garbage from economic activity and households. Source: Eurostat Statistics Explained - 08/12/2020

The share of significant economic activity and households in total garbage produced in 2018: Construction accounted for 36.0 percent of whole waste generation in the EU-27 in 2018, followed by mining and quarrying (26.2 %), manufacturing (10.6%), waste and water services (9.9%), and households (8.2%); the remaining 9.1 percent was waste generated by other economic activities, primarily services (4.2 %) and energy (4.2%) (3.5 %).

1.6 global problems

According to “What a Waste 2.0,” World Bank research has been in the works for several years, annual global waste production will increase by 70% if current conditions continue.

Each year, around 2.01 billion metric tons of municipal solid waste (MSW) are generated worldwide. According to the World Bank, global garbage production will reach 3.40 billion metric tons by 2050.

Today's waste is recycled 13.5 percent of the time and composted 5.5 percent of the time. However, according to the survey, one-third and 40% of the waste produced worldwide is not effectively managed, dumped, and burned into the open.

This current edition, which builds on previous research from 2012, gathered data from 217 countries and 367 cities. Given the various measuring methods, all that data was standardized as much as possible. The 200 page report offers a plethora of data, case studies, and analysis, as well as multimedia features available online.

•Rich countries (such as the United States, Canada, and European Union members) account for only 16 % of the worldwide population but produce 34 % of global waste. An estimated 93% of rubbish is mishandled in low income countries, compared to only 2% in high income countries.
•In North America, daily waste generation per capita is projected to be 4.87 pounds, compared to 1.01 pounds in Sub Saharan Africa. According to the World Bank, waste is expected to triple in Sub Saharan Africa and double in South Asia by 2050, accounting for a full 35 percent of world output.
•Collection is more widespread in urban areas than rural areas in these low income countries, although it is still significantly less common than in developed ones.

The World Bank discovered that the collection has grown from around 22% to 39% in low income nations since 2012, albeit statistics may not be directly comparable.

1.7 climate issues

In 2016, worldwide waste generation accounted for around 5% of global emissions, with 1.6 billion metric tons of carbon dioxide equivalent produced. By 2050, the figure is predicted to rise to 2.6 billion metric tons.

Food waste accounted for 47% of those emissions, indicating a significant issue and an opportunity to use the gases emitted by food waste to generate energy. These emissions "are mostly caused by open dumping of waste and then landfilling of waste without landfill gas systems." As climate change progresses, underdeveloped waste management infrastructure may become an increasing symbol of global disparity. Open dumpsites in developing countries can cause devastating landslides, which weather events and contamination in streams can exacerbate.

Writers note:

The governments and their municipalities must regulate the dividedness of these problems. The most considerable variance is that these common and most effective treatments have the highest cost. If we consider developing countries equivalent to the dominant ones, the solution won't be as easy as it seems.

As we are all witnessing the enormous economic diversity globally, the research, technological developments, and various innovations about waste management and treatments must be correlated with funding principles and practices as much as they could be. Construction and demolition waste (C&DW) collection and recycling should not be viewed as a stand alone operation but rather as part of a larger picture of resource and waste management.

photograph no:3 by author (Can Aktoluğ)

Annex 1

C&D WASTE CLASSIFICATION

The Commission Decision on the European List of Waste (Commission Decision 2000/532/EC[1]) is the source of this list. Excavated soils (17 05) are on the list but are not covered by the Protocol.

"Overview of C&D waste"

17 01 CONCRETE, BRICKS, TILES AND CERAMICS

- **17 01 01** concrete
- **17 01 02** bricks
- **17 01 03** tiles and ceramics
- **17 01 06** mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances
- **17 01 07** mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 01 06.

17 02 WOOD, GLASS AND PLASTIC

- **17 02 01** wood
- **17 02 02** glass
- **17 02 03** plastic
- **17 02 04** glass, plastic and wood containing or contaminated with dangerous substances

17 03 BITUMINOUS MIXTURES, COAL TAR AND TARRED PRODUCTS

- **17 03 01** bituminous mixtures containing coal tar
- **17 03 02** bituminous mixtures other than those mentioned in 03 01.
- **17 03 03** coal tar and tarred products

[1] Commission Decision 2000/532/EC, http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32000D0532

17 04 METALS (INCLUDING THEIR ALLOYS)

- **17 04 01** copper, bronze, brass
- **17 04 02** aluminium
- **17 04 03** lead
- **17 04 04** zinc
- **17 04 05** iron and steel
- **17 04 06** tin
- **17 04 07** mixed metals
- **17 04 09** metal waste contaminated with dangerous substances
- **17 04 10** cables containing oil, coal tar and other dangerous substances
- **17 04 11** cables other than those mentioned in 04 10.

17 06 INSULATION MATERIALS AND ASBESTOS-CONTAINING CONSTRUCTION MATERIALS

- **17 06 01** insulation materials containing asbestos
- **17 06 03** other insulation materials consisting of or containing dangerous substances
- **17 06 04** insulation materials other than those mentioned in 06 01 and 06 02
- **17 06 05** construction materials containing asbestos

17 08 GYPSUM-BASED CONSTRUCTION MATERIAL

- **17 08 01** gypsum-based construction materials contaminated with dangerous substances
- **17 08 02** gypsum-based construction materials other than those mentioned in 08 01.

17 09 OTHER CONSTRUCTION AND DEMOLITION WASTES

- **17 09 01** construction and demolition wastes containing mercury
- **17 09 02** construction and demolition wastes containing PCB (for example PCB containing sealants, PCB-containing resin-based floorings, PCB-containing sealed glazing units, PCB-containing capacitors)
- **17 09 03** other construction and demolition wastes (including mixed wastes) containing dangerous substances
- **17 09 04** mixed construction and demolition wastes other than those mentioned in 09 01, 09 02 and 09 03.

2

What is C&D waste defining the concept about waste and disposal practices.

2

What is C&D waste: defining the concept about waste and disposal practices

2.1 introduction

It is mandatory to understand the concept and the necessities of the waste and disposal practices.
It is possible that we can divide this concept into five different topics, which will define the life cycle process of a so called “waste generation.”
All cycles begin with the creation, which we can call the “design” phase, but we need raw material to create that product.

So, the life cycle begins with “raw materials,” then “design,” “construction,” “use,” and finally “end of life.” So, when we add up with the main principles of the C&D waste management procedures, it is mandatory to look up these waste management protocols.

Design and disassembly, material passports, selective demolition, high grade products with high recycled content, and finally. Extension of construction service life. In this chapter, the goal is to explain the life cycle of waste and figure out how to manage it with substantial disposal practices.

2.2 what is C&D waste management?

What is C&D Waste, and how does it differ from other types of waste?

The debris generated during construction and demolition activities is called Construction and Demolition (C&D) Waste. Concrete, metals, bricks, glass, plastics, organics, and other materials are frequently found in this garbage, depending on how and where it was formed. The goal is to understand and find the right solution for each kind of waste and apply the most attainable and feasible treatment. In addition, there are several ways to solve this problem.

2.3 what is considered as C&D waste?

This category of waste is complex due to the different types of building materials being used but, in general, may comprise the following materials. These materials can broadly be classified as major and minor components. Construction and demolition materials are generated when new buildings and civil engineering structures are erected. When existing buildings and civil engineering structures are rehabilitated or demolished, construction and demolition materials are developed (including deconstruction activities). Streets and highways, bridges, utility facilities, piers, and dams are all examples of civil engineering structures.

Writers note:

Environmental Consideration for the C&D wastes is a crucial issue to focus. While many C&D materials have appropriate applications, it is essential to remember that a tiny fraction of them contain elements of potential concern that, if not appropriately handled, can be damaging to human health and the environment. Protective government restrictions or recommendations are in place for many of these elements to ban or restrict the use of these materials or to promote the best management protocols. Asbestos, polychlorinated biphenyls (PCBs), and lead, for example, are all regulated by the federal government. An organization that oversees C&D materials with these or other federally regulated constituents must adhere to all applicable federal regulations, requirements, and standards.

Major components are:

• Concrete
• Wood (from buildings)
• Asphalt (from roads and roofing shin-gles)
• Gypsum (the main piece of drywall)
• Metals
• Bricks
• Plastics
• Salvaged building components (door, windows, and plumbing fixtures)
• Trees, stumps, earth, and rock from clearing sites
• Cement Plaster
• Steel (door and window frames, roofing support, railings of staircases, etc.)
• Rubble
• Stone (marble, granite, sandstone)

Minor components are:

• Conduits (iron, plastic)
• Pipes (GI galvanized iron, iron, plastic)
• Electrical Fixtures (copper, aluminum wiring, wooden baton, Bakelite/plastic switches, wire insulation)
• Panels (wooden, laminated)
• Others (glazed tiles, glass panes)

photograph no:4 by author (Can Aktoluğ)

photograph no:5 by author (Can Aktoluğ)

2.4 waste generation and treatment in the EU and several non-member countries

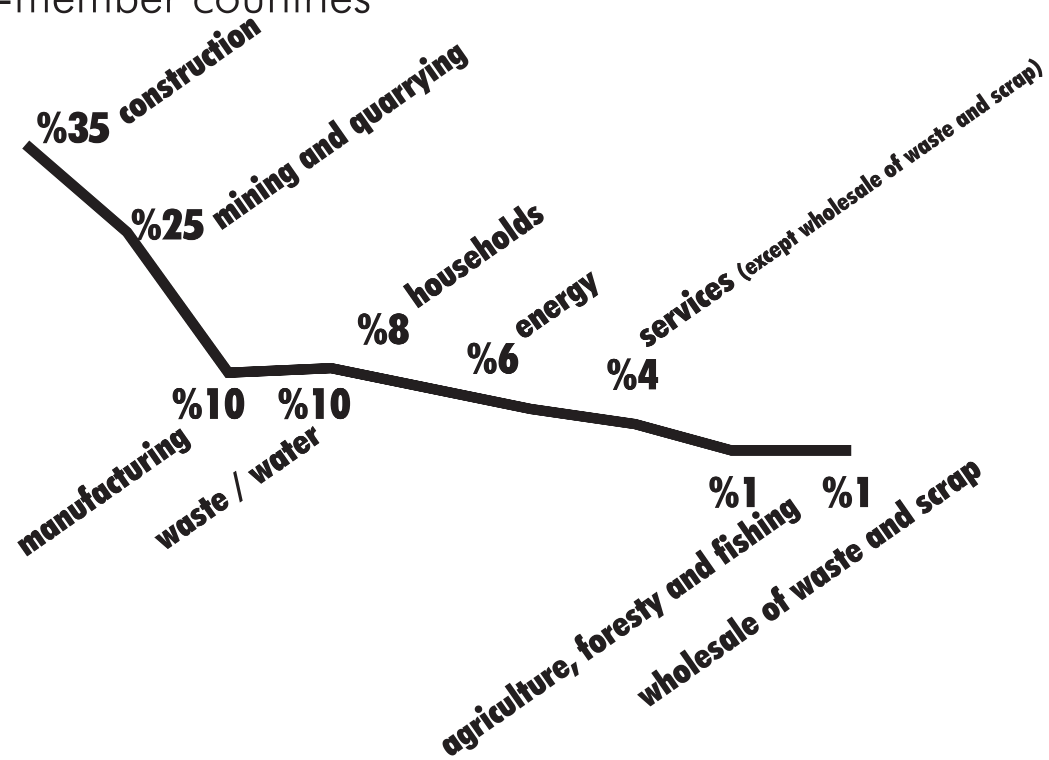


Figure 3 elaboration by the author / source: Waste generation by economic activities and households EU-27, 2018 source: https://ec.europa.eu/eurostat/statistics-explained

In 2018, the EU-27 handled around 2.149 million tons of garbage. This does not include the waste that has been exported. However, the treatment of waste imported into the EU-27 is included. As a result, the given figures are not directly comparable to those for waste generation.
Figure 5 indicates the evolution of waste treatment in the EU-27, both in terms of overall waste treatment and the two main treatment types.

Recovery disposal during the period 2004-2018. The quantity of waste recovered from 870 million tons in 2004 to 1.165 million tons in 2018, the amount of waste recycled, used for backfilling (the use of manure in excavated areas for slope reclamation or safety, or for engineering purposes in landscaping) or incinerated with energy recovery increased by 33.9 percent; as a result, the share of such recovery in total waste treatment increased from 45.9% in 2004 to 54.2 percent in 2018.
The amount of waste needed to be disposed of fell by 4.2 percent from 1.027 million tons in 2004 to 984 million tons in 2018. The percentage of total waste treatment that is disposed of has declined from 54.1 percent in 2004 to 45.8

As previously indicated, more than half of the garbage in the EU-27 was processed in recovery activities in 2018, including recycling (38.1 percent of total treated waste), backfilling (10.1 percent), and energy recovery (6.0 percent). The remaining 45.8% was either landfilled (38.7%), burned without energy recovery (0.7%), or disposed of in some other way (6.3 percent).

Significant disparities in the adoption of these various treatment approaches were noticed throughout the EU's 27 member states. Some Member States, for example, had relatively high recycling rates (Italy and Belgium), whereas others (Greece, Bulgaria, Romania, Finland, and Sweden) preferred dumping.
Source: (Eurostat/ Waste Generation)

Writers note:

Regarding these pieces of information, there are various ways to dispose of and treat the waste; One of the most common pillars about this subject is so called "waste treatment plants." Therefore, it is crucial to understand how these plants work, how to manage them, how to create and finally adapt to the construction site or disposal site.

The EU created some regulations and directives a long time ago, in 1994, and it's been constantly developing since then due to technological innovations and processes. Especially for managing the C&D wastes. Waste plants are one of the most important aspects to reduce waste generation throughout the construction site, including on and off-site manufacturing. There are several more treatment methods besides waste treatment plants. "Aerobic treatment, anaerobic treatment, mechanical and biological treatment, incineration, thermal treatment, co-incineration plant, and landfill site."

The goal of EU Directive 94/67/EC (which went into effect on December 31, 1994) was to establish measures and procedures to prevent or, where that was not possible, to reduce as much as possible the negative impact on the environment, particularly pollution of air, soil, surface and groundwater, and the resulting risks to human health, caused by the incineration of hazardous waste, and to set up a system to do so.

It is applicable without prejudice to other relevant Community legislation, particularly in waste and worker health and safety in incineration plants. Permits will only be granted if the application demonstrates that the incineration plant is constructed, equipped, and managed in such a way that necessary pollution prevention measures will be taken.

For example, the goal of EU Directive 2000/76/EC (enacted on December 28, 2000) was to prevent or limit, as far as possible, negative environmental effects from waste incineration and co-incineration, including pollution of air, soil, surface water, and groundwater, as well as the resulting risks to human health.

It includes both incineration and co-incineration facilities. However, the following plants are prohibited: Plants that treat vegetable waste from agriculture and forestry, vegetable waste from the food processing industry, fibrous vegetable waste from virgin pulp production and paper production from pulp, wood, cork, radioactive, and animal carcasses and waste from oil and gas exploration and exploitation. In addition, plants that treat fewer than 50 tons of garbage per year are used for research, development, and testing to improve incineration. No incineration or co-incineration facility may operate without permission to carry out these actions.

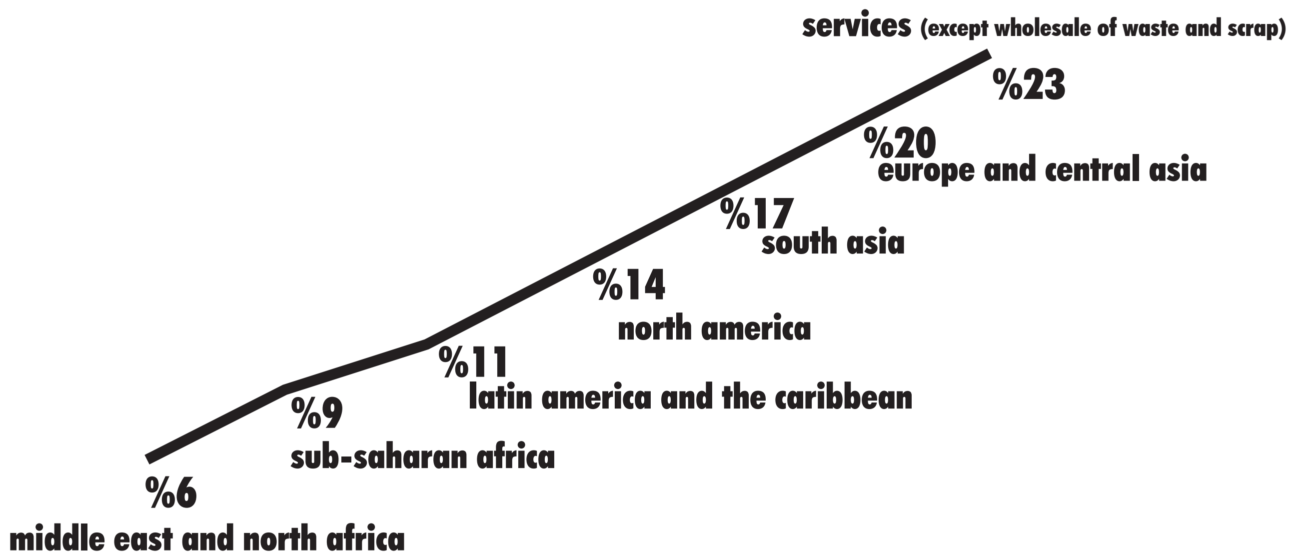
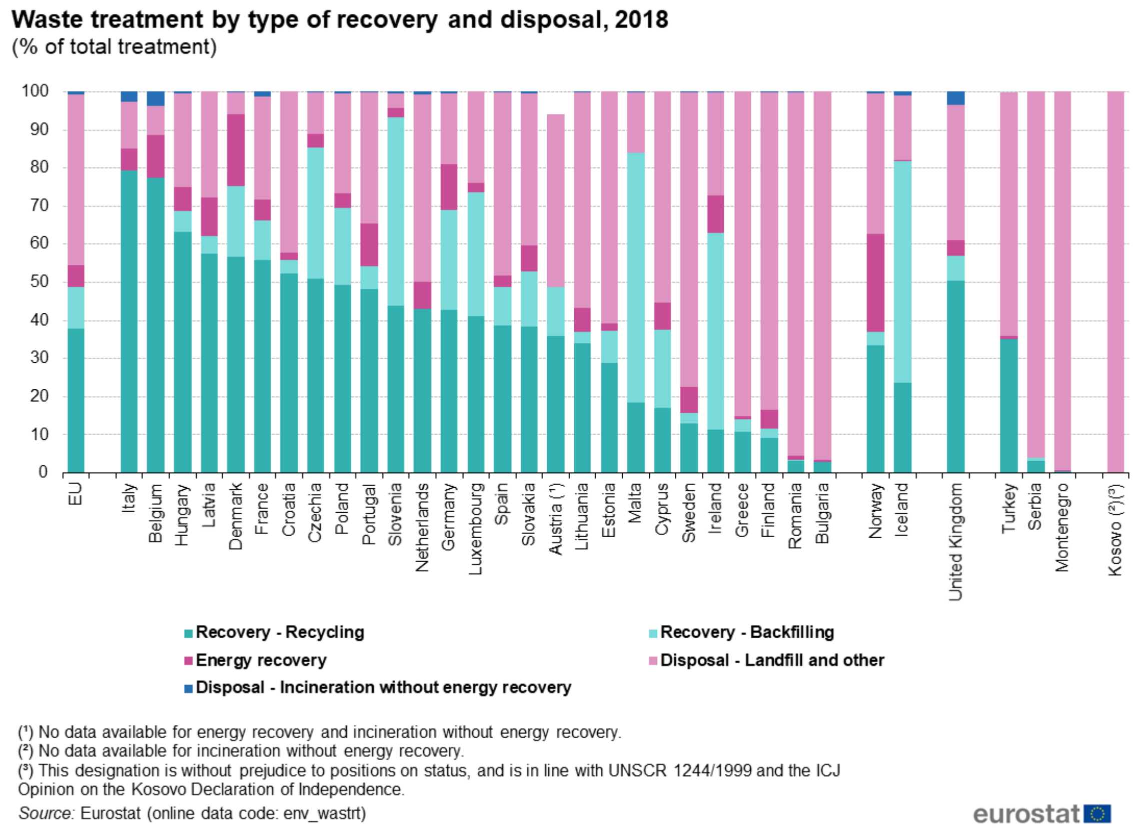


Figure 4 elaboration by the author / source: "What a Waste 2.0 A Global Snapshot of Solid Waste Management to 2050 Silpa Kaza, Lisa Yao, Perinaz Bhada-Tata, and Frank Van Woerden / world bank group" Waste Generation by Region / Share of waste generated by region percent.



taken from: Eurostat / Waste treatment by type of recovery and disposal, 2018 (% of total treatment) figure 5

Writers note:

Look at the "waste treatment by type and disposal" chart composed of the numerical data throughout the EU countries. When it comes to waste treatment, landfilling is one of the easiest and unfortunately ineffective treatment methods for various kinds of solid wastes, including municipal wastes. However, according to the "Eurostat" research in 2018, 50% of European Union countries still use landfills. Therefore, we must see other disposal methods such as energy recovery, backfilling, recycling.

It is vital to reduce the nonadditive methods such as landfills and incineration without energy recovery methods. It's essential to understand the big difference between treating waste as disposal and seeing if it is an excellent opportunity to gain, recover energy, and contribute to the environmental system.

2.4.1 how does Italy manage the waste?

Legislative Decree 22/97 issued in 1997 is the most important part of Italian waste legislation. It contains the national waste management system, defines the responsibilities of the actors involved, introduces targets for separate collection of municipal waste, establishes the National Packaging Consortium, and provides the progressive replacement of the old waste tax with a new waste tariff.

According to the published report of Eurostat in 2012, the generation of MSW[1] topped in Italy in 2007, with 32.5 million tons, and has since then decreased to 32 million tons in 2010.

Italy has regulated the price to discourage the use of plastics, and it has been accepted through the governmental court. One euro to 45 cents per kilo plastic tax in January 2020 has been postponed due to the Covid-19 pandemic. Legislative decree 22/97 also addressed the price imbalance between virgin plastic and recyclables.

1 Abv. Municipal Solid Waste

Besides, because of tough conditions in Italy, some of the garbage is now being rerouted to Central and Eastern Countries like the Czech Republic and Romania, which are battling the phenomenon together with the NOE[1] as part of the EU-funded Opfa Waste project. (Interpol report "alerts to the sharp rise in plastic waste crime" 27 august 2020).

President of Assorimap[2] Walter Regis, the federation of Italian recyclers, described the crisis as a watershed moment for Italy. "China is closed to imports, and now we have two options: either we find new countries to ship to, or we seize the opportunity to rethink the system." A first step would be limiting plastic production to high quality materials. The idea is to cut down on the amount of plastic being produced and sold, making scenes like in that Turin warehouse much rarer.

"We need to redesign products upstream to reduce the waste," said Justine Maillot, consumption and production campaigner at Zero Waste Europe. "If a product is not recyclable using the infrastructure that is currently available, then it should not be on the market at all."

According to the data provided by Province in Turin (2009), the city area has a population of about 2.25 million inhabitants, the annual C&D production is 1.8 meters and recycling services hold an overall processing capacity of 1.84 Mt. Consistently with the proposed objectives, the main findings of the research results can be summarized as follows:

The LCA of the C&D waste recycling chain in Turin showed that avoided impacts are higher than induced impacts, showing net environmental profits; This supports waste management policies to increase separate collection and recycling.

[1] Abv. Operational Unit for Environmental Protection (NOE).

[2] Associazione nazionale riciclatori e rigeneratori di materiel plastiche.

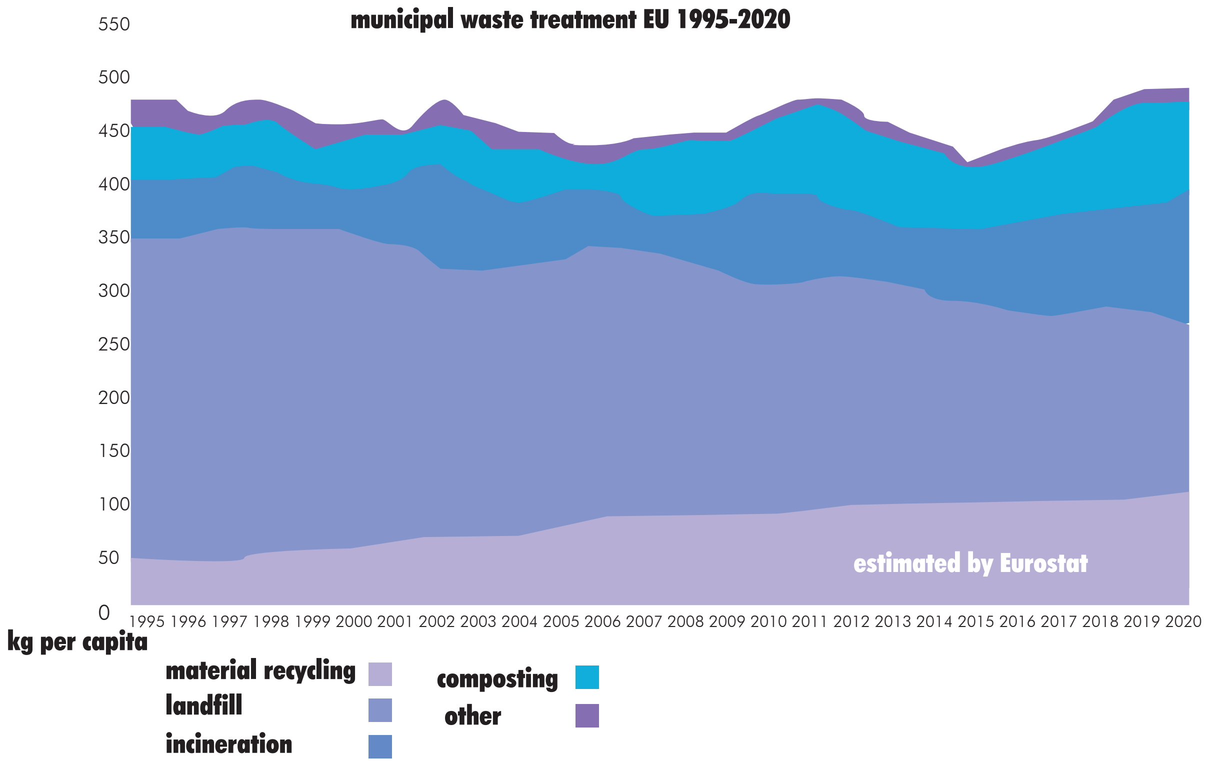


Figure 6 elaboration by the author

source:Eurostat, Municipal waste treatment by waste operations, at national level (ISPRA)

The Sustainable Development Foundation produce annual reports on waste in Italy. In addition, Italy has introduced measures to increase separated collection and recycling since 1997. Using a scientifically solid methodology such as LCA and the adoption of internavtionally recognized indicators have helped criticize C&D recycling for those who believe that the impacts and energy use for recycling can overcome the environmental advantages.

2.5 waste practices

2.5.1 landfill

The landfill is the oldest and most common form of waste disposal, although the systematic burial of the waste only began in the 1940s. A landfill site, also known as a tip, dump, rubbish dump, garbage dump, or dumping ground, is a site for the disposal of waste materials.

A landfill refers to a disposal facility or part of a facility that transports hazardous waste on land or ashore, rather than a land treatment facility, a surface impoundment, or injection as well. A landfill of discrete volumes is a hazardous waste landfill that uses liners to isolate fragments from adjacent cells or wastes.

Writer's note:

Despite the development of novel technologies for treating hazardous waste, land-filling remains the technology of choice, at least for now. The land is a freely available commodity in many countries, and non-productive land may frequently be used for waste disposal. In many cases, industrial enterprises can save transportation expenses by using the region nearby or on-site. Reclaiming specific areas for recreational use also has potential.

In addition, landfills take up space, polluting the air, water, and soil, while incineration releases pollutants into the atmosphere.

2.5.2 biomass burning

Our civilization produces large quantities of waste, municipal as well as industrial. Therefore, thermal processing is also possible for use in boilers as co-firing. Although there is a separate field of boiler technology for garbage incineration, the boilers used in the industry were initially being developed for this purpose.

Biomass has positive and negative consequences for energy. According to the U.S. Energy Information Administration, Biomass and biomass biofuels constitute alternate energy sources for fossil fuels, such as coal, petroleum, and natural gas. The consumption of carbon dioxide (CO2), a greenhouse gas[1] , as fossil fuel and biomass. But biomass plants are virtually as high as CO2 through photosynthesis as when the biomass is consumed, and biomass can become a carbonneutral energy source when it is produced.

About burning wood: Wood and wood pellets and charcoal can substitute fossil fuels for heat and cooking and decrease overall CO2 emissions. Wood can be obtained from the forests, woodlands diluted, or urban trees sunk or cut.

1 Greenhouse gases are both natural and anthropogenic gaseous components of the atmosphere that absorb and emit radiation of certain wavelengths within the infrared radiation spectrum emitted by the Earth's surface, atmosphere, and clouds. Due to these features, they cause the greenhouse effect.

Complex pollutants such as carbon monoxide and particulate particles are contained in the wood smoke. Modern wooden fireplaces, pellet stoves, and fireplaces inserts can reduce the number of burning wood particles. Wood and coal are significant cooking and heating fuels in developing countries, but when harvested more quickly than trees, wood gets deforested.

In waste to energy plants, combustion of municipal solid waste (MSW) or waste could lead to less waste entering landfills. On the other hand, burning rubbish causes air pollution and discharges chemicals and materials into the air. Certain chemicals can be dangerous if humans and the environment do not adequately manage them.
"The U.S. Environmental Protection Agency (EPA), which uses waste energy plants for air pollution control equipment such as scrubbers, cloth filters, electro-purposes' to collect atmospheric pollutants, implements rigorous environmental regulations."

2.5.3 co-incineration plant and its definition

"Co-incineration plant" denotes any plant that employs waste as a regular or extra fuel, whose principal objective is the generation and production of energy and waste for disposal. On the other hand, Incineration is a waste procedure involving combustion[1] in waste materials of organic compounds. At high temperatures, thermal treatment is defined in incineration and other waste treatment systems. Waste incineration transforms waste into ash, flue gas, and heat.

According to the European Commission, incineration and co-incineration are explained as follows; "Any stationary or mobile technical unit and equipment dedicated to the thermal treatment of waste without recovering the combustion heat generated. It is to be distinguished from a waste co-incineration plant "whose main purpose is the generation of energy or production of material products, and which uses waste as a regular or additional fuel or in which waste is thermally treated for disposal."

1 Combustion reactions are exothermic redox reactions between the combustion fuel and the oxidizing product that result in oxidizing. Through combustion, heat is created. Combustion reactions are phenomena of chemical activity.

2.5.4 anaerobic & aerobic digestion & treatment

The biological processes used in the presence of oxygen are aerobic wastewater treatment. As the dissolved organic quantities of untreated wastewater are preferable for anaerobic treatment, aerobic treatment is commonly utilized as a subsequent step and occurs at an anaerobic level.

Anaerobic digestion is when bacteria, such as animal manure, wastewater biosolids, and food waste break down organic substances when oxygen is absent. In a digester known as co-digestion[1], multiple organic materials can be mixed.

2.5.5 mechanical biological treatment

Mechanical biological treatment (MBT) is a type of waste treatment plant that combines a sorting facility, such as composting and anaerobic digestion, with a kind of natural treatment. MBT systems are intended for the processing of mixed residential garbage industrial and commercial waste.

2.6 reduce-reuse-recycle phenomenon

Reducing sources, recovery, recycling, and reuse of existing materials can assist in diverting building and demolition waste from disposal. You can also buy things and materials used and repurposed. We must do our part to keep as much material out of the dump as possible. The 3 Rs of waste management –Reduce, Reuse, recycle can also implement this approach.

1 Co-digestion is adding to the excess capacity of dairy or wastewater streams rich in electrical organic waste material (e.g., fat, oils, and grease (FOG) and/or food waste.

Writers note:

As previously mentioned throughout this research, as humans, inevitably, we are in a cycle of producing and creating wastes. Therefore, it is mandatory to find a solution about the usage and consumption of the raw materials that we are extracting from our mother nature. The raw materials that we are using for our day-to-day products such as medical, cosmetics, construction materials, etc.; we must understand that these materials are not infinite, and we must change our perspective that everything is replaceable. Each element that we have on this planet relates to a delicate chain. Therefore, our purpose should not be focusing on replacing the things that we are enormously eliminating and decreasing from the earth; it should be finding a solution on how to properly manage these resources, regarding the increasing population and the need for materials, nourishment, water, oxygen, etc. As a result, the 3 R’s (reduce, reuse, and recycle) of the waste management concept is one of the most important phenomena for our current situation.

2.7 WMP & WMF (waste management plan – waste management form)

The requirement for a Waste Management Plan (WMP), or a Waste Management Form (WMF), to be completed and submitted before the start of the project includes most of the construction and demolition (C&D) diversion ordinances. The primary purpose of a WMP or WMF program is to estimate the number of C&D debris produced by the project and how the materials are handled. A project applicant will need to estimate how much C&D is generated and how, where, and how much they will divert.

The applicants' plans for deconstruction and salvage before demolition could also be included in the WMP for demolition projects because many projects represent potential sources of C&D debris that could be recovered before demolition deconstruction and salvaging.

However, the specifications in the project should allow sufficient time for diversion activities to be undertaken before demolition (e.g., deconstruction time) or before construction (for example, time for salvaging after destruction).

"Deconstruction": In the preparation of the WMP, applicants shall consider deconstruction, to the extent practicable, to be permitted for building and demolition involving the removal of any or all existing structure, thereby making available to rescue material generated before recycling or landfilling.

2.7.1 types of information in a WMP & WMF (waste management plan & form)

According to the CalRecycle[1] waste management program;
(a guide for creating a layout.)

- Project name and address.
- Job permit number.
- Date(s). (demolishment & construction schedule)
- Building type.
- Project cost.
- Size (square feet).
- Applicant's name and contact information including address.
- Type of permit or project (construction, demolition, renovation, deconstruction, land clearing, and grading).
- Calculation of deposit (for size or cost, etc.).

1 California's Department of Resources Recycling and Recovery (CalRecycle) brings together the state's recycling and waste management programs and continues a tradition of environmental stewardship.

- List of materials and estimate of amounts to be generated for each material type.
- Estimate of amount diverted (can separate into reuse & recycling categories) vs. amount to be landfilled.
- Recycling facilities receiving materials.
- Disposal facilities.
- Hauling company.
- Signed statement of intent to divert.
- Application signature.

2.8 benefits of reducing the disposal of C&D

• Creating jobs and economic activity in the recycling industry and providing increased business opportunities in the local community, mainly if deconstruction and demolition are applied selectively. For example, "EPA[1] 's 2016 Recycling Economic Information (REI) Report showed that in 2012 the recycling of C&D materials created 175,000 jobs."

• On the other hand, it is possible to reduce total building project costs by avoiding purchasing/disposal and donating recuperated material to charitable organizations that provide a tax benefit. Also, it could be reused on-site and reduce the cost of transport.

• Conduct fewer waste disposal facilities, which can reduce the environmental problems involved, and as a result, it will maximize the recovery of materials.

• In combination with traditional demolition methods, communities can create local economic activities around the production or reprocessing of reclaimed materials.

• Offset the environmental impact of extracting, consuming, and producing new material of virgin resources, including the landfill spaces' conservation.

1 Abv. U.S. Environmental Protection Agency

Writer's note:

There are many limitations and obstacles to the waste management system but reducing these environmentally harmful materials is a credential. Especially for third world countries, finding a proper market recycling facility or organization is grueling. In addition, waste reuse will require aggressive marketing efforts to target those markets for waste to be sold at reasonable prices and recycled material to be recycled.

The government and the regulatory authorities should monitor this process, not just for security. These authorities have also increased the trust between the so-called reliable source and the user. The tricky thing about these markets is to focus on investing such time and funding in establishing relationships, tracking the changes in prices, and developing into a reliable material supplier. Construction waste materials can continuously be absorbed. Lack of customer awareness and ownership, lack of qualified employees, and ultimately adequate education and training for employment could be the other main problems for this subject. Reducing the C&D waste should be solved by creating proper on and off-site waste management. This topic could be the first intention for the Governments; to mitigate this problem, especially for the issues on landfills.

2.9 c&d waste hazards

If construction and demolition wastes are not managed properly, they may cause a major urban threat. As known, construction waste is the main source of air pollution. The rampant illegal disposal in lakes and rivers destroys our water bodies. The designated landfill site is enormous, with billions of dollars worth of land buried under C&D waste.

Structures and areas that are not secured and abandoned can be used as illegal dumping sites (also called fly dumping or midnight dumping). Dumping may result in the presence of household waste, decaying cars, used tires, etc., left behind in abandoned buildings. This action can cause environmental and health issues. According to the "an illegal dumping prevention guidebook. (EPA 905-B-97-001) and IDEA (Illegal Dumping Economic Assessment) Cost Estimating Model User's Guide (EPA 905-B-00-002). These are harmful materials that can typically be found in a house.

- Asbestos[1] containing materials (ACM)
- EPA guidance and applicability determinations on the National Emission Standards for Hazardous Air Pollutants for asbestos (the asbestos NESHAP)
- Mercury containing devices
- Lead based paint[2]
- PCBs in caulk[3]
- Household hazardous waste
- Light systems
- Mercury
- PCBs
- Mold
- Refrigerant containing appliances
- Electronic waste (e-waste)
- Automobiles Tires
- Pharmaceuticals and controlled substances
- Furniture, mattresses, and household garbage's

---

[1] Asbestos is a naturally occurring mineral composed of soft and flexible fibers that are resistant to heat, electricity, and corrosion.

[2] Lead is a highly toxic metal that may cause a range of health problems, especially in young children.

[3] Caulk containing potentially harmful polychlorinat-ed biphenyls (PCBs) was used in many buildings in the 1950s through the 1970s. PCB caulk was com-monly used to seal the joints of brick, masonry, stone, and metal window frames. PCBs in caulk have not been found in single-family homes. source: EPA.

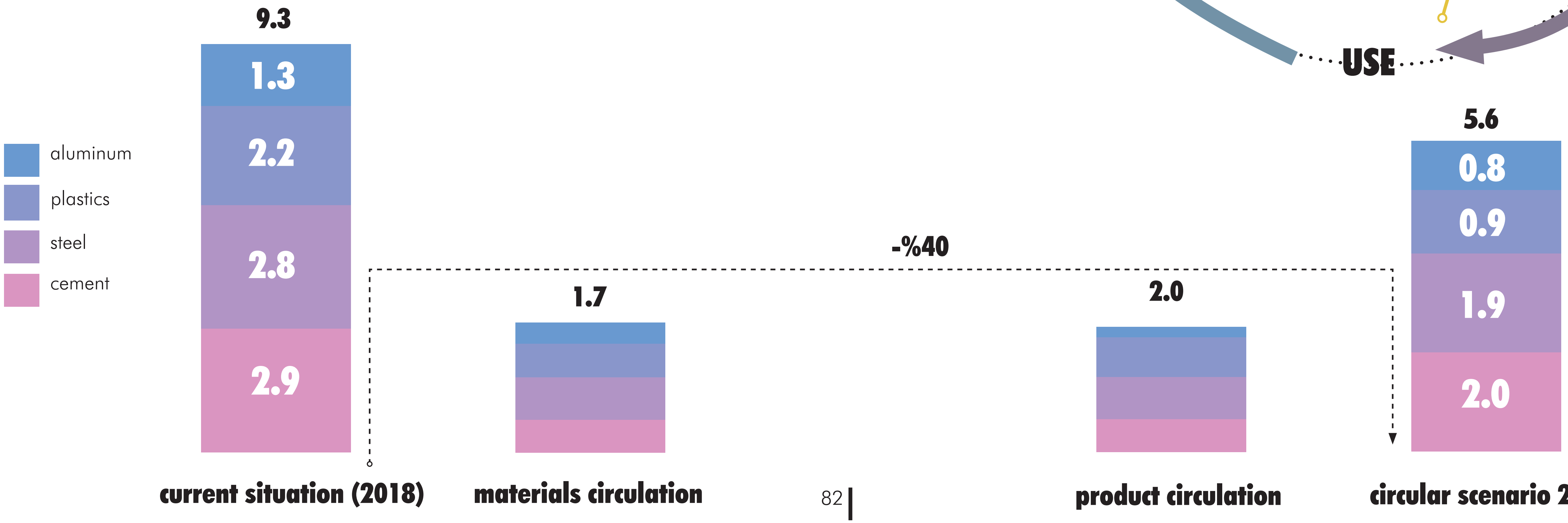
2.9.1 circular economy (recovery system)

A circular economy's environmental benefits go far beyond lowering greenhouse gas emissions. Recent high-profile international studies show that circular principles such as reducing food waste, improving plastic waste management, and integrating solid waste and sewerage systems are required to achieve the transformative changes required to prevent significant biodiversity loss[1] and protect human health.[2] Victoria's current attempts to combat plastic waste and other trash will be aided by a circular economy. After just one usage, 95% of the value of plastic packaging material is lost.[3] This material has the potential to leak into the environment, contaminating land, streams, and oceans, with negative consequences for human health, ecosystems, and wildlife. Promoting reuse, recycling, and phase out of single use and disposable items decreases the environmental impact of litter in a circular economy.

[1] Díaz, Settele, and Brondízio, Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - advance unedited version. 2019, IPBES Secretariat: Bonn.

[2] Williams, M., R. Gower, and J. Green, No time to waste: Tackling the plastic pollution crisis before it's too late. 2019, Tearfund: Teddington.

[3] Ellen MacArthur Foundation and McKinsey & Company, The New Plastics Economy 2016, MacArthur Foundation London.

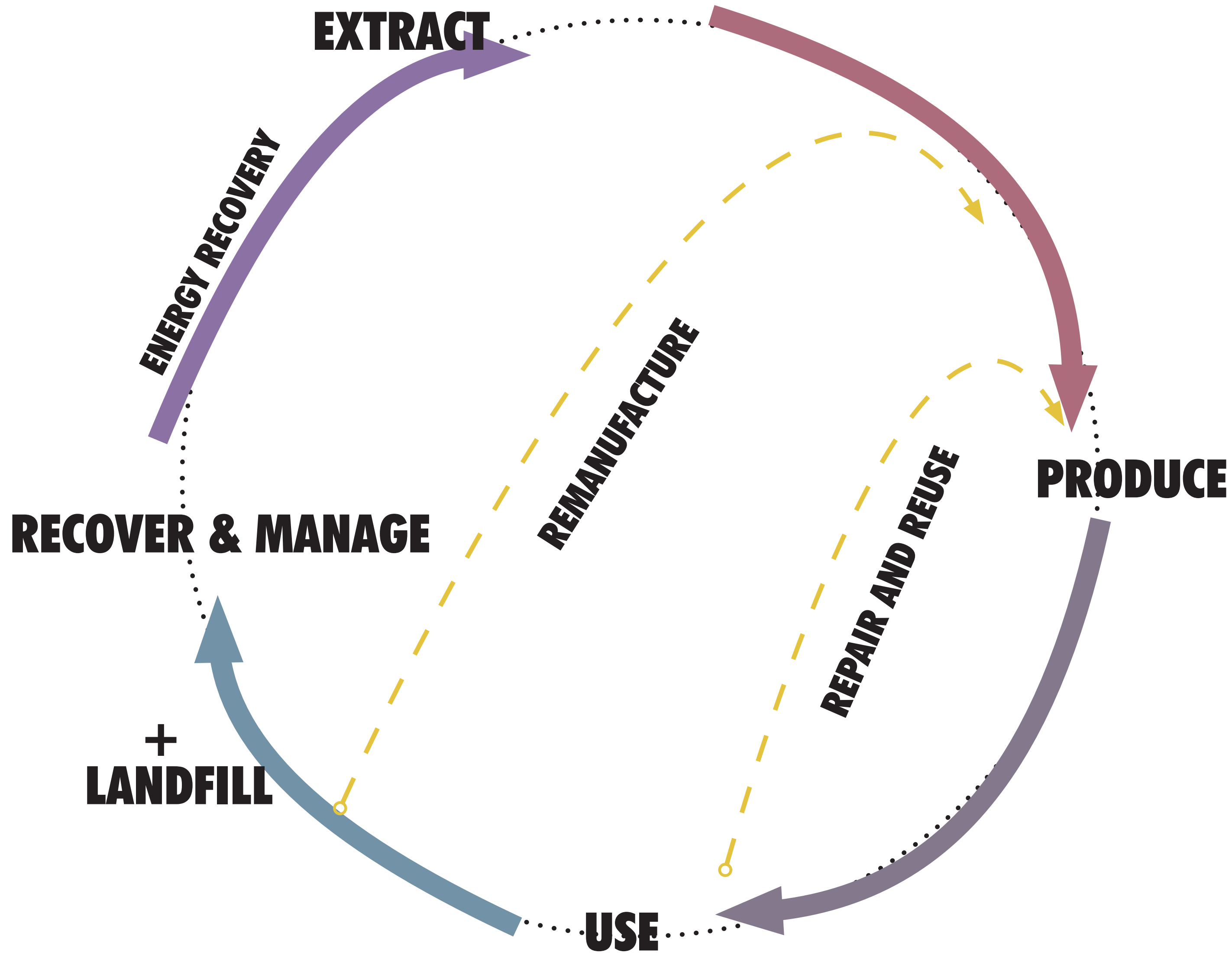


Global emissions reductions potential from a more circular economy by 2050
(gigatonnes of CO2-e per year)

Source: Energy Transitions Council (2018)

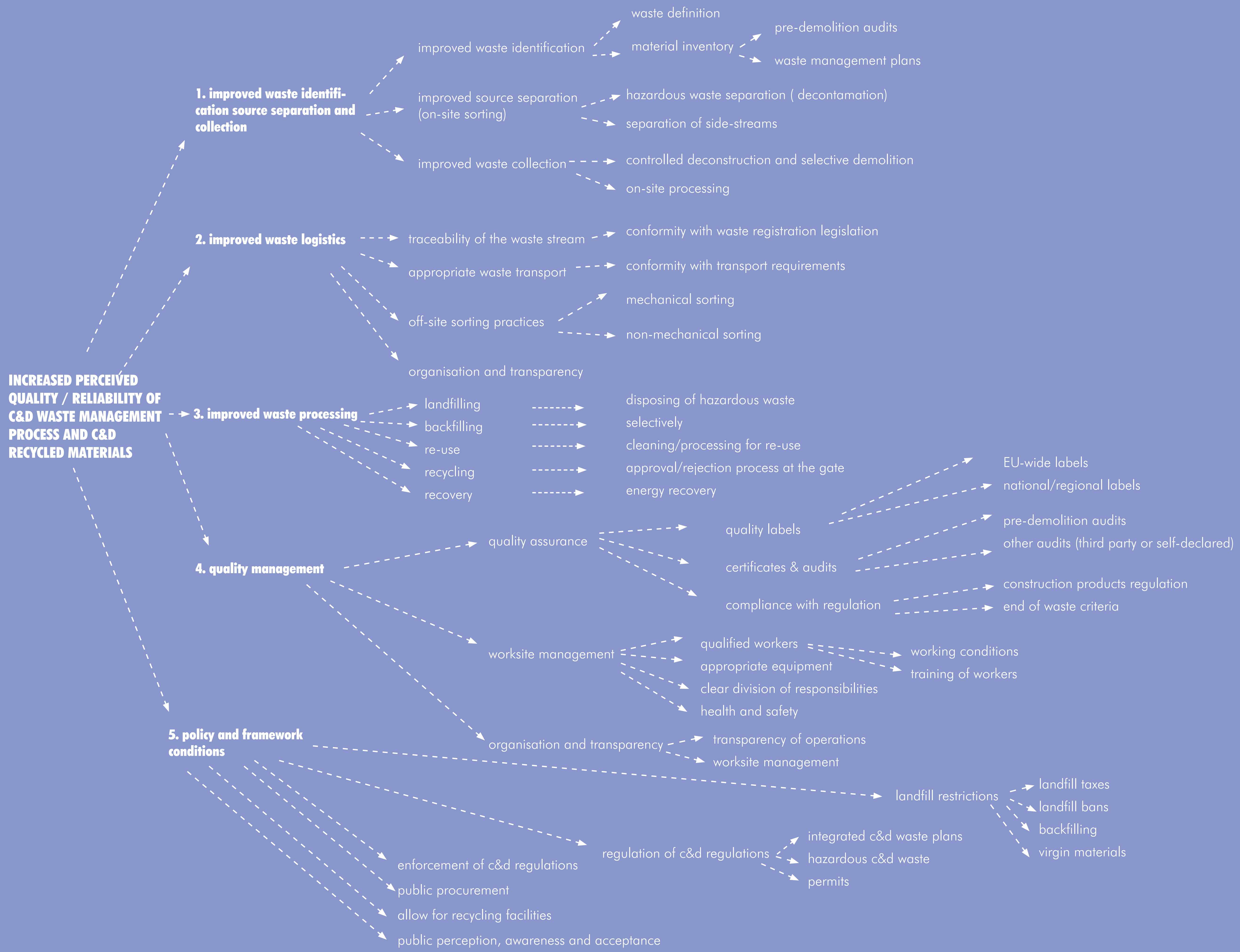
elaboration by the author figure 7

A circular economy for RECVOERY SYSTEM



Annex 2

The objectives and actions tree of the EU C&D Waste Management Protocol



3

waste management: hierarchy and treatment practices per waste category

3

Waste management: hierarchy and treatment practices per waste category

3.1 introduction

Resource recovery, the second priority, maximizes reuse, recycling, reprocessing, and energy recovery options. When avoiding and reducing waste isn't an option, the next best option is to reuse the materials without further processing, which avoids the costs of energy and other resources associated with recycling. Many household and industrial items, for example, can be repaired, repurposed, sold, or donated to charity. Regarding these pieces of information, it is crucial to under-stand how waste management and waste hierarchy works.

Recycling (processing waste materials to make the same or different products) and reusing (processing waste materials to make the same or other products) keep materials in the productive economy and benefit the environment by reducing the need for new materials and waste absorption. Where further recycling is not possible, it may be possible to recover the energy contained in the material and reinvest it in the economy if the community agrees.

Some materials may not be suitable for reuse, recycling, or energy recovery, and instead, need to be treated to stabilize them and reduce their environmental or health impacts.

3.2 waste hiearchy

The waste hierarchy is a set of priorities for resource efficiency that underpins the Waste Avoidance and Resource Recovery Act 2001's goals.
The waste hierarchy is a tool for evaluating processes that protect the environment while reducing resource and energy consumption, from the most beneficial to the least helpful actions. The goal of the waste hierarchy is to get the most practical benefits out of products while producing the least amount of waste.

1. Avoidance is at the top of the waste hierarchy, which includes actions to reduce waste generated by households, industry, and all levels of government.

2. Resource recovery includes reuse, recycling, reprocessing, and energy recovery, all following the most efficient use of recovered resources.

3. Environmentally responsible management of all disposal options.

Avoiding and reducing waste generation is the highest priority, which encourages the community, industry, and government to reduce the number of virgin materials extracted and used. The goal is to increase efficiency and reduce waste by adopting behaviors such as.

- Choosing items that require the least amount of packaging or resources to manufacture
- Avoiding single use or disposable products
- Purchasing recycled, recyclable, repairable, refillable, or biodegradable products.
- Rather than throwing away leftover food, make use of it.

The directive establishes a five step hierarchy of waste management options that the Member States must implement in this priority order. Waste prevention comes first, followed by reuse, recycling, recovery (including energy recovery), and safe disposal as a last resort.

The hierarchy, in a sense, determines the elements that can be burned and from which WDF (Waste Derived Fuel) will be generated. Thermal treatment, and thus combustion, is the last stage of waste management. It's in the bottom tier therefore it only applies to the garbage that can't be put to better use.

Waste is currently used as a raw material in the manufacturing of RDF[1] (refuse-derived fuel). The "recovery" stage can also result in the production of fuel. The solid recovered fuel (SRF[2]) is the result, and it is more homogeneous, less contaminated, and has a higher calorific value than RDF. A classification document for recovered solid fuels has been prepared in the EU [94][3].

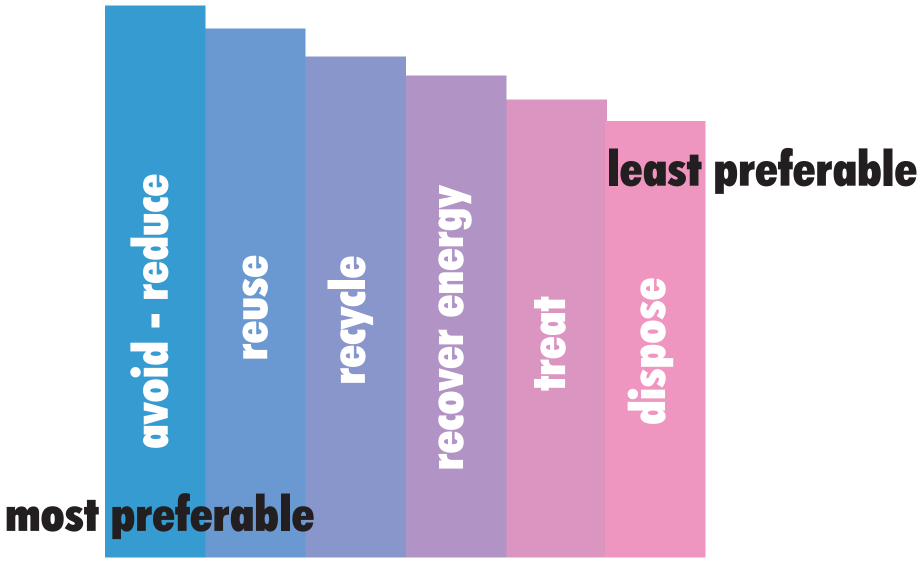


Figure 8: adapted from source/ Nagapan S, Rahman I A and Asmi A 2012 Construction waste management: Malaysian perspective Int. Conf. on Civil and Env. Eng. Sustaina-bility (IConCEES) (Johor Bahru) vol 2 (Batu Pahat: Penerbit UTHM) pp 299-309

[1] Refuse derived fuel (RDF) is a fuel produced from various types of waste such as municipal solid waste (MSW), industrial waste or commercial waste. RDF consists largely of combustible components of such waste, as non-recyclable plastics (not including PVC), paper cardboard, labels, and other corrugated materials.

[2] SRF (Solid Recovered Fuel) is a fuel produced by shredding and dehydrating solid waste, typically consisting of combustible components of municipal solid waste (MSW) such as Biodegradable waste, food and kitchen waste, green waste, paper. Inert waste; construction and demolition waste; dirt, rocks, debris.

[3] DIRECTIVE 2014/94/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 22 October 2014 on the deployment of alternative fuels infrastructure

3.3 what is considered debris?

C&D waste is a significant source of secondary raw materials, primarily concrete, wood, masonry, drywall, glass, plastics, metals, and other materials. The composition is highly variable, as can be seen.

This is due to the various demolition techniques used, the lack of adequate treatments for RA production, and the high variability of the materials used in building construction over time. As a result, waste and debris from building construction and demolition can contain hazardous materials. Although many of these materials are not necessarily hazardous, they can have an impact on the environment and water if improperly managed.

In addition to CDW from existing buildings that may contain lead, asbestos, and other toxic materials, new building construction materials may generate treated wood, paint, and solvent wastes, glues and roofing tars, and other potentially harmful materials. Most of these CDWs are processed in dedicated mobile plants that perform rough treatments like single crushing and simple screening. As a result, the RA (recycled aggregate) produced has highly variable physical and chemical properties that frequently fail to meet the environmental and technical standards required for use as aggregates in building construction.

The final quality of recycled mavterials, on the other hand, is affected not only by the treatment techniques used but also by the demolition activities. Indeed, separating CDW into homogeneous fractions more effectively during the demolition phase will result in a more efficient and clean recycling process.

Construction and demolition waste should ideally be subjected to presorting potentially hazardous materials (e.g., by selective demolition), ensuring that the CDW consists primarily of non problematic materials. Chromium and sulfate are the most critical compounds in RA leachates in terms of environmental and chemical aspects of composition and contaminant release. Ceramic materials and partially carbonated samples release the total chromium, whereas gypsum based materials and other CDW compounds (such as mortar particles) release the most sulfate.

As a result, because there is still a lot of uncertainty about the qualitative characteristics of CDW and RA, the current study aims to evaluate and develop new knowledge about the aspects of these materials related to their substantial heterogeneity, which makes a recovery difficult.

3.4 aggregate

(high value recycled sand and aggregates)

The construction industry generates a large amount of waste that must be salvaged and utilized as recycled aggregates (RAs) to replace natural aggregates in part or entirely. Recycling helps to reduce waste and energy consumption, resulting in a more sustainable building sector.
Due to the porous nature of the RA and the old adhesive cement mortar on the surface of the aggregates, RA concrete has lower compressive and flexural strengths and a lower modulus of elasticity and fracture.
With increased RA content, capillary shrinkage, water permeability, and water absorption increase. A proper mix design incorporating additional cementitious ele-ments, on the other hand, can counteract the reduced performance.

image 12 source/ google images

CA6 recycled PCC

3.4.1 recycled aggregate

The second way to make concrete more sustainable is to use recycled materials instead of natural aggregates. Because aggregates have a lower carbon footprint than cement, this technique may appear to be less effective than replacing cement with SCMs.[1] However, it is worth noting that indicators for land use are rarely used in LCA, resulting in an underestimation of environmental problems such as soil depletion and topographical change, both of which are directly related to aggregate consumption.

1 Supply Chain Management - A generic term applied to the practice of volume consolidation or leverage. Demand for identical or similar categories is grouped together to offer the buyer greater economies of scale when negotiating with potential suppliers.

Furthermore, aggregates typically account for around 70% of total concrete volume, implying a significant amount of material that may be saved through effective recycling procedures. C&DW, one of the most abundant wastes created worldwide, makes recycled aggregates. C&DW encompasses various materials from several operations, such as construction, restoration, demolition, land clearance, and even natural disasters.
Due to the lack of a consistent description of its ingredients, it is often difficult to determine the volume of C&DW produced annually in a single state or globally. As a result, obtaining reliable estimates of this waste stream is challenging; more complications arise when determining the recycling rate of this material.
When C&DW is formed because of a calamity, such as an earthquake, tsunami, or tornado, this single event may be responsible for 5 to15 times the region's annual waste output rate (Reinhart & McCreanor, 1999). In these circumstances, the waste's composition is determined mainly by the disaster's structural type and the event itself. Hurricane debris, for example, is typically highly mixed, whereas earthquake debris in a historic district is primarily made up of stone or brick masonry.

3.4.2 situation in Europe

C&DW output in Europe was predicted to be at 868 million tons in 2014, accounting for roughly 34.7 percent of total waste streams, with a composition that differed significantly by country. Currently, the rate of C&D recycling and material recovery varies by state (between less than 10% and over 90%), even though it is projected that in the not too distant future, the recycling rate will be roughly the same for all European countries.
Indeed, Article 11.2 of the Waste Framework Directive (2008) specifies that "The Member States shall take the appropriate steps to ensure that a minimum of 70% (by weight) of non hazardous construction and demolition waste is recycled by 2020." However, because virgin aggregates are widely available (at least on a regional or national scale), recycled C&D debris is frequently used as road base or subbase material, as recycled aggregates are generally less expensive or "valuable" than the high quality concrete aggregate.
Green Public Procurement (GPP) was introduced in Europe to encourage the use of recycled aggregate and increase the recycling rate of C&D Waste. GPP is a voluntary instrument that helps to stimulate a critical mass of demand for more sustainable goods and services that would otherwise be difficult to obtain.

In Italy, for example, concrete structures constructed under a GPP must contain at least 5% recycled materials by weight (i.e., 120 kg/m3), and "0-km" goods should be chosen above others. (Sustainability of Construction Materials (Second Edition), 2016).

3.5 concrete & recycled concrete aggregate

C&D waste is transformed into recycled aggregates in treatment plants, which can be fixed or mobile and is equipped with screens, crushers, and magnetic separators. The goal is to reduce debris dimensions, separate ferrous elements and other pollutants, and finally achieve the required grading. From a technical standpoint, extensive study has been conducted to determine how the usage of recycled aggregates affects concrete performance. But, first, it's essential to figure out what kind of recycled aggregates can be made, based on their composition and grading:

- RCA (recycled concrete aggregate), which is primarily made up of coarse concrete particles.
- Recycled masonry aggregate, which is primarily made up of coarse brick particles; and
- Fine aggregate (FA) is made up of solely fine particles and is made up of a mix of coarse concrete and brick particles (maximum size less than 4 mm).

The composition of recycled aggregate and its grading significantly impact the qualities of recycled concrete; this distinction is crucial. EN 12620 (2008) and EN 206 are two standards that regulate recycled aggregates in concrete (2016).

table 1.0 adapted from / maximum percentage of replacement of course aggregates (% by mass) according to EN 206 (2016).

	EXPOSURE CLASS			
recycled aggregate type	**X0 %**	**XC1 XC2 %**	**XC3, XC4, XF1, XA1, XD1%**	**ALL OTHER EXPOSURES CLASSES**
TYPE A: (Rc90, Rcu95, Rb10-, Ra1-, FL2-, XRgl-)	50	30	30	0
TYPE B: (Rc50, Rcu70, Rb30-, Ra5-, FL2-, XRg2-)	50	20	0	0

Type A recycled aggregates from a known source may be used in exposure classes to which the original concrete was designed with a maximum percentage of replacement of 30%. Type B recycledaggregates should not be used in concrete with compressive strength classes C30/37.

Table 2.3 shows the maximum replacement ratio allowed per EN 206 (2016), based on the aggregate type and concrete exposure class. For example, fine aggregate isn't permitted in any concrete structural applications, regardless of the structure's strength class or exposure.

Writer's note:

Breaking, removing, and crushing concrete from an existing place to generate a new, reusable material is what recycling concrete entails. Recycled concrete has numerous advantages and applications, and it is frequently the best alternative for concrete removal.
Whether you work in the construction industry or just want to know what to do with that old concrete slab in your garden, the following material will give you an overview of the uses and benefits of recycled concrete.

Concrete that is no longer needed can be recycled and used to make recycled aggregate. Recycled aggregate is typically used as a subbase, but it can also be combined with virgin materials and utilized as an aggregate in fresh concrete.

CA6 recycled PCC[1] , and Grade 8[2] recycled aggregates are common recycled concrete aggregates. They're widely employed as a road base, parking lot base, and driveway base, as well as backfill and shoulder stone.
Concrete recycling has numerous advantages economically and for the environment. Constructionrelated debris landfill costs are continuing to climb, and the cost of moving the material from one location to another is an extra expenditure. Recycling saves money by reducing the amount of money spent on transportation and disposal.
In addition to increased expenses, landfills are becoming increasingly regulated, making it difficult for many contractors and homeowners to dispose of certain materials, such as concrete. You won't have to worry about landfill rules if you recycle concrete; instead, you'll be allowed to dispose of your materials in a reusable manner.

---

1 CA6 is commonly used for driveways, as a base stone for roads, building pads, and parking lots. It is also commonly used as a trench backfill.

2 Grade 8 is the most popular crushed stone choice for subbases and has light grey color. CA6 designates that most crushed stone is 3/4 and smaller containing fines. Grade 8 designates that it is made from limestone.

Concrete recycling is also incredibly environmentally friendly. Concrete debris takes up a lot of space in landfills, and many of them can't handle it because of its size and volume. Recycling these materials keeps them out of landfills and allows them to be utilized in various ways.

Recycling also helps the environment by conserving energy that would otherwise be used to mine, process, or transport new aggregates. Using recycled aggregate has its own set of advantages. CA6 recycled, for example, is 15% lighter than virgin CA6, which means you'll get 15% more volume per ton with your order.

3.6 wood (how to maintain the durability of the material & how to apply in the designs)

Wood wastes mainly originated from forestry and C&D sites activities. Among them, three types of wood waste can be identified:

- untreated wood waste
- lightly treated wood wastes
- highly treated wood wastes

Firstly, untreated wood waste is raw wood which is considered biomass. Secondly, lightly treated wood wastes include woods treated by gluing or coating treatments. And the third one, highly treated wood wastes, has wood that was issued from impregnation treatments with creosote, which are considered hazardous wastes.

According to the regulation, the management of these wastes in Europe is oriented towards recycling and less elimination. Landfilling, incineration, particleboards, and combustion are the four main methods used to treat wood wastes.

Salvaged wood from a construction site

image 13 source: google images

Moreover, studies show that around 4 million tons of wood wastes are issued from C&D sites activities. Recent studies prove that 70% of them are hazardous treated wood, but also specify wood has good qualities for sustainable energy production. [1]

It is certain that several advantages would be derived from this management. First, it appears that there is a real potential for wood waste recovery as fuel. Second, the traceable management of wood waste from C&D and controlled contamination from recovery methods could reduce the environmental impact of human activities. Third, it might lead to ensuring stable economic growth and job opportunities.

While complete deconstruction is the preferred and most environmentally friendly technique of removing or upgrading a structure, it is not always practicable due to the type of structure and its components. According to the Department of Housing and Urban Development; The "stick-by-stick" architecture of wood-framed buildings, especially those with heavy timbers and beams or unusual woods like Douglas fir, American chestnut, and old growth southern yellow pine, lends itself well to the deconstruction process. However, these types of wood can also be used in a variety of ways.

Writer’s note.

About how to maintain the durability of the material and how to apply it in the designs, it is essential to understand that with minimal maintenance, most timber structures will perform their intended purpose for the duration of their service life. However, all the aspects that determine the wood's endurance must be correctly examined for this to happen. Regardless of the endurance qualities of the chosen wood, the designer must consider the level of care, repair, or replacement that may be required during the structure's design life. When designing longlasting timber constructions, it's essential to consider the qualities of the building materials and the preservation treatments that can be used on them. It also includes a review of potential service hazards affecting the timber building components. According to the national association of forest industries, there are some directives on designing the building for durability.

1 Bowyer. (1995). Wood and other raw materials for the 21st century. For Production, 45(2):17024

There are two key factors; the performance requirements of the element or structure combined with the factors affecting the durability of the component or system during on and off site construction. It is necessarily recommended that assessing the potential durability of the timber is assisted by relating the timber's required performance standards. (Historical test data).

3.7 design process

- Determine specific application

estimate required performance by considering.

1. required life
2. required reliability
3. initial versus ongoing cost

- Determine what hazards, if any, present
- Determine the hazard level

- Develop specifications and details to satisfy the above by considering factors affecting durability

1. timber members, elements, cladding, etc.
2. joints

- Determine required natural durability class and combination of required natural durability and preservative treatment level of the material.

- Establish correct detailing and specifications as follows;

1. Detailing for protection from insects or marine borers
2. Architectural detailing
3. Member type and glue specification
4. grade, size, and moisture content
5. finishing and maintenance

Most of the wood is employed in situations where its long-term viability is assured. Timber has performed well in the face of weathering, moisture, insects, and harsh chemicals. For ages, it has worked remarkably effectively. However, whether natural or artificial, the dangers that timber may be exposed to should be considered.

These can be summed up as follows:

- deterioration
- Insect infestation
- a fungal infection
- deterioration of chemicals
- deterioration
- creatures from the sea
- fire and other natural disasters
- deterioration of mechanical properties

Suppose unpainted or unfinished wood is exposed to the elements for an extended period. In that case, it will discolor, develop checks and cracks, and become brittle quite clumsy erosion[1] , moisture, and other factors may have caused this deterioration.[2]

The process of drying (leading to shrinkage and swelling of the timber), chemical changes (light impacts, especially UV) freezing, and oxygen) or, in alpine locations, radiation, and oxygen). Surface erosion is a problem for unprotected timbers, and it happens slowly, at a rate of 6–13 millimeters each century. The rate is determined by the type of wood and the degree of decay and exposure.

1 the process of eroding or being eroded by wind, water, or other natural agents.

2 the process of becoming progressively worse.

application	part	life expectancy	reliability requried SAFETY	application COST OF FAILURE	remarks
temporary structures					
bridges - road diversion, trench shoring, temporary construction props and bracing	all	0.5-1	HIGH	HIGH	very high degree of structural reliability requried
hoarding	structural components	2 to 3	HIGH	LOW	made up 5 to 6 reuse applications
formwork	framework	2 to 3	HIGH	LOW	5 to 6 re-use applicaitons
	sheeting		LOW	LOW	
classrooms transportable	structural framework	10 to 20	LOW	LOW	
PERMENANT STRUCTURES					
farm buildings	all	15 to 25	LOW	LOW	
bridges-roads and rail and wharves	all	20 to 50	HIGH	HIGH	require a very high degree of reliability with respect to durability and structural integrity
domestic construction	framework	+50	LOW	LOW	
	cladding	20 to 50	LOW	LOW	
	add-ons pergolas	20	LOW	LOW	
industrial buildings	framework	50	HIGH	HIGH	usually non-loadsharing
	sheeting cladding etc.	25	LOW	LOW	
commercial buildings	structural	50 to 100	HIGH	HIGH	
	sheeting cladding etc.	50	HIGH	HIGH	
public and institutional buildings, hospitals etc,	structural	+100	HIGH	HIGH	
	sheeting cladding etc.	50 to 100+	HIGH	HIGH	

table 2.0 elaboration by the author: timber design durability / national association of Forest Industries 2003 Edition / Austalian Government forest and wood products research and development corporation

3.8 asphalt (RAP / recycled asphalt pavement)

Asphalt is an utterly recyclable material with great reuse/recycle properties. Using recycled asphalt in the road industry is a cost-effective solution in economic terms, which results in significant savings when implemented.

- According to Europa Infra, which focuses on Infrastructure and Investment matters; Recycled Asphalt Pavement (RAP) is made from excavated asphalt pavement, or when the asphalt is planed with a cold milling machine, pavement screened hard milled material, on the other hand, mined bits of stone can be recycled directly A specific mill is used to compress asphalt pavement.

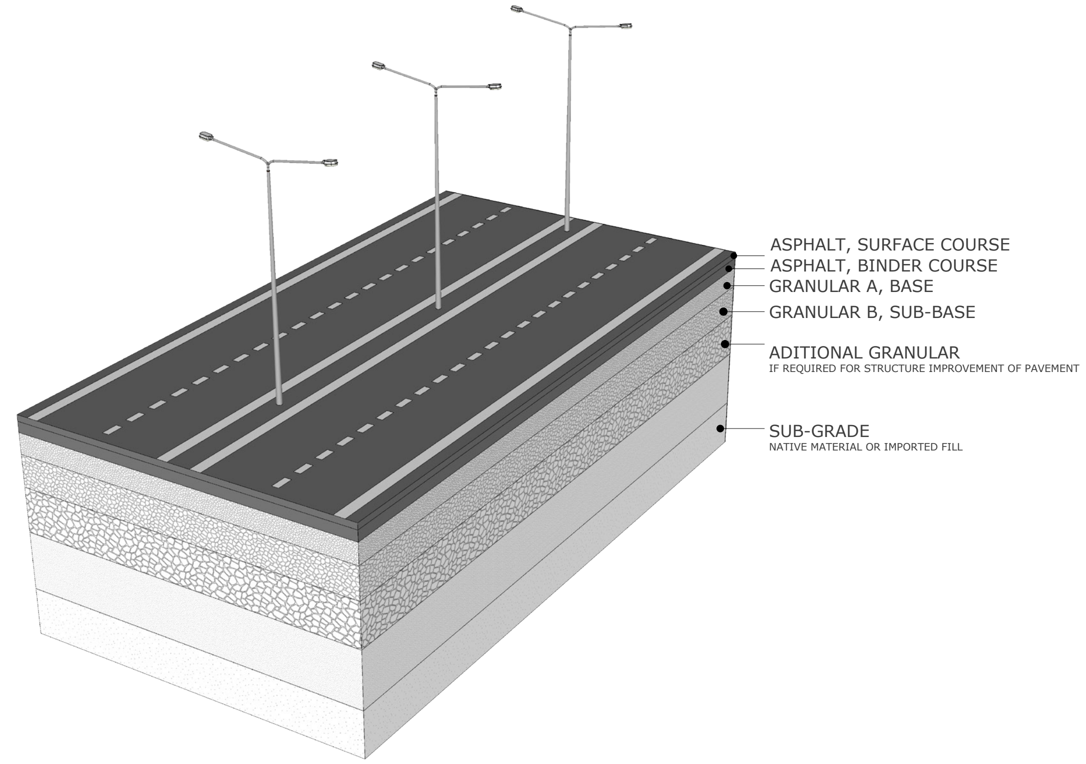


figure 9 created by the author
asphalt construction & material layers

- To ensure that the original grain is preserved, a crusher (granulator) is used. The aggregate size is maintained, but it is excessive and reduces fines and asphalt dust throughout the whole process.

To precise the technologies used in recycling, we should define cold recycling and heat generation. According to studies, cold recycling allows up to 100% recycling and is economical.

Flexible pavement is one of the most common types of pavements. According to statistics, flexible pavement is used on 95 percent of the world's highways. The two most common pavement varieties, flexible and stiff, are distinguished by the binder they use. Portland cement is used as a binder in rigid pavement, while bitumen is utilized in flexible pavement. Aggregates and bitumen are mixed to make asphalt concrete. Based on the gradation of the aggregates, the asphalt concrete mix can be divided into two categories: hot mix asphalt (HMA) and stone mastic asphalt (SMA).

3.8.1 hot mix asphalt

HMA is a type of asphalt mixed with other materials (HMA). Dense or open graded hot mix asphalt (HMA) is available. Dense graded HMA has a wide diversity of particle sizes to distribute through the asphalt concrete mix properly. Furthermore, dense graded HMA is the most widely utilized type of asphalt concrete globally, suiting all traffic conditions. Due to its increased void ratio, which allows the mix to absorb more, open graded HMA is commonly employed in drainage layers.

3.8.2 mastic stone asphalt

(SMA) Stone mastic asphalt (SMA) is a gap graded HMA that is widely utilized in Europe. Because of their superior physical and mechanical qualities, which are essential for the stone to stone contact structure, the aggregates used in SMA mixes are frequently of a greater grade than those used in standard HMA mixes. The high coarse aggregate concentration of SMA provides excellent rutting resistance and increases the structure's lifetime.

Writer's note:

Waste asphalt utilized as a foundational road material or subgrade must be covered with compacted material and enough topsoil to encourage vegetation and reduce water migration through the asphalt product. To promote runoff, the material must be correctly slanted. Because asphalt is a degradable substance, it should not be placed in a location where it can become saturated or influenced by changing groundwater levels. Seasonal groundwater changes must be considered when using the material in the foundation of a road, and waste asphalt must be situated above the foundation's most significant predicted seasonal saturation level.
The material should not be placed in ephemeral drainages or within 100 feet of standing water or groundwater wells.

Waste asphalt is considered helpful when it is used as foundational road material, subgrade, or compacted driving surface. The best results will be obtained when the material is employed and placed shortly after being generated (milled).

Then, the texture is compacted and treated with a rejuvenating agent and chip-sealed application. Paved parking and storage areas; foundational support behind guardrails; paved pullouts (mailbox pullouts, approaches); traffic gravel, County roads, or temporary construction roads; and pavement for drainage ditches to convey stormwater are approved beneficial reuses of the compacted material.

3.9 gypsium

1. What is Gypsum and how can we de-fine Gypsum Board?
    a. What is the difference between other types of construction used boards?

1. It's found mostly in sedimentary deposits and is utilized in the construction industry. Gypsum is a soft sulfate mineral made up of calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$).
A hydrated calcium sulfate mineral that is soft white or grey in color. It is widely mined and utilized as a fertilizer as well as a primary ingredient in a variety of plaster, blackboard/sidewalk chalk, and drywall products.

a. Gypsum board is the generic term for a group of panel products that have a non-combustible gypsum core with a paper covering on the face, back, and long edges. Because of its noncombustible core, it's also known as drywall, wallboard, or plasterboard. These products are different from plywood, hardboard, and fiber board.

According to "Construction Dimensions article / published in February 1992,": The calcined gypsum is mixed with water, foam, and additives to make a slurry that is passed between continuous sheets of paper on a continuous belt line to produce gypsum board.

The calcined gypsum recrystallizes or rehydrates as the board passes down the beltline, reverting to its original gypsum form, and the paper sheets become firmly bound to the rehydrated core. The board is then cut to length and dried to remove any remaining moisture. On the other hand, Gypsum is a non-combustible material thus it's not surprising that gypsum products are considered fire resistant by building, fire, and insurance authorities worldwide.

Gypsum is a non-toxic material to humans, and it can be beneficial to animals and plants. When utilized properly, it benefits both humans and the environment:

- As a calcium-sodium exchange soil additive to promote soil workability and water penetration. It's also known as "land plaster," and it's especially good for corn, cotton, wheat, and other crops that need a lot of sulfate Sulphur.

- To provide readily available calcium to plants, such as potatoes, cranberries, and peanuts.

- Sulfates are added to the soil to neutralize the corrosive effect of alkali[1] on plant roots.

- To settle turbid water[2] , particularly ponds, of debris and clay particles without harming aquatic life.

- Acidic waters are neutralized and buffered.

- As a key component of blackboard chalk.

- To eliminate sulfur shortages in sheep and cattle feed.[3]

- To mix with ammonia (NH,) and minimize odor in animal excrement.

- Plaster molds are used to make dental work, as well as other products like China plates, cups, and saucers.

- Plaster of Paris[4] is used for surgical and orthopedic casts.

---

[1] Alkalis are strong bases that turn litmus paper from red to blue; they react with acids to yield neutral salts; and they are caustic and in concentrated form are corrosive to organic tissues.

[2] Turbidity is the measure of relative clarity of a liquid. It is an optical characteristic of water and is a measurement of the amount of light that is scattered by material in the water when a light is shined through the water sample.

[3] Compound cattle feed is a mixture of various concentrate feed ingredients in suitable proportion. Commonly used ingredients in compound cattle feed include grains, brans, protein meals/cakes, agro-industrial by products, minerals, and vitamins.

[4] Plaster of Paris, quick setting gypsum plaster consisting of a fine white powder (calcium sulfate hemihydrate), which hardens when moistened and allowed to dry. Known since ancient times, plaster of Paris is so called because of its preparation from the abundant gypsum found near Paris.

The US Food and Drug Administration has approved gypsum (calcium sulfate) for human consumption and a wide range of applications (FDA).

- As a source of calcium as a vitamin and/or dietary supplement.
- As a conditioner for water used in beer production, as well as a control agent for wine tartness and clarity.
- As a component in food containers since it is regarded as a non-migrating substance from such containers.
- As a pigment to color food contact surfaces and as a color additive base for pharmaceuticals and cosmetics.

3.9.1 gypsium as a building material

Gypsum building materials waste is produced in three ways: during the gypsum board production process, new construction, and remodeling/demolition.

In a manufacturer's most significant interest, it is to make the highest quality board with the least amount of waste possible for economic and competitive reasons. To facilitate mechanical handling and storage, a particular gypsum board that does not meet product specifications is broken into pieces and used as risers between stacks of the final product.

Gypsum board waste is also generated during the construction of a new building. It's believed that 10% of all construction site boards get thrown away. This is because cutting out essential gaps in the panel is less expensive than pre-measuring around the opening and cutting the board accordingly.

Much of the material removed for ducts, small windows, electrical outlets, and other purposes ends as waste.

Remodeling and demolition are other sources of gypsum waste. For example, waste gypsum is produced when an old structure is demolished or refurbished. Additionally, waste gypsum may be generated when office space is renovated for example, to accommodate new tenants and when homeowners rebuild their houses.

Much of the material removed for ducts, small windows, electrical outlets, and other purposes ends as waste.

Remodeling and demolition are other sources of gypsum waste. For example, waste gypsum is produced when an old structure is demolished or refurbished. Additionally, waste gypsum may be generated when office space is renovated for example, to accommodate new tenants and when homeowners rebuild their houses.

Some gypsum board waste is not recyclable. Due to the presence of impurities from other goods that cannot be removed and may impair the gypsum board production process or subsequent board quality, demolition and renovation waste cannot be recycled into gypsum board. As a result, this waste board must be handled differently.

As a conclusion: Reusable or recyclable materials are becoming more cost effective. Any unfavorable publicity about gypsum waste disposal, whether true or not, serves to increase the motivation to recycle for both independent recyclers and gypsum board manufacturers.

Most gypsum manufacturing businesses are now learning how to expand the amount of recycling they perform and are searching for new uses for waste products, many of which were previously involved in some type of restricted recycling. Independent recycling companies are creating gypsum waste recycling systems where the economics are reliable.

images 14-15 source/ google images
gypsum boards (during the application process)

3.10 metal & steel

Metal waste/scrap garbage can be recycled multiple times without losing its qualities. For example, steel is one of the most recycled metals on the earth. Aluminum, brass, copper, silver, and, of course, gold is all highly recyclable metals. It implies that, in addition to assisting the firms that create it in contributing to a better environment, it is also beneficial to the environment.

Recycling metal trash contributes to the conservation of finite finite resources. It also helps to reduce global warming by emitting less carbon dioxide during the recycling process than mining and processing new metal.

Because scrap metal[1] and recycling are so important, the government of the United Kingdom passed the Scrap Metal Dealer Act (SMDA) in 2013. The act made it illegal to sell scrap for money, one of its main provisions. Cash transactions cannot be traced, and traceability is one of the most important aspects of a successful metal recycling system.

Metal garbage/scrap waste is often divided into ferrous and non-ferrous. Metals that combine iron and carbon are known as ferrous metals. Alloy steel, carbon steel, cast iron, and wrought iron are ferrous metals.

Aluminum, copper, lead, tin, and zinc are non-ferrous metals. Non-ferrous metals include most of the more common precious metals. Gold, iridium, palladium, platinum, and silver are among them.

1 Scrap consists of recyclable materials left over from product manufacturing and consumption, such as parts of vehicles, building supplies, and surplus materials. Unlike waste, scrap has monetary value, especially recovered metals, and non-metallic materials are also recovered for recycling.

3.10.1 recycle of the metal and how does this process occurs.

Some metal waste generators will sort the different metals and keep them in separate containers until they are collected. This does not happen most of the time, this does not happen, and the scrap metal dealer is left to sift everything back at their shop. Magnets and sensors are frequently used in automated recycling setups to aid in sorting.

Another method used by dealers to aid in sorting is to distinguish metals by color or, in some cases, weight. Aluminum, for example, has a silvery appearance and is light in weight. On the other hand, Copper has a yellowish hue, white brass has a reddish color.

Shredding the metal is the next step in the recycling process. It makes it a lot simpler to deal with; another significant benefit of shredding scrap is that it makes melting it easier. This is due to the enormous surface area and volume of tiny scrap metal fragments. Another advantage of making it easier to melt is that it reduces the amount of time it takes to melt. It uses less electricity. Scrap steel is often chopped into small sheets before being transformed into blocks.

Melting is the next step in the recycling process. Scrap metal is fed into massive furnaces. Each type of metal requires its furnace. This process consumes most of the energy.

Purification and solidification follow melting. Cleansing ensures that the process's result is of high quality and free of contaminants. Electrolysis[1] is the most popular form of purification utilized by numerous businesses. The molten metal is moved away by conveyor belts during the solidifying step to cool and solidify.

[1] Electrolysis, the process by which electric current is passed through a substance to effect a chemical change. The chemical change is one in which the substance loses or gains an electron (oxidation or reduction).

3.10.2 about hazardous waste management

(Hazardous Waste Management: Business and Industry [Online] // Government of Ontario. - October 6, 2016)

Corrosive, flammable, or fundamentally toxic materials are usually designated as hazardous waste and must be appropriately disposed of metal producers should consider hiring third party organizations to dispose of hazardous waste because they can provide the following services:

- Treatment of sewage (wastewater)
- Product destruction must be assured
- Transport in a safe manner
- Proper containers specifically intended to transport hazardous waste items
- Power washing/vacuum trucks
- Government regulations knowledge must be taken into consideration

Writer's Note:

Building related waste management involves a coordinated effort by governmental, business, and professional entities and their activities. Consistent and stable markets for recovered materials cannot be achieved or sustained without coordinated rules, realistic economic prospects, and the dedication of design and construction experts and their clients to continuous improvement of industry practices.

Building related waste management is costly and frequently has unforeseen consequences. On the other hand, common sense indicates that failing to minimize, reuse, and recycle trash is unsustainable. Therefore, the efficient and effective removal and minimization of waste and the reuse of materials are apparent features of design and construction activity.

Design and construction experts need creativity, perseverance, knowledge of available markets and enterprises, and an awareness of current rules.

Steel construction products and systems produce minimal waste at all stages of the building life cycle, including production, construction, and, most importantly, building end of life. However, it's crucial to reduce construction, demolition, and excavation (CD&E) waste and steel's credentials as a low waste, circular building material.

Some tips for design for off-site construction (steel construction)

- use steel frame design
- use prefabricated steel stairs
- use bi-steel for lift cores and core units
- use H-pile foundation to enable future reuses.

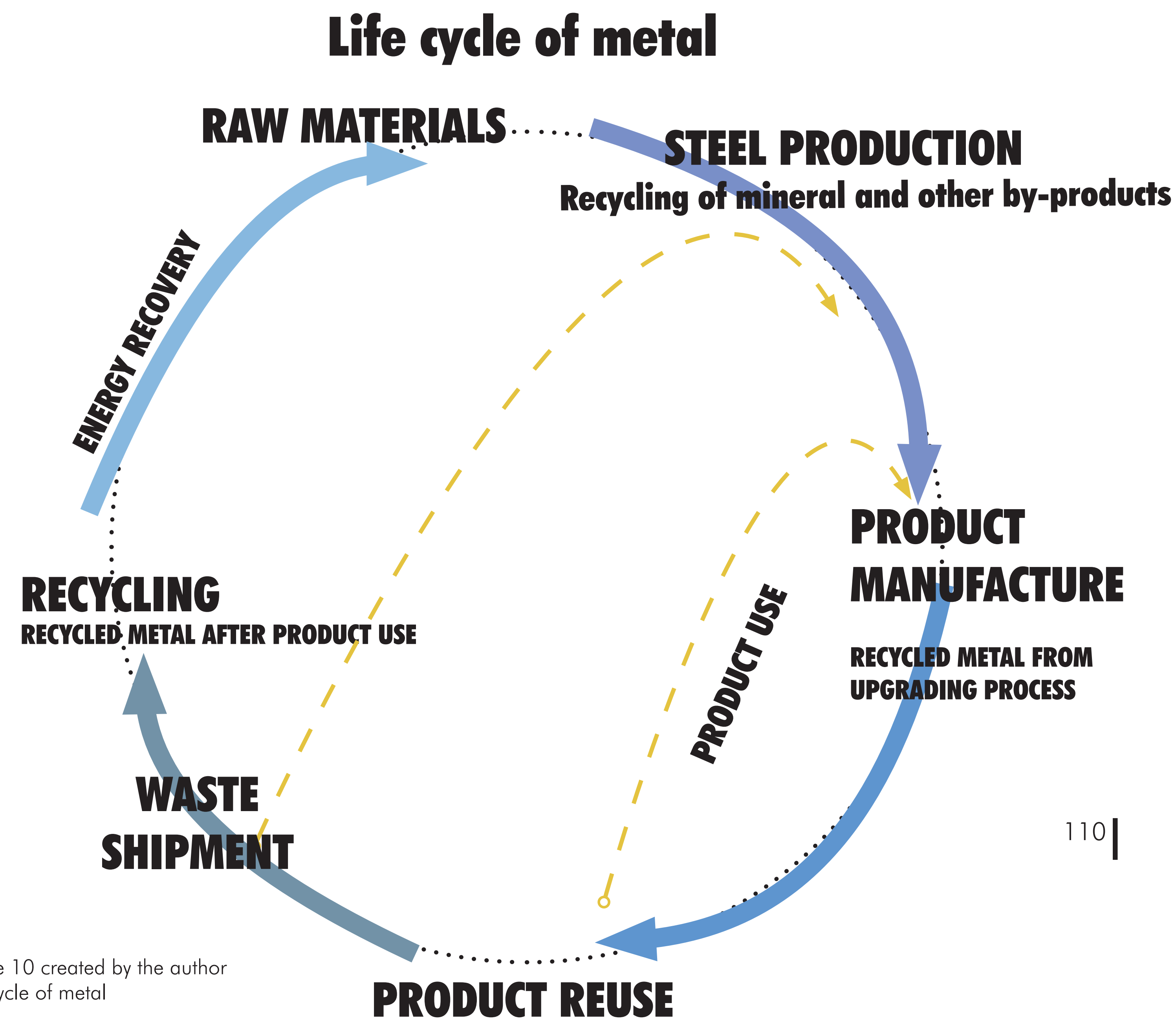


figure 10 created by the author
life cycle of metal

3.11 clay brick

Brick is one of the most challenging masonry materials to work with. It has the most diverse product line, with an infinite variety of designs, textures, and colors. In 1996, the industry produced 300 million bricks in Victoria, accounting for around 55% of the total production capacity of the available facilities.

Clay brick constructions can be found all over the world. Many clay brick structures were created in the early days of China's development.[1]

Unfortunately, many buildings have outlived their design lifetime or have become dysfunctional over time because of improper construction or inappropriate materials.

In addition, earthquakes were common, destroying many buildings and generating a considerable amount of garbage. Furthermore, old structures had to be removed due to urban development and repair needs, resulting in clay brick waste.

According to a European Union report from 2011, the European Union produced around 1 billion tons of construction and demolition waste (CDW) each year, including many bricks.[2]

It remains very competitive with other structural and field systems, both technically and economically. Clay and clayey soils, soft slate, and shale are the most common raw materials for bricks, and they are typically mined from open pits, causing drainage, vegetation, and wildlife habitat disruption (Hendry and Khalaf, 2001).

Clay bricks are extremely long lasting, fire resistant, and require very little maintenance. The strength, fire resistance, endurance, aesthetic, and appropriate bond and performance with mortar are the main characteristics of bricks that make them superior building units (Lynch, 1994; Hendry and Khalaf, 2001).

---

[1] Bricks: An Excellent Building Material for Recycling Wastes – A Review.

[2] S. Manfredi, R. Pant, D. W. Pennington, and A. Versmann, "Supporting environmentally sound decisions for waste management with LCT and LCA," The International Journal of Life Cycle Assessment, vol. 16, no. 9, pp. 937–939, 2011.

Furthermore, bricks do not contribute to poor indoor air quality. The thermal mass effect of brick masonry can be an important component of energy efficient, natural heating and cooling strategies like solar heating and night time cooling. Many studies have investigated the possible wastes recycled or included into burnt clay bricks due to the high demand for bricks as building materials. Previous studies have successfully mixed numerous types of waste into burnt clay bricks, even in high percentages, due to the flexibility of the brick composition (Lynch, 1994; Dondi et al., 1997; Christine, 2004).

The inclusion of waste materials appears to range from the most used wastes, such as various types of fly ash and sludge, to sawdust, kraft pulp residues, paper, polystyrene, processed waste tea, tobacco, grass, spent grains, glass windshields, PVB foils[1], label papers, waste used by phosphoric acid plants, boron concentrator, and cigarette, according to literature reviews. The use of these wastes will help to mitigate the harmful impacts of their disposal.

The most common way to dispose of CDW is at landfills or reclamation sites. A landfill's foundation is of inadequate quality. Using landfills or reclamation sites is also an expensive option. Recycling one ton of concrete, brick, and masonry costs about $21/ton, whereas landfilling the same material costs about $136/ton.[2]

Clay brick waste has a significant resource value, and several countries are repurposing it for a variety of purposes in building. The European Directive (2008/98/EC) of November 19, 2008[3] created a waste framework for moving toward a European recycling society with a high level of resource efficiency. By 2020, the European Union has set an aim of recycling 70% of building waste.[4]

source: Opportunities to reduce brick waste disposal by: Salman Shooshtarian

1 Polyvinyl butyral (or PVB) is a resin mostly used for applications that require strong binding, optical clarity, adhesion to many surfaces, toughness and flexibility.

2 M. Lennon, Recycling Construction and Demolition Wastes: A Guide for Architects and Contractors, Commonwealth of Massachusetts, Department of Environmental Protection, Boston, MA, USA, 2005.

3 E. C. Directive, "Directive 2008/98/EC of the Eurpean parliament and of the council of 19 November 2008 on waste and repealing certain directives," Official Journal of the European Union, vol. 312, no. 3, pp. 3–30, 2008.

4 EU Commission, Roadmap to a Resource Efficient Europe, European Commission, Brussels, Belgium, 2011.

3.11.1 mortar made from clay brick waste

The refuse from clay bricks can be crushed into fine particles and utilized in mortar. CBP[1] and fine aggregates are two types of CBP. The former has pozzolanic activity, resulting in a denser combination, whereas the latter can be used as a sand replacement.

The increased use of brick has resulted in substantial brick waste.

• Waste is generated throughout the brick supply chain
(e.g.,manufacturing, procurement, construction, and demolition)

• Brick generates a lot of waste in general (Al-Fakih et al. 2019)

• Australia's brick waste (2018 National Waste Policy) In Australia, 1,872,467 tons of brick refuse were recycled.

• Consequences for society, the economy, and the environment (Shooshtarian et al., 2020)

"Structures and items that survive longer, are easily repaired, improved, or used differently in future cycles are designed to eliminate waste." – RMIT University

3.11.2 design, contract and planning for brick waste management

• Design flaws are responsible for a significant amount of C&D waste. Ekanayake and Ofori (Ekanayake and Ofori, 2000)

• The most significant contribution to waste generation is design alterations.

• Detailing complexity, low quality material choices, and lack of acquaintance with alternative products

1 The clay brick powder (CBP) has similar surface chemical properties as quartz. The effect of CBP on the early hydration of cement is due to its physical properties, rather than the chemical activities. The interface between CBP and hydrates is very weak

• Contract clause errors or missing contract documentation
• Standardization of design to increase buildability and cut down on waste and offcuts
• The idea of repurposing old bricks is promoted through innovative and new designs.
• Government, industry, the media, and community organizations forming partnerships

3.11.3 procurement

• Correct brick estimating can save a large number of waste resources.

• Over ordering and inaccuracy in quantity takeoff result in waste.

• The brick ordering structure caused the misleading economy.

• To account for offcuts and waste, builders often buy 2-3 percent more than is required.

• If bricks are only given in huge order increments, and only a tiny portion of the previous order increment is required, this can be a substantial contribution in minor works.

• Suppliers might be urged to offer more flexible "last pack" sizes, for example, a "fractional" pallet rather than a full pallet to reduce waste from over ordering.

3.11.4 brick transportation and delivery

• One of the two main factors of brick wastage is damage during shipping related to unpacked supplies (Tam et al., 2006)
• Hand unloading and a lack of rigid strap stabilizers at corners and edges of brick piles can result in wastage. An uneven landing pad could damage bricks for stacks.
• Transportation waste can be decreased if the transportation companies that brick makers frequently use follow appropriate work practices.
• Site bricklaying is being replaced with drywall panel systems.

3.11.5 demolition

Most of the brick waste generated during demolition derives from residential or pavement destruction. The resource recovery market strongly favors separation at the source for construction materials. Isolation of materials is accomplished using fixed equipment and automated handling devices (Hyder, 2011). Deconstruction, as opposed to demolition, is a method of deconstruction that tries to demolish structures to maximize the reuse potential of their components. Selective deconstruction is a type of deconstruction that focuses on repurposing and recycling specific resources.

3.11.6 reuse

Without recycling, demolished bricks or bricks that have been damaged during shipping, construction, or renovation might be reused in construction projects. Reusing old bricks has environmental benefits, such as a CO_2-emission reduction of 0.5 kg (Gamlemursten,2019). There are programs to encourage ancient bricks in new construction: Consider Australia's brick industry. REBRICK is a new European Union funded project (Gamlemursten, 2019). Reuse as a source of raw materials: Demir et al. (2013) investigated the use of brick waste as a raw material addition in brick manufacture. They found that up to 30% of a fine brick waste additive mixture might be utilized successfully in fresh brick manufacturing.

3.11.7 recycling

Brick waste can be treated and reused in the building sector or other industries (recycling) (upcycling), because of its hydrophobic nature and physical reprocessing needs, brick refuse is highly recyclable. It is well known that brick waste can be used for other purposes. (Forsythe and Máté 2007) recommend crushing the garbage and using the finished product as a landscaping aggregate or low-grade road base.

Writers note:

It is crucial to consider building standardization to improve buildability and reduce the number of offcuts. From the gathered information it is seen that the packaging of the supplier has an important role in the usage and waste production afterward. Another important issue is to find a way to ensure that there won't be any leftovers in and out of the construction site. Another important aspect is to provide storage space to keep bricks in a flat, stable area to avoid breaking due to falling over.

LIFE CYCLE MODEL FOR BRICK WASTE

REDUCING WASTE DURING..

1 **design**
2 **manufacturing**
3 **procurement**
4 **transportation**
5 **constrcution**
6 **demolition**
7 **landfilling**

8 **reducing illegal dumping and stackpiling**
8.1 **reducing waste through upcycling**
8.2 **reducing waste through reusing and**

figure 11 created by the author
life cycle model for brick waste

3.12 glass

Glass can be found in municipal solid waste (MSW) in the form of beer and soft drink bottles, wine and liquor bottles, food, cosmetics, and other product bottles and jars.

Although most of the data relate to glass containers, this study also analyzes glass in durable furniture, appliances, and consumer electronics.

Glass could be melted down and transformed into a variety of products, including. Drinking glasses and glass fiber. Glass is broken down into tiny bits called cullet when it is taken to a manufacturing or recycling operation.

Crushed, sorted, cleaned, and ready to be mixed with other raw materials like soda ash and sand, the broken parts are crushed, sorted, cleaned, and combined with other natural materials like soda ash and sand. In a furnace, raw materials and glass fragments are melted and molded into molds to create new bottles of various colors and sizes. This method is used to create new recycled bottles and jars.

3.12.1 how to dispose glass waste

Glass waste must be cleaned before being disposed of in an authorized glass waste container, whether broken or complete. Typical glass waste containers are labeled broken glass boxes available from laboratory suppliers, although a full, labeled cardboard box with a plastic liner and sealable cover is also suitable.

Nothing besides glass should be disposed of away in a glass waste container. Containers should not be overfilled. To close the box tightly, you must pop up the middle cardboard. When the bins are full, work area staff seal them, tape them shut, and dispose of them in a municipal dumpster.

It may be safer to dispose of chemically polluted broken glass as solid chemical waste rather than clean broken glass pieces.

The chemically contaminated glass should be placed in a sealable container, and each chemical should be listed on the orange EHS waste label.
Using an appropriate solvent, remove any stuck on remains (e.g., acetone, ethanol, water, etc.). Collect the solvent as hazardous waste, drain, dry, then dispose of the glass in a glass trash container.
The use of glass items has risen, resulting in a massive volume of waste glass. The United Nations estimates that 200 million tons of solid waste are disposed of each year, with glass accounting for 7% of the total (Topcu and Canbaz, 2004). Waste glasses come in two varieties: colored and colorless. Most colorless discarded glasses may be recycled successfully.

Colored trash glasses are commonly discarded in landfills due to their low recycling rate. Landfilling, on the other hand, is becoming increasingly challenging due to a scarcity of disposal sites. Landfills are not an environmentally beneficial alternative because glass is not biodegradable.

Italy: items recycled as glass waste 2017

According to Statista survey in 2017, glass bottles were recycled by approximately 94 percent of Italian households performing waste separation. Other items commonly put in the glass waste bin were jars and drinking glasses, recycled by 86.7 and 77.5 percent of respondents, respectively.

Number of respondents: 1,003 respondents

Age group: 18-70 years

Residents who separate wastes

3.13 plastics

Plastics are a unique family of materials that have recently gained a lot of attention due to their widespread use in the global economy, low material recovery rates, and the environmental consequences of present disposal methods.

image 16; taken by Peter von Bechen, pixelio.de (plastic recycle center)

Plastics rapid expansion in manufacturing and use is partly due to the material's unique qualities. Plastics have a high strength to weight ratio, can be easily molded into various shapes, are impervious to liquids, and are resistant to physical and chemical degradation. Plastics can also be manufactured at a minimal cost.

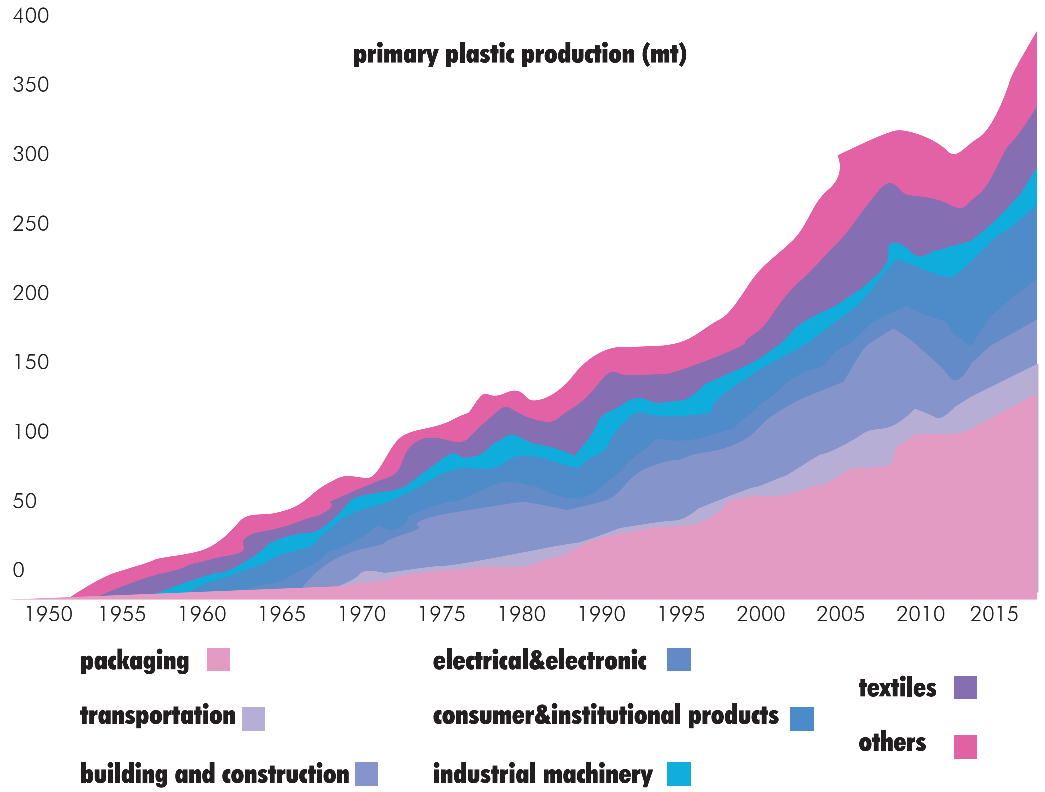


figure 12 adapted from / global plastics production 1950-2015 Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", Science Advances, Vol. 3/7, p. e1700782, http://dx.doi.org/10.1126/sciadv.1700782.

Plastics' versatility has been used in practically every major product category. Plastic packaging is the most common use by weight, but it's also found in the textile, consumer products, transportation, and construction industries.

The growing usage of plastics has resulted in various socio-environmental benefits. Plastics are frequently used to protect and preserve foods, which helps to reduce food waste. Plastics are also used in vehicles, where their lightweight results in reduced fuel consumption and greenhouse gas emissions.

Plastics are commonly employed in infrastructure applications, where their impermeability and durability positively affect the water savings in urbanized areas.

3.13.1 environmental side effects of plastics production and usage

Plastic pollution occurs when the manufacture and disposal of plastics are not properly managed, resulting in considerable greenhouse gas emissions and plastic contamination in the natural environment.

Furthermore, the loss of natural resources because of current waste treatment systems constitutes a lost economic opportunity.
Between 1950 and 2015, around 6.300 million tons of plastic trash were produced, of which only 9% was recycled and 12% was burnt, leaving nearly 80% to collect in landfills or the natural environment. All the world's top ocean basins, including inaccessible islands, the poles, and the deep seas, have plastic pollution.
Human health is also endangered by plastic pollution. Concerns concerning chemical bioaccumulation in the food chain have arisen because of the presence of plastic in seafood, such as fish and shellfish, and their subsequent consumption by the public. Plastics are also making their way into the food chain in a more direct way. Microplastic contamination has been discovered in tap water, and bottled water in several nations, and plastic contamination has also been found in sea salts.

Writers note.

In the first instance, changes in product design, such as the use of alternative materials in place of plastics, could reduce the manufacture, usage, and disposal of plastics. Changes in design methods, such as product light-weighting, could also help to reduce plastic trash output. Finally, by minimizing the environmental footprint of plastics, a shift to biobased or biodegradable plastics could lessen the negative environmental impacts of plastics more directly.

Better waste management systems would allow waste plastics to be gathered before they become an issue in the natural environment by promoting increased garbage collection and recycling rates. In addition, clean-up and remediation activities, such as beach clean-ups and technology to remove plastics from oceans, would allow plastics already present in the natural environment to be released.

Another critical issue is understanding that several countries could manage plastic wastes properly by using their resources innovatively to recycle plastics. The expansion of trash inventories in exporting countries has prompted a hunt for new market outlets for waste plastic recycling. The second half of 2017 resulted in significantly more significant trade inflows for Thailand, Malaysia, Vietnam, Turkey, and India.

It has also raised worries about these countries' potential health and environmental consequences, given their lack of plastic recycling infrastructure and insufficient ecological and treatment standards.

The consequences of import restrictions can also be seen in China. The quick decline in imported waste plastics has resulted in feedstock shortages in China's recycling industry and a rise in domestic waste plastics prices. The textiles industry, which relies significantly on importing recovered polyethylene (PET) from bottles, is experiencing a material shortage. On the other hand, diverting waste plastics exports to other countries could be difficult, particularly for mixed plastic garbage collected from houses, which is difficult to recycle. Regional and global environmental consequences may increase if the recipient country's recycling capacity and treatment regulations are less severe than China's.

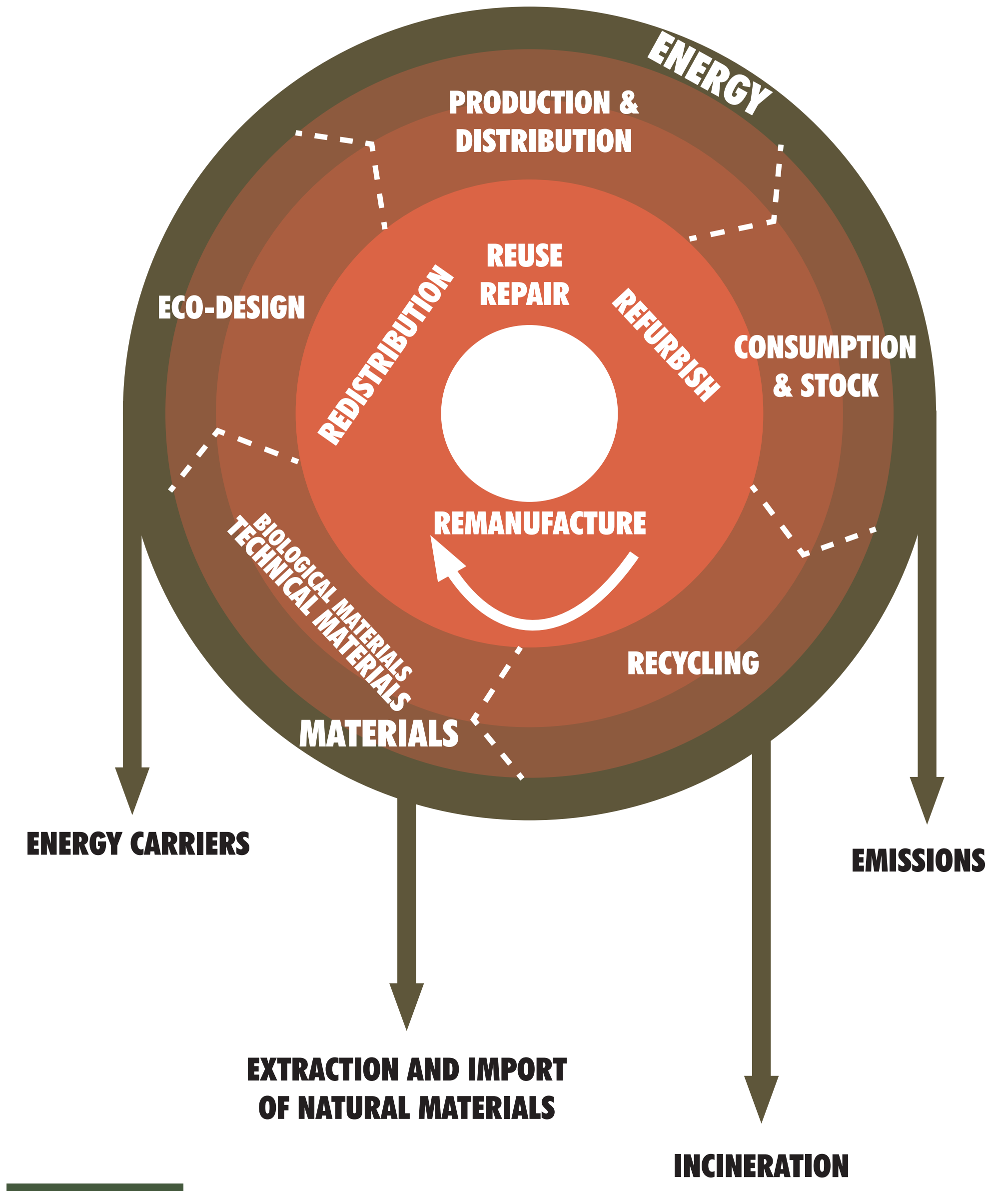
Finally, some acknowledgments need to be seen for the further steps.

- Taxes on the usage of virgin plastics and separate value added tariffs on recovered plastics and plastic goods could be considered.
- Introduction of recycled content standards, targeted public procurement regulations, or recycled content labeling; and Reform of subsidies for fossil fuel production and consumption.
- Consumer education and awareness initiatives are being developed in an attempt to increase demand for products made from recycled plastics.

IMPROVING PLASTICS MANAGEMENT © OECD 2018

Plastic recycling is converting recovered plastic scraps or trash into useable products. Because most plastics are non-biodegradable, the most significant effort is reducing trash emissions, managing garbage effectively, and recycling waste [1,2]. Plastic recycling is an essential part of the global effort to reduce the 8 million tons of plastic debris that enters the ocean each year [3]. According to Hopewell et al. [4], plastic recycling terminology is complicated because there are so many different types of recovery and recycling.

1. Foldi L, Halasz L (2009) Környezetbiztonság. Complex KiadóKft, Budapest, Hungary.
2. Padanyi J, Foldi L (2014) Environmental responsibilities of the military soldiers have to be "Greener Berets". Ecology Manage 2: 48-55.
3. Hardesty BD, Good TP, Wilcox C (2015) Novel methods, new results, and science based solutions to tackle marine debris impacts on wildlife. Ocean & Coastal Management 115: 4-9.
4. Hopewell J, Dvorak R, Kosior E (2009) Plastics recycling: Challenges and opportunities. Philos Trans R Soc Lond B Biol Sci 364: 2115-2126.



11.5 **tonnes of materials per person were extracted in the EU in 2014**
direct material consumption

3.0 **tonnes of materials per person were imported to the EU in 2014**
direct flows

2.2 **tonnes of waste per person were incinerated in the EU in 2012**

0.3 **tonnes of waste per person were sent to landfill in the EU in 2012**

figure 13: elaboration by the author source&data Eurostat 2015
material flow accounts and treatment of waste http/ec.europa.eu/eurostat.

Annex 3

General flow of construction and demolition waste processing

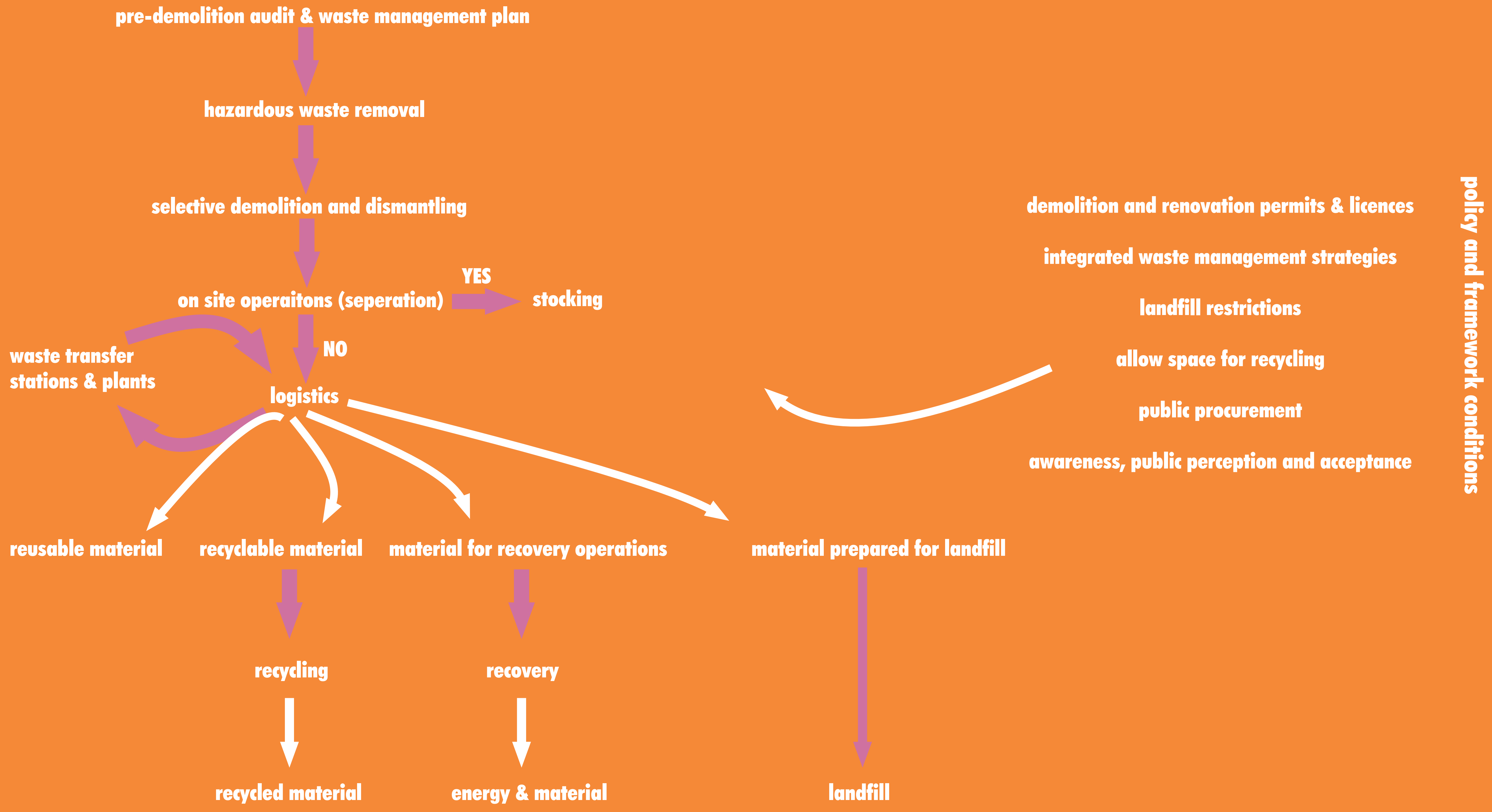


figure 14: elaboration by the author
source: EU Construction & Demolition Waste Management Protocol

4

Design for reuse and recovery

4

Design for reuse and recovery

4.1 introduction

The present market for salvaged or reusable materials is made up of a variety of outlets with different sizes, types of materials sold, and degrees of modification or preparation for sale. Reuse centers make up a small percentage of all reuse retail businesses, but they handle the most material.
They primarily sell doors, windows, cabinets, plumbing fixtures, lumber, millwork, metals, flooring, hardware, bricks, and fencing, but they also sell used goods like architectural salvage, furniture, appliances, and lighting fixtures.
Smaller quantities of higher-value goods, such as used furniture and antique fixtures, are sold in reuse businesses. Materials and waste exchanges are market places where reusable and recyclable goods can be bought and sold. Some are physical warehouses with printed catalogs advertising available goods, while others are simply websites that connect buyers and sellers. Some are managed by state and local governments, while others are run entirely by for profit companies. Waste exchanges, on the other hand, deal with hazardous materials and industrial process waste, whereas materials exchanges deal with nonhazardous products.

In the waste hierarchy (see figure 6), reuse is often preferred to recycling, which involves different processes, some of which have environmental consequences. In the construction industry, reuse can refer to the reuse of onsite resources or 'new' materials containing a high percent age of recycled material (also known as ‘recycled content'). Reusing existing materials does not have to be limited to materials or components that are immediately available on site but can also include materials and components rescued from other sites.

4.2 project buildability

The concept of buildability can be stated in a more defined and practical method for its improvements by identifying the minimal features of the design. Unfortunately, the construction business divides practitioners with varying proficiency levels and specialties because of its fragmented character. This dividing line has resulted in misunderstanding and decreased productivity.

This is especially evident in the traditional procurement approach, when contractors are brought in only after the design is completed. Proponents of buildability argue that early considerations will lead to greater adoption of costnand labor-saving construction methods, as well as a reduction in material waste (CIRC 2001).

One of the most significant obstacles is arguably designers' inability to grasp the abstract concept of buildability. Designers will undoubtedly benefit from a better understanding of the aspects that influence buildability to overcome these obstacles. Clients and contractors can use the research findings to maximize the usage of building resources in the meanwhile.

4.2.1 buildability attributes for design

The following sections are buildability attributes related to the design process.

Site specific factor

The type and choice of the site have a considerable impact on buildability. To avoid further delays and changes after construction has begun, the site conditions should be thoroughly investigated (Adams 1989).

- Site and ground investigation (e.g., boreholes, topography survey, cable detection, survey of adjacent buildings).

- Consider the effects of possible timing to avoid carrying out structural work, external finishes, etc., during rainy or typhoon season.

Below ground

Where works are to be undertaken below ground, careful considerations should be given to minimizing the time of underground construction (Adams 1989) and the effects of results on the surroundings and ensuring safety.

- Designing for minimum construction time below ground.
- Designing for safe construction below ground.
- Consider the effects of below groundwork on surrounding buildings (e.g., destabilizing foundations).

Weather

Designs should make it as easy as feasible to enclose a building at the earliest practicable stage to avoid obstructing and damaging it due to severe weather (Adams 1989; Nima et al. 1999).

- Consider the effects of possible timing to avoid carrying out structural work, external finishes, etc., during rainy or typhoon season.

Innovations

Innovative ideas could be used in the sequencing of site activities, temporary construction materials or systems, hand tools, temporary facilities that support site procedures directly, and so on (CII Australia 1996).

The goal of implementing new building methods is to reduce the amount of labor on the job site while increasing production (Low and Abeyegoonasekera 2001).

- Designing to allow for innovative construction techniques to be proposed by the contractor.
- Suggesting non-obligatory construction methods for the contractor to consider.

Coordination and rationalization of design information

To make the building process on site go more smoothly, the design should allow for more accessible communication with the contractor on the job (Adams 1989; Griffith and Sidwell 1995).

- Coordinating drawings and specifications
- Updating specifications and removing ambiguities and misunderstandings.

Dimensional coordination

- Providing and facilitating combined services drawings
- Showing accurate positions for pipe sleeves and penetrations

Detailing

Simplifying design features could make the building more accessible on the job site, thereby boosting constructability (Griffith and Sidwell 1995). Standardization and coordination are suitable to developing achievable tolerance specifications when it comes to tolerance specifications (Griffith 1984).

- Specifying tolerances for as many items as possible
- Coordinating tolerances specifications for interfacing items (e.g., window frame tilt and turn window opening)
- Designing to aid visualization of finished work
- Referring to typical or standard details for repetitive items
- Using blow up details to examine possible clashes in the design, e.g., build-ing services clashing with reinforcements.

Flexibility

Designs that specify desired outcomes and allow contractors to choose construction approaches or methods, such as formwork systems, shoring types, and piling methods can aid in proving constructability (CII Australia 1996). On the other hand, adaptive design with interchangeable components allows for changes to suit different situations.

- Designing for interchangeability (e.g., left–right orientation of fittings, such as cabinets, kitchen sinks) and subassemblies.

Tools, plant, and equipment

During the design and construction stages, accessibility to employees, materials, and equipment is critical for constructability performance (Adams 1989; CII Australia 1996). Designers should consider plants and equipment's features and capacity while optimizing their use. Site restrictions that affect the layout of the cranage should also be considered (CII Australia 1996).

- Designing for optimum use of plant and equipment.
- Designing with knowledge of plant and equipment capacities.
- Designing for temporary plant and equipment anchorages in a permanent structure.

Materials, fittings, products, and subassemblies

For maximum buildability, designers should select widely available and easily converted materials that can be worked on quickly and economically (Ferguson 1989). In addition, the products and materials to be utilized must be shown appropriately for the reasons for which the manufacturer's recommendations must be followed (Adams 1989).

- Designing for locally available materials, fittings, products, and subassemblies (including imports).

- When imported materials, fittings, products, or subassemblies are specified, consider supply conditions (e.g., checking lead times and foreseeable shortages).

- Specifying robust and suitable materials and components or giving directions for protecting fragile items (e.g., precast stairs).

4.2.2 attributes related (design output)

Safety

Designers should be aware of job-site safety, which has significant moral and long-term economic implications for the project (Young 1998). When materials and components are handled, and when traveling for access is required, designs should support a safe working environment, particularly in foundation and earthworks (Adams 1989).

When working on a structure already in use, extreme caution should be exercised to prevent causing harm or inconvenience to existing elements and tenants.

- Allowing a safe sequence of trades (e.g., heavy mechanical and electrical plant hoisted into position before the building is fully enclosed).

- Sizes and weights of materials and components are safe for workers to handle using a commonly available plant.

- Site layout, access, and environment

Designers must address builder issues such as access to and around sites, site layouts, material storage and unloading facilities, and component and material distribution during building, especially in congested areas (Adams 1989; Nima et al. 1999; Ballal and Sher 2003). Dust, noise, and the disruption of access and services should all be avoided by taking protective measures (Ferguson 1989). For good buildability, the efficient positioning and distribution of temporary works and storage areas are also required (Ferguson 1989).

- Allowing sufficient working space for labor and plant.
- Enabling efficient site layout, storage, and site access.
- Allowing fewer wet trades on site.
- Causing less environmental nuisance (e.g., noise, vibration, wastewater, chemical waste, and dust) to surroundings.
- Allowing for early enclosures from the weather.
- Allowing for construction traffic on permanent structures early after erection (e.g., left-in steel decking on structural steel).

Use of resources

At the design stage, improving buildability or constructability should be pursued by planning for cost-effective labor and widely available and versatile tools, plant, and equipment (Ferguson 1989; Griffith and Sidwell 1995; Glavinich 1995; Nima et al. 1999; Gray and Hughes 2001). In addition, factors influencing the availability of resources and talents, such as the site's geographic location, market conditions, and geopolitical context, should all be considered (CII Australia 1996).

- Allowing use of plant and equipment available locally
- Allowing use of know-how and labor skills functional locally
- Allowing economic use of labor and plant (e.g., balancing between labor and plant used to reduce overall cost)
- Avoiding as far as possible multiple handling and visits by different trades.

Material systems

Griffith and Sidwell (1995) stated that unifying material selection can aid accomplish ease of construction since designs involving many distinct materials are more likely to produce coordination issues. However, this does not imply that the range of materials to be employed is limited. Furthermore, the dimensions of architectural elements should reflect material sizes and be planned to save labor needs and material waste by customized cutting (Griffith and Sidwell 1995).

- Allowing use of a wide range of materials to fulfill required performance.
- Giving rise to lower cutting wastages (e.g., tiles, rebars).

- Installation sequence

Designers should develop the most superficial details suitable to the general needs for the building and specific aspects for executing efficient and defect-free work, according to Adams (1989).

The sequence of construction work, including material handling and how operations overlap and interrelate, and the sequencing of different trades, is concerned with task dependence aimed at decreasing the complexity of task sequence and simplifying the interrelationship of crafts (Griffith 1984). As a result, understanding the series of operations and trade interrelationships on-site can help with design constructability (Griffith and Sidwell 1995).

- Allowing easy connection interfacing between components.
- Allowing adaptation (e.g., piping around obstacles instead of penetrations) by a contractor onsite without an extensive rework and trying to find the best adaptation/solution for the problem.

Standardization

One of the three essential elements of the buildable design appraisal system, which was created to measure the buildability performance of designs in Singapore, is standardization. Standardization is defined in this system as the repetition of grids, component sizes, and connection details.

A reused grid pattern, for example, will speed up construction regardless of whether formwork or precast components are employed. Similarly, whether onsite or in the factory, columns or external claddings of repeated sizes will reduce the amount of mold changes (BCA 2005).

- Geometry, arrangement, and shape are simple.
- Allowing components to be settled in a modular fashion
- Allowing for a great deal of standardization and repetition
- Allowing the usage of standard details with several repetitions, allowing workers' learning curves to be built up quickly.

Prefabrication

Using precast components can avoid significant on-site tasks, resulting in increased site productivity (BCA 2005). Designers should consider the economics of repetition and standardization, reducing the sequence of fixes and providing sufficient details for all the pieces to fit together as intended if prefabrication is employed (Ferguson 1989). Furthermore, combining standardization and prefabrication would allow for better management in the long run (Gibb 2001).

- Allowing off-site prefabrication
- Enabling the use of single integrated elements (e.g., a complete toilet with sanitary ware, pipes, and finishes) at the contractor's choice
- Offsite work (e.g., prefabrication, precasting, and preassembly) and on-site work (e.g., prefabrication, precasting, and preassembly) mix optimization (e.g., final leveling and fixing)

- Factors affecting buildability of building designs.

2006 NRC Canada798Can. J. Civ. Eng. Vol. 33

Integration of Buildability Issues in Construction Projects in Developing Economies D TINDIWENSI Department of Civil Engineering, Makerere University P. O. Box 7062, Kampala, Uganda

4.3 deconstruction of a building

When C&D materials are disposed of, they destroy resources and landfill space and pollute the environment when new building materials are made in their place. Deconstruction can be used on various levels to recover useable materials, decrease waste, and reduce disposal. This can include everything from reusing a whole structure or foundation to selecting assemblies and systems for reuse, as well as the precise removal of specific materials.

According to the U.S Environmental Protection Agency, complete deconstruction is the preferred and most environmentally friendly technique of removing or upgrading a structure. However, it is not always practicable due to construction and its components.

buildability

The interpretations have a common ground:

Ease of construction

Efficient and cost-effective construction

"The ability to establish a building efficiently, at low cost, and to agreed-upon quality levels from its constituent materials, components, and sub-assemblies," according to Ferguson (1989).

"The amount to which a building's design facilitates ease of construction, subject to the overall requirement for the completed building," according to Ciria (1983).

"Buildable designs will lead to improvements in quality... based on the ease of construction and the need for fewer skilled workers... the 3S principles of Standardization, Simplicity, and Single Integrated elements to achieve a buildable design," according to BCA (2005).

"The extent to which decisions are taken throughout the entire building procurement process, in response to factors influencing the project and other project goals, eventually facilitating the ease of construction and the quality of the finished project," according to Chen et al. (1991).

4.3.1 deconstructible buildings

• Wood framed buildings are very deconstructible. The "stick-by-stick" architecture of wood framed buildings, especially those with heavy timbers and beams or unusual woods like Softwood, American chestnut, and old-growth southern yellow pine, lends itself well to the deconstruction process.

• Specialty materials with high resale value are contained in this type of lumber. These are examples of hardwood floors, multipaned windows, architectural moldings, and unusual doors or plumbing/electrical material fixtures.

• Use low quality mortar on a high quality brick laid structure. This design makes dismantling and cleaning very simple.

• Are reasonably easy to break up and clean. Buildings with fewer rotten and degraded elements have the greatest deconstruction potential.

Partial deconstruction is an excellent alternative for structures that do not fit one or more of these criteria. In addition, a mix of deconstruction and demolition can be used in certain situations.

4.3.2 key aspects of deconstruction

1- Building deconstruction is the process of demolishing structures to salvage as much material as possible for reuse.

2- This strategy is easily found in the model for sustainable construction, which explains how to apply sustainability principles to the resources used in a structure at different stages of its existence.

3- Building deconstruction is not only a technique for removing buildings that can be used to improve demolition contractors' performance, but it can also be used as a waste minimization strategy to reduce waste generated by the construction industry, an urban renewal tool to help dismantle, renew, and reuse old and abandoned buildings, and a community economic regeneration strategy to help create jobs and local businesses.

4- Salvaged construction materials can offer to the low-end markets of low-income populations looking for low-cost building materials and the high-end needs of discerning purchasers looking for high-quality salvaged materials. Furthermore, a new industry is emerging, consisting of clients and practitioners who seek to design green buildings as part of their commitment to environmental responsibility in construction.

5- Deconstruction is essentially construction done backward, and it mainly employs laborintensive methods. As a result, it's a good tool for teaching construction employees. This has two main consequences for the construction sector: it produces a vast labor pool and can absorb excess labor from the building industry.

6- Labor difficulties, environmental issues, and occupational health and safety demand special attention because deconstruction is a labor-intensive operation.

7- If practicable, building deconstruction can help promote a secondary con-struction materials market and ensure that secondary materials are available to fulfill demand.

8- Because the decisions taken during design affect the deconstructability of a structure at its end-of-life, designers must increasingly consider design for deconstruction during the design stage. (By incorporating design for deconstruction, later building stages of remodeling, repair, and removal will be more efficiently completed.)

9- Before deciding whether to implement deconstruction, a feasibility analysis must be completed. Physical conditions, such as available building stock and building condition, and economic conditions, such as local economic and construction activity and secondary markets, influence viability.

10- Deconstruction has economic and social benefits that can aid the economy and enhance people's lives, but the environmental benefits are likely the most important.

4.3.3 building deconstruction permit

A formal notification of intent to remove a building is required by land and building jurisdictions. Building deconstruction, like demolition, is a technique for eliminating structures that necessitates a permit.
The following requirements must be met for the approval process to proceed:

- Turning off the power, electrical layers
- Capping all gas and sewer lines
- Asbestos, lead, and other hazardous chemicals reduction.
- Payment in advance for a building authority site inspection (or air pollution authority).

The third condition connects the permit procedure to the environmental site assessment process, requiring that all hazardous material inspections be completed satisfactorily by certified employees for a permit to be granted because building deconstruction takes longer than traditional demolition (due to labor). Many proponents of the practice demand for an obligatory waiting period between the approval of the permit and the start of new construction to allow for building deconstruction and material salvage.

4.3.4 design for deconstruction

The term "design for deconstruction" refers to a building's design to manage its end-of-life more efficiently. The goal of the procedure is to make building disassembly as straightforward as possible to reduce waste and maximize the recovery of high-value secondary building components and materials for reuse and recycling. In addition, this novel technique encourages architects and designers to use DFD concepts throughout the design phase of construction projects to ensure that the future stages of remodeling, repair, and demolition go smoothly.

Designing a structure for longterm use can save money and minimize the negative environmental implications of operation and maintenance, such as material consumption and waste generation during restorations.

- International Council for Research and Innovation in Building and Construction (CIB) Prepared by: Dennis S. Macozoma Research Engineer CSIR Building and Construction Technology Pretoria South Africa.

4.3.5 life cycle of deconstruction phase

Writers note

Building destruction is traditionally a waste generating activity. The created trash can be handled in various ways, depending on the amount of concern. A traditional demolition aims to remove only the construction materials from the job site. The simplest method is to destroy the elements without regard for their individual qualities.

When looking for a selected approach to the types of materials to demolish (selective demolition), waste can be separated by material composition, allowing materials with varied characteristics to go to different places, such as recycling or deposit.

However, it is frequently discovered that not all structural components in the demolition phase have reached the end of their useful life. Some may be in excellent condition, and eliminating them would be a waste. Buildings that have recently undergone partial rehabilitation are an excellent source of construction elements since they may include much materials with a long lifespan.

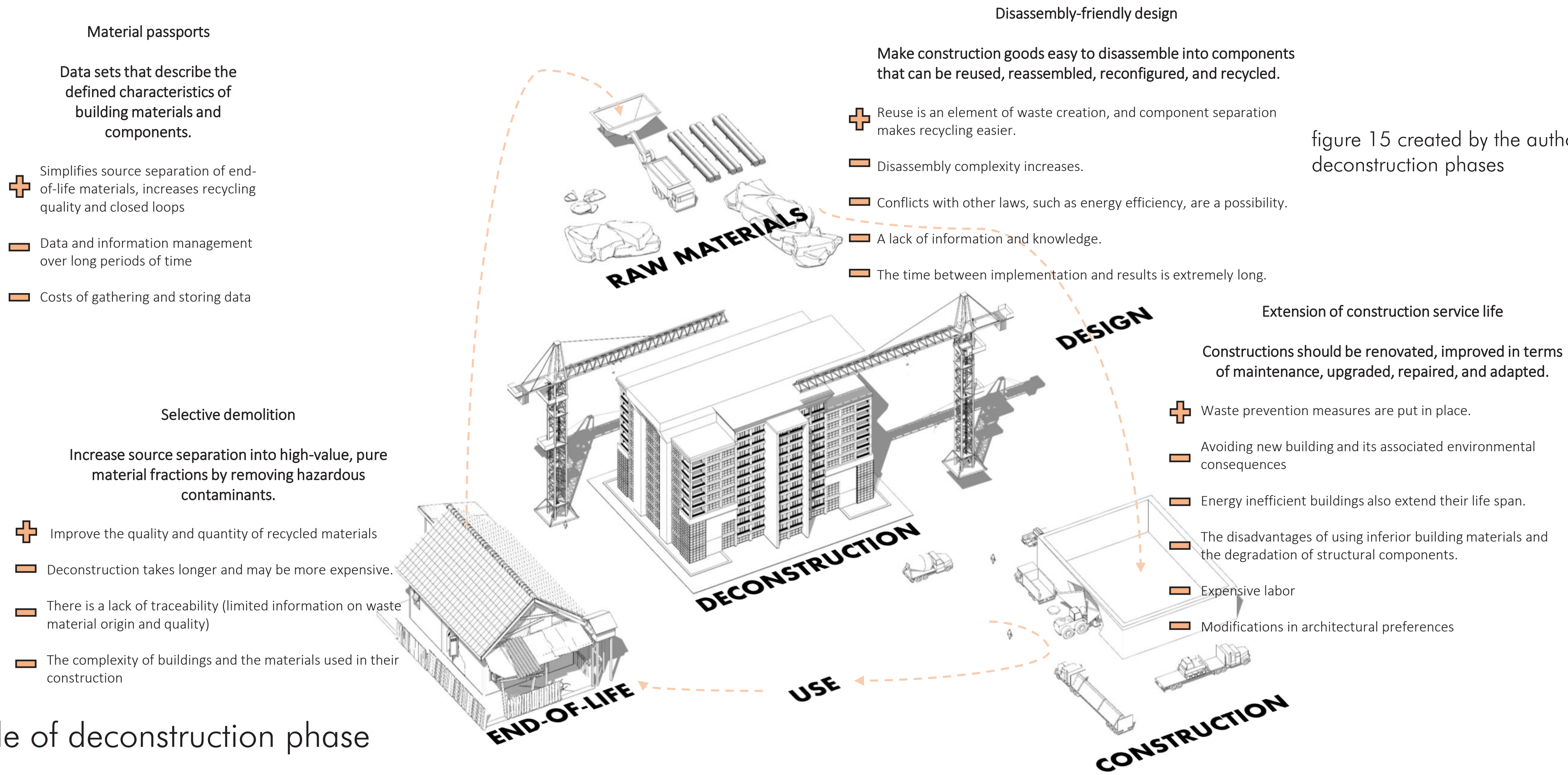


figure 15 created by the author; life cycle of deconstruction phases

4.4 life cycle of deconstruction phase

- Fixtures:

-Doors, windows, shelving, cabinets, appliances, HVAC systems, wiring, water heaters, boilers, and other fixtures are commonly removed.
-Typically, hand tools are used to strip. Materials are kept indoors, such as in a warehouse.

- Roof:

-Typical shapes are sheeting, rafters, truss system, chimney top, ceiling joists, gypsum board, gutters, and other roof materials.
-Stripping, which is usually done with hand tools.
-Usable materials are processed, while the rest is disposed of in dumpsters and recycling containers.

- Walls:

-Exterior walls, internal walls, framing material, chimneys, tiles, and other wall components are standard. In addition, timber, brick, gypsum drywall, steel, and other common materials are used.
-Stripping is usually done with a combination of hand tools and mechanical equipment. Finally, the valuable materials go to processing, and the rest are thrown away in dumpsters and recycling bins.

4.5 sources and types of reclaimed building materials

Low-value Material: Type at a price range as % of retail price (10-25)
materials with a value that is a fraction of that of new materials. Their condition or initial worth determines the low weight.

Suitable value Material Type at a price range as % of retail price (50-85)
Materials with a significant portion of their value in new materials. These materials can be replaced with readily available new materials in a one-to-one ratio. The method they can be reused is unaffected by previous use.

High-value Material Type at a price range as % of retail price (100+)
Materials with a value that is equivalent to or greater than new materials. Due to scarcity, comparable qualities are currently expensive to obtain, and their reprocessing adds value; the worth of these materials has increased over time.

4.6 material extraction from deconstruction phase and its properties on how to process & store the material.

component	typical material	processing	storage
fixtures	Timber e.g. doors Metal e.g. Window frame, wiring Ceramics e.g. Sanitary ware	Cleaning and packing	indoors
roof	Timber e.g. rafters, truss Asphalt e.g. roof tiles Metal e.g. sheeting, gutters Gypsum e.g. ceiling board	De-nailing, sizing, stacking	Indoors – timber stored in stacked bundles Outdoors – metals in recycling containers, gypsum and asphalt will either be stored in recycled containers or disposed in dumpsters depending on the economics and markets
walls	Timber e.g. Framing, exterior walls Bricks e.g. Exterior walls, chimneys, interior walls Gypsum drywall e.g. İnterior walls	De-nailing, sizing, stacking Cleaning	Indoors – timber stored in stacked bundles Outdoors – bricks stored in stacked piles, gypsum will either be stored in recycling containers or disposed in dumpsters depending on the economics and markets
floor	Timber – floor Concrete – floor Ceramics – finishing	De-nailing, sizing, stacking Cleaning Crushing	Indoors – timber stored in stacked bundles Outdoors – Concrete stockpiled for recycling and ceramics stored in recycled containers or disposed in dumpsters

4.7 design for deconstruction requirements for building components.

component	elements	materials	properties
foundation and floor	Foundation Floor bed Floor finish	Concrete, timber, ceramics, carpets	Concrete is not instantly reusable; however, it can be recycled into secondary products. Timber - may be reused and repurposed into a variety of items right away. Ceramics are long-lasting, can't be reused right away, but can be recycled. Carpets are recyclable, but the procedure is difficult, and the market is small.
roof	Frame Siding Wall finish	Timber, steel, concrete, brick, gypsum	Timber as above Steel - needs extra care if immediate reuse is considered, most recycled material Concrete as above Brick has a significant potential for reuse and can be recycled into secondary materials. Gypsum drywall makes up the majority of building waste, is recyclable if not contaminated, and has a tiny market
walls	Frame Sheeting Ceiling	Timber, metal, asphalt, concrete, polymers, gypsum	Metal is a long-lasting material, which becomes less expensive over time. It is also the most recycled material category, with a well established secondary market. Asphalt is a low-cost, non-recyclable substance that, depending on policy, can be recycled into road materials. Polymers are composite materials that are not reusable or recyclable. Timber, gypsum and concrete as above

table 3.0 elaborated by the author
source / Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials 2021, 11, 939.
https://doi.org/10.3390/app11030939
Published: 20 January 2021

4.8 disassembly and reuse

Buildings that are designed to support adaptation, disassembly, and reuse decrease waste and extend their useful lives, resulting in economic and environmental benefits for builders, owners, and tenants, as well as communities. This approach also permits materials to be cost effectively and quickly dismantled and directed for further usage, avoiding the need for complete demolition. Design As a result, designations are discovering new options.

When designing for adaptation, disassembly, and reuse, consider the following strategies:

- Creating a plan for adaption or disassembly includes critical information (e.g., built drawings, materials, key components, structural properties, repair access, and contact information).
- Using standard size, modular construction components, assemblies, and simple open-span structural systems.
- Using long lasting materials that are worth reusing and recycling.
- Making connections visible and accessible while minimizing the use of various sorts of materials.
- Instead of sealants and adhesives, mechanical fasteners such as bolts, screws, and nails are used.

[1]. Wang Song, Liu Xinmin. “Based on the Theory of Complex Adaptive System, the Evaluation Model of Enterprise Supply Chain Is Established” [J]. Operation and Management, 2012, 115- 116.

[2]. Chen Xiao. “Research on Complex

4.9 supply chain

In today's complex and changing dynamic market environment, enterprise competition has shifted from competition between individual firms to competition among alliances and supply chains. Users' needs are similarly insecure in a continuously moving market context [1]. To adapt rapidly to the changing marketing environment and optimize the entire supply chain operation, the supply chain must respond quickly to the changing marketing environment.
This is the common purpose of all supply chain partners [2]. The supply chain is a complex network system generated by a succession of nonlinear effects that are tightly related to the environment and continuously changed along with changes in the background, rather than a simple system made of a single linear combination of individuals on the chain.

4.9.1 complex adaptative system theory

The theory of complex adaptive systems (CAS) is a system science that evolved around the twentieth century. "A system composed of interacting bodies specified by rules," proposed John Holland of the United States in 1994. The most basic idea in CAS theory is an adaptively active individual, referred to as "the subject" for short [3]. The subject can interact with the environment, communicate with other issues in the background, and continuously learn in communication, therefore changing the structure and behavior mode in response to such an experience, according to the general stimulus-response paradigm.

The function of repeated interaction between the subject and the environment in the system is referred to as "Adaptation" in CAS theory. The development or evolution of the method includes the generation, differentiation, aggregation, development of new subjects, and the hierarchical and complex nature of the system, all of which are gradually derived from the basis of "adaptation"; and the changes in the system can also find their roots in the individuals' behavior.

[3] Tan Yuejin, Deng Hongzhong. “Complex Adaptive System Theory and Its Application Research” [J]. System Engineering, 2001, 1-6.

CAS theory

stage 1
infrastructure

- purchase
  - material
    - control
      - production
        - sales
          - distribution

stage 2
functional integration

- material management
  - manufacturing management
    - production
      - distribution

stage 3
internal supply chain integration

- material management
  - manufacturing management
    - production
      - distribution

stage 4
external supply chain integration

- supplier
  - internal supplier
    - user

stage 5
integrated supply chain dynamic alliance

- source
  - supply chain alliance
    - exchange

+customer service and logistics

figure 16: created by the author

5

waste efficient design regarding the con-struc-tion site & off-site

5

the efficient waste design regarding the construction site & off-site

5.1 introduction

The benefits of off-site factory production in the construction sector are well known. They include the ability to significantly reduce waste, primarily when factorymade materials and components are widely used. In addition, its implementation might significantly alter on-site operations, reducing the number of trades and site activities while also transforming the construction process into a rapid assembly of pieces that can provide a variety of environmental benefits.

As a result of rising awareness of the environmental implications of construction wastes, waste management has evolved as an essential strategy for building project management. It is vital to manage construction waste to cope with future sustainable development. Construction waste management methods were created to protect the environment and understand that construction and demolition debris contribute significantly to environmental damage. [4] Reduced construction-related transportation movements; improved site health and safety through accident prevention; improved workmanship quality and reduced on-site errors and rework, all of which cause significant waste, delay, and disruption; and reduced construction time-scales and improved programs would be the positive effects of this methodology.

[4] Shen L Y, Tam V W, Tam C M and Drew D 2004 Mapping approach for examining waste management on construction sites J. of Const. Eng. and Mngmt. 130 472-481

This chapter will try to give answers to the following key questions:

1. Is it possible to manufacture the design off-site or any element of it?
2. Is it possible for site operations to take the form of an assembly process rather than a construction process?
3. Is it possible to simplify the design, form, and layout without jeopardizing the design concept?
4. Is it possible to coordinate the design to avoid/minimize wasteful cutting and jointing of materials?
5. Can waste-reduction construction approaches be designed in collaboration with the contractor and specialized subcontractors?
6. Is it possible to maintain, improve, or replace building parts and components without generating waste?

As a result, the intention to support Off Site Construction should be taken early in the design process because of its impact on:

- Spatial planning, particularly grids for structural and planning purposes.
- A structural design or system has been chosen.
- A project's ability to be built.
- Purchasing routes.
- Considering how Off-Site Construction affects aesthetics.
- Consider the effects of possible timing to avoid carrying out structural work, external finishes, etc., during rainy or typhoon season.

5.2 design for material optimization

This concept is built on various "best practice" initiatives that designers should consider implementing in their work.
It is best practice to apply a design strategy that focuses on materials resource efficiency in this domain. As a result, less material is used in the design (i.e., lean design), and less waste is produced in the construction process without discarding the design concept.

- Excavation is kept to a bare minimum.
- Material and component selections are simplified and standardized.
- Dimensional coordination is a term that refers to the coordination of two or more dimensions.

Concrete

- Instead of using reinforced slabs, use post-tensioned slabs[1].
- For slabs, cores, and other areas, use reusable/modular shuttering.

Design

- Simplify the plan shape and structural form.
- Reduce the external surface area concerning the inside volume.
- Car parking should be questioned and, if possible, reduced.
- Material functionalities should be combined.

Services

- Plan M&E[2] plant and distribution networks meticulously to limit access requirements and make future maintenance easier.
- Plan M&E layout and distribution routes meticulously to decrease builders' work by integrating risers, ducts, and other components.

[1] Post-tensioning is a form of prestressing concrete to provide reinforcement and overcome concrete's weaknesses. Post-tension concrete slabs are used to create a monolithic (single pour) slab that is stronger than a traditional slab without reinforcement.

[2] An M&E Plan is a document that describes a system which links strategic information obtained from various data collection systems to decisions that will improve health programs. Monitoring and Evaluation plan

- To limit M&E penetrations in already finished surfaces, consolidate trades.
- Reduce run-off collection areas instead of reducing the size of surface water attenuation systems and piping, and examine other options:
- The installation of a green roof.
- Grasscrete[1] can be used to minimize vehicle surface areas.
- Increasing the use of soakaways[2] (dry well).

Detail Design

- Examine the need for all finishes.
- Reduce cutting and offcuts by optimizing tile layouts of any size.
- To lower the depth of wall thickness and maximize the overall building net/gross areas, use innovative thin insulations.
- Consider using formless materials for finishing instead of formed materials for irregular plan shapes.
- To avoid cutting plasterboard sheets and blocking natural air ventilation, use full-height doors or doors with fan lights above.
- Rather than doubling up on board, use a thicker plasterboard sheet.
- Make sure sound insulation isn't over-specified for the room's or building's intended use.

Avoidance of excavation

- Instead of replacing piles, use rotational pile foundations.
- Optimize the location and levels of the building to reduce the amount of excavation necessary.
- Consider whether a basement is essential.

image 17; ukdnwaterflow.co.uk / soakaways

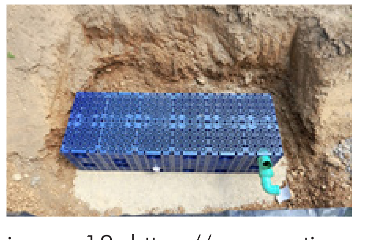


image 18; https://www.certifiedenergy.com.au/

1 Grasscrete is a pervious reinforced concrete structure for all types of trafficked areas that is either covered with grass, has grass growing in the voids of the structure or has stone in the voids of the structure.

2 Soakaways are used to manage surface water at its source and serve as an alternative option to draining off surface water via a stream or sewer system.

5.2.1 dimensional coordination

To avoid additional services/structure/etc. clashes/conflicts, use 3D modeling. 3D modeling will provide foresight. As a result, building faults and subsequent rework are reduced.

Structure and services should be coordinated such that they may be used together off-site, minimizing the need for on-site chase cutting and other construction work.

To eliminate offcuts, coordinate the structural grid and planning grids, among other things.

- finishes on the outside
- the interior finishes
- Internal divider layout using grids on the ceiling and floor.

To eliminate on-site waste, use 3D modeling to evaluate all finish layouts and op-tions, such as sheet and tile, fittings, and lamps.

Light fixtures and lamps should be standardized.

5.2.2 standardization of materials

/design for reuse and recovery

This section aims to understand how to deal with the materials on-site and off-site regarding the waste management scenarios. It is crucial to select the best material for the designated design and achieve sustainability goals. Therefore, material selection and usage are critical aspects of waste management on and off the construction phases. The sections implemented in this section help designers understand the purpose and repurpose of the construction materials and give an idea on how to use those materials after their life is complete and becomes wastes.

LANDSCAPING

Use on-site demolition and excavated debris as reuse or recycle pavement and asphalt for pathways, automobile parking, construction storage space, hard standing for plants, etc. (assuming there is on-site storage).

- Keep topsoil on site, treat it with compost (or other), and utilize it for green roofs, soft landscaping, and other treatment purposes.
- Make topsoil from excavated earth that has been combined with compost.
- Bricks, concrete paving blocks, and excavated rock can all be reused for landscaping finishes, among other things.
- Existing soft landscapes that can't be kept (trees, bushes) can be used as compost, soft landscape top mulch, external furniture, and more.

CONCRETE

- Use recycled aggregates (on-site or off-site) as fill, etc., in concrete mixes.
- Concrete parts can be recycled as aggregates and used as a thermal heat storage system (thermal mass used as fabric energy storage to reduce the operational energy requirement.)

PACKAGING

- Reuse packaging by returning it to the supplier/manufacturer or repurposing it.

FOUNDATIONS

- Repurpose old foundations.
- Existing H-pile foundations can be extracted and reused.

TIMBER

- Sprung flooring can be reused.
- Recycled wood can be used for cladding, fencing, and other landscape projects.
- Separate, denail, and chip any demolition wood for composting, top composting, or transporting off site for energy generation.

BRICKS, STATES, ROOFING TILES, AND BLOCKS

- Bricks, blocks, and similar materials can be reused for masonry, internal walls, and fair-faced cladding. Marble can be used for roofing and gardening.

- Dismantled elements, columns, beams, portal frames, and curtain walling can all be reused on or off-site, which is a good demolition practice.

- Within the design brief, reuse water tanks on-site for usable space.

- Encourage the customer to use a "soft strip" method of demolition.

- All recovered fixtures and fittings will be salvaged and donated to charities or sold for reuse.

5.3 cradle to cradle concept

According to ARUP, "The Cradle to Cradle ("C2C") concept" is a bioinspired way for modeling human industry on natural processes, with materials treated as vitamins passing through healthy and safe metabolisms. Its goal is to create systems that are both efficient and waste-free. A growing number of building owners and developers are exploring adding it into their structures, whether to increase employee efficiency or distinguish their constructions.

According to (Deilmann, Reichenbach, Krauß, & Gruhler, 2017, p. 8), The construction sector consumes many resources and has a significant negative influence on the environment. Moreover, its resources are traditionally consumed not to be recycled to a similar quality or restored to nature without causing harm.

Other difficulties include energy use throughout the lifecycle of a building, water pollution, soil erosion, and the influence of built structures on their users (e.g., indoor climate, social isolation). The Cradle to Cradle (C2C) idea is an attempt to address and overcome these issues: It strives to mitigate the consequences and for buildings to contribute positively to the listed areas. The goal of C2C-inspired structures is to prevent waste generation and leave a positive environmental footprint.

Unlike prior notions such as eco-efficiency ("reduce and recycle"), the C2C concept focuses on producing a positive ecological imprint rather than reducing the negative impact of humans on the environment. As a result, a new perception of humanity emerges, one in which society leaves a positive rather than a negative footprint.

To do so, a paradigm shift from basic eco-efficiency to so-called eco-effectiveness is required, which considers the type, usage scenario, and quality of materials or technology rather than just the quantity of a substance or pollutant.

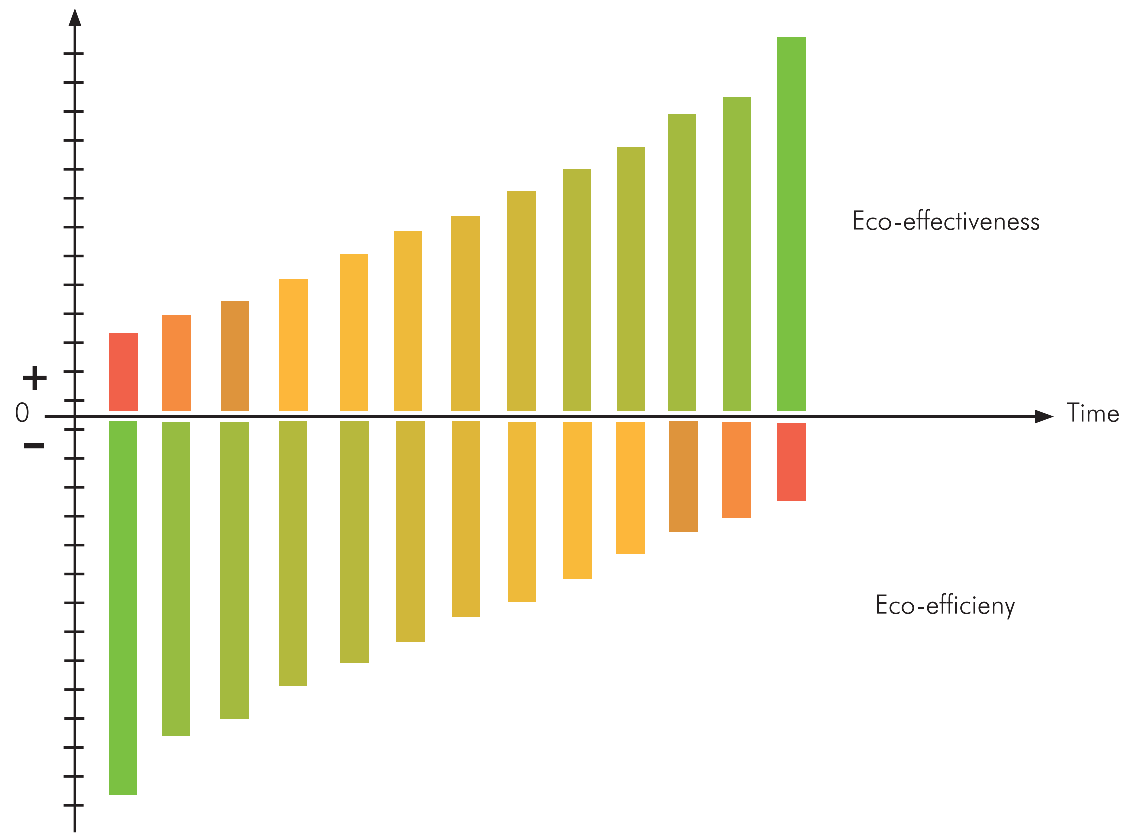


figure 17 elaboration by the author: source / The upcycle chart for continuous improve-

5.3.1 c2c principles regarding the construction and infrastructure systems

- Water supply systems
- Fuels and gases
- Heating and cooling systems
- System of ventilation
- Cooling systems
- Installations of electricity
- ELV (extra-low voltage) systems
- Transport systems that move vertically
- Specialized / usage-specific systems
- Control and management systems for buildings

Principle 1

All materials must be assessed and classified in terms of their health impact in the specific usage scenario; this applies to both the manufacturing process and the actual use of the materials.

Waste always results in a reduction in the material's value. To address this, C2C promotes material quality and value preservation, which benefits both the economy and the environment.

While economic concerns cannot justify ignoring C2C regulations, C2C implementation should have no negative influence on the economy; in fact, it should enhance the economy. For this reason, it makes sense to look for solutions that meet multiple C2C criteria at the same time.

Principle 2:

Use of renewable energy - renewable energy is a necessary component of a holistic and effective recycling strategy. It may be used for building operations and the entire manufacturing process of materials and products. [1]

Principle 3:

Value diversity - just like nature, there can be a wide range of answers and options. Regional, cultural, creative, and material diversity should be embraced and actively fostered, not just accepted.

The C2C concept's application aims to improve the social environment, starting with the working conditions in the material's manufacturing and continuing with the product's social advantages.

Figure 14 illustrates a high-level overview of the C2C idea, including the many bio- and Technosphere cycles stages.

Materials cycle indefinitely as 'supplements,' according to the C2C theory, whether in the biosphere or the Technosphere. All material properties are known, and all materials are assigned to one of the two spheres, suggesting that all chemicals that make up a single material or product are safe for their specific application and can be assigned to a future application.

5.3.2 biosphere

All consumable materials, that is, materials that wear out and end up in the environment (i.e., materials that cannot be reused for another cycle), must be designed for the biosphere. They must be both edible (i.e., free of hazardous chemicals) and biodegradable to become biological nutrition for new plants.

[1] Cradle to Cradle e. V., 2017

5.3.3 technosphere

All materials must be created for the so called Technosphere if they do not wear out in the relevant usage situation and are only used and not consumed. To become raw materials for a new use, they must be non-harmful, easy to disassemble, and reusable.

figure 13 : Criteria for Cradle to Cradle Certified™ of the C2CPII[1]

Material health

A list of product ingredients utilized throughout the supply chain is compiled and exam-ined for human and environmental health implications. The criteria for each level of certification get increasingly strict, to eliminate all hazardous and unidentified substances and transform them into nutrients for a safe, continuous cycle.

Repurposing materials

As a biological nutrient, products are meant to biodegrade safely, or as a technological nutrient, they are designed to be recycled into new products. To advance to the next certification level, more work must enhance material recovery and keep them in continuous cycles.

Energy from renewable sources

At each level of certification, the standards for carbon neutrality and the usage of renewable energy to power all operations get more stringent, intending to reach 100%.

Management of the ecology

Water is examined in production processes to evaluate if it is regarded as a valuable re-source for all living beings. To advance to the next level of certification, more effort must be put into cleaning effluents to meet drink-ing water standards.

Social equity

All people and natural systems must be treated with respect by manufacturers. Therefore, more effort is required to obtain the next certification level to have an overall beneficial influence on humans and the world.

[1] There are several levels for a Cradle to Cradle Certified™ Product (Basic, Bronze, Silver, Gold and Platinum); certified products must recertify and improve at regular intervals – otherwise their certificates expire. The individual criteria for the certification levels are not covered here; further information can be found on the homepages of the C2CPII or of the Cradle to Cradle Certified™ assessors, who support companies in the certification process (find assessors on www.c2ccertified.org/get-certified/find-an-assessor).

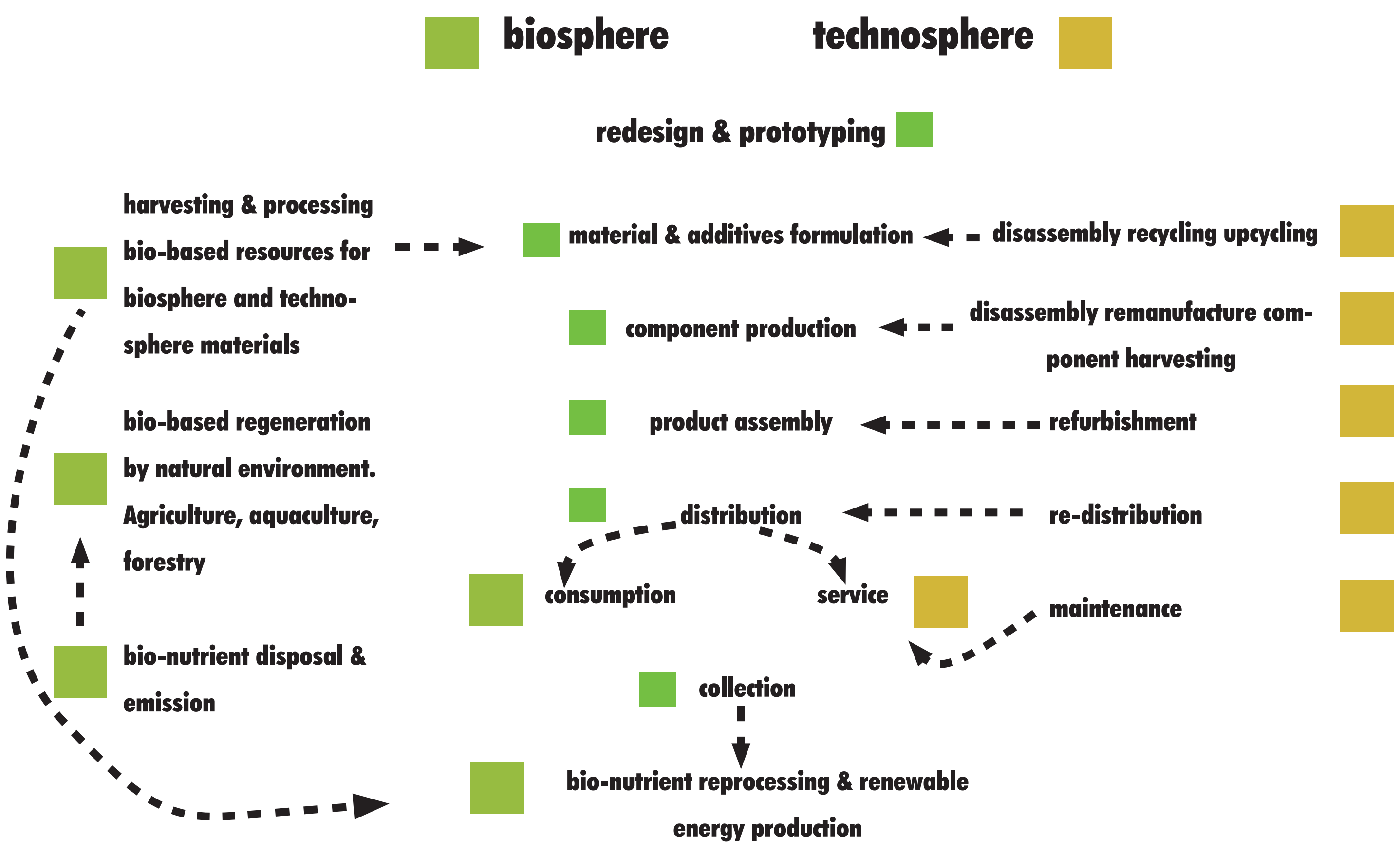


figure 18 based on source / Bio and Technosphere (EPEA).

5.4 sustainability goals

The United Nations set up 17 life-changing goals in 2015. Ending extreme poverty, improving healthcare, and achieving gender equality are among the Global Goals, commonly known as the Sustainable Development Goals (SDGs).

One hundred ninety three countries agreed on the Sustainable Development Goals (SDGs) in 2015 after the most inclusive and thorough UN discussions ever. They have inspired people from various industries, geographies, and cultures.

Regarding these 17 sustainable development goals, some critical ones are directly about waste management in the construction and building. Therefore, these goals must be considered carefully before and after the construction.

Goal 6: clean water and sanitation
Goal 7: Affordable and clean energy
Goal 9: Industry, Innovation, and Infrastructure
Goal 11: sustainable cities and communities

figure 15:

sustainability goals Department of Economic and Social Affairs Sustainable Development/United Nation UN https://sdgs.un.org/goals/

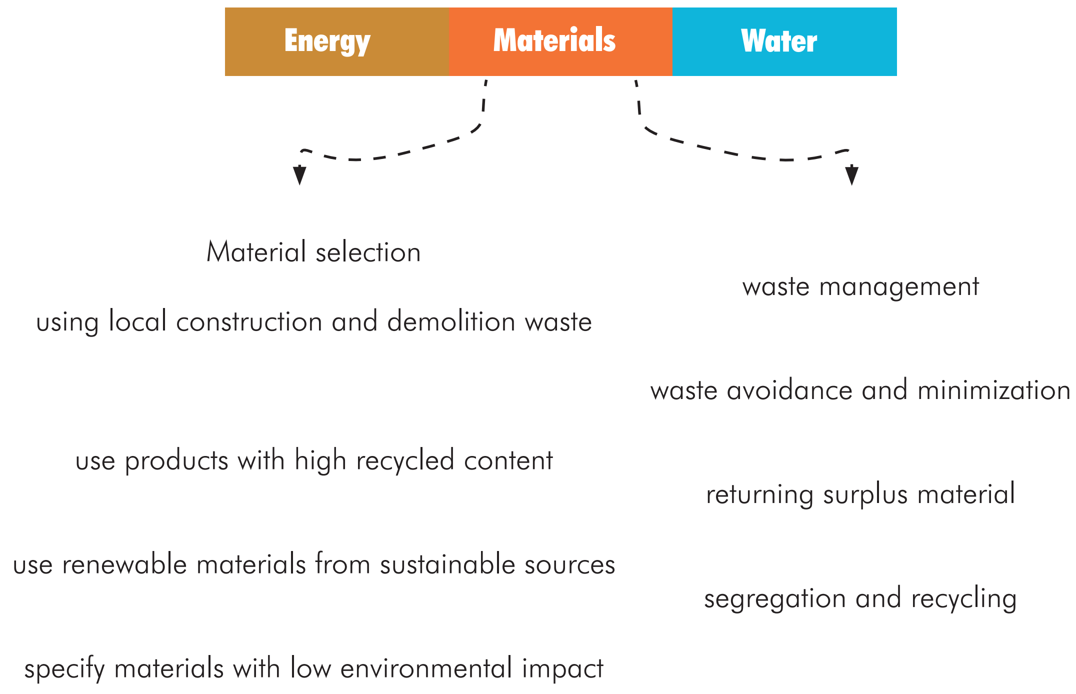


figure 16: Materials resource efficiency as part of sustainable construction

Target **6.3**

By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater, and substantially increasing recycling and safe reuse globally.

Target **9.1**

Develop quality, reliable, sustainable, and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, focusing on affordable and equitable access for all.

Target **11.3**

By 2030, all countries will enhance inclusive and sustainable urbanization and capacity for participatory, integrated, and sustainable human settlement planning and management.

Figure 19: created by the author source/ United Nations Department of Economic and Social Affairs (sustainable Development and goals)

Target **11.b**

By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels.

Target **12.1**

Implement the 10-year framework of pro-grams on sustainable consumption and production, all countries acting, with developed countries taking the lead, considering the development and capabilities of developing countries.

Target **12.4**

By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil to minimize their adverse impacts on human health and the environment.

Target **12.5**

By 2030, substantially reduce waste generation through prevention, reduction, recycling, and reuse.

Target **12.8**

By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.

sustainability goals
Department of Economic and Social Affairs Sustainable Development/United Nation UN https://sdgs.un.org/goals/

5.5 zero waste policy

Zero Waste: The conservation of all resources through responsible production, consumption, reuse, and recovery of products, packaging, and materials without burning or discharging that endanger the environment or human health.

Zero Waste is an ethical, economical, efficient, and imaginative objective that guides people in modifying their lifestyles and behaviors to mimic sustainable natural cycles. All discarded materials are planned to become resources for others to utilize.

Zero Waste is methodically avoiding and eliminating the amount and toxicity of waste and materials, conserving and recovering all resources, rather than burning or burying them.

Zero Waste will remove all discharges to land, water, or air that endanger the health of the world, humans, animals, or plants.

Zero Waste is a 21st-century philosophy and design principle. It includes ‘recycling' but goes beyond that by taking a 'whole system' perspective to human society's huge flow of resources and waste.

Instead of seeing used materials as trash that needs to be disposed of, they are seen as precious resources. A pile of 'waste' represents communal and economic possibilities, such as new goods made from raw materials and jobs.

The zero-waste method aims to maximize recycling, reduce waste, and ensure that items are designed to be reused, mended, or recycled back into nature or the marketplace.

- Redesigns the current, one-way industrial system into a circular design based on Nature's successful strategies creating durable, reusable, or easily recyclable items and packaging.
- Provides chances for trash-based businesses to produce jobs from waste.
- Recognizes the value of producer accountability.
- Rather than managing waste, this initiative aims to eliminate it. It aims to reduce taxpayer subsidies for the use of virgin resources, allowing reused and recycled products to compete.

According to U.S. 83rd Annual Meeting

In Support of Municipal Zero Waste Principles and a Hierarchy of Materials Management; Solid waste management is one of the most basic services that a city must give to its citizens, and the operational and financial burdens of sustainable municipal solid waste management are primarily carried by towns and local government organizations. https://www.usmayors.org/

Today, the United States generates an estimated 251 million tons of municipal solid waste (MSW) each year, recovering only 87 million tons, or 34% of that amount, through recycling and composting a small percentage of the recyclable/compostable amount; and the majority of MSW - 135 million tons in 2012 ends up in landfills, generating significant amounts of methane the second most common greenhouse gas in the United States as it decomposes.

The United States Conference of Mayors adopts a concept of Zero Waste, as well as a set of Zero Waste principles, that acknowledges the following Hierarchy of Material Management:

- Producer Responsibilities Expanded and Product Redesign
- Waste, toxicity, consumption, and packaging should all be reduced.
- Repair, Reuse, and Donate
- Recycle
- Compost
- Beneficial Reuse and Down Cycle
- waste-based energy
- landfill waste

5.5.1 zero waste policy in Europe

“European Commission on Environment eco-innovation action plan.”

A European campaign involving municipalities, corporations, and citizens' groups encourages participants to pledge to eliminate residual waste, effectively ending landfills and incineration as waste management options.

Local waste management infrastructure change is encouraged by Zero Waste Europe. It argues for waste avoidance to be included in local planning, for towns to undertake garbage separation so that waste streams can be sorted at the source, and for the steady elimination of waste.

So far, the zero-waste movement has gained traction in Italy Capannori, a town of around 47,000 people in Tuscany, is the pioneering zero-waste champion. Since 2004, the quantity of waste generated per person per year has decreased by 39%, from over 700 kilograms to around 430 kilograms. Capannori's trash is now sorted at the source and reused, repurposed, or composted more than 80%.[1]

[1] http://ec.europa.eu/environment/waste/target_review.htm Last update: 12/11/2021
[2] https://zerowasteeurope.eu/

Writers note:

Waste is only a symptom of humanity's much larger problem.
Zero waste is a philosophy aimed at eliminating all waste sources. [2]
Our planet has always followed the zero-waste principle. For thousands of years, up to the industrial age, waste was not a concept because most discarded material from civilizations was recycled as inputs for other processes, circularly preserving its value, much as nature does. On the other hand, Humankind must design what nature has accomplished thus far through evolution.

We've learned that to sustain the value and energy embodied in resources while allowing civilization to flourish and prosper, we need to rethink how we produce and consume. So zero waste is not just about separating economic activity from environmental impact when it comes to zero waste.

In the interests of the environment, Waste management and reduced plastic manufacture will become increasingly crucial in decreasing global greenhouse gas emissions as we get closer to the climatic emergency. We must target all areas of society at both the international and national levels to keep global warming below 2 degrees.

Zero Waste Europe acknowledges the underlying climatic implications of waste, and it aims to underline the reciprocal benefits of a zero-waste lifestyle for both the environment and the climate. [2]

For the world after COVID-19

On the one hand, the COVID-19 pandemic has demonstrated how fragile we are as a species; on the other hand, it has been shown how, when we work together, we can combat common challenges. The most crucial takeaway from this disaster is that we must stop the environmental degradation that breeds new pandemics to avoid further outbreaks.

Rebuilding ecosystems and developing ways to prosper with them, rather than against them, is at the heart of zero waste. The zero-waste mission is all about figuring out how to make life more meaningful for both humans and the environment: a win-win situation. [2]

For cities

The evident and provable commitment to moving toward zero-waste, as well as the outcomes that will be delivered in the following years, are what characterize a "Zero Waste Municipality."

Zero Waste Europe gathers and promotes European communities that have publicly committed to constantly lowering garbage generation and enhancing waste separation collection, thereby reshaping the human-waste interaction.

Leading candidates in waste resource and management, such as the highest performing entity in Europe, the Contarina district in the Italian region of Veneto, are part of the network of European municipalities working towards zero waste. However, the goal of Zero Waste Europe is not just to highlight the best performers but also to facilitate and recognize the dedication of communities that, despite now producing disappointing results, are steadfastly dedicated to moving toward zero waste. [2]

Finally, zero waste" is becoming a trend and creating a discussion across Europe and beyond as individuals try to cut costs, optimize their day-to-day, and go "smart." Is it possible to live a waste-free life at home? It all starts with wise purchasing selections, proper planning, and establishing a system for determining what and how materials enter your home.

Our cities and municipal waste management systems still have a long way to go before being considered main-stream zero waste. It is our job to push this conversation forward at the European level. Until then, there are many things you can do to save money, live more efficiently, and lessen your carbon footprint.

5.6 embodied energy-co2-waste resulting from the construction & energy consumption

By weight, the building industry uses more raw materials than any other industry.

Construction materials account for around half of all materials mined from the Earth's mantle [1].

A wide range of materials are used in building construction, and the manufacture of each item uses energy and produces CO2. As a result, buildings and construction are responsible for more than 36% of worldwide energy consumption and up to 40% of energyrelated CO2 emissions, according to the United Nations Environ-ment Program (UNEP) [2].

According to the UNEP, overall CO2 emissions from buildings (including energy related emissions from building construction) were more than 11 GtCO2 in 2017 [2]. Compared to other industries such as manufacturing and transportation, buildings and the construction sector consume the most energy and pollutants. Because of the exponential growth of the building sector and high urban population growth, especially in emerging nations, embodied energy and CO2 emissions are expected to climb even more in the future.

According to the United Nations Environment Program (UNEP), the globe will add 230 billion square meters of new structures in the next 40 years, the equivalent of Paris every week. More than half of the buildings expected to be completed by 2060 will be built in the next 20 years, with two-thirds of them being constructed in nations without required building energy codes [3].

[1]. Torgal, F.P.; Jalali, S. Eco-Efficient Construction and Building Materials; Springer-Verlag London Limited: London, UK, 2011.

[2]. UNEP. 2018 Global Status Report: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector. 2018. Available online: https://www.globalabc.org/uploads/media/default/0001/ 01/f64f6de67d55037cd9984cc29308f3609829797a.pdf (accessed on 25 January 2019)

[3] UNEP. Global Status Report 2017: Towards a Zero-Emission, Efficient, and Resilient Buildings and Construction Sector. 2017. Available online: https://www.worldgbc.org/sites/default/files/UNEP%20188_ GABC_en%20%28web%29.pdf (accessed on 2 February 2019).

5.6.1 energy consumption in the building sector

Buildings are one of the leading causes of high energy use and its accompanying environmental difficulties, a significant subject of concern worldwide. The embodied and operational energy make up its lifespan energy [4–5].

Buildings' embodied energy can be divided into three categories [5,6,7]: (1) - Initial embodied energy (IEE): Energy used in the manufacturing and transportation of a product, from the extraction of raw materials and processing of natural resources to the manufacturing and transportation of products to construction sites. It also includes the energy that is directly linked to the construction process. As a result, IEE refers to all energy spent during a building's lifecycle pre-use period.

(2) - Recurrent embodied energy (REE): The amount of energy necessary to maintain, repair, and refurbish buildings throughout their useful lives. REE is determined by how a building's occupants utilize it, their maintenance needs, their service life, and the life span and quality of the materials and components.

(3) - Demolition embodied energy (DEE) is the energy used to demolish a structure at the end of its useful life, recycle and reuse some components, and dispose of others by transporting debris and waste to landfills or incinerators. The embodied energy can be used directly in building construction and other associated operations or indirectly in extracting raw materials, manufacturing of building materials and related products, and transportation. [8]

	coefficients	
materials	**embodied energy (MJ/Kg)**	**Co2 Emissions (Kg/Kg)**
cement	3.32	0.730
sand	0.06	0.004
coarse aggregate	0.16	0.010
HCB	7.96	1.550
rebar	15.97	1.060

table 4.0 based on/ source: Embodied Energy and CO2 Emissions of Widely Used Building materials: Ethiopian Context
Woubishet Zewdu Taffese 1, * and Kassahun Admassu Abegaz 2

Even though building construction consumes a lot of embodied energy and generates a lot of CO2s, the trash generated throughout the process is a source of inflation. In addition, the embodied energy of construction materials and the associated CO2 emissions is a debt burden for future generations, as it will be released into the environment at the end of the buildings' lifecycles. On the other hand, construction waste is a current reality in terms of embodied energy and CO2 emissions. Therefore, the waste will either be disposed of in a landfill or recycled. When used as a landfill, it poses a threat to the entire ecosystem as a source of contamination.

We can list the generally used materials throughout the constructions as follows:

- cement
- sand
- coarse aggregate [1]
- HCB [2]
- Rebar

[4] Dixit, M.K. Life cycle embodied energy analysis of residential buildings: A review of literature to investigate embodied energy parameters. Renewable Sustainable Energy Rev. 2017, 79, 390–413.

[5] Azari, R.; Abbasabadi, N. Embodied energy of buildings: A review of data, methods, challenges, and research trends. Energy Build. 2018, 168, 225–235.
[6] Dixit, M.K.; Singh, S. Embodied energy analysis of higher education buildings using an input-output-based hybrid method. Energy Build. 2018, 161, 41–54

[7] Lotteau, M.; Loubet, P.; Sonnemann, G. An analysis to understand how the shape of a concrete residential building influences its embodied energy and embodied carbon. Energy Build. 2017, 154, 1–11.

[8] Azari, R.; Abbasabadi, N. Embodied energy of buildings: A review of data, methods, challenges, and research trends. Energy Build. 2018, 168, 225–235.

[1] Coarse aggregates refer to irregular and granular materials such as sand, gravel, or crushed stone, and are used for making concrete. In most cases, Coarse is naturally occurring and can be obtained by blasting quarries or crushing them by hand or crushers.

[2] The "Hybrid-Composite Beam" or HCB®, is a structural member developed for use in bridges and other structures. The HCB is comprised of three main sub-components that are a shell, compression reinforcement and tension reinforcement.

5.6.2 energy consumption phases of buildings during their lifecycle.

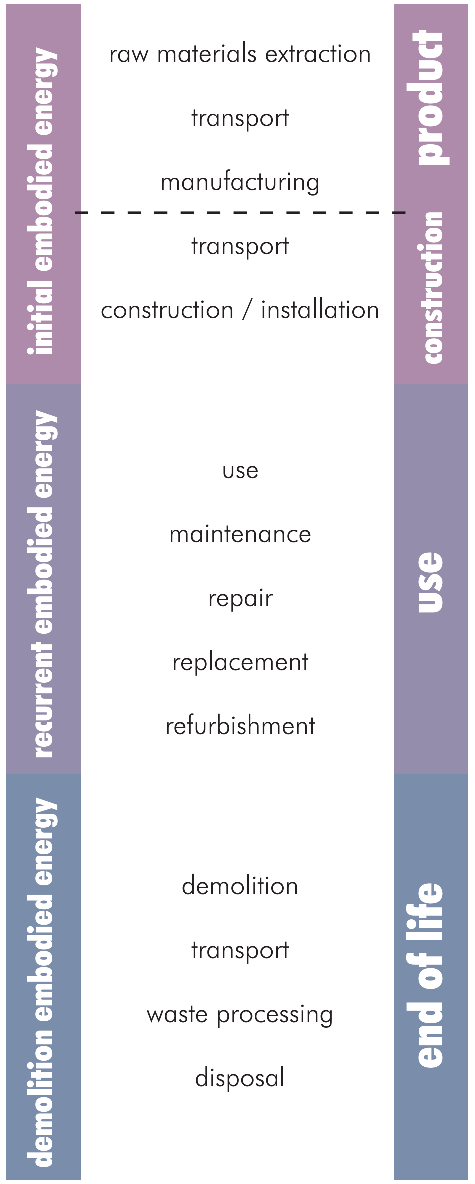
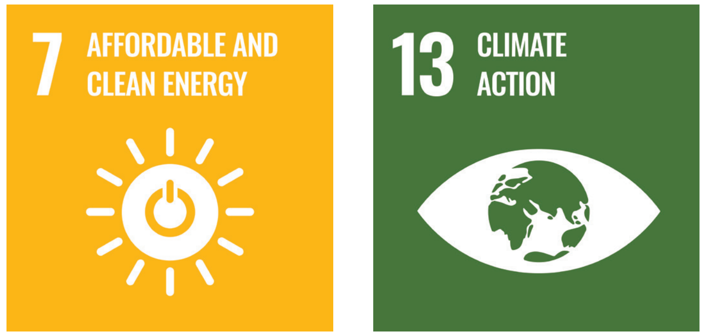


Figure 20: based on Birgisdottir, H.; Moncaster, A.; Wiberg, A.H.; Chae, C.; Yokoyama, K.; Balouktsi, M.; Seo, S.; Lützkendorf, T.; Malmqvist, T. IEA EBC annex 57 'evaluation of embodied energy and CO2eq for building construction'. Energy Build. 2017, 154, 72–80.

To optimize the whole energy footprint of the construction sector, it is essential to reduce both embodied and operational energy. Standardized procedures and technologies are now available to accurately analyze operating energy. Despite this, lowering embodied energy usage and CO2 emissions has received little attention. Computation of embodied energy is still complex and resource intensive. It necessitates a large volume of high quality data, which is sometimes unavailable [9]. In addition, the operating phase of the lifecycle has traditionally been defined as the largest consumer of a building's total energy usage due to its length.

As a result, improved energy-efficient space conditioning appliances and auxiliary systems are being installed in buildings that gradually lower their operational energy in most industrialized countries. These improvements, however, are offset in developing countries by the usage of inefficient operating energy systems. Energy efficient buildings are essentially non-existent in these countries due to various problems, including a lack of knowledge and awareness, a lack of experience, high transaction costs, and a lack of regulation [10].



[9] Dixit, M.K. Embodied energy analysis of building materials: An improved IO-based hybrid method using sectoral disaggregation. Energy 2017, 124, 46–58.

[10] Ponomarev, P. Achieving Energy Efficiency in Buildings in Developing Countries. Bachelor's Thesis, California Polytechnic State University, San Luis Obispo, CA, USA, June 2006.

6

circular economy and waste

6

circular economy analysis in waste

6.1 introduction

Recycling resources from waste is critical for a circular economy to 'complete the loop.' Energy recovery from trash plays an essential role as well. Waste disposal should be phased out, and where it is inevitable, it should be adequately controlled to ensure human and environmental safety.

The JRC[1] has been giving research support on waste related components of the circular economy, as the EU has prioritized circular economy initiatives. To that purpose, it has engaged in well-structured and transparent consultation processes with stakeholder specialists. Proposing end-of-waste criteria for specific waste streams and safety and quality requirements for recycled materials; generating reference information on best available techniques and best practices; and conducting techno-economic and environmental assessments of recycling processes, waste-to-energy options and waste disposal operations are among the outputs.

In the EU-28 alone, in 2014:

- On average 16 tons of raw material per person was produced, of which 6 tons went on to become waste.
- 2,053 million tons of waste were generated.
- On average, 481 kg of municipal waste per person was produced.
- Households contributed only 8.3% of the total waste.
- 2,320 million tons of waste were treated (including 267 million tons imported into the EU).

1 The Joint Research Centre is the Commission's science and knowledge service. The JRC employs scientists to carry out research to provide independent scientific advice and support to EU policy.

6.2 EU in the circular economy

Shifting from a linear to a circular economy is significant for member states, their regions, and municipalities. However, as indicated by the European Commission's publication of the New Circular Economy Action Plan last month, things are changing in this field, and more significant and systemic reforms are required. In addition, the plethora of binding European waste management targets in a circular economy that have been set or raised in recent years may present a challenge for governments.

The policy brief includes an overview of the European Commission's Circular Economic Action Plan and recent legislation, targets, messaging, and methods. On the other hand, its strength is in bringing insights and inspiration from several well funded initiatives that have already discovered excellent examples in three main areas: garbage reduction, reuse, and recycling, food waste prevention, and landfill rehabilitation.

The circular economy (CE), which arose from the movement for sustainable development, has recently come to the top of the EU's policy agenda. In the 1960s, the foundations of sustainable development were created, focusing on the link between environmental degradation and resource extraction and the economy and social well-being.

In the 1990s, the term "sustainable development" became popular, subsequently being given several names. Sustainable consumption and production, green growth, the low carbon economy, and resource efficiency became more integrated into the description of the new economy model known as the "Green Economy" by the end of the first decade of the 2000s.

The European Commission released its Circular Economy Action Plan in December 2015, placing CE at the center of its new mainstream sustainable development agenda. According to the European Commission's policy, the EU economy should be re-thought through changing the five stages of product and service lifecycles:

1- design,
2- production,
3- consumption,
4- waste management
5- secondary materials treatment.

Furthermore, the plan identifies five main areas, each with its issues. According to the Action Plan, these issues will be addressed between 2015 and 2019 by amending relevant legislation and introducing many legislative initiatives. This process has already started with proposed directives on waste, landfills, and increased use of organic and waste-based fertilizers (European Commission, 2016a, 2016b).

One of the primary EU strategies to help Europe meet its UN Sustainable Development Goals obligations will be the transition to a circular economy (SDGs).

The circular economy impacts several of the 17 goals, either directly or indirectly. Goal 12, which strives to ensure sustainable consumption and production patterns, is immediately affected.

Goals 7 and 11 on clean energy, Goal 11 on sustainable cities, Goal 13 on climate action, and Goals 14 and 15 on the ocean and terrestrial ecosystem conservation are also likely to have more indirect effects. The European Commission is now working on a specific plan to transform these goals into EU internal and external policies.

6.3 what is the circular economy and its correlation with the phenomenon "waste."

High levels of material consumption deplete resources and leave enormous environmental footprints (Global Footprint Network, 2016). These two trends of continued urbanization (for example, in China and India) and a growing global middle class, expected to reach 3 billion people by 2030 (UNEP, 2015), are likely to boost global material consumption even further.

In the EU28, the average annual domestic material consumption per capita has dropped from roughly 16.5 tons in 2007 to around 13 tons in 2014. (Eurostat, 2016a). Reduced resource demand during the 2008 economic crisis and subsequent recession could explain this pattern (EEA, 2016). However, overall material consumption in OECD Europe in 2010 was 26 tons per capita, including imported items (OECD, 2016). As a result, much more must be done in the EU to reduce material use. This will demand a reconsideration of Europe's consumption and manufacturing habits.

6.3.1 a variety of issues arise because of the linear model: negative aspects of the linear economy

The extraction of virgin resources outpaces the rate at which they can be replaced.

Products are treated as garbage after they are discarded, and they are frequently burnt or disposed of in landfills, resulting in the waste of valuable and rare natural resources.

Hazardous compounds leach into the land, water, and air because of unsafe waste management practices.

Both product manufacturing and transportation produce pollution and consume a lot of energy, which can be avoided in a circular economy.

6.3.2 in a circular economy, resources are reused. /Positive aspects of circular economy

Resources are handled more responsibly in a circular economy. The goal is to ex-tend the product's life and reuse all materials without generating waste.

Because most materials lose value when recycled, product reuse is more resource-efficient than recycling. As a result, the best strategy to reduce a product's environmental impact is to extend its lifespan. Products in a circular economy are designed to last. They're long-lasting and may be improved or repaired.

When products reach the end of their useful lives, they become precious resources that can be utilized to create new ones. As a result, the requirement for virgin resources in the circular economy is reduced. Product and material life are considered early in the design process, with components that are easy to separate and do not contain dangerous elements that make them unsuitable for recycling or reuse in new products.

6.4 main barriers of circular economy actions in waste management

Three pillars support the shift to a circular economy:

- environmental advantages, particularly in terms of reduced ecological consequences and resource consumption.
- Cost reductions due to lower natural resource requirements.
- the development of new markets, resulting in further economic benefits from circular economy methods, such as creating jobs or wealth.

The circular economy, in principle, promises substantial environmental and economic benefits and should quickly replace the linear economy, but in practice, the 'linear model' continues to dominate the economy. Two of the critical factors for this paradox are the complexity of the circular economy idea and dropping commodity prices. To begin with, the circular economy is a hugely complicated concept with farreaching implications across the economy. CE has diverse meanings and impacts on different industry sectors and other economic actors, even though several definitions exist (see, for example, EMF, 2013; European Commission, 2015a). What's the difference between a city's CE and a multisectoral corporation's or a startup's CE? Private sector decision-makers and policymakers of various sizes, from the local to the national and macro regional, require more clarity on how CE is important to each type of economic actor and sector of economic activity.

Second, the circular economy became an EU policy priority in reaction to high commodity prices and resource scarcity. Commodity prices today, particularly regarding energy, food, and metals, are around half of what they were from 2010 to 2014 and about 20% lower than in 2005. (IMF, 2016). Low commodity prices undermine one of the circular economy's three pillars by limiting the potential cost savings associated with reduced resource use. In this delicate subject of circular economy there are various difficulties in applying the circular economy varieties and strategies without facing any problems. Therefore, there is an urgent need to find a standard solution to change any of the linear economies ongoing and change it to a circular economy which is an excellent joint decision at the end also for the consideration of our future.

We can do several things to boost this reaction to the circular economy.

Use the things you buy for a longer time, even an extra year provides significant environmental benefits.

Choose goods that are made to be repaired, upgraded, or upcycled.

Don't only consider the purchase price; a more expensive product may be less costly to maintain in the long run, saving you money.

In the circular economy, consider product contents precious resources that should never be abandoned.

Jaeger, B. and Upadhyay, A. (2020) describe the main barrier of the circular economy as follows:

The manufacturers researched are primarily concerned with trash reduction and recycling. These policies have a negligible or negligible CE effect. Policies with a high CE effect, such as maintenance and reuse, aim to achieve zero waste's CE ideal are almost non-existent. Seven main barriers to CE were identified:

- high start-up costs,
- complex supply chains,
- challenging business-to-business (B2B) cooperation,
- lack of information on product design and production,
- lack of technical skills,
- quality compromise, and
- time consuming and expensive product disassembly.


photograph no:6 by author (Can Aktoluğ)

7

A study case in Turin North

7.1 district 6 and the Regio Parco district

District 6 107,369 inhab.
25,206 km^2

- Barriera di Milano
- montagna bianca
- Parco reale
- Barca
- Bertolla
- Falchera
- (Pietra alta)
- Rebaudengo
- Villaretto
- fraz. Famolenta

Regio Parco (Regi Parch in Piedmontese) is a semi-peripheral district in Turin's Circoscription 6 that is located near the confluence of the Stura di Lanzo and the river Po in the city's north-east section. To the north, route Botticelli and the Stura di Lanzo river; to the east, the river Po; to the west, corso Giulio Cesare; and to the south, via Cimarosa. It is sometimes associated with the districts of Barca and Bertolla, which are separated by the Stura river. [3]

Via Stradella from Corso Vigevano to the Turin-Venice Railway - Turin-Venice Railway to the bridge over the Stura di Lanzo Stream - Mezzeria del Torrente Stura di Lanzo to the border with the Municipalities of Borgaro Torinese and Venaria Reale - Border of the Municipality of Borgaro Torinese and in continuation with the Municipalities of Settimo Torinese and San Mauro Torinese up to the middle of the River Po - Mezzeria del Fiume Po and imaginary line that joins it to Via Pindemonte - Via Pindemonte and in continuation Corso Regio Parco up to Corso Novara - Corso Novara and continuing (for Piazza Crispi) Corso Vigevano up to Via Stradella. District 6 also includes the administrative island called "Quartiere Famolenta". [3]

The region was left in devastation after the destruction of the Royal Park and the adjacent Palazzo delle delizie. The park was demolished in 1829 to make way for what is now Turin's monumental cemetery, and the Royal Tobacco Factory was established in 1758 to replace the Palazzo delle Delizie, which was completed in 1760. The factory had to house "the plantation, the seedbed, and the hanging of the tobacco leaves," as well as the processing (mincing and beating) that reduced the leaf to ground smoke or snuff powder, all in one protected location. Tobacco processing was rigorously regulated and was a state-led initiative. As a result, it had to reflect the king's majesty as well as the central power's efficiency. Giovanni Battista Feroggio was entrusted with the design of the industrial complex. The chapel would be built in the center of the new building, bordered by two wide courtyards for planting and hanging, and circumscribed by the processing and dwelling buildings. An informal derivation, known as the Regio Parco Canal, was dug to provide the hydraulic driving force required for the "plague" and other tobacco processing devices. [1]

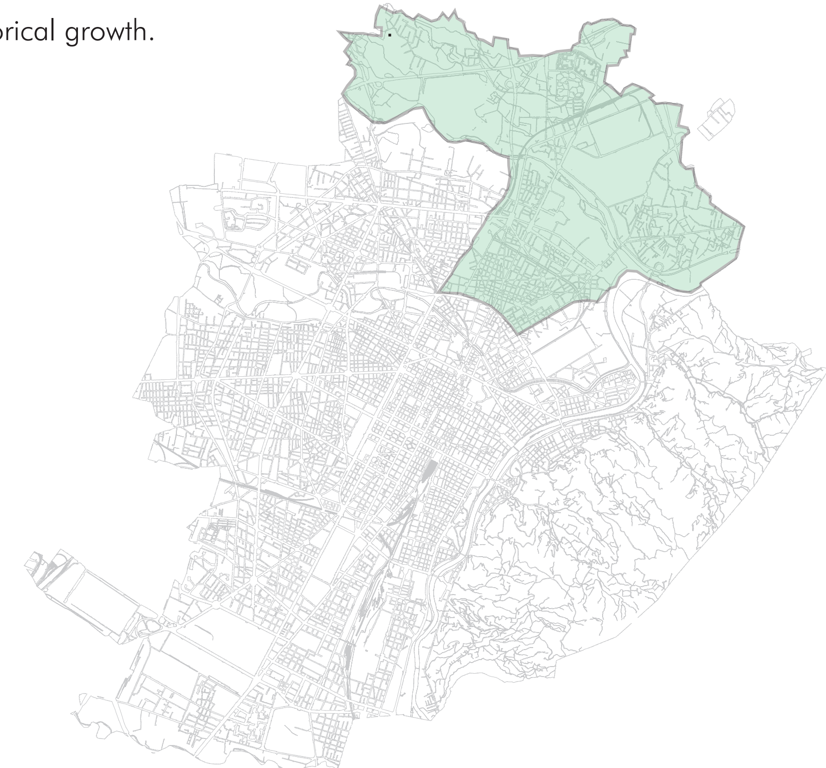
[1] https://web.archive.org/web/20080203205333/http://www.torinocuriosa.it/curiosita.php?cdcur=67
[2]http://www.comune.torino.it/ucstampa/comunicati/article_120.shtml
[3]https://it.wikipedia.org/wiki/Portale:Torino

In 1840, the structure was converted into a true tobacco factory with an adjacent paper mill. Between 1855 and 1858, subsequent extensions included the enclosing of the central courtyard with two sleeves and the expansion of the area of canopies and warehouses. The church at the main entrance had to be dismantled later to enable for the erection of the power plant.

The factory's workforce were largely blue-collar workers from the adjacent Barca and Bertolla neighborhoods, as well as Regio Parco. Workers at the tobacco plant were the heroes of a wonderful scene at the end of WWII, when they cut the tires of the trucks, repelling the black fascist brigades who had taken the facility in revenge for a collection gathered in support of the partisan militias.

After a lengthy period of crisis, the Manufacture finally closed its doors in 1996, and after years of increasing structural ruin, a rehabilitation design study was put up to dedicate the land to university structures, but the University of Turin decided to abandon it in 2017. The Turin Municipality gave its approval to a new feasibility proposal for the development of a health residence and other personal services, as well as a public area and additional green spaces, in February 2019. [2]

The ancient Maddalene road, which is now pedestrianized, as well as Piazza Cesare Abba, which was once the Royal Tobacco Factory's main entrance, continue to shape the area's historical growth.



Map. 1 Map of Turin with subdivision of the territory into Circumscriptions

7.2

waste collection and recycling centers

The growing volume of construction and demolition waste (C&DW) in Italy is creating a challenge to public officials who are seeking to ensure that collection and recycling are managed sustainably. They must assess if and to what extent recycled aggregates may supplement natural aggregates in the building industry's sustainable supply mix (SSM). According to data provided by Provincia di Torino (2009), the research region has a population of around 2.25 million people, annual C&DW production is 1.8 Mt, and recycling facilities have a total processing capacity of 1.84 Mt. The actual recycling rate is 42 percent (759,000 t/y), and the RA produced is primarily used for environmental filling or road construction, with the remaining 58 percent now being landfilled (Provincia di Torino, 2009).

Despite the disparity between recycling capacity and actual recycling, this is a respectable outcome when compared to the national recycling rate of 10–20 percent (ANPAR, 2007). According to the Provincia di Torino, which is in charge of issuing quarrying and recycling licences, there are 31 plants processing NA, 68 plants processing RA, and 21 hybrid plants that process NA and RA alternately in the research region). NA quarries and nearby processing plants were also considered, as some of the crushing units produce both NA and RA (hybrid plants), and many exhausted quarries are repurposed as recycling facilities.

Table 5.0 taken from/

[1] G.A. Blengini, E. Garbarino / Journal of Cleaner Production 18 (2010) 1021–1030

Construction aggregates processing plants in the study area.

Type	NA	RA	NA/RA
Stationary	18	3	5
Semi-mobile	2	7	5
Mobile	11	58	11
Total	31	68	21

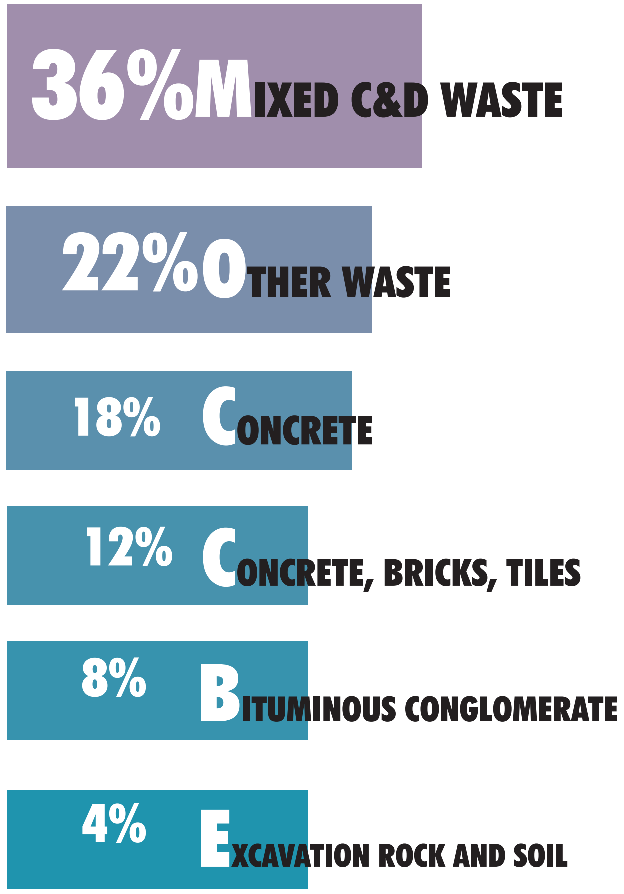


figure 21: created by the author / source: Provincia di Torino

Average composition of C&DW in the study area (Provincia di Torino).

It's worth mentioning that appropriate rubble recycling in mobile plants necessitates sorting processes that would benefit from compact water clarification and sludge disposal devices that are now not fully available on an industrial scale. The Politecnico di Torino investigated the creation of such a technology and its application, with the first results published in Garbarino et al (2007).

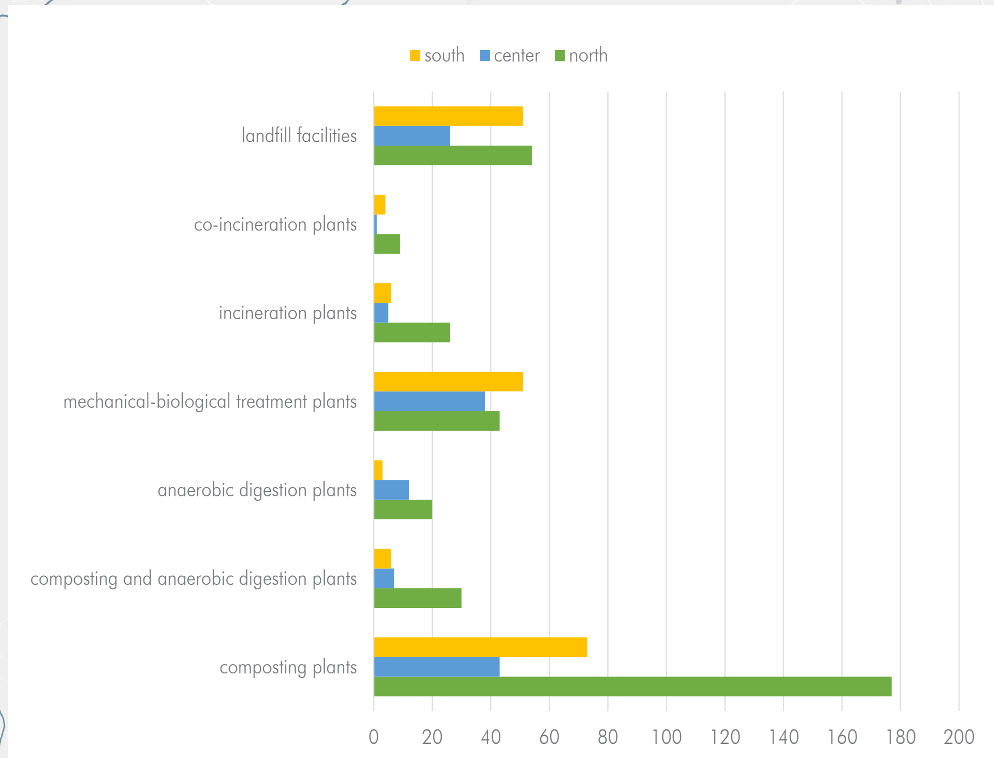
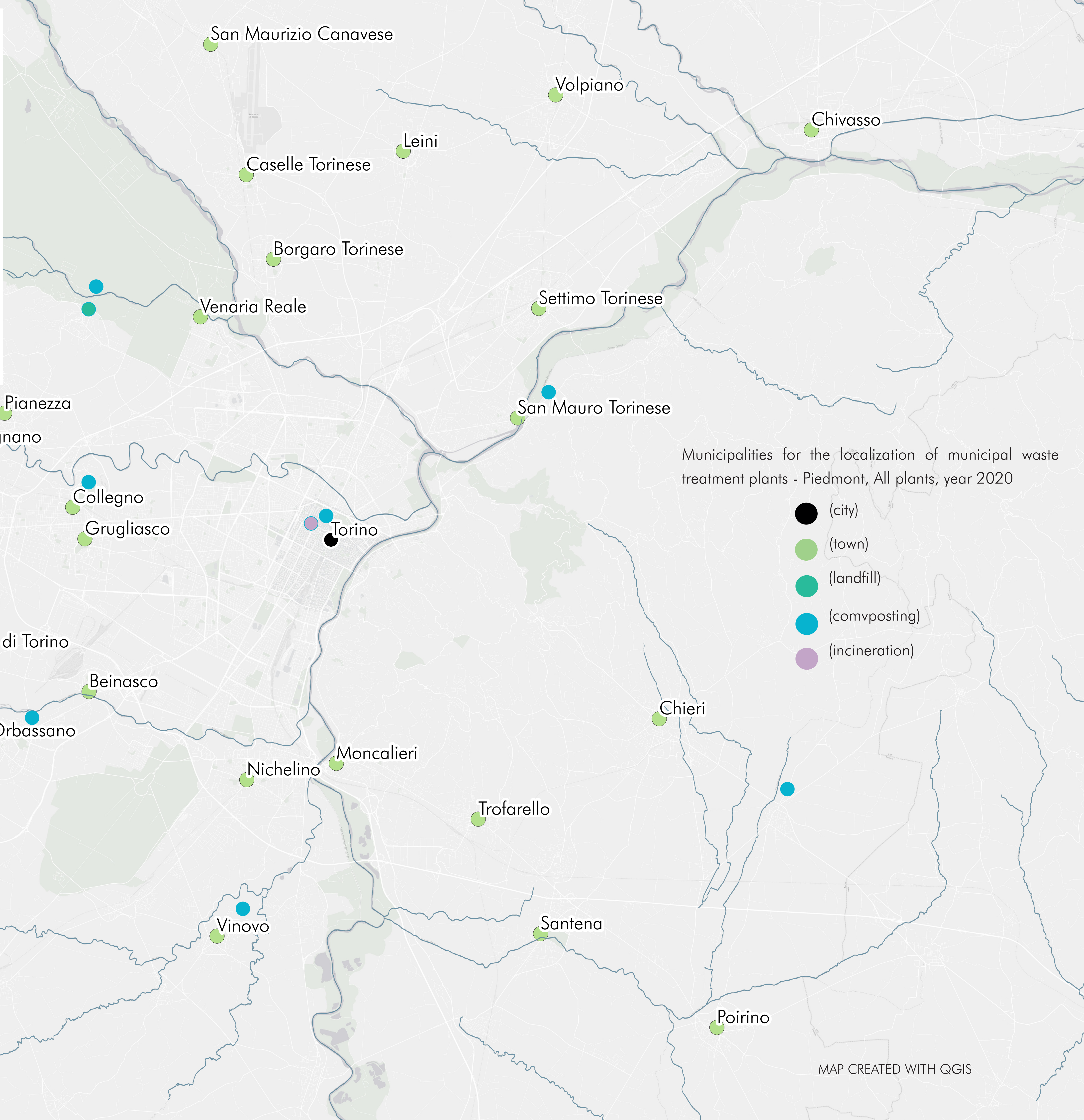
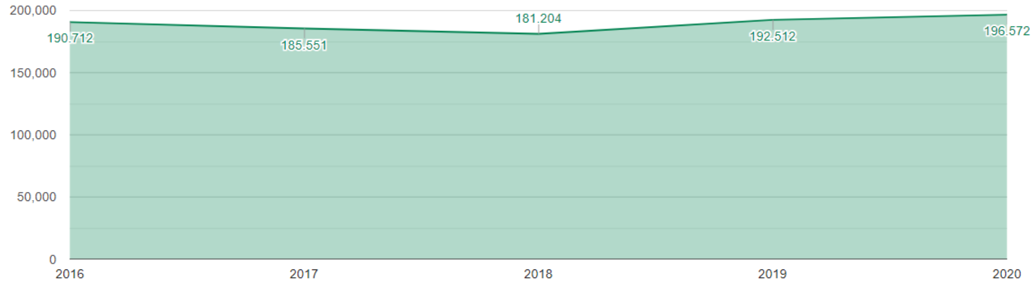


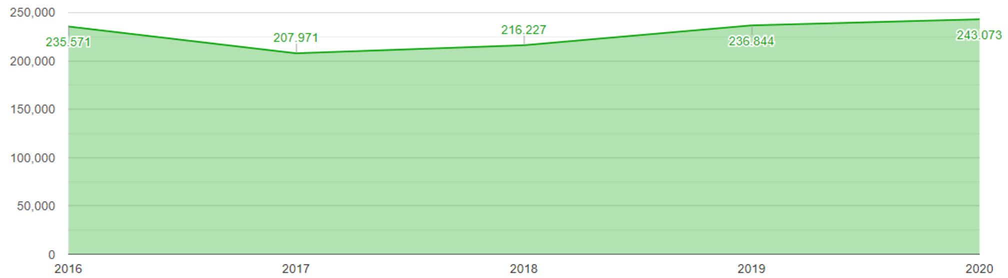
fig 22 : elaboration by the author/source : ISPRA
ref. ISPRA - Higher Institute for Environmental Protection and Research
National Center for Waste and Circular Economy



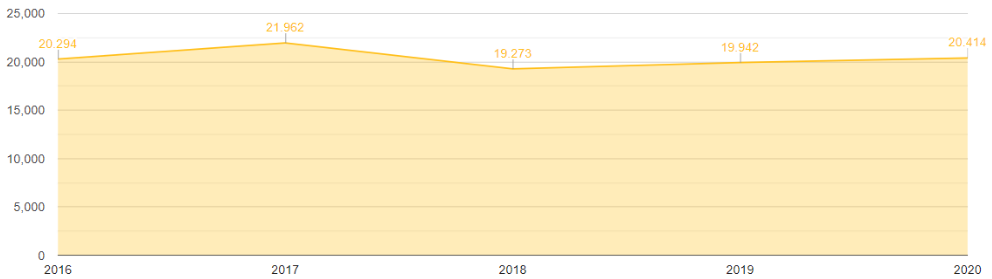
quantities of municipal waste treated in composting plants - piedmont



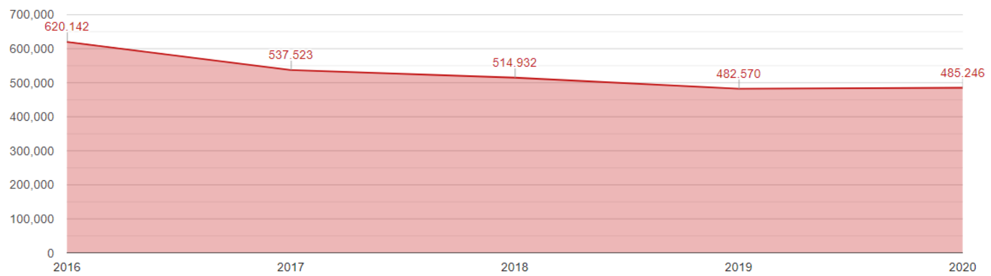
quantities of urban waste treated in integrated composting / anaerobic digestion plants



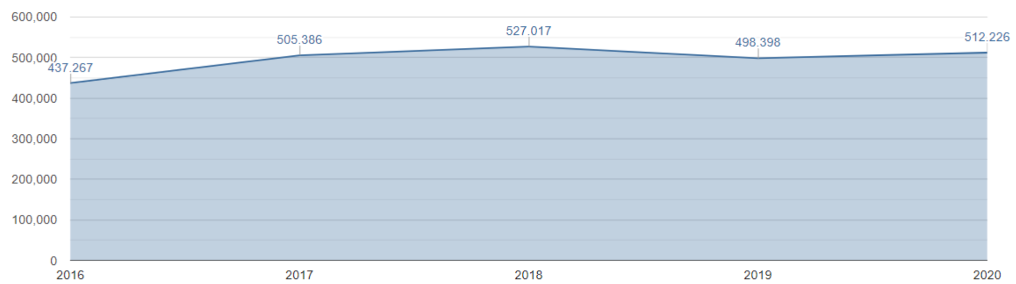
quantities of organic fraction treated in anaerobic digestion plants



quantities of RU and waste from RU treatment treated in TMB plants



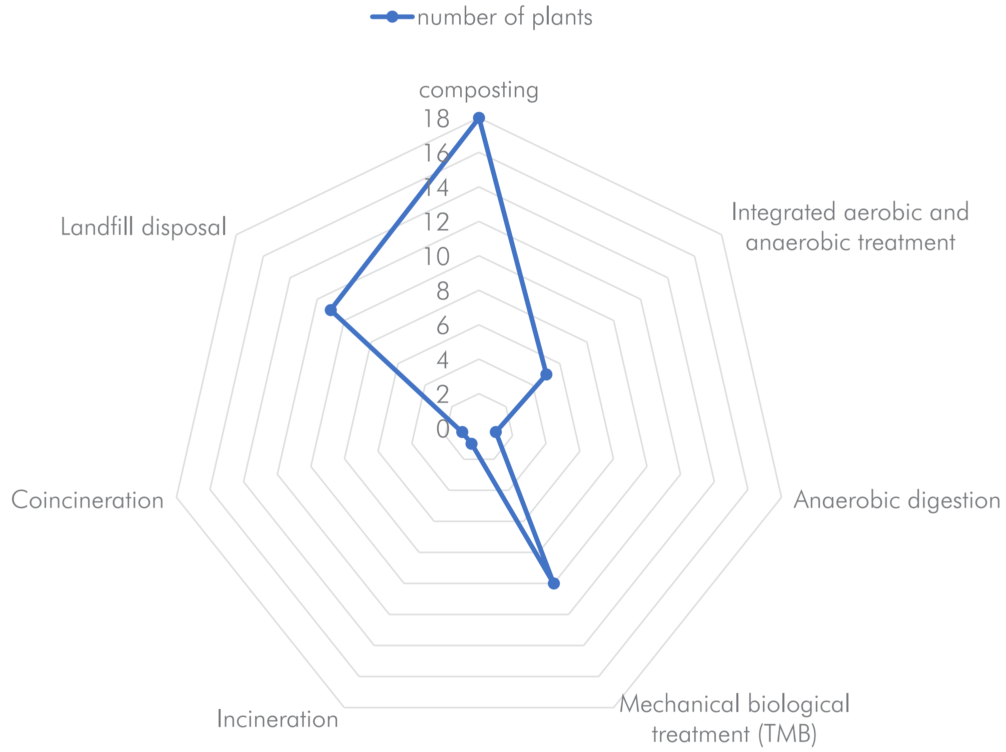
quantities of MSW and waste from MSW treatment treated in incineration plants



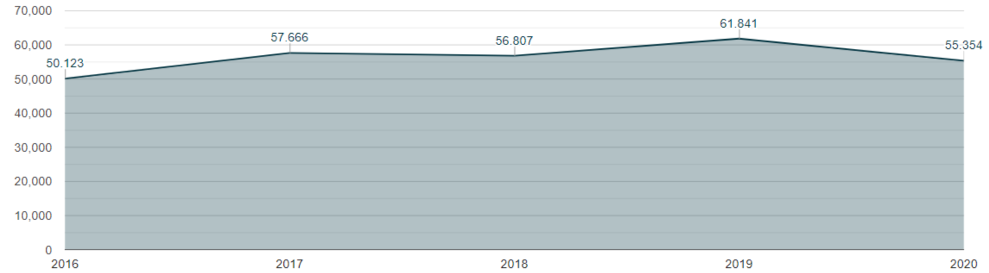
7.2.1 municipalities for the localization of municipal waste treatment plants

-Piedmont, All plants, year 2020

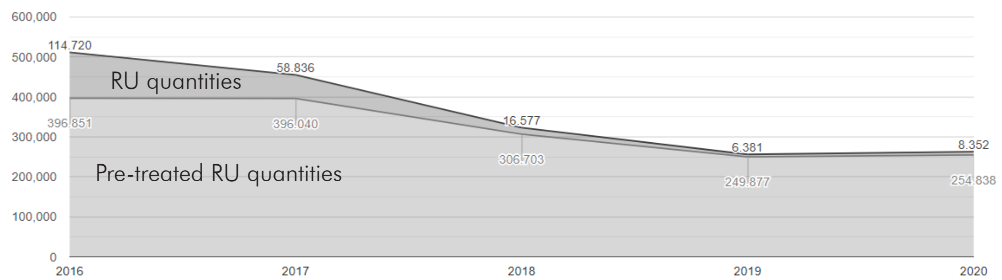
number of plants



quantities of MSW and waste from MSW treatment treated in co-incineration plants



quantities of RU and waste from RU treatment disposed of in landfills



charts 6-7-8-9-10-11-12-13 taken from source / ISPRA - Higher Institute for Environmental Protection and Research National Center for Waste and Circular Economy chart 14 based on source / ISPRA - Higher Institute for Environmental Protection and Research National Center for Waste and Circular Economy

National management of urban waste - year 2020 (ISPRA)							
Composting							
Geographic area	Number of implants	Wet fraction (t)	Green (t)	Tot. RU (t)	Sludge (t)	Others (t)	Total (t)
North	177	438.002	1.104.083	1542.085	224.793	242.468	2009.346
Centre	43	322.466	181.279	503.745	59.16	44.935	607.84
South	73	1.003.014	122.62	1125.634	181.544	38.57	1345.748
Italia	293	1.763.482	1.407.982	3171.464	465.497	325.973	3962.934
Integrated aerobic and anaerobic treatment							
North	30	2284.072	328.653	2612.725	66.623	108.7	2788.048
Centre	7	199.236	72.939	272.175	14.889	709	996.064
South	6	178.055	20.08	198.135	0	88	286.135
Italia	43	2661.363	421.672	3083.035	81.512	109.497	3274.044
Anaerobic digestion							
North	20	289.701	441.23	28.993	759.924	x	788.917
South	3	48.198	9.907	63.947	122.052	x	185.999
Italia	23	337.899	451.137	92.94	881.976	x	974.916
Mechanical biological treatment (TMB)							
North	43	1479.79	398.806	109.572	1988.168	149.703	2247.443
Centre	38	2286.334	301.879	73.326	2661.539	72.301	2807.166
South	51	3823.726	772.292	43.462	4639.48	8.743	4691.685
Italia	132	7589.85	1472.977	226.36	9289.187	230.747	9746.294
Incineration							
North	26	2498.1	1240.979	3739.079	33.482	830.426	4602.987
Centre	5	82.999	449.4	532.399	0	5.079	537.478
South	6	79.769	973.397	1053.166	24.759	24.121	1102.046
Italia	37	2660.868	2663.776	5324.644	58.241	859.626	6242.511
Coincineration							
North	9	25.062	167.073	192.135	0	219.04	411.175
Centre	1	0	7.024	7.024	0	17.593	24.617
South	4	0	90.329	90.329	0	70.668	160.997
Italia	14	25.062	264.426	289.488	0	307.301	596.789
Landfill disposal							
North	54	196.543	1282.317	1478.86	1735.823	x	3214.683
Centre	26	105.59	1645.579	1751.169	567.765	x	2318.934
South	51	64.422	2522.677	2587.099	606.098	x	3193.197
Italia	131	366.555	5450.573	5817.128	2909.686	x	8726.814

Because of past illegal operations, Italy is cautious of using materials derived from C&D activities. The waste material is typically utilized in road building since its properties are similar to those of fresh materials, but if not properly handled before use, it can cause major legal and technical issues for the construction company. It is critical to properly complete the recycling process in order to obtain high-quality material. In light of this, ISPRA's official numbers on waste output from C&D are simply estimates, and it is possible that illegal practices continue to exist today.

An intervention in the public administration would be beneficial in removing all of the waste produced by building refurbishment and demolition. If the required percentage of 70 percent request from the European Union is met, a proper value of reused C&D waste can be evaluated and estimated with the accurate quantification of data. The absence or lack of appropriate instruments, such as unique specifications, updated to the harmonised European sector requirements, may be one of the key reasons for the limited large-scale manufacturing of recycled aggregates and the expansion of their use.

The many sections of the country provide a wide range of data that demonstrates how the economy and industrial development are directly linked to the various data acquired [1]. The three zones must be seen as having a little division in which everyone serves a purpose in the country's development; the north is in charge of industries and production, the center is in charge of administration with the capital, and the south is in charge of agriculture production.

On a national level, this country has a sophisticated and up-to-date data collection system for waste management, but one of the primary issues is that the data are not homogenized at the regional level [2]. The information is collected by the country's 20 separate regions using their own internal norms and scales, and when it is required to collect it for a bigger research on a national basis, it is frequently impossible or limited to statistical data [3].

[1] Barbaro, G. Rifiuti speciali non pericolosi da C&D: La gestione eco-efficiente in Italia. Archit. Sostenibile 2012, 31-5. Available online: https://www.architetturaecosostenibile.it/materiali/smaltimento-e-riciclo/rifiuti-speciali-non-pericolosi-ced-gestioneeco-efficiente-italia-760 (accessed on 14 April 2021).

[2] Deloitte. Screening Template for Construction and Demolition Waste Management in Italy v2. October 2015. Available online: https://ec.europa.eu/environment/pdf/waste/studies/deliverables/CDW_Italy_Factsheet_Final.pdf (accessed on 30 June 2021).

[3] Paleari, M.; Campioli, A. I Rifiuti da costruzione e demolizione:LCA della demolizione di 51 edifici residenziali. Ingegneria dell'Ambiente 2015, no 4.

Challenges in Italy regarding waste management

1-Lack of confidence in the utilization of waste-derived goods

2-Lack of trustworthy data on inert waste production

3-Lack of updated technical tools

4-Waste separation from poor sources and selected demolition procedures

5-The absence of mining taxes

6-No ban or requirement to contribute to the landfilling of inert trash;

7-Obligation to analyze waste delivered for recovery or recycling


image generated from google earth
300 m


image generated from qgis
1/10000

Between the streets Juvenal Ancina, Giovanni Cravero, Giambattista Pergolesi, Bologna, and Gotthard is the district known as rural village. The project was started in the early 1940s by the Institute for populated dwellings (IAPC), but due to the war, it was not completed until 1946. The goal was to make nine dwellings out of a free supporter provided by the town, which tended to replicate the model of country chevaliers on a modest scale. Later, the site was managed by Ina-casa, and the idea was reduced back. In 1956, he built five tiny structures next to the "Soli" and ten three-story building plans above ground, while preparing the area for the local market at the settlement's entrance.

The houses of the original plant were demolished and gradually replaced, with the need for new housing triggered by the economic boom and "the ruralist nostalgia emphasized by fascism having faded," two in 1965 by a seven-story building above ground on Via Bologna and the remaining in 1981 by three-story buildings above ground prepared along the central street inside the block. Unlike the previously studied neighborhoods, the village rural is not like a normal Turin block: the perimeter is porous, and the amount of private green space is significantly increased. The public green, on the other hand, is spread along the two orthogonal axes of cars that pass the parking lot, as well as along the square's borders facing the block's entry. Maple and platano are the most common trees. Finally, proximity to the former railway loop, which is gradually being renaturalized, is crucial from a microclimatic standpoint. 725 individuals live in the region, with the majority of them being between the ages of 15 and 64. Foreigners account for 58 people, or 8.0 percent of the total population.

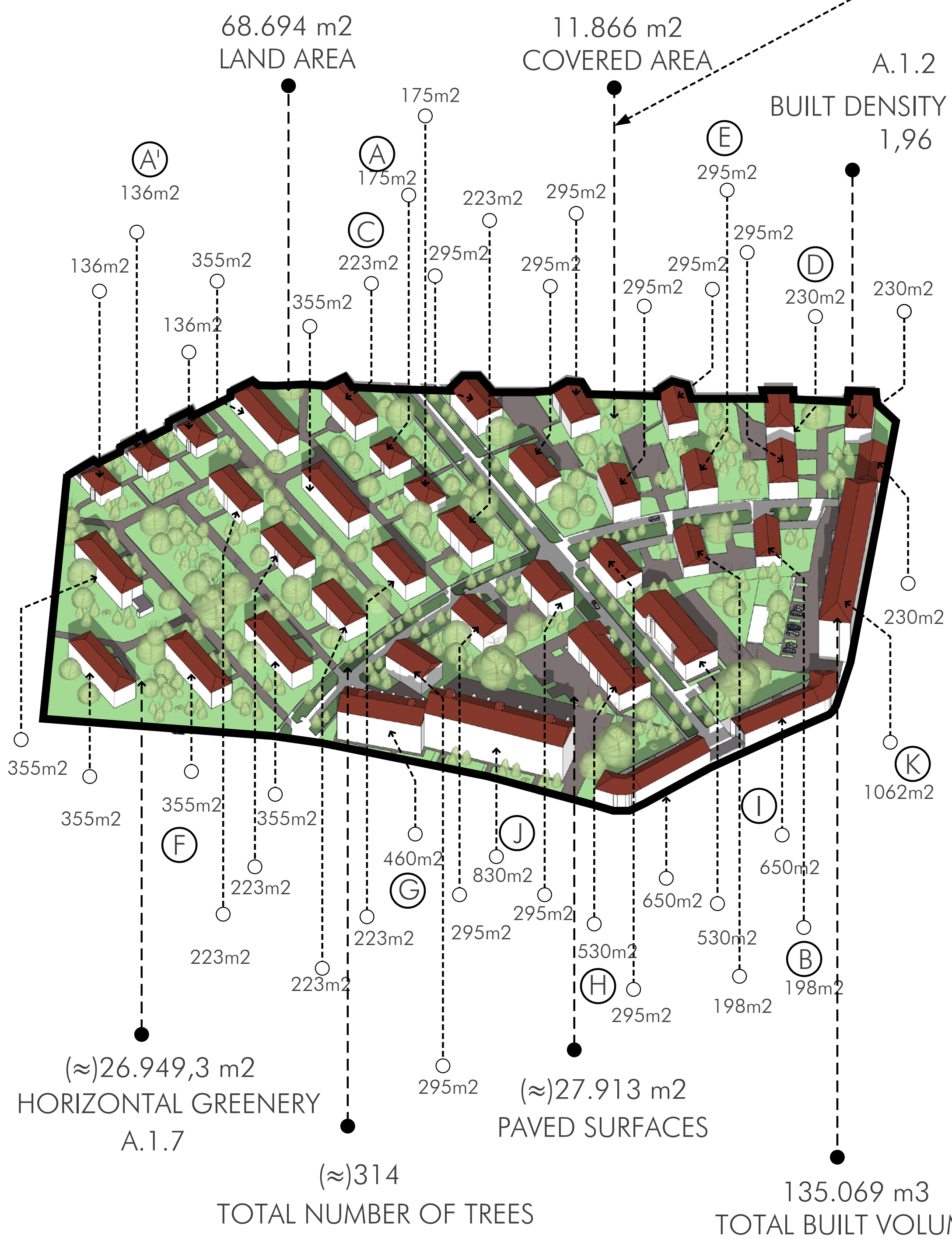
http://geoportale.comune.torino.it/
web/cartografia/cartografia-scarico

MuseoTorino, https://www.museotorino.it/
view/s/9a451a7c7deb4f- 3181d632c4ab851422, consultato il 25/06/2021.

ref: Morfologia Urbana e Microclima
Il caso studio del quartiere Regio Parco a Torino Tesi di Laurea Magistrale
Federico Calorio

PLOT DATA

Orientation: mainly north/south



Types and quantities of buildings located in the area

2.448 m3	TYPE A' (136m2) 2 FLOORS	X3
2.100 m3	TYPE A (175m2) 2 FLOORS	X2
2.376 m3	TYPE B (198m2) 2 FLOORS	X2
12.042 m3	TYPE C (223m2) 3 FLOORS	X6
6.210 m3	TYPE D (230m2) 3 FLOORS	X3
29.205 m3	TYPE E (295m2) 3 FLOORS	X11
19.170 m3	TYPE F (355m2) 3 FLOORS	X6
5.520 m3	TYPE G (460m2) 4 FLOORS	X1
9.540 m3	TYPE H (530m2) 3 FLOORS	X2
11.700 m3	TYPE I (650m2) 3 FLOORS	X2
14.940 m3	TYPE J (830m2) 6 FLOORS	X1
19.116 m3	TYPE K (1062m2) 6 FLOORS	X1

WATERPROOF SURFACES 41.745m2

PERMEABILITY RATIO %39.20

GREEN AREAPER INHABITANT 37.17m2

demographic situation

number of residents: 725
age between 0 to 14: 68
age between 15 to 64: 417
over 64 years of age: 240

1/1000 — 1000 2000 4000 6000 10000 15000cm


ZONE 1
ZONE 2
ZONE 3
1/500
1000
5000
10000 cm

ZONE 1

material usage

envelope elements	technology	quantity (m2)	%	data source
roof	**cement-concrete-timber-tiles**	**4.559**		GIS + survey + architectural drawings
opaque envelope (external surface)	**total**	**3.596,51**		GIS + survey + architectural drawings
	plaster	**3.596,51**	**%100**	estimated from survey +google earth
	brick wall	**x**	**%0**	estimated from survey + google earth
glazed envelope	**total**	**889,85**	**/opaque env. %32**	GIS + survey + google earth
	wood frame single glass	**x**		survey + google earth
	pvc frame single glass	**213,56**	**%24**	survey + google earth
additional materials	**pvc frame double glass** 90 balconies %25 was additionally covered	**150,26 ≈**		survey + google earth
additional materials	**aluminum/steel** railing systems on the balcony	144,57		survey + google earth
additional materials	**plastic / pvc** manual blinds throughout the glazed surfaces	729,67	**%82**	survey + google earth
additional materials	**stone covering** sub-basement concrete covering	**797,41**		survey + google earth
	pvc frame double glass	**526,03+150,26**	**%76**	survey + google earth
	aluminum + steel double glass	**x**		survey + google earth
number of total apartments (13) gross floor area		**3.823**		
road and parking areas / asphalted area (m2)		**3.258**		GIS + survey + google earth

addition to these materials

plastics PVC (for the water outlets from the roof)
brick covered with plaster has been used for the drip elements on the bottom parts of the window frames. stone covering has been used in 7 buildings (residential)

The same application has been made for some buildings' upper part of the window fittings.

via giovanni cravero

via giovanni cravero

via giovenale ancina

via gottardo

ZONE 2

material usage

envelope elements	technology	quantity (m2)	%	data source
roof	cement-concrete-timber-tiles	5.115		GIS + survey + architectural drawings
opaque envelope (external surface)	total	11.291,9		GIS + survey + architectural drawings
	plaster	3.613,40	%32	estimated from survey +google earth
	brick wall	7.678,49	%68	estimated from survey + google earth
glazed envelope	total	6.895,14	/opaque env. %61	GIS + survey + google earth
	wood frame single glass	x		survey + google earth
	pvc frame single glass	2.413,29 ≈	%35	survey + google earth
additional materials	pvc frame double glass 358 balconies %80 was additionally covered	3.585,48 ≈		survey + google earth
additional materials	aluminum/steel *railing systems on the balcony*	1.144,4		survey + google earth
additional materials	plastic / pvc *manual blinds throughout the glazed surfaces*	5.240,30	%76	survey + google earth
additional materials	stone covering *sub-basement concrete covering&first floor*	984,73		survey + google earth
	pvc frame double glass	3.585,48+896,37	%65	survey + google earth
	aluminum + steel double glass	x		survey + google earth
number of total apartments (13) gross floor area		4.238,72		
road and parking areas / asphalted area (m2)		3.366		GIS + survey + google earth

addition to these materials

plastics PVC (for the water outlets from the roof)
brick covered with plaster has been used for the drip elements on the bottom parts of the window frames. stone covering has been used in 4 buildings (retail&residential)
The same application has been made for some buildings' upper part of the window fittings.


via bologna


via bologna


via gottardo


via gottardo

ZONE 3

material usage

envelope elements	technology	quantity (m2)	%	data source
roof	cement-concrete-timber-tiles	3.059		GIS + survey + architectural drawings
opaque envelope (external surface)	total	6.134		GIS + survey + architectural drawings
	plaster	2.973	%48	estimated from survey +google earth
	brick wall	3.161	%52	estimated from survey + google earth
glazed envelope	total	2.522,39	/opaque env. %41	GIS + survey + google earth
	wood frame single glass	x		survey + google earth
	pvc frame single glass	1.510,52 ≈	%60	survey + google earth
additional materials	pvc frame double glass 100 balconies %50 was additionally covered	775,87 ≈		survey + google earth
additional materials	aluminum/steel *railing systems on the balcony*	234,56		survey + google earth
additional materials	plastic / pvc *manual blinds throughout the glazed surfaces*	2.471,94	%98	survey + google earth
additional materials	stone covering *sub-basement concrete covering&first floor*	546,28		survey + google earth
	pvc frame double glass	775,87+236	%40	survey + google earth
	aluminum + steel double glass	x		survey + google earth
number of total apartments (14) gross floor area		2.515,64		
road and parking areas / asphalted area (m2)		3.366		GIS + survey + google earth

addition to these materials

plastics PVC (for the water outlets from the roof)
brick covered with plaster has been used for the drip elements on the bottom parts of the window frames. Stone has been used for the sub-basement concrete covering.
The same application has been made for some buildings' upper part of the window fittings.

via giambattista pergolesi

via giambattista pergolesi

via giambattista pergolesi

via giambattista pergolesi

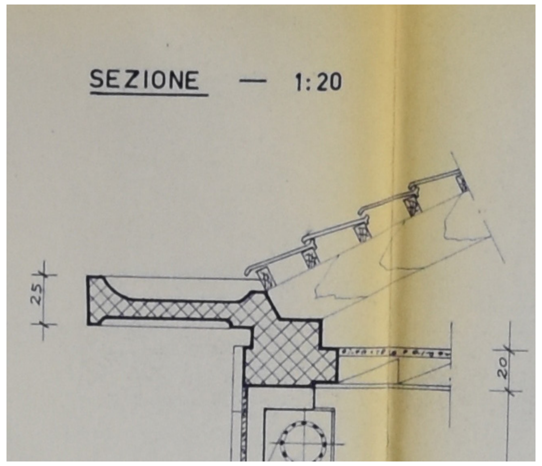
7.4

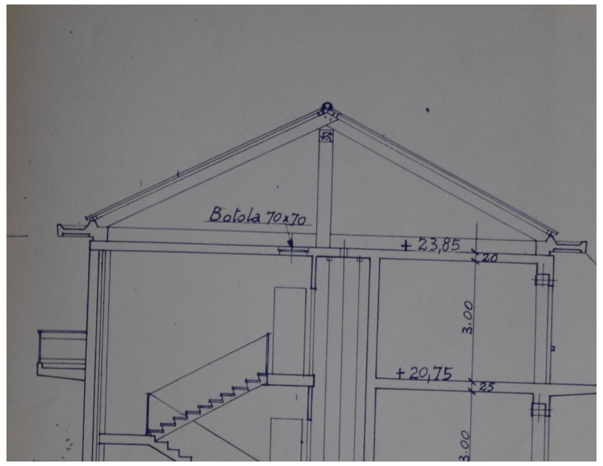
scenario 1 **current situation** (roof) vs. **renovation** (roof)

In this case scenario, the objective is to calculate the roof structures in the plot area and develop a hypothesis about the current situation and how it could be renovated with the existing materials that have been significantly used on these roof structures. Throughout the investigation, the formal hand drawings of some buildings have been re-created and re-drawn in the Autocad format to understand the main structural elements and find the precise measurements. One of the most crucial aspects of this study was to get the right results about the material used in these buildings. *The existing buildings have been constructed in different years. The project started in the 1940s, and the last building in the area was built in 1981. So there are 40 years of a span between various buildings. This 40-year gap between some facilities has not been included throughout the calculation.*
The hypothesis of the roof elements;
It was clear that they had used wooden elements throughout the roof; when we look at the eaves throughout each building, we can detect that they have placed wooden rafters in every 1-meter span. Also, from the images, it has been seen that they have used wooden coverings which are parallel to the significant length of the roof surface. They have used this wooden covering throughout the bottom part of the eaves.

image 1&2 (via giambattista pergolesi)

via gottardo - architectural drawing (section)image 3

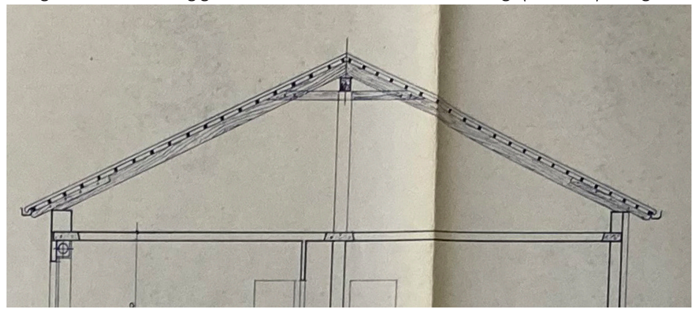




via bologna 257 architectural drawing (section) image 4

In these architectural drawings, we can see that they have placed a prefabricated concrete element directly connecting with the roof slab to create the eaves. These modules have been designed to collect the water and dispense it throughout the roof with the help of plastic water outlets. (hypothesis). In addition, we can detect that they have placed the principal rafter and anchored it to these prefabricated modules. (theory). [image3&4] We can see that they have used a king post to hold the roof's weight, but it's not visible throughout the drawings that they have used a scissor beam or strut to split the collected load from the ceiling. Finally, they have placed the roof tiles on top of the purlins. [image3]

via gottardo - villaggio rurale architectural drawing (section)image 5

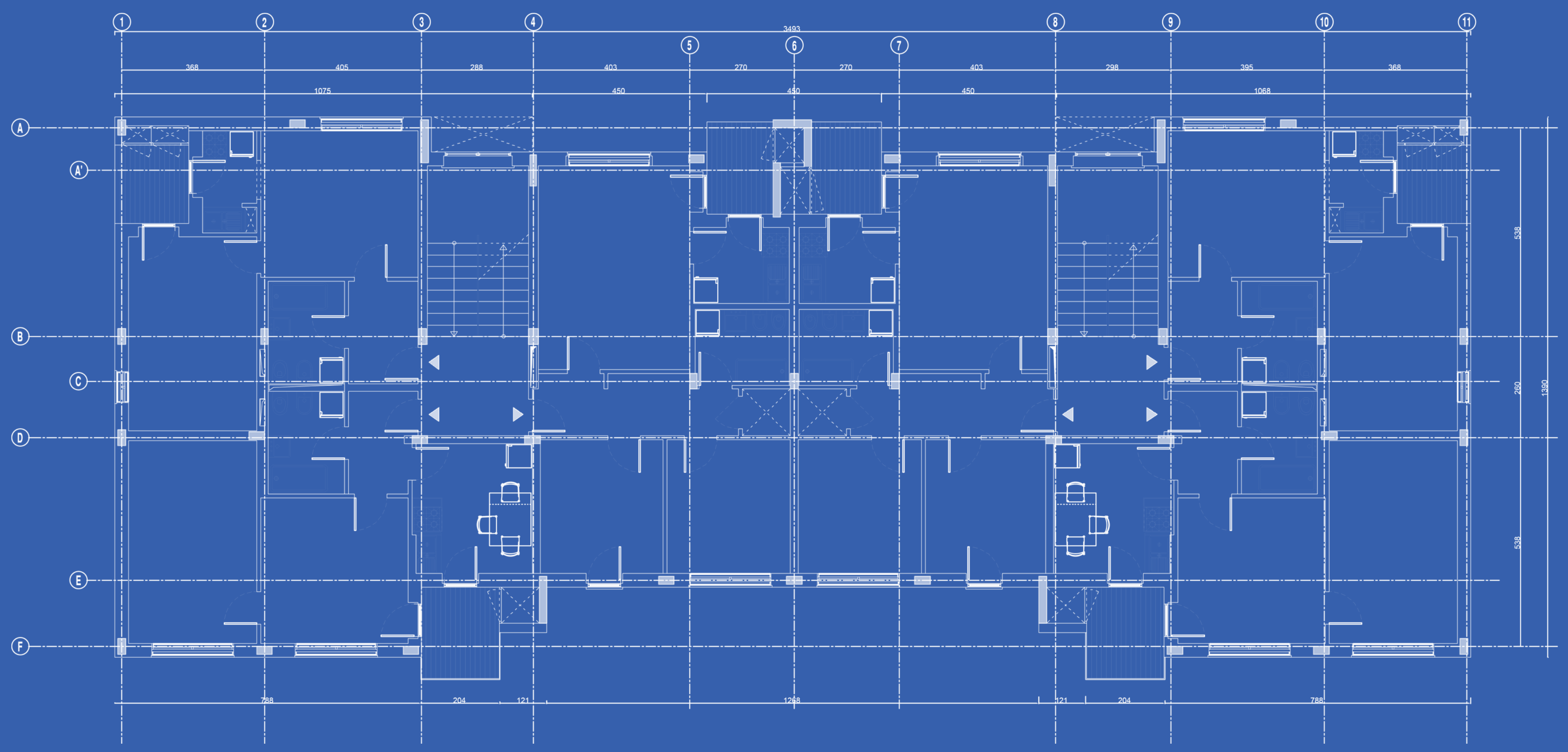


via gottardo - architectural drawing (roof plan)image 6

We can see some significant constructional differences between various buildings. For example, in this specific drawing, they have not used a prefabricated module for the eaves. Instead, each element was drawn as a wooden element. So, first, the rafters are placed on top of the gable walls, and then an additional rigid(wood) component has been placed/anchored with metal nails to create the 50-80 cm eaves. [image5&6]

Scenario 1

type H 1st floorplan 1/100

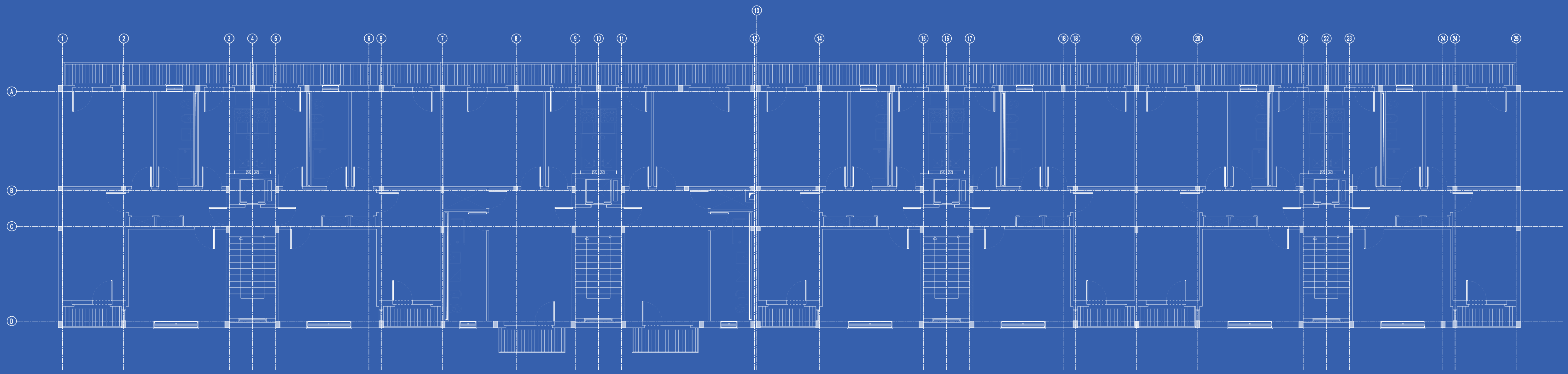


The architectural drawings have been made with the help of high-resolution pictures. The first step is to analyze the perimeters of the selected building. The diameters of the building were extracted from the qgis platform.

Then with the help of AutoCAD software, the high-res picture has scaled to the exact defined measurements to draw the plans on the correct scale. Since the images were slightly misoriented, the used picture has been rotated according to horizontal and vertical lines.

Some of the parts have been interpreted since there is not enough information about the structural walls and partitional walls.

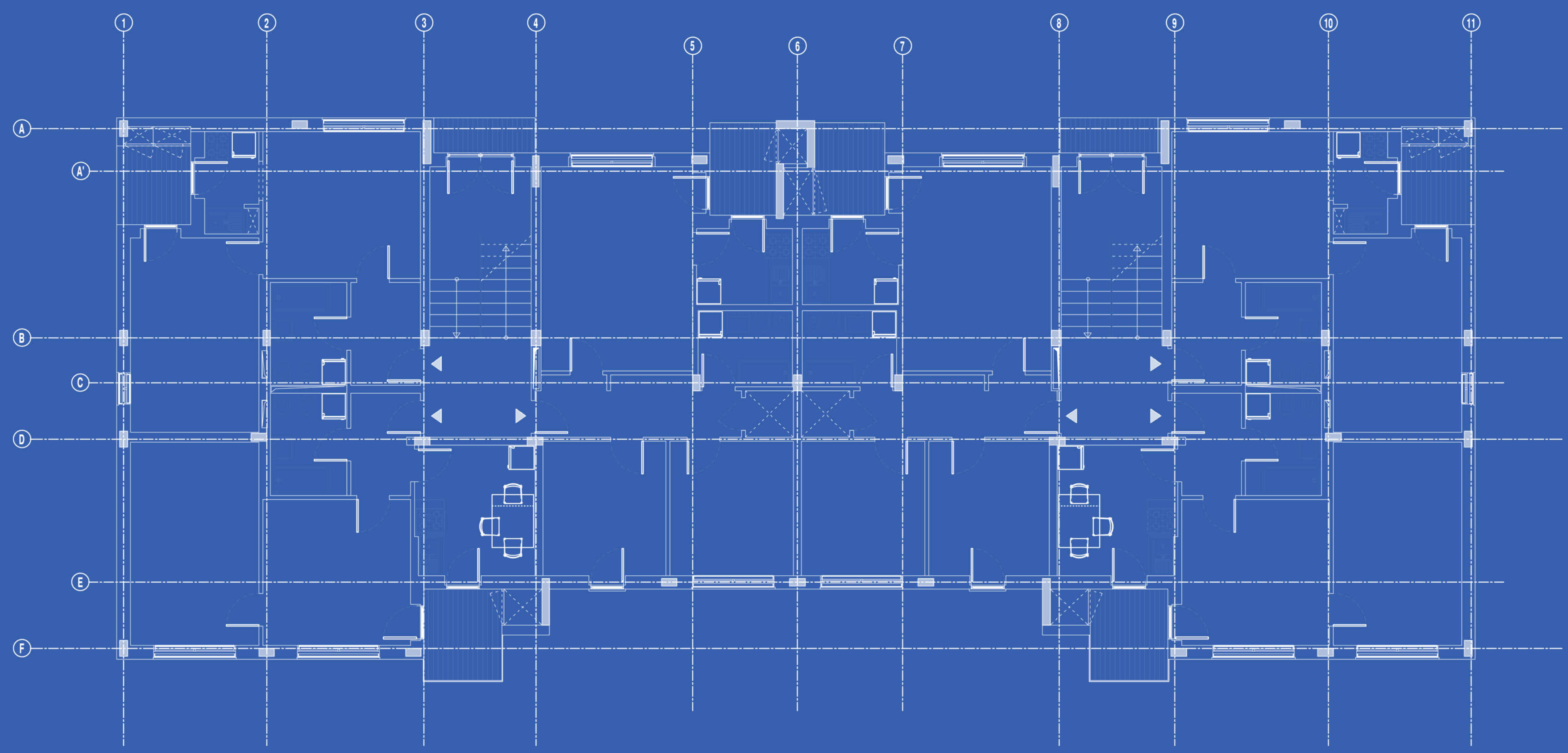
It was hard to extract the correct measurement from the hand-drawn architectural plans for the column's dimensions, so it has been drawn in an approximative way without dereliction of the gathered pieces of information.

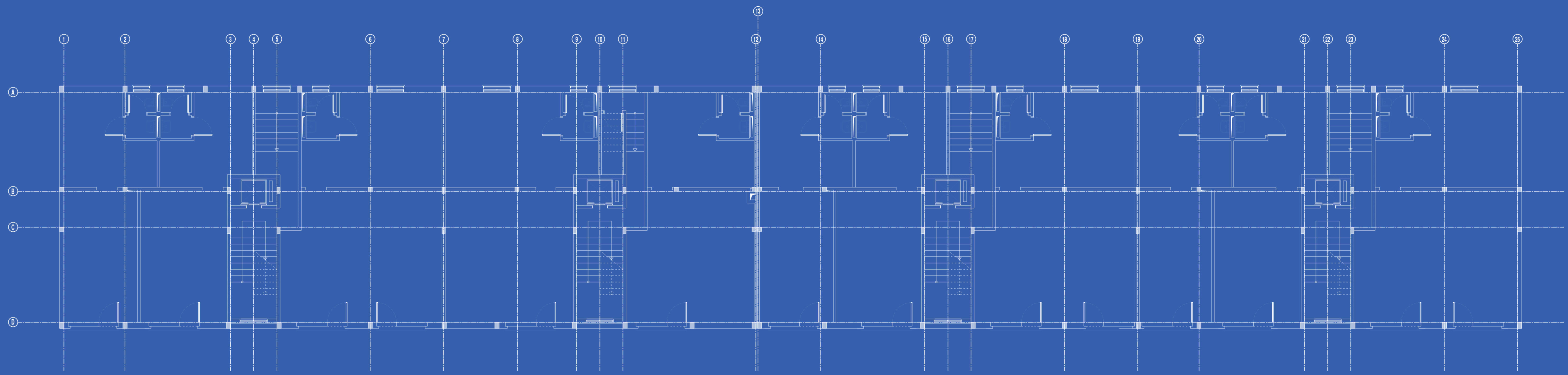


type K 1st floorplan 1/100

Scenario 1

type H ground floorplan 1/100

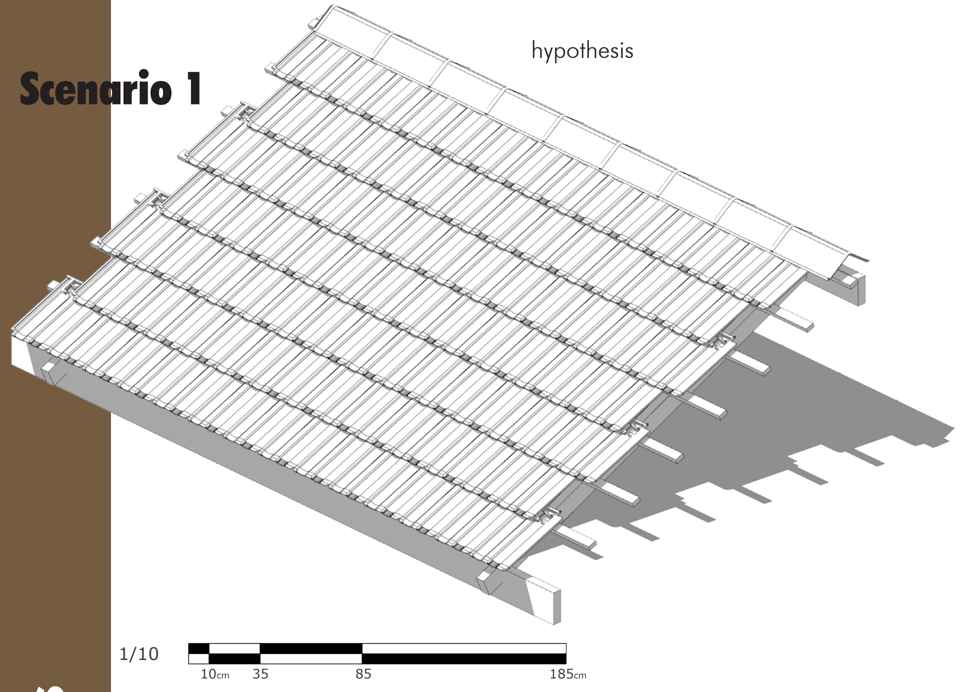


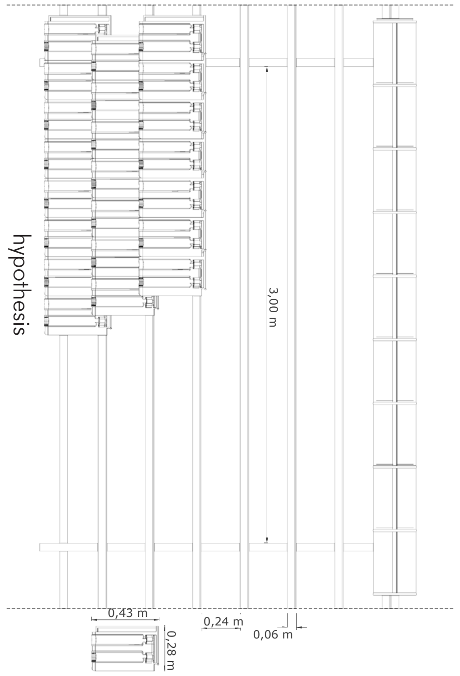


type K ground floorplan 1/100

Hypotheses; roof sutructural elements / current status

Scenario 1





Roof materials;

wood: (rafters, purlins, hip rafter, diagonal trusses, jack rafter, covering for the eaves)

metal: anchoring materials to connect the main wooden elements, nails for the roof tiles, supporting features such as metal, aluminum profiles)

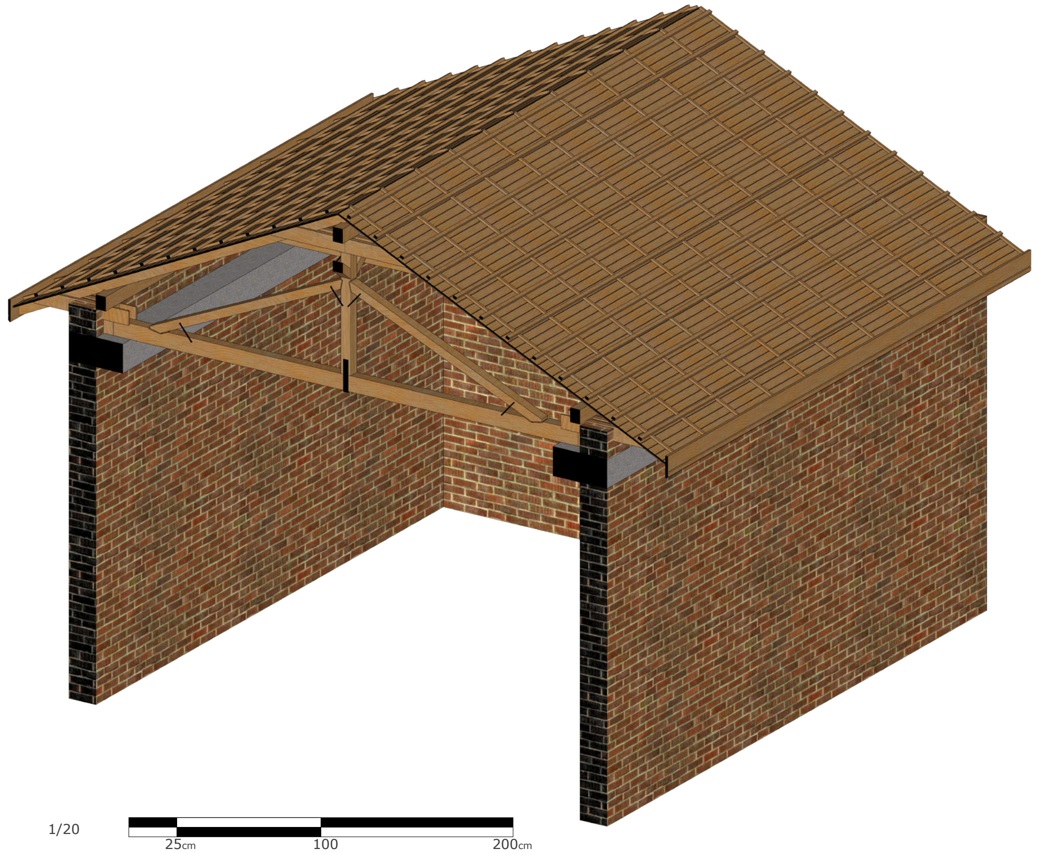
concrete: main beams and columns of the buildings, slabs

brick: main element for the wall structures, coverings, gable wall / **roof tiles**

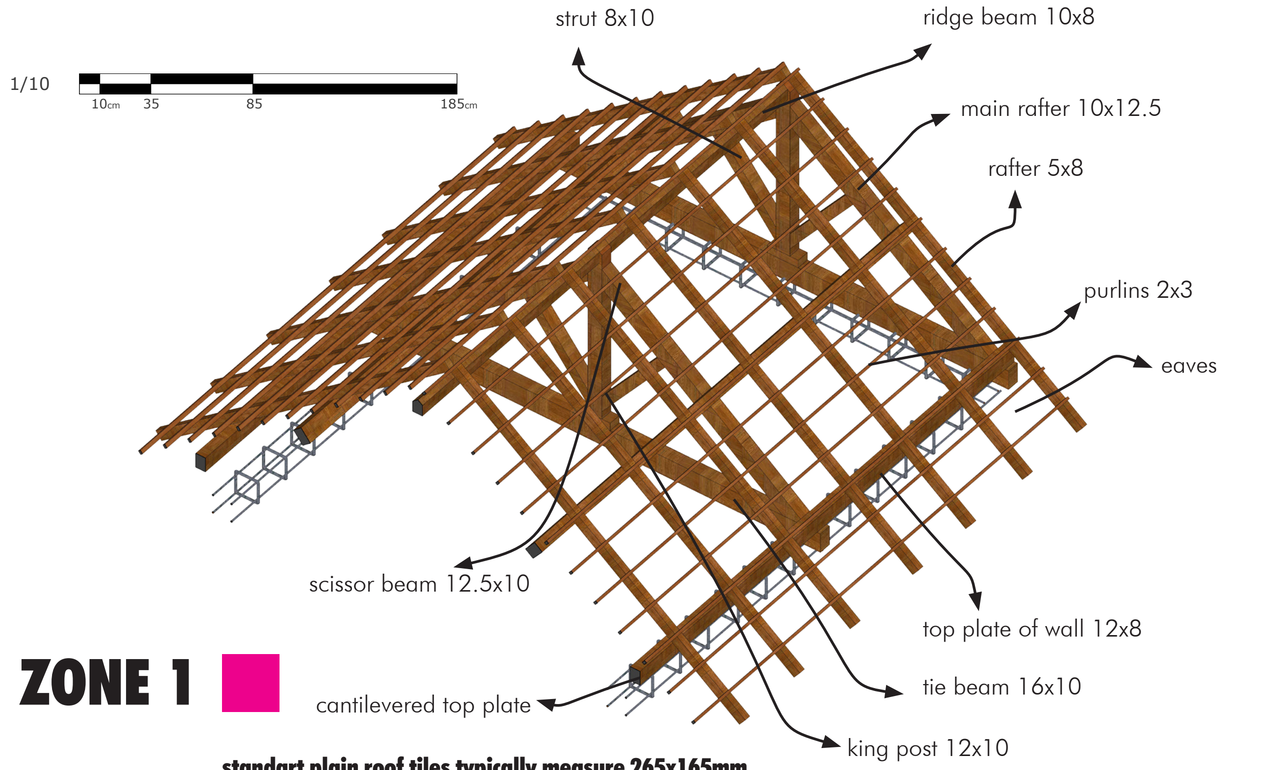
Hypothetically; The king post that is placed to one of the main beams and the roof trusses was constructed diagonally inside the roof area.

We can assume that; the main rafters are placed parallel to the main walls; the purlins placed horizontally to these rafters.

purlin and rafter (up to 5 m span between gable walls or other supporting structure). For medium sized buildings purlins can be used to support the rafters. This allows a free span between gable walls of up to 5m.



roof element analysis and c&d waste calculation



ZONE 1

standart plain roof tiles typically measure 265x165mm

Each tile weighs about 4.1 kg. (Marseille tile)

ROOF TILE **4.559 m2 roof surface** **≈106.023 tiles** **434.6 tons**

Clay tiles are made from natural resources that may be recycled easily. "Unlike most other building materials, clay tiles can be recovered and reused on another roof." Clay tile is completely reusable. It can be crushed and reintroduced into the tile manufacturing process.

WOOD **1.846 m2** **2.336 m3** **934 tons**

The calculation has been made by adding all the cubic meters of each roof element and multiplying with the roof surfaces' dimensions. Then, the estimated m3 usage of wood converted to kg. (A cubic meter of dry wood (volume measured when green) weighs 400 kilograms; its essential density is 400 kg/m3, and its specific gravity is 0.40.)

BRICK **720 m2** **36.000 bricks** **115.2tons**

Each clay brick weighs about 3.2 kg. 1m3 comprises 500 bricks / standart brick size (65mm x102.5mm x215mm)

PLASTER

720 m2

5.000 tiles have been removed due to the un-covered eaves

ZONE 2

standart plain roof tiles typically measure 265x165mm

Each tile weighs about 4.1 kg. (Marseille tile)

ROOF TILE **5.115 m2 roof surface** ≈ **113.953 tiles** **467.2 tons**

Clay tiles are made from natural resources that may be recycled easily. "Unlike most other building materials, clay tiles can be recovered and reused on another roof." Clay tile is completely reusable. It can be crushed and reintroduced into the tile manufacturing process.

WOOD **2.071 m2** **2.620 m3** **1047.5 tons**

The calculation has been made by adding all the cubic meters of each roof element and multiplying with the roof surfaces' dimensions. Then, the estimated m3 usage of wood converted to kg. (A cubic meter of dry wood (volume measured when green) weighs 400 kilograms; its essential density is 400 kg/m3, and its specific gravity is 0.40.)

Each clay brick weighs about 3.2 kg. 1m3 comprises 500

BRICK **1.536 m2** **76.000 bricks** **245.7 tons**

PLASTER **723 m2** **3.5 tons**

Depending on the number of layers used and the amount of plaster below the lath keys, plaster can be quite heavy. We estimate that plaster weighs roughly 4.95 kilograms per square meter as a general guideline.

ZONE 3

standart plain roof tiles typically measure 265x165mm

Each tile weighs about 4.1 kg. (Marseille tile)

ROOF TILE **3.059 m2 roof surface** ≈ **71.139 tiles** **291.6 tons**

Clay tiles are made from natural resources that may be recycled easily. "Unlike most other building materials, clay tiles can be recovered and reused on another roof." Clay tile is completely reusable. It can be crushed and reintroduced into the tile manufacturing process.

WOOD **1.238 m2** **1.566 m3** **626 tons**

The calculation has been made by adding all the cubic meters of each roof element and multiplying with the roof surfaces' dimensions. Then, the estimated m3 usage of wood converted to kg. (A cubic meter of dry wood (volume measured when green) weighs 400 kilograms; its essential density is 400 kg/m3, and its specific gravity is 0.40.)

Each clay brick weighs about 3.2 kg. 1m3 comprises 500

BRICK **633 m2** **31.650 bricks** **101.2 tons**

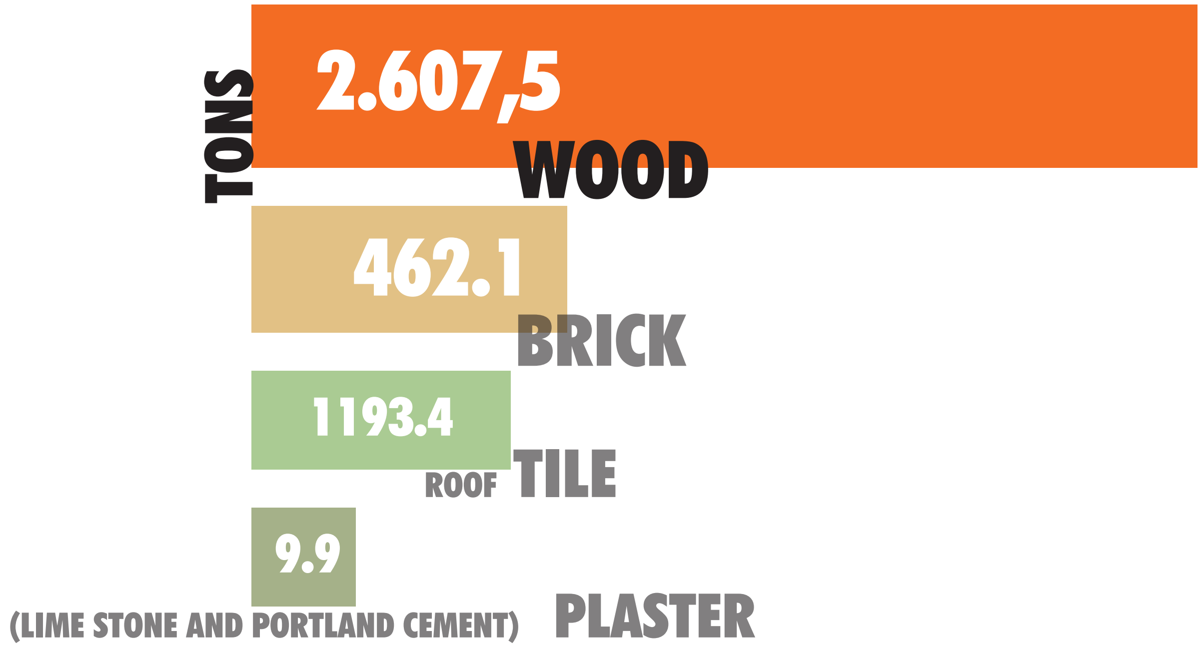
PLASTER **595 m2** **2.9 tons**

Depending on the number of layers used and the amount of plaster below the lath keys, plaster can be quite heavy. We estimate that plaster weighs roughly 4.95 kilograms per square meter as a general guideline.

roof element analysis and c&d waste calculation / recyclability (wood)

Scenario 1

total amount of materials used (roof)



Roof materials;

wood: (rafters, purlins, hip rafter, diagonal trusses, jack rafter, covering for the eaves)

metal: anchoring materials to connect the main wooden elements, nails for the roof tiles, supporting features such as metal, aluminum profiles)

concrete: main beams and columns of the buildings, slabs

brick: main element for the wall structures, coverings, gable wall / **roof tiles**

plaster: as facade covering material

WOOD:

Although wood can be recycled, not all timbers can be recycled. Woods that have been chemically treated aren't considered recyclable. Therefore, they don't belong in the recycling bin. Likewise, the woods that have been painted; won't be regarded as an accessible recyclable material. If you try to recycle these mentioned materials, they'll most certainly contaminate the rest of the recyclables. **Avoid attempting to recycle the following types of wood**: Wood that has been **treated, coated or painted, contaminated by chemicals in the past.** You should take wood that can't be reused or repurposed owing to the application of chemicals to your local landfill to properly dispose of it. Toxic elements such as lead and chromated copper arsenate (CCA), which contains arsenic, are present in wood used in construction projects from the twentieth century. It is unsafe to burn treated, painted, or varnished wood. When heated, hazardous compounds are released, posing a threat. As a result, treated wood should never be used in a fireplace or fire pit.

Mixed C&D processing plants get the majority of C&D-related wood. Depending on the material type, excavators such as front-end loaders may be used to sort the material before it is fed to an in-feed system. Bulk reduction equipment, such as a compactor or hydraulic shears, may be necessary to reduce debris sizes so that it can be entered into the wood grinding system for huge pieces of wood debris.

According to a research conducted in the United Kingdom, approximately 10 to 15% of the wood used in new building ends up in recycling or garbage streams. [1]

There is an untapped resource of 17.3 million tons of urban waste wood accessible for recycling on a yearly basis after existing recovery efforts or wood unusable for recycling owing to chemical treatments or other difficulties. [1]

As an assumption, the timber materials in the plot area could not be considered %100 recyclable timber; many of these timber structures must have gone through a chemical process. (coated, treated, or painted).

"between 50-80 per cent of timber can be recovered from roof beams and wall studs. Full deconstruction recovers more timber for reuse and recycling, but requires more time than demolition." [2]

- Roof beams, wall studs, and floors can typically be salvaged for reuse, and up to 75% of wood waste from building and demolition can be recovered for reuse. [2]

- Timber can be re-milled and utilized in construction, furniture manufacturing, and as floors, as well as recycled into woodchips and engineered wood products. [2]

- Recovering wood provides significant environmental benefits by lowering logging demands on forests (including soil degradation and loss of habitat). [2]

- By keeping wood out of landfills, greenhouse gases that would otherwise be released during the decomposition process are prevented. [2]

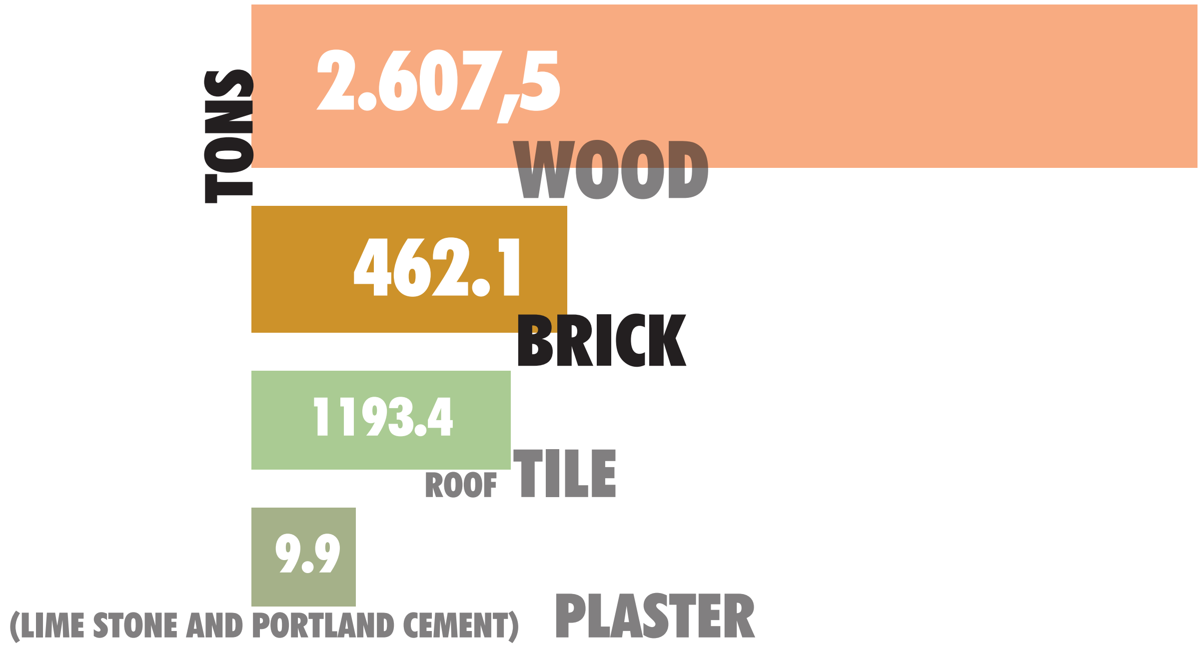
no estimated time / recovering time is longer than demolition

[1] https://www.thebalancesmb.com/wood-recycling-construction-2877760

[2] Roof beams and timber removal/Department of Environment, Climate Change and Water NSW 59–61 Goulburn Street, Sydney DECCW 2010/82 ISBN 978 1 74232 436 4 Published July 2010 © Copyright State of NSW and the Department of Environment, Climate Change and Water

Scenario 1

total amount of materials used (roof)



Roof materials;
wood: (rafters, purlins, hip rafter, diagonal trusses, jack rafter, covering for the eaves)
metal: anchoring materials to connect the main wooden elements, nails for the roof tiles, supporting features such as metal, aluminum profiles)
concrete: main beams and columns of the buildings, slabs
brick: main element for the wall structures, coverings, gable wall / **roof tiles**
plaster: as facade covering material

BRICK:

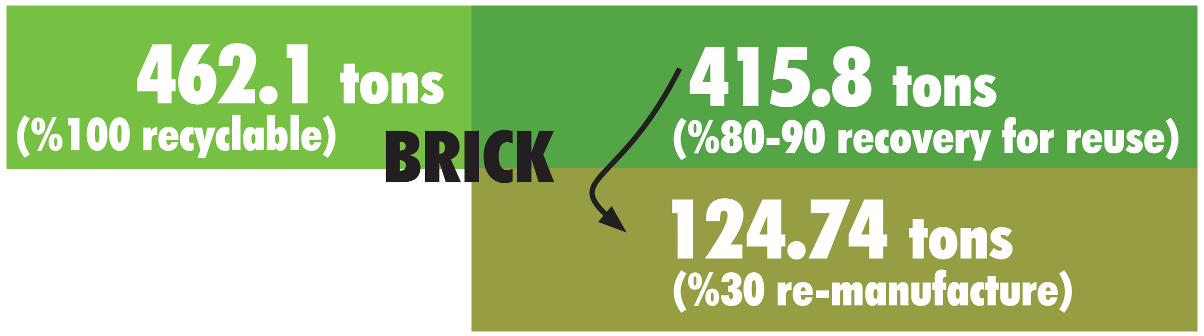
Most people trust bricks since they are among the earliest and most conventional construction materials. Bricks are formed of clay and have various advantages that no other type of construction material can match. Brick is composed of organic resources that, from an ecological standpoint, satisfy modern sustainability criteria. Because they are so popular and widely utilized, they frequently account for a significant portion of the construction trash generated by demolition and renovation operations. Recovering these prevents them out of landfills. Extraction sandstone and other raw materials are used to make bricks, which are both expensive and harmful to the environment. If waste materials can be reused, not only will mining be reduced, but it will also save money, which would be a positive scenario for both the environment and future generations.

Bricks can be recycled in a variety of ways. They are chippable and can be utilized in landscaping. When crushed into a fine powder, bricks can be used in place of sand or even utilized to make new bricks. [1]

[1] https://gosmartbricks.com/all-you-need-to-know-about-brick-recycling/

According to a research conducted in the United Kingdom, approximately 10 to 15% of the wood used in new building ends up in recycling or garbage streams. [1]

There is an untapped resource of 17.3 million tons of urban waste wood accessible for recycling on a yearly basis after existing recovery efforts or wood unusable for recycling owing to chemical treatments or other difficulties. [1]



Recycled bricks are a versatile building material that may be used for a range of projects. It's very impossible to purposely recreate the worn appearance of old, recycled bricks. As a result, recycled bricks are in high demand in places where a worn, antique look is desired. [1]
Reclaimed bricks are also used in new construction, remodeling, and small construction projects, as well as fireplaces, walls, and boundaries. Reclaimed bricks can also be used to make unique projects like sidewalks, landscaping projects, and patios.[1]
The bricks can be broken down into aggregate, recycled as new bricks, or used as a base compound on ground surfaces if they are in bad state but still have some usable life left in them.[1]

After recycling, waste-site bricks can be utilized for projects such as:

In infrastructure projects, filler and stabilizing material are used.

Aggregate for concrete and mortar, both poured and prefabricated.

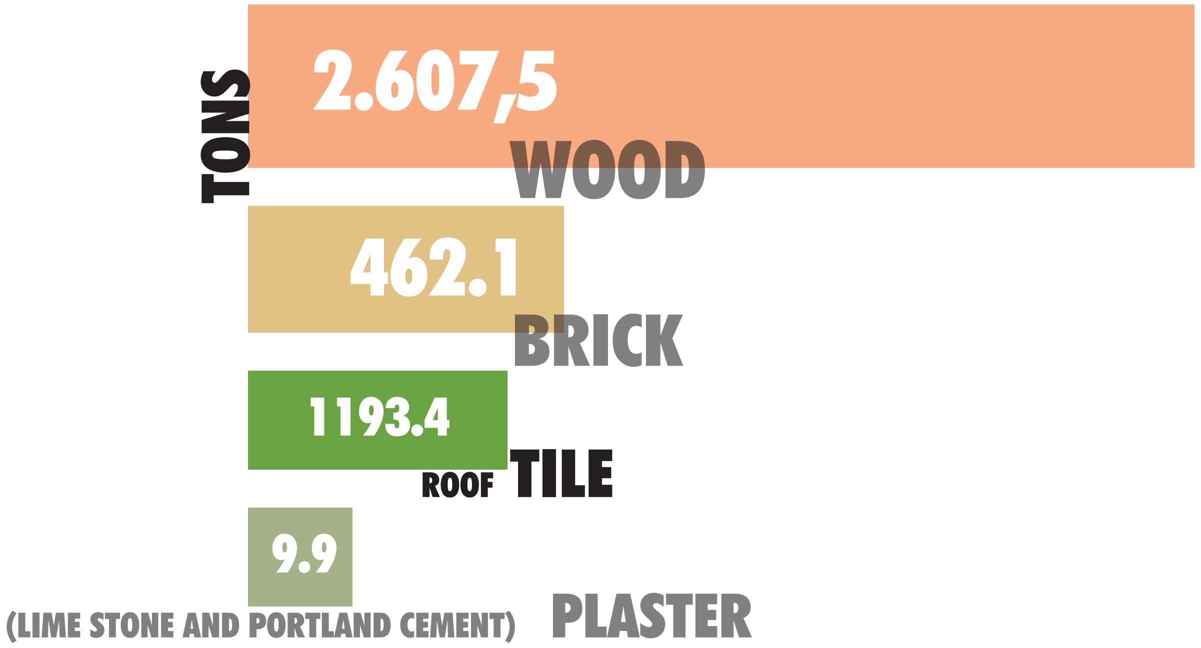
Calcium silicate aggregate is used to make bricks.

A tennis court with a red 'crushed brick' surface.

It takes longer to recover bricks for reuse than it does to dismantle a roof.
Removing bricks for recycling needs less effort: they can simply be tossed into transport bins.

Scenario 1

total amount of materials used (roof)



Roof materials;
wood: (rafters, purlins, hip rafter, diagonal trusses, jack rafter, covering for the eaves)
metal: anchoring materials to connect the main wooden elements, nails for the roof tiles, supporting features such as metal, aluminum profiles)
concrete: main beams and columns of the buildings, slabs
brick: main element for the wall structures, coverings, gable wall / **roof tiles**
plaster: as facade covering material

ROOF TILE:

Roofing tiles are formed from burnt clay in the same way bricks are and were initially prepared by the same companies from local clays for use in the near vicinity of the works. As a result, there are several regional differences in tile color, size, thickness, and profile. A well-maintained tile roof should have a well over a century lifespan, just as slates. Various ways of fastening are employed. Some clay tiles are nailed like slates, while others have 'nibs' on the backside that hook over the battens (nibs are standard in profiled tiles). [1]

The most common problems are loose or broken tiles, damaged timber battens, and board substrates. With time, tiles can become porous and weak. [1]
Clay's durability and longevity may allow it to outlast the structure on which it is put. Clay tile is fully recyclable. It can be crushed and reintroduced into the tile manufacturing process.[2]

[1] https://ihbconline.co.uk/caring/elements/roofCoverings/clayTiles/
[2] Minimizing environmental impacts with clay roofing / https://www.constructionspecifier.com/minimizing-environmental-impacts-with-clay-roofing January 6, 2015

The goal of a roof is to protect the occupants from the factors, such as winds, rain, snow, and sun. Clay tile does this by limiting the availability of solar radiant heat that strikes the roof, reflecting some of that heat away from the structure, and restricting the passage of radiation from the tiles to the roof deck and the inside of the structure. Clay tile, especially in light and terra cotta tones, offers a high thermal reflectivity.

Both tile and steel are 100% recyclable. If the tiles are in good condition, they can be reused, but removal must be done with caution.

Recycling tiles necessitates less caution when removing them.

Terracotta tiles of good quality are in high demand for renovations and repairs, especially on older homes, and can fetch high resale values.

Terracotta tiles of poor quality can be crushed and used as a landscaping material, saving money on landfill disposal.

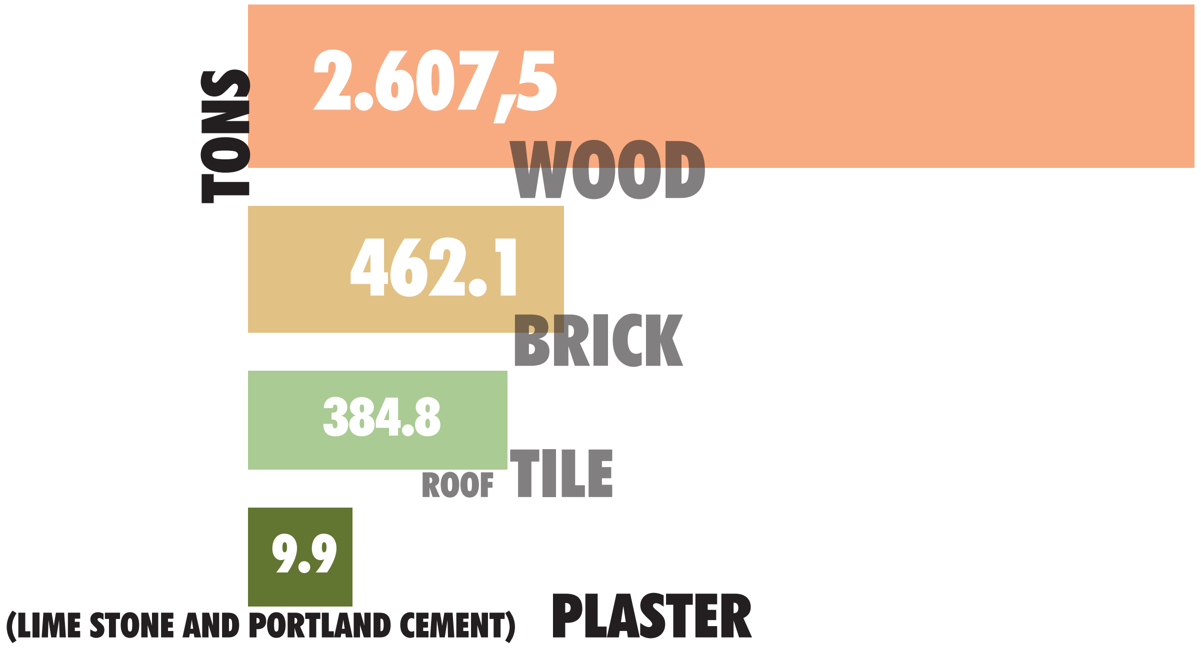
Before reusing tiles that have weathered, they must be completely cleaned and re-sealed.

Reusing and recycling roofing materials can help to cut down on energy and resource use, greenhouse gas emissions, and waste sent to landfills.

It takes longer to recover tiles for reuse than it does to dismantle a roof.
Removing tiles for recycling needs less effort: they can simply be tossed into transport bins.

[3] Roof beams and timber removal/Department of Environment, Climate Change and Water NSW 59–61 Goulburn Street, Sydney DECCW 2010/82 ISBN 978 1 74232 436 4 Published July 2010 © Copyright State of NSW and the Department of Environment, Climate Change and Water

Scenario 1



Roof materials;

wood: (rafters, purlins, hip rafter, diagonal trusses, jack rafter, covering for the eaves)

metal: anchoring materials to connect the main wooden elements, nails for the roof tiles, supporting features such as metal, aluminum profiles)

concrete: main beams and columns of the buildings, slabs

brick: main element for the wall structures, coverings, gable wall / **roof tiles**

plaster: as facade covering material

PLASTER:

Plastering is a thin layer of mortar put over the masonry that acts as a damp-proof covering. Plastering also offers a solid and smooth finished surface over the masonry, which improves the building's appearance. Plastering's main goals are to preserve the surface from atmospheric impacts, to cover defective masonry work, to conceal porous elements, and to give a good painting surface. According to Camarini et al. [1], recycled gypsum plaster can be made using simple crushing, sifting, and heating methods. Many researchers have conducted a series of research studies on recycled gypsum plaster in order to encourage the widespread use of recycled gypsum plaster in construction activities. Primary, secondary, and tertiary recycled gypsum plaster performed similarly to commercial gypsum plaster, according to Erbs et al. [2].

[1] G. Camarini, M. C. C. Pinto, A. G. D. Moura, and N. R. Manzo, "Effect of citric acid on properties of recycled gypsum plaster to building components," Construction and Building Materials, vol. 124, pp. 383–390, 2016.
[2] A. Erbs, A. Nagalli, K. Querne de Carvalho, V. Mymrin, F. H. Passig, and W. Mazer, "Properties of recycled gypsum from gypsum plasterboards and commercial gypsum throughout recycling cycles," Journal of Cleaner Production, vol. 183, pp. 1314–1322, 2018.

This waste is created when previously placed plasterboards (drywalls, wallboards, or gyprock boards), which were typically erected many years ago, are removed in conjunction with the demolition or renovation of a structure. As a result, some people refer to this material as "ancient gypsum waste," although the trade calls it "demolition waste." Unlike the two other categories of gypsum waste discussed above, gypsum waste from repair, refurbishment, and demolition projects is more likely to contain contamination in the form of nails, screws, wood, insulation, and wall coverings, among other things.

4% to 15% of construction and demolition waste [4]

Gypsum is entirely and eternally recyclable, making gypsum waste one of the few construction materials that can be recycled in a closed loop.

Gypsum recycling in Europe began in 2001 with the establishment of Gypsum Recycling International A/S in Denmark. After a few years, the recycling system has received garbage from roughly 85% of all public civic amenity/recycling centers, with a recycling rate of 60% of all gypsum waste. [5] Other European countries have been covered by the scheme. [3]

Both tile and steel are 100% recyclable. If the tiles are in good condition, they can be reused, but removal must be done with caution.

Plasterboard, ceramics, road surfaces, plaster of Paris (medical uses), and soil conditioner are just a few of the novel gypsum products that may be made from all sizes.

Gypsum is a 'clean green' soil conditioner that works best in thick clay soils to improve structure.

Reducing greenhouse gas emissions, environmental damage from new gypsum mining, and garbage transferred to landfills.

recovering is 2.5 times longer than demolition

[3] WRAP. Plasterboard Case Study. International practice in plasterboard recycling: Denmark. Gypsum Recycling International A/S.
[4] Characteristics of Gypsum Recycling in Different Cycles Article in International Journal of Engineering and Technology · June 2015 DOI: 10.7763/IJET.2015.V7.794
[5] EUROGYPSUM, Environmental and Raw Material Committee. Factsheet on: What is gypsum? http://www.eurogypsum.org/_uploads/dbsattachedfiles/whatisgypsum.pdf Archived 2013-12-02 at the Wayback Machine Retrieved 26 September 2013.

Roofs need to be replaced for a variety of reasons.

In this study case, two of these reasons have been selected as a reason for renovation.

- Renovation of energy/thermal systems – to reduce energy costs

- Repairing damage caused by aging, such as leaks (selected) Scenario 1

- Attic conversion and construction to increase existing living space

- Visual renovation - for example, when a house is being remodeled from top to bottom.

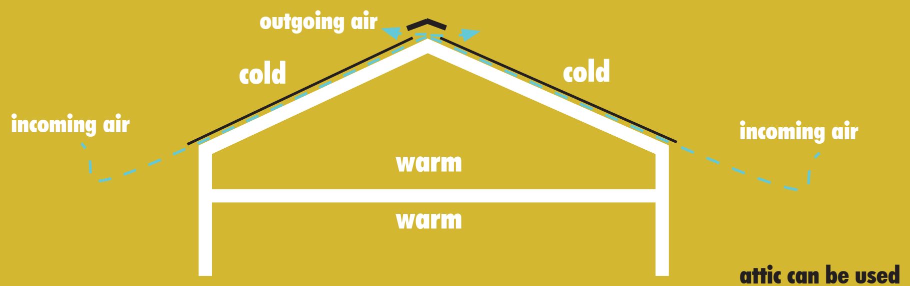
- Extreme weather occurrences, such as heavy snowfall, hail, or storms, can cause significant damage.

- Physical faults that emerge as a result of poor planning or incorrect execution - for example, mold - are removed.

- Solar or photovoltaic system installation (selected) Scenario 2

RENOVATION IDEAS (preserving the current roof design)

A vented roof structure is required if the attic is to be used as living space, as flowing air improves the internal climate in both summer and winter and also removes moisture. There are various forms of insulation available, such as between-rafter insulation, which is the most common.
Above-rafter insulation, on the other hand, is used when a visible roof structure is required or when more insulation is required on an existing expanded roof. If an acceptable thickness of between-rafter insulation is not achievable due to structural constraints, appropriate thermal insulation can be achieved by placing extra under-rafter insulation. This under-rafter insulation acts as a second layer of insulation between the insulation layers, reducing the transfer of heat between the rafters.



If the attic isn't going to be used as a dwelling area, it can be used as a ventilated cavity if the building's circumstances allow it. Metal roofs, as well as roof and wall coverings composed of metal sheets, should be planned as ventilated structures in principle (cold roof). Warm roof structures (structures without a ventilation gap) are unique solutions that must be structurally developed independently. Other work, costs, and material requirements may occur as a result of the roof structure, necessitating a different rehabilitation timeline.

MATERIAL AS ALUMINUM (preserving the current roof design)

The building and roof should ideally form a single entity that either fits in with the surrounding neighborhood or serves as a central focus for your town. Here, the correct material, color, shape, and surface structure are crucial. It's possible that the shape and incline of your roof, as well as any local building codes, have already limited your material options (e.g. development plans, local authority regulations). Conventional roof materials such as roof tiles, concrete blocks, flat tiles, wood shingles, or slates are constantly replaced with more flexible, modern, and durable materials in current construction. These can also be color-coordinated with the surrounding environment and other aspects such as gutters, fences, shutters, shades, blinds, and windows, among other things.

The optimal interplay between the ceiling, drains, façades, and solar panel mounting system is possible with aluminum roof materials. Regardless of the roof's design, aluminum provides a lot of versatility, both technically and artistically, as well as a lot of creative freedom. Not only on flat roofs, but also on roofs with extremely low pitch. Another notable benefit is that, in compared to a heavier new roof, when utilizing aluminum roof tiles, the gable roof does not normally need to be strengthened, which offers substantial cost savings, especially when remodeling historic structures. Because of the lightweight aluminum roof, the structural system will not be subjected to undue pressure in locations where heavy snow loads are forecast.

Because the material is so simple to work with, it's also possible to fill all corners and angles securely, which is especially important in the case of historic structures. Uneven roof structures, which are common on historic farmhouses, can be effectively covered with a made of aluminum roof.

CONCLUSION

In terms of a roof renovation, the cost-effectiveness will be hard to maintain due to the various factors. However, the current technology offers multiple options to its users. Therefore, it was essential to understand and analyze the plot area's current situation.

The roofs were made a long time ago. Consequently, it won't be wrong if we consider that the materials of these roof structures have been rotted and aged throughout the time. The roof structure and materials have been analyzed. It has been seen that a significant portion of the wood is not reusable for the renovation part. The current timber material has a low ratio of recovery. (**586,75 tons of debris**). **As for the other materials; (brick, roof tiles, and plaster), there are %100 recyclable, and they have a good percentage in terms of recovery. 260.75 tons of wood, 462.1 tons of brick, 1193.4 tons of tile, and 9.9 tons of plaster could be recycled. On the other hand, 1760 tons of timber, 415.8 tons of brick, 1074 tons of clay tile, and 9.9 tons of plaster could be recovered and reusable for the new roof structure.**

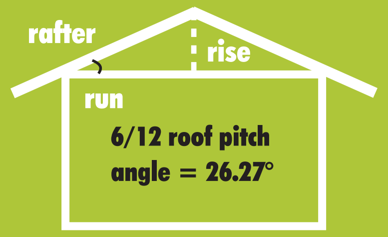
Roofs need to be replaced for a variety of reasons.

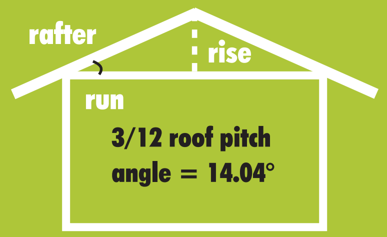
In this study case, two of these reasons have been selected as a reason for renovation.

- Repairing damage caused by aging, such as leaks (selected) Scenario 1

Available in a variety of hues and forms. Spanish, Roman, Shakes, or flat tiles are the most common tile profiles. The most prevalent hues are red, brown, and grey.

Some homes weren't even built for the installation of heavy clay tile roofs because clay tile can be heavier than slate. Depending on the type, style, and pattern of the tiles, different minimum roof pitch requirements apply. Some clay tiles can be laid on roofs with a minimum pitch of 3:12, while others need a pitch of 6:12 or higher.





+ Excellent resistance to strong wind.
+ Clay tile that is flat has a very high impact resistance. Even while large hail can destroy high profile tiles, they remain one of the most impact resistant roofing materials.
+ Clay tile is a non-flammable substance.
+ High resistance against snow and ice is provided by properly installed quality clay tile. Roofing material that is largely moss resistant.
+ Clay tile has outstanding durability features and could survive at any weather.
+ The longevity of clay tiles is often around 75 years, but it also relies on how properly they are installed. Long-lasting tile roof performance is guaranteed by the use of high-quality, non-rusting fasteners like stainless steel or hot-dipped galvanized nails and an appropriate installation method.
+ Cleanliness and free drainage of water from the roof surface are requirements for clay tile roofs. Roof tiles should be inspected for any that are cracked, loose, or otherwise damaged, and if any are found, rapid replacement is crucial.
+ Clay tile manufacturing flaws are often covered by a 35–50+ year manufacturer's guarantee. Roofing contractors frequently provide installation warranties covering any post-installation concerns with a roof brought on by subpar labor, which can range in length from one to two years.
+ On a well constructed roof structure, just one layer of clay roofing tiles needs to be laid.

- Each square of a roof made of clay tiles weighs between 900 and 1100 pounds (408 and 499 kg).
- Clay tiles are not a sort of roofing that may be walked on.
- Clay roofing tile is a costly material, yet prices greatly vary.
- Installing clay tile roofs is a very expensive project.
- Clay tile roof repair may be a very difficult task.

You need to be aware of the issue's root cause. Several problems could cause the clay tile roof of your home to leak. There are specific issues with clay tiles that affect the entire roof and are related to other elements of the roofing or installation procedures. Some of the most frequent issues with clay tiles include the following:

damaged tiles
tile fragments
faulty or outdated waterproof membrane
Your roof valley has accumulated debris.

You must first deal with the problem that affects you in order to fix the leak. Keep in mind that under tension, clay roof tiles are vulnerable to shattering. As a result, it is wise to use caution when looking for the leak's origin on your roof.

Membrane's repair
You'll need to remove and replace the tiles and install a new one if the waterproof membrane is the issue. After that, your roof will need to be retiled. You might need expert help with the disassembling and retiling.
Taking out the trash from your roof

Roof valleys will gather a lot of trash, especially those that are closed. It might cause leaking. You must remove the tiles from the area in order to clear the debris and halt the leaks. Reapply the tiles after cleaning it out.

Historical Importance

Older residences are recognized as historical landmarks. To guarantee that they keep both their historical significance and structural integrity, these homes need extra time and attention. Depending on local laws, historic homes could additionally need special permits.

Roof's Accessibility

It could be challenging to access the roof of certain properties because of the extensive planting and rows of bushes. It can be challenging to move hardware in and out of dense metropolitan locations where other homes are close to your own.

7.5

scenario 2 (roof renovation & additional solar panel systems)

Each square meter of roof space can create roughly 15 watts of solar energy. A solar panel installation on a small home may only require 18.5 m2 of roof space, whereas a larger home may require more than 92.9 m2 of roof space to adequately offset power usage. In this specific scenario, the investigated area has different house typologies. While the lowest building has two floors, the most prominent building is 7-floor height. As a result, the gross floor areas of these buildings are not the same. Therefore, when we consider putting solar panels on these roof surfaces, it is mandatory to calculate the various square meters of the roof, the slope of these roofs, and finally, the orientations. These three significant indicators must be precise so the system can work properly. [1] [2]

There are roughly 1000Watts of sunlight per square meter in optimal conditions. Depending on your budget, modern solar panels range from 18% to 23% efficiency. So, per square meter, between 180W and 230W. Actual circumstances vary by region and season, with low latitude locales achieving the highest results with 5–6 hours of optimal conditions per day — between 0.9kWh and 1.4kWh per square meter per day. [2]

To account for the needed solar setback, multiply the square footage of your roof by 0.75. Divide that number by 17.5, which is the average square footage of a typical solar panel size. The result is the maximum number of solar panels that can be installed on your roof. [1] [2]

It is essential to investigate the C&D waste produced by a solar panel. Can a solar panel be recycled? Regarding these questions; Solar panels have a life expectancy of roughly 30 years before they need to be decommissioned, according to studies.

A 20% reduction in power capacity may occur over the life of solar panels. The biggest reduction in efficiency occurs between the tenth and twelveth years, and between the twentieth and twenty-fifth years. The majority of manufacturers guarantee these figures.

[1] https://palmetto.com/learning-center/blog/how-much-roof-space-is-needed-for-solar-panels

[2] Intech Open Solar Panels and Photovoltaic Materials Edited by Beddiaf Zaidi (e-book)

amount of solar panel waste in Italy (in tons)

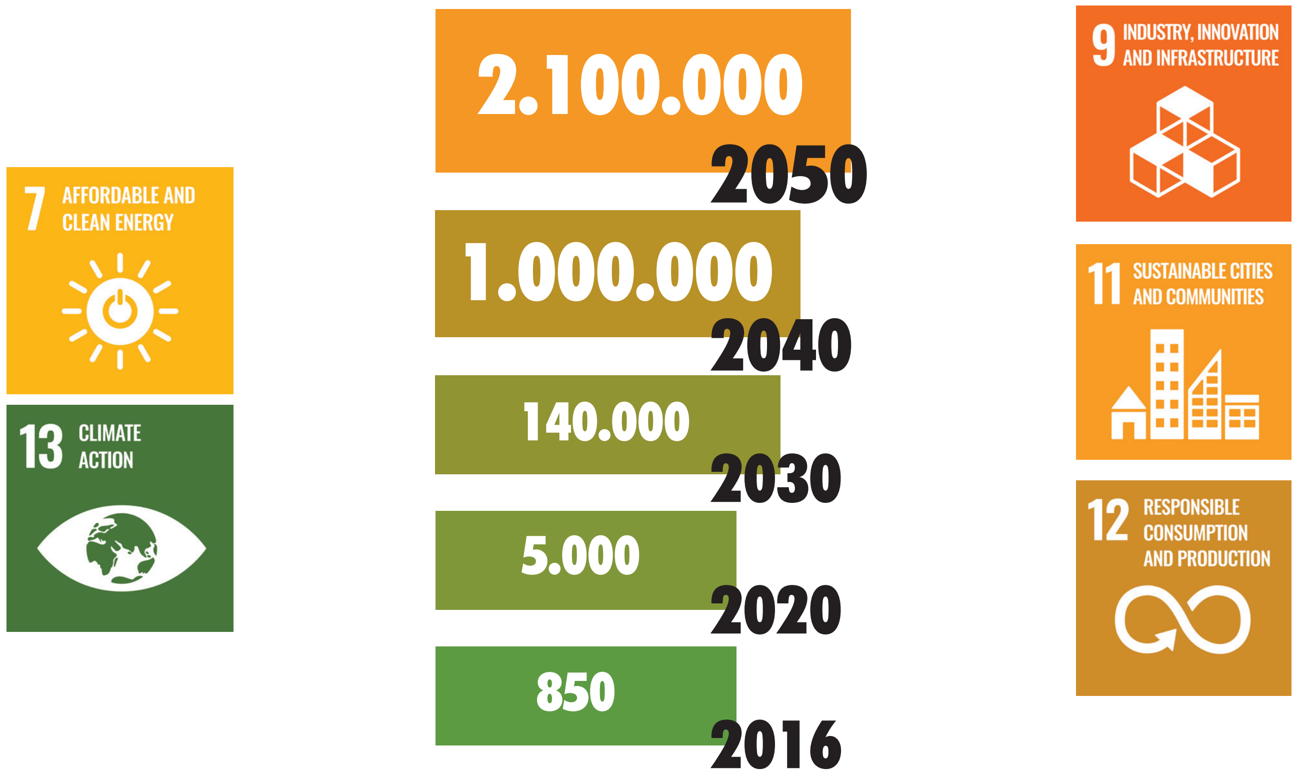


figure 23 elaboration by the author

source/https://www.greenmatch.co.uk/

Despite this, experience has shown that after 25 years, efficiency reduces by only 6 to 8%. Solar panels may thus have a substantially longer lifespan than is officially indicated. High-quality PV panels can last for 30 to 40 years and still function, though at a lower efficiency. PV panel trash is still classified as normal waste under regulatory guidelines.

PV panels are classified as e-waste in the EU's Waste Electrical and Electronic Equipment (WEEE) Directive, which is the only exception. This directive, in addition to other legislative frameworks, governs the management of PV panel waste. [3] In order to ensure that solar panels do not become a burden on the environment, solar cell producers are required by law to meet strict regulatory requirements and recycling norms. That's when solar panel recycling solutions began to emerge. [3] Photovoltaic manufacturers teamed up with government agencies to devise a few strategies for dealing with solar waste. [3&4]

[3] https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling

[4] https://www.cedgreentech.com/article/can-solar-panels-be-recycled

Processes for Recycling Solar Panels

There are two types of solar panels, each of which requires a distinct technique to recycling. Using different industrial methods, both types silicon-based and thin-film-based can be recycled. Currently, silicon-based panels are more widespread, but that does not rule out the possibility of considerable value in thin-film-based cell materials.

Numerous technologies have emerged as a result of research into the recycling of solar panels. Some of them even achieve astounding recycling efficiency of 96 percent, but the goal is to lift the bar even higher in the future. [4]

Silicon based pv panels

76%	10%	8%	5%	1%
glass	plastic	aluminum	silicon	metals

Thin-film based pv panels

89%	4%	6%	1%
glass	plastic	aluminum	metals

Despite the modules' recyclability, the material separation process is time-consuming and needs sophisticated technology. The following are the key steps in successfully recycling a silicon module: Taking off the aluminum frame (100 percent reusable) Using a conveyor belt to separate the glass (95 percent reusable) At 500 degrees Celsius, thermal processing takes place.

This permits little plastic components to evaporate and the cells to be separated more easily. Silicon wafers are etched away and melted into reusable slabs (85 percent reusable) A solar PV module recycling sector is steadily emerging, thanks to increased PV capacity in many European countries in the 1990s. The European Union's WEEE program assisted in the formation of PV Cycle, a member-based organization dedicated to the development of a comprehensive recycling infrastructure.

[4] https://www.cedgreentech.com/article/can-solar-panels-be-recycled

roof space= height of the top point (a) x distance from the apex horizontally at joist level until the eaves of the roof (b) x length of the roof's apex (c).

$a2+b2=x2$ x= the distance from the apex to the edge of the roof

c x (x) = area of the roof / solar panel's measurements (area)

The average size of a solar panel is 78.74 x 157.48 cm.
1.24 m2

96% recyclable

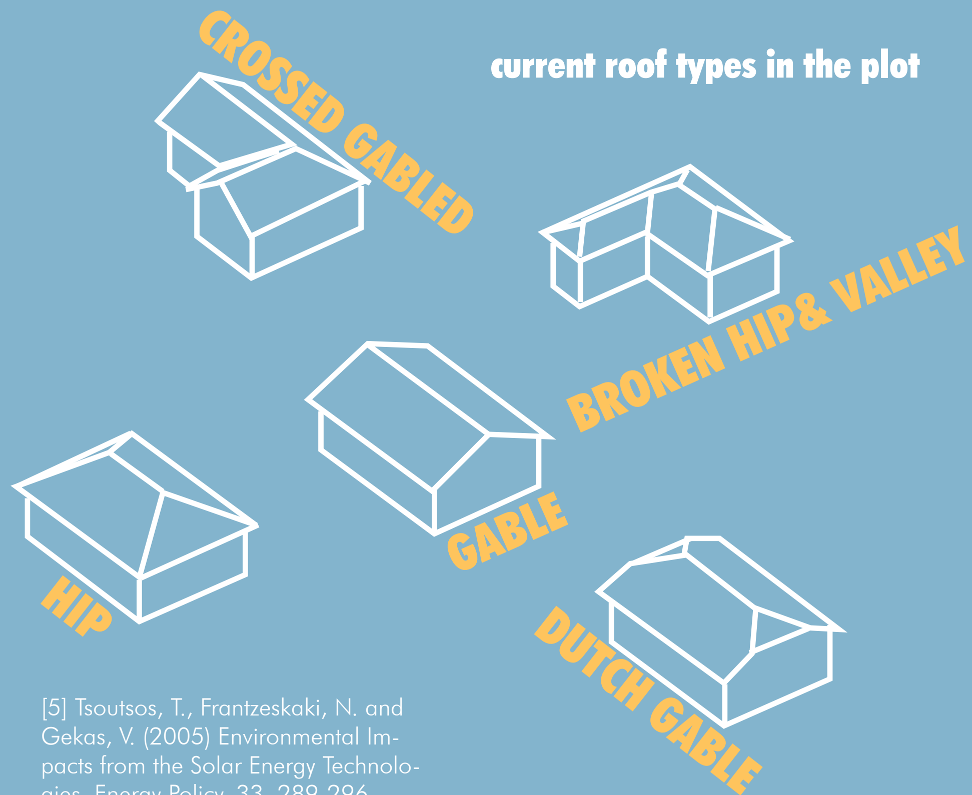
ZONE 1	ZONE 2	ZONE 3
4.200 m2 roof surface	4815 m2 roof surface	2759 m2 roof surface
1566 solar panels	2497 solar panels	1309 solar panels
620,4 kWp	998,8 kWp	523,6 kWp

calculations has been made with the help of; https://powercalculator.ibc-solar.com/

CONCLUSION

With this additional material usage, it has to be beneficial in terms of C&D waste to recover the total amount of energy usage in the plot area. To begin with, solar panels provide numerous advantages on their own. Solar panels use the sun to generate clean energy. Solar panels can aid in the reduction of greenhouse gas emissions and the use of fossil fuels in general. Buildings are generally heated using coal or natural gas, both of which are finite and environmentally destructive. Solar panels do not emit any gaseous or liquid pollutants into the atmosphere, making them a significantly cleaner alternative to fossil fuel-based technologies [5]. In general, solar panels are better for the environment than traditional heating sources. In addition these pv systems are 96% recyclable.

current roof types in the plot



[5] Tsoutsos, T., Frantzeskaki, N. and Gekas, V. (2005) Environmental Impacts from the Solar Energy Technologies. Energy Policy, 33, 289-296. http://dx.doi.org/10.1016/S0301-4215(03)00241-6

PV SYSTEM DETAILS

Requested Location	turin
Weather Data Source	(INTL) TORINO-CASELLE
Latitude	45.18° N
Longitude	7.65° E
PV System Specifications (Residential)	
DC System Size	25.3 kW
Module Type	Crystalline Silicon
Array Type	mono- / multicrystalline
Array Tilt	35°-45°
Array Azimuth	0°
System Losses	0.14%
Inverter Efficiency	0.96%
DC to AC Size Ratio	1.20%
Economics	
Average Retail Electricity Rate	0.500 €/kWh
Performance Metrics	
Capacity Factor	0.07%

PVGIS-5 estimates of solar electricity generation:

Provided inputs:

Latitude/Longitude:	**45.093,7.712**

Horizon: Calculated

Database used:	**PVGIS-SARAH2**
PV technology:	**Crystalline silicon**
PV installed:	**1 kWp**
System loss:	**14 %**

Simulation outputs

Slope angle:	**35 °**
Azimuth angle:	**0 °**
Yearly PV energy production:	**1356.51 kWh**
Yearly in-plane irradiation:	**1747.5 kWh/m²**
Year-to-year variability:	**60.55 kWh**

Changes in output due to:

Angle of incidence:	**-2.67 %**
Spectral effects:	**1 %**
Temperature and low irradiance:	**-8.18 %**
Total loss:	**-22.37 %**

Monthly PV energy and solar irradiation

Month	E_m	H(i)_m	SD_m
January	85.9	101.9	16.9
February	89.8	109.1	18.5
March	122.4	153.1	17.6
April	125.7	162.1	16.3
May	135.3	177.8	12.2
June	139.4	187.3	10.4
July	151.8	206.8	7.7
August	142.3	192.7	8.4
September	120.5	158.6	8.8
October	92.4	116.2	14.2
November	72.0	88.1	16.7
December	79.0	94.0	13.2

E_m: Average monthly electricity production from the defined system [kWh].
H(i)_m: Average monthly sum of global irradiation per square meter received by the modules of the given system [kWh/m²].
SD_m: Standard deviation of the monthly electricity production due to year-to-year variation [kWh].

Report generated on 2022/05/29

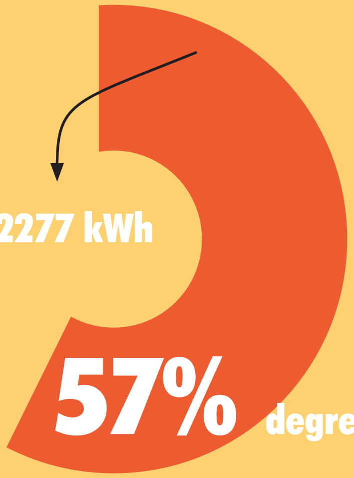
Scenario 2

savings from PV systems (plot area)

Without solar power storage unit

electricity purchased 1716 kWh

self-sufficiency 2277 kWh



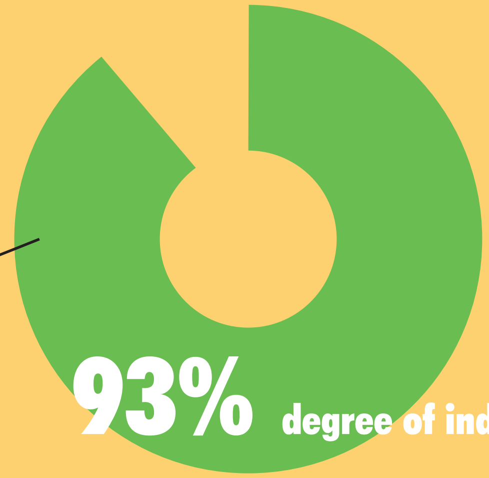
degree of independence

savings from PV systems (plot area) + power storage unit

With solar power storage unit

electricity purchased 283 kWh

self-sufficiency 3710 kWh



degree of independence

electricity cost savings	767.52 €	electricity cost savings	1251.24 €
revenue through feed-in	184,362.37 €	revenue through feed-in	184,216.00 €
total savings	185,129.88 €	total savings	185,467.24 €

plant dimensions in total	2142.80 kWp	annual electricity consumption	4000 kWh
module pitch	35 °	current electricty price	29.0ct / kWh
yield per year	1,902,920 kWh	current electricity costs	1160.00€
		annual electricity price increase rate	2.0%

pv panels costs	annual elect.cost of the case	saving	average annual cost saving
6,661,000.00	€ 447,687.66	60%	€ 268,612.60

Solar power systems:
integration and energy production
Prof. Arch. Riccardo Pollo
PhD cand. Matteo Giovanardi

The potential for financial gain is one advantage of using a sustainable energy source, like solar panels, to power your home. Due to your own energy generation, your electricity bill will be reduced, but you may also use the Feed in Tariff to sell any extra energy you produce to a power provider.

The cost of installation and purchase, as well as the caliber and grade of the installed system components, all play a role in determining the return on investment for residential solar panels.

The amount of cells you can have installed on your roof and how much energy you can produce will depend on the size and orientation of your roof, as well as the type of solar cells utilized in each panel.

With the proper maintenance, most solar panel systems should last between 20 and 25 years or longer, and the initial cost can typically be recovered within the first 12 to 18 years. When calculating the payback period for solar panels, there are numerous elements to take into account.

For residential buildings, the return on investment is often higher the larger your solar panel installation. Although you might want to check with your local authority first, installing solar panels typically doesn't require planning approval. The initial cost of solar panels for household homes might vary depending on the kind chosen, such as tiles or linear panels.

Since energy prices are expected to increase over the next few years, having your own supply could very well result in a higher return on capital and financial savings than what we have calculated. Independent suppliers are becoming increasingly critical to the maintenance of the electricity supplied to the Power Company, according to an increasing number of energy companies.

Solar cells that are monocrystalline

Single crystalline cells is another name for these solar cells. Their rich black color and squared edges make them simple to recognize. The most effective material for converting sunlight into electricity is silicon, and monocrystalline solar cells are constructed from an extremely pure form of the element.

The most space-efficient variety of silicon solar cell is the monocrystalline variety. They actually occupy the smallest amount of space of any solar panel technology now available. With a current life expectancy of roughly 50 years, they also offer the significant advantage of being the most durable solar cell technology.

Because of this, you will discover that the manufacturers will provide you with warranties on these photovoltaic cells that can last up to 25 years, or half of its predicted lifetime.

When compared to other versions, this system does continue to be superior in almost every area, although it does have a heavy price tag. Out of all the available solar cell varieties, mono - crystalline photovoltaic cells are regarded as the most expensive alternative. This is mostly because each of the four edges is chopped, which generates a significant amount of waste. Because of this, polycrystalline serves as a less expensive substitute.

Monocrystalline Solar Panels: Pros

At 15-20%, they have the highest level of effectiveness.

Due to their excellent efficiency, they take up less space than other types.

This type of solar cell is said to have the longest lifespan according to the manufacturers, who often offer a 25-year warranty.

They work better in low light conditions, making them perfect for cloudy environments.

Monocrystalline solar cells' drawbacks

They are the priciest solar cells available, hence they are not affordable for everyone.

An increase in temperature usually results in lower performance levels. However, compared to other types of solar cells, it is a negligible loss.

When silicon is sliced during manufacturing, there is a lot of waste material.

7.6

scenario 3 **roof redesing (flat roof)** & (blue-green roof)

Flat roofs can be incredibly space-efficient, reducing a building's significant resources and giving easy access to HVAC, photovoltaic panels. *In addition, terraces and green roofs can enhance a new elevation aesthetic while also providing a valuable amenity for residents. Also, green roofs benefit from increased biodiversity, pollutant filtration, improved insulation values, rain run-off control, and inexpensive maintenance.*

Water attenuation is also a key component of blue roofs, which are designed to hold some water during heavy rain before draining in a controlled environment. As a result, using a hybrid blue/green roof, combines the water-attenuating qualities of a green roof with the water-attenuating features of a blue roof.

There are several elements to consider when considering the roof covering's long-term viability. First and foremost, what is it made of, and is it recyclable? TPO[1] membranes, for example, are 100 percent recyclable and contain no polymeric plasticizers, liquid plasticizers, or chlorine. FDT Rhepanol PIB[2] is the only membrane now available with a comprehensive Life Cycle Assessment that meets **DIN EN ISO 14040 part ff[3].** In addition, it is made of polyisobutylene (a synthetic rubber). This means it has no substantial environmental impact in its life cycle, from manufacture to disposal. [1,2]

[1]https://architecturetoday.co.uk/sustainability-flat-roofing-part-1/

[2]https://www.singleply.co.uk/flat-roofs/fdt-rhepanol-pib/

[1] Thermoplastic Polyolefin (TPO) is a mono roofing membrane that has become one of the most popular commercial roofing systems. Flat roofs can be covered with TPO roofing systems, which are made composed of a single layer of synthetics and reinforcing fabric.

[2] Rhepanol PIB is a homogeneous and fleece-laminated synthetic roofing membrane made from polyisobutylene (PIB). The Rhepanol system is certified with the Environmental Product Declaration according to ISO 14025 and EN 15804., showing that it has no significant environmental impact at any time between its manufacturer and eventual disposal.

[3] BS EN ISO 14040:2006+A1:2020 Environmental management. Life cycle assessment. Principles and framework / european standards

Flat roofing; should be considered in terms of detailed techniques and future maintenance. In addition, flat roofs must be subjected to a proper and regular inspection regime for the benefit of clients and end-users. This systematization will ensure that drainage outlets remain unblocked and foresight the necessary repairs or replacements for the roof. [1]

In this case scenario, the existing roof structure; will be demolished. The material debris; will be eliminated according to the calculation that has been made throughout **scenario 1**. *The recycled materials; will be processed to be reused for the new roof's structural elements. This additional material usage has to be beneficial in terms of C&D waste to recover the total energy usage and should be helpful from the environmental point of view. (flat roof with PV panels and greenery.)* **scenario 2**

Flat roof materials

EPDM membrane roofing EPDM (ethylene propylene diene terpolymer) is a black synthetic rubber membrane that is widely utilized in commercial and medical settings. EPDM is mostly utilized in commercial roofing, although it also has a position in residential roofing. [3] **%100 recyclable**

TPO membrane roofing

TPO (thermoplastic polyolefin) is a single-ply white roofing membrane that is utilized in both commercial and residential applications. TPO's white membrane, unlike EPDM, radiates heat rather than absorbing it. [4]**%100 recyclable**

PVC membrane roofing

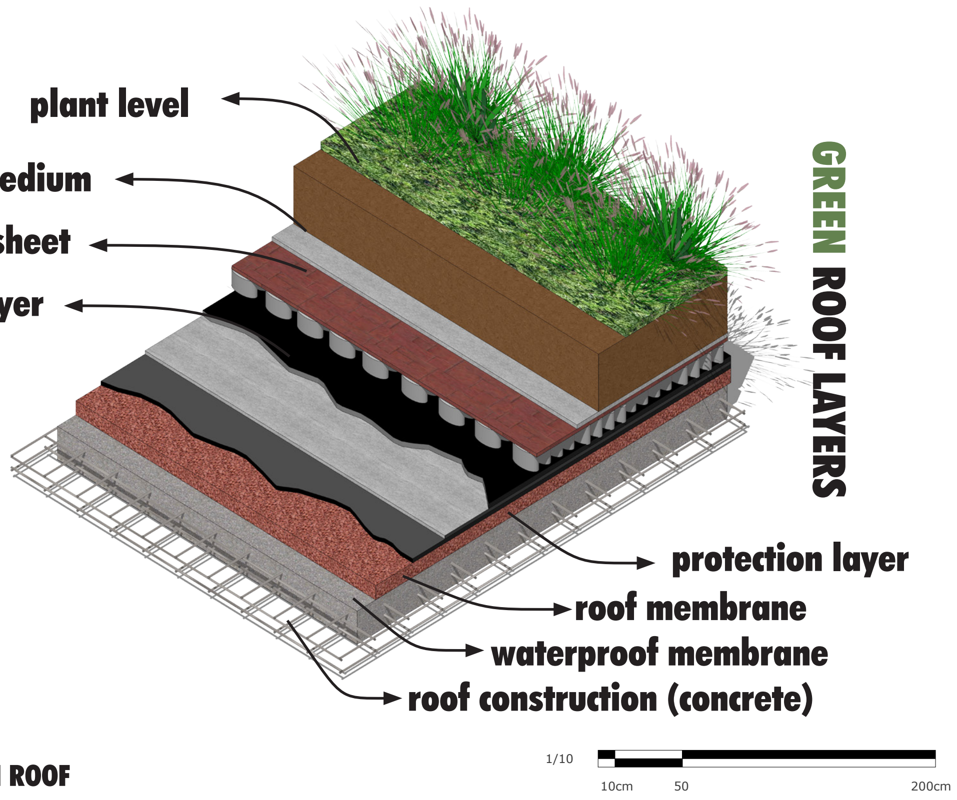
PVC (polyvinyl chloride) is a single-ply white membrane that can be used for both commercial and residential roofing. PVC is also an excellent choice for any flat or low-sloped roof over a living room or bedroom. [4]**%100 recyclable**

Standing seam metal roof%100 recyclable

A standing seam metal roof system is made up of a series of metal panels that are mechanically seamed or fastened together at the seams. When metal panels expand and contract due to thermal expansion, this allows the panels to expand and contract freely.

EPDM sheets are **100 percent recyclable** and can be recycled after usage for things like rubber matting in playgrounds or used as fuel to help reduce reliance on fossil fuels. EPDM rubber is the material of choice for those who care about the environment.

[3] https://www.tporoofing.org/tpo-roof-recycling/#:~:text=Among%20the%20three%20single%2Dply,the%20process%20of%20TPO%20recycling.
[4] https://www.rubber4roofs.co.uk/blog/8-reasons-why-epdm-rubber-roofing-is-the-most-eco-friendly-roofing-system/#:~:text=8.-,100%25%20Recyclable,choice%20for%20the%20environmentally%20conscious.



GREEN ROOF

Green roofs have long been scolded for having insufficient water storage capacity during heavy rains and for being vulnerable to droughts when additional irrigation is unavailable. One way to address these issues is to add a blue water retention layer beneath the green layer. More stormwater can be held on blue-green roofs, and the reservoir can serve as a water source for the green layer during capillary rises[1].

BLUE & GREEN ROOF

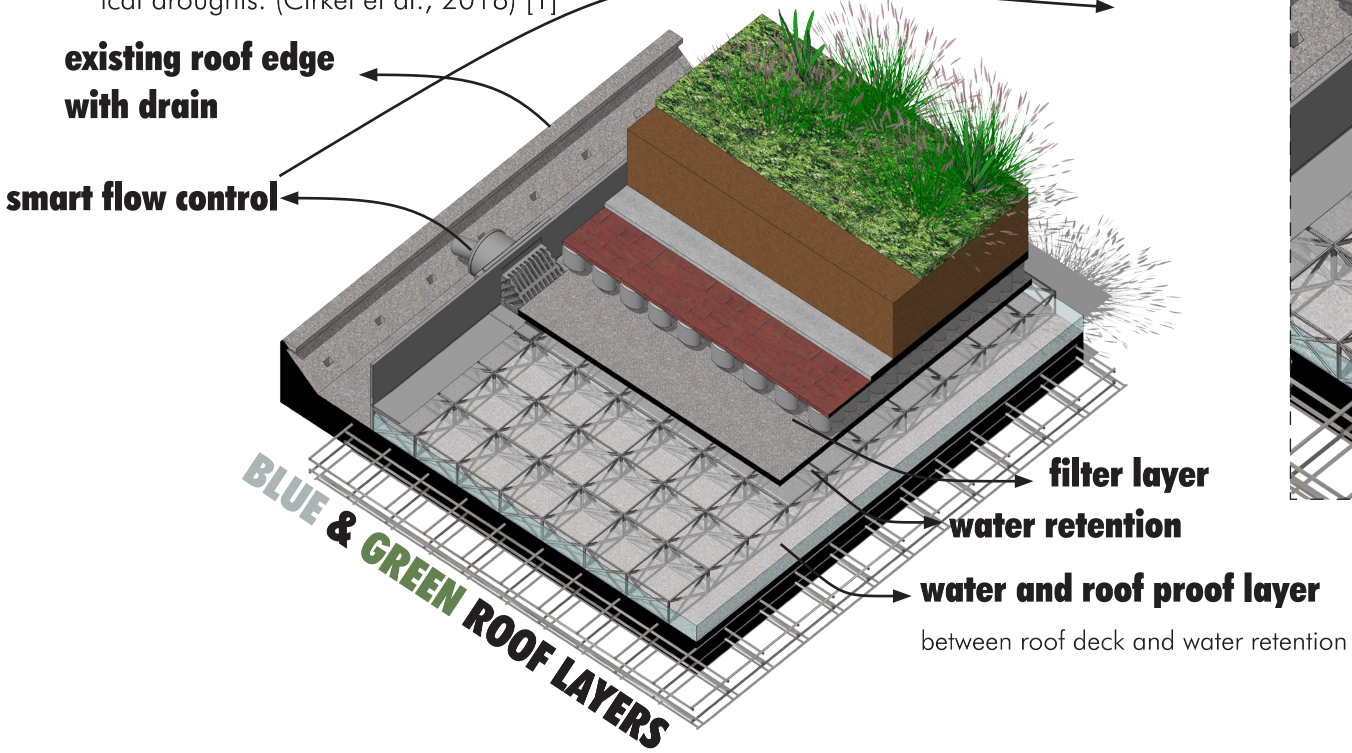
"On hot summer days, blue-green roofs allow for high evapotranspiration rates (about 70%) compared to potential evapotranspiration, which is higher than standard green roofs (30 percent). This emphasizes blue-green roofs' superior ability to mitigate heat stress. [1] In July 2011, Copenhagen was hit by a rainfall of unprecedented proportions, with 150 millimeters of rain falling in less than two hours. The city of Amsterdam was given a wake-up call by this storm, which led the launch of the Amsterdam Rainproof Program in January 2014. The city has started pilots and research on blue-green roofs through the Smartroof 2.0 initiative and, more recently, the RESILIO project, in keeping with the program's goals (RESILIO, 2020). Underneath the green soil layer and above the roof deck lies the blue layer of those roofs." [1]

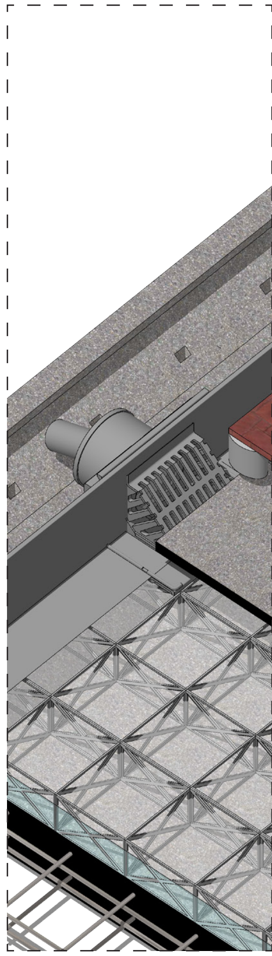
[1] Blue-green roofs with forecast-based operation to reduce the impact of weather extremes / https://doi.org/10.1016/j.jenvman.2021.113750 /Received 20 June 2021; Received in revised form 10 September 2021; Accepted 11 September 2021

1 Capillary rise is a well-known unsaturated soil phenomena that describes the transfer of pore water from a lower to a higher elevation as a result of a hydraulic head gradient acting across the curved pore air/ pore water interface.

BLUE & GREEN Flat roof

It is made up of 8-centimeter-deep plastic crates that provide additional rainwater storage capacity. To avoid leaks and root damage, a water- and root-proof layer is placed beneath the blue layer. Furthermore, the current roof deck must be reinforced with an additional cement layer as well as waterproof and root-resistant bitumen. Plants in the green layer can use capillary fibre cylinders to absorb water from the blue layer, reducing the need for irrigation and increasing the plant layer's resistance during meteorological droughts. (Cirkel et al., 2018) [1]





The general difference between a green roof and a blue-green roof is the presence of water retention elements located just underneath the filter layer (water permeable). The smart valve system is another essential addition to the roof drain system. The valve works like a water gauge in the presence of rain. As the water passes through the soil to the filter layer, the water retention field starts to fill with water slowly. The valve won't open unless the water fills the gap between the water retention area. (71mm) This system also controls the evaporation process, which is beneficial as a water source to the soil.

As for the existing roof edge, an additional concrete parapet was added with 30-35 percent of a slope with rain gutters in case of a capillary rise.

FLAT ROOF

example of a typical flat roof section and layers

concrete 12.733 m2 (for the coverage of roof surface)

concrete (for creating the vertical parapets 110 cm) **510 m2**

parapet volume in the roof approximately covers %4 of the total roof surfaces in the plot area

%5-8

more concrete usage than the existing roof structure

+additional access to the roof % 4 more brick and plaster usage

EPDM membrane

%100 recycable

EPDM (Ethylene Propylene Diene Monomer) is a type of rubber that is widely used around the world and has a long history of resilience and longevity. This synthetic rubber membrane, on the other hand, offers a number of excellent qualities that combine to make it the most cost-effective and ecologically friendly roofing system on the market.

Many of the EPDM membranes we buy at the UN have already been used and are made from recycled materials like tires. This is advantageous since recycling them does not necessitate burning or the release of hazardous gases into the atmosphere. When the membrane cover needs to be changed, the same procedure applies, and the rubber roof can be recycled once again.

non-hazardous

non-toxic

last up to 50 years

11.235 m2 (for the coverage of roof surface)

500.000 €

For the material and installation of EPDM roofing membrane, you may anticipate to pay between €45 and €60 per square meter.

https://www.roof-info.co.uk/roofing-materials/epdm

%100 recycable

TPO membrane

PVC membrane

TPO, like PVC, is one of the three single-ply membranes that is **100% recyclable**. Many TPO manufacturers have begun programs to educate roofing contractors and building owners about the benefits and process of TPO recycling in recent years.

4.5€-6.00€ /m2

Highly resistant to UV rays, heat, and extreme weather conditions

11.235 m2 56.000 €

gravel & tar

Tar and gravel roofing is a multi-layer roofing option for your flat roof. It's just a felt sheet soaked in asphalt that can help prevent water penetration. This sort of roofing can last for a long period if properly maintained and inspected. For example, it's necessary to cover the entire area with gravel to prevent the felt sheet from drying up due to exposure to the sun.

Lower material cost compared to other roofing solutions

Easy to repair

Gravel is a coarser-than-sand aggregate made up of more or less rounded rock particles. It could be generated from C&D wastes.

FLAT ROOF + GREEN

There are three types of green roofs: **extensive, semi-intensive, and intensive.** The classification is based on the depth, kind of vegetative cover, and function of the plant.

extensive

choosen type

Green roofs with a lot of vegetation are low-maintenance. They have deep soils or other soil amendments ideal for succulents and other low-growing plants like Sedum. **They serve primarily as an ecological barrier layer, such as a stormwater filter. These green roofs are generally kept at 7,62cm to 12,7 cm and are not irrigated.** They're shallow, with small grasses, herbs, or plants covering them. This makes large green roofs suitable for rooftops with limited load-bearing capacity. A large green roof weighs 6 to 13 kg per 0.1 square meters. Green roofs with a large area of vegetation are also the least expensive. [2]

between 675 kg - 1460 kg with greenery and soil

+ weight

Green roofs with somewhat deep substrates (10 to 12 cm) are particularly excellent storm water management techniques. In fact, most studies have found that the depth of growth is the most critical component in determining how successfully a green roof captures rainfall. **Green roofs retain 45 to 60 percent of the rain that falls on them on average, with intense roofs storing more rain than extensive roofs.** [2]

+ clean air
+ support urban wild life
+ produce food
+ reduce stormwater runoff
+ reduce building's energy use

[2]https://www.soils.org/about-soils/green-roofs

FLAT ROOF + BLUE & GREEN

Build-up height: ca. 150 mm

Weight, saturated: ca. 155 kg/m²

Water retention capacity: ca. 80 l/m²

[1] PLANNING GUIDE
Green Roof 4.0
SYSTEMS FOR ROOF UTILISATION
FOR THE FUTURE / Zinco

Green roof technologies can aid in the reduction of **urban heat islands** and energy conservation. **Rooftops with green roofs have been demonstrated to be cooler than those with conventional roofs.** They also have a cooling impact on the temperature of a city's surface. Rooftops can also cut energy use in a variety of conditions. The quantity of cooling provided by a green roof is determined by the roof's material. Green roofs are usually coated with a culture conditions that contains soil but is not the same as soil found on the ground. It is a mixture of soil and inorganic elements such as crushed clay and liquid fertilizer that has been properly prepared. This keeps the material flexible and allows for effective water drainage. [1]

requirements

- Structure with a zero-pitch roof
- Roof load-bearing capability that is relevant
- Between the top of the water layer and the filter sheet, there must be an air layer. For significant rain occurrences, the remaining overflow is critical. Overflows are still required in the event of an emergency.
- For each specific building, the maximum water spreading quantity, the time until the storage space is available again, and the maximum drainage quantity per time unit must be determined. [1]

+

The benefit is that it is constantly available as a source of water, even in the sweltering summer heat. It could be one of the elements utilized to provide water to the Urban Climate Roof.

7.7

scenario 4 **roof redesing (flat roof)** & (blue-green roof) + pv systems

Photovoltaic systems and rooftop gardens are two popular ecologically friendly roof choices. Solar panels, also known as photovoltaic (PV) systems, are more environmentally friendly and sustainable than electricity provided by natural gas or coal since they emit fewer greenhouse gases (Qualitative Reasoning Group 2016; Tsoutsos et al. 2005). A blanket of vegetation is grown on top of the roof to create a green roof. Extensive, intensive, and semi-intensive are the three categories. Extensive rooftops are often shallow, with less than 15 cm soil layer, minimal plant diversification, and low watering needs. Intensive roofs feature more soil, often several feet, and a greater variety of materials. Semi-intensive green roofs combine the two, utilizing a medium volume of soil (Technical Preservation Services 2015).[1]

This scenario will focus on large-scale green roofs to reduce the building's weight since they often have lower construction and maintenance expenses. In addition, green roofs are widely utilized to reduce stormwater runoff, save energy, and improve a building's thermal insulation. Furthermore, shadowing from plants on green roofs can lower a building's temperature and the surrounding temperature due to the urban heat island effect. This occurs when the temperature in metropolitan areas is higher than in the nearby neighborhoods (Hui et al. 2011). Both environmentally friendly roof choices have numerous environmental benefits when utilized separately.

Solar panels may also improve the diversity of plants and, as a result, fauna that live on the green roof. This is accomplished by the solar panels producing darkened areas beneath them. Rain runoff would create a more humid environment in front of solar panels, while the backside would remain dry. This would create a "habitat mosaic," allowing a larger diversity of blooms to thrive, attracting a wider range of wildlife (Living-Roofs 2017). This study is significant because it demonstrates how well solar panels and green roofs function together. This demonstrates that combining different sustainable characteristics might be more practical and result in a more diversified environment in a limited space.

7 AFFORDABLE AND CLEAN ENERGY

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

13 CLIMATE ACTION

[1]Feasibility of Combining Solar Panels and Green Roofs on the Activities and Recreation Center Final Report December 15, 2017 CEE 398PBL Kara Kessling, Abby Cohen, Jadon Jasso

"see Scenario 2"

The average size of a solar panel is 78.74 x 157.48 cm. **1.24 m2**

96% recyclable

ZONE 1	ZONE 2	ZONE 3
4.200 m2 roof surface	4815 m2 roof surface	2759 m2 roof surface
1566 solar panels	2497 solar panels	1309 solar panels
620,4 kWp	998,8 kWp	523,6 kWp

This project's solar panel and green roof combo will cover approximately 65% of the plot area's 11.774m2 available roof area with greenery first. Then, above the flora, solar panels will be placed. Finally, the remaining ten percent of the rooftop will be used for gravel pathways that will allow water to drain away from the solar panels and maintenance paths for the PV panels and plants.

As for the PV systems:
The conventional solar panel systems are mainly installed on the roof with an anchorage system. However, an additional structure has been made to establish the crystalline cells to avoid water leakages throughout the roof's surface. In terms of C&D waste management, the structural elements of this additional part have been selected as timber, glass, and metal. This procedure will drastically eliminate the solar panel numbers by %25 in comparison with the case scenario 2. The material usage has affected the solar panel system usage to reduce the C&D wastes.

-35% efficiency
in terms of pv system vs scenario 2

ZONE 1	ZONE 2	ZONE 3
2.730 m2 roof surface	3.129 m2 roof surface	1.793 m2 roof surface
1017 solar panels	1623 solar panels	850 solar panels
402,9 kWp	649,2 kWp	340 kWp

%10 gravel 1.177 m2

7.653 m2 for greenery and PV systems

+ %5-8 more concrete usage than the existing roof structure

+additional access to the roof %4 more brick and plaster usage

+ wood and brick usage %45 + glass


open envelope roof garden


open&closed envelope roof garden

7.8

waste collection and recycling building scale (proposal)

The trash room with a single chute and multiple bins is depicted in the diagram above. Trash is dumped into a compactor through a chute, and MGP and paper recycling are collected in trash room bins. There may be additional space for cardboard or a separate dedicated location. The garbage room is frequently cramped and poorly ventilated, with only enough capacity for a few small recycling containers.

Benefits - Convenient for locals
Disadvantages - Each story requires space and work to collect recyclables.
Alignment with industry best practices
- Trash is usually emptied into a compactor to reduce volume.
- Disposal with equal ease: With a big, well-ventilated waste room that is serviced daily, co-location of trash, recycling, and organics is possible (often not the case in existing buildings).

Thousands of truckloads of materials, new items, clothes, and food enter our city every day to be parceled out in boxes, delivered quickly, and eaten. Our streets are littered with trash bags, which attract vermin and take up important public space. Thousands of additional heavy collection vehicles transport these materials to garbage transfer centers, cluttering roadways, polluting the air, and deteriorating the quality of life in nearby communities. The majority of these items are trucked to landfills in other states, where they become trash and pollute the soil and air. The inhabitants of Torino pay over a billion dollars in taxes each year as a result of this process. This system could be improved through design.[1] & [1] Discarded materials are a valuable resource that may be reused, repaired, or recycled into new materials, compost, and energy while also creating employment in the city.

[1]https://www.idealista.it/en/news/financial-advice-italy/2019/02/26/2377-how-much-tari-tax-do-you-have-pay-italy-2019#:~:text=The%20Italian%20waste%20tax%20called,required%20to%20pay%20the%20tax.

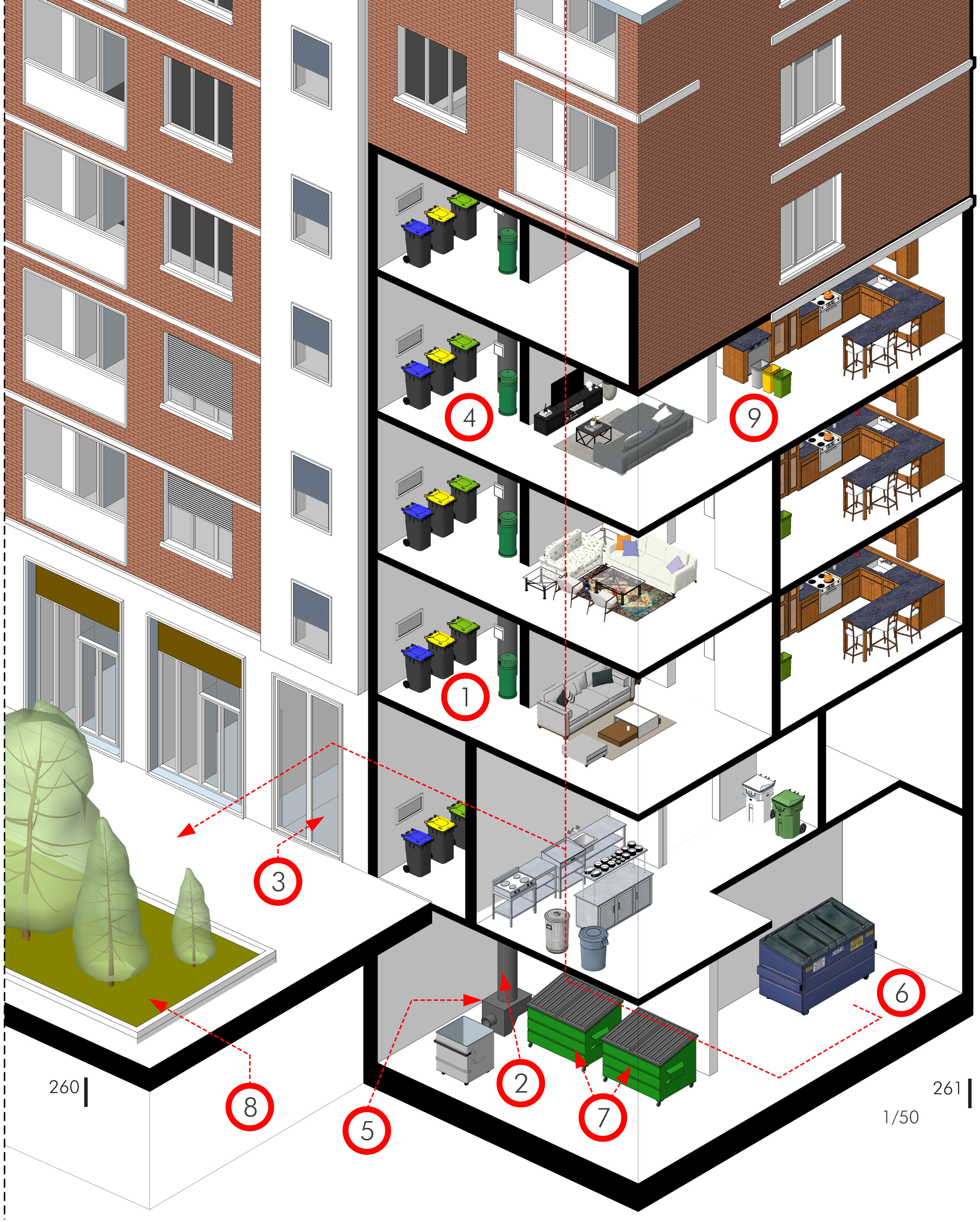
1 The Italian waste tax called tassa sui rifiuti or TARI is a municipal charge on the cost of disposal of solid waste and refuse. If you own or have a property in Italy that is likely to produce trash, you are required to pay the tax.

We need our buildings to assist the separation of additional material streams such as organic trash, textiles, and e-waste as they are collected. In most buildings, trash collection takes precedence, making diverting other resources more difficult. Organics bring new challenges: they are heavier than other recycling streams, and they degrade, necessitating more frequent containerization, ventilation, and collection.

It's simple to separate unwanted materials for reuse and recycling thanks to good design. The waste calculator included in the standards makes this easier by allowing designers to calculate the volumes of all the streams that must be captured and handled. Best practice solutions demonstrate how architects and building operators can plan for material flows through buildings by decreasing waste, isolating waste streams, and compacting them for simpler transport and storage. They also demonstrate how to ensure that the different waste streams are collected efficiently.

Conclusion
Design plays a critical role in reshaping our city, its processes, and its residents to achieve zero waste. Design can push us to adjust our behavior and consumption patterns so that we can minimize, share, reuse, and allocate space for handling discards so that they can be reused or recycled as well.

1. Consider the size of the room, ventilation, lighting, and labeling.
2. A chute and recycling disposal on each floor. (≥ 5 storeys and ≥9 apartments.)
3. Consider how waste is transported vertically (by chute, residents, or building employees in a regular or service elevator).
4. All waste streams, including organics, should be disposed of in one site. Other waste sources that could clog chutes include cardboard, textiles, and hangers.
5. Trash compactors are necessary for collecting rubbish. This trash can has a hydraulically powered metal ram that compresses the waste into a tiny, dense package.
6. Consider the waste's path to the curb as well as the time required by staff.
7. Unless the room is rat- and fire-proof, use containers. Consider the amount of space needed, ventilation, and container cleaning.
8. Compost can be created and used in gardens on-site.
9. Place bins where they're needed (all waste streams) and have an organics container nearby.



This study was conducted to find construction management techniques to reduce on-site construction waste. Up to 50 research papers were analyzed, and the mapping method was used to identify the essential practices for each management group. The study analyzes previous research on C&D waste management techniques and provides a conceptual framework for closing the current debris recovery gaps. It discusses the need for interconnected primary strategies, such as waste prevention, upstream waste separation and recognition of different types of wastes, on-time waste collection throughout the cities with proper collecting and separating systems, and finally, the three main components of the phenomenon known as the "3R's" of waste management (reuse, recycle, reduce).

The proposed framework rests on eight core elements: 1) collection of lifecycle data about each C&D material, 2) current and new recycling methods based on connected and involved citizens for sharing products and service information to avoid waste generation locally, 3) investigating the existing recycling plants and their working systems for each construction material for waste recovery operations, 4) the reusability and recyclability of the c&d materials, 5) the current and provisional global status on total waste generation, including per capita ratios, 6) the side effects of waste on human health and the environment, 7) the current status of the governments on waste regulations and directives, 8) new models and methods for avoiding/minimizing waste production (micro-macro urban scale). These elements aim to prevent waste and improve the efficiency of waste collection and recovery operations in construction and demolition activities. This study concluded that; to accomplish on-site waste minimization, it is crucial to increase staff awareness and education in construction waste management. To encourage on-site construction waste reduction, additional practices like using offsite products and components (low waste construction technology), the provision of waste skips for particular materials (waste segregation), standardization of design and material, and proper handling of construction materials are crucial. Focusing on environmental consideration for C&D wastes is essential. While many C&D products have practical applications, it's important to remember that a small percentage contain substances that, if mishandled, could harm human health and the environment. Moreover, for several of these components, protective government recommendations or limits are in place to forbid or restrict the use of these materials or to promote the best management practices. Lead, polychlorinated biphenyls (PCBs), and asbestos, for instance, are all subject to federal regulation. Therefore, an organization in charge of C&D materials containing these or other federally controlled components must abide by all relevant federal laws, rules, and regulations.

Furthermore, without adequately accounting for the entire product lifetime and the opportunities for the circular economy across the complete product lifecycle, traditional methods to waste management mainly focus on boosting trash collection activities. Instead, waste management should focus on identifying value chains rather than waste collection methods. In addition to automating current processes, the waste collection and recovery infrastructure should also incorporate best practices to add value. Therefore, it is essential to first determine the needs and requirements of the city before deciding on the type of technology that will be implemented, such as embedded tracking technologies for waste collections and waste stream detection optimization. Regarding the Smart City Management phenomenon, Waste management software is necessary for each typology of urban layer and criteria. A map interface with geolocation should be implemented in the system, displaying devices according to the selected measure, including a sensor for the type of collected waste or materials. As a final step, flexible collection routes should be detected based on capacity and road traffic. This kind of system will eventually provide a unique data collection and waste overfill prevention. It should be considered that implementing the concept of information flows can have a considerable potential to reduce the uncertainties about the amount and quality of waste generation rate. However, it is essential to acknowledge the possibility of rebound effects and creating more tensions due to making technology available to citizens.

Regardless of the building methods, this study offered soft measurements that might be used in site management strategies. The general aim of this study was to offer/provide helpful information to the reader. Therefore, the idea behind the whole study structure is to analyze each material generally used throughout building construction. Thus, the first step was understanding the C&D concept. Then, each material is studied and explained regarding the structure and demolition waste management phenomenon. Main waste categories and components were also issued through the study, including the waste policies and directives around the globe. The delicacy of this subject showed that it is impossible to consider construction and demolition wastes on their own; the topic should be run together with gathered knowledge of climate, demographical, technological, socio-cultural, socio-economical, and environmental aspects. Without these sub-topics, crucial to architectural and ecological understanding, performing the C&D waste management correctly is impossible.

The data collected throughout the study was essential to understanding the global situation, especially in Europe, Italy and finally in Turin. It has been seen that, besides the European Union and The United States, not much of a country can give the exact detailed numerical information about the C&D wastes. The lack of this information shows us that some countries have not taken the issue seriously. For this reason, it has been demonstrated that the governments should come up with some severe precautions and limitations for the sake of our nature-based projected future and environmental status. As we call "the laws" for the C&D wastes, the regulations should be considered and take effect in each country. Besides this topic, the embedded and operational energy must be reduced to optimize the construction sector's overall energy footprint. The ability to precisely analyze operating energy is now possible because of standardized processes and technologies. Despite this, there hasn't been much focus on reducing embodied energy and CO2 emissions. Embodied energy computation is still a labor- and resource-intensive process. It calls for a significant amount of high-quality data, which is occasionally accessible. In addition, because of how long it lasts, the operating phase of a building's lifecycle is typically regarded as the most significant energy consumer. As a result, in most developed nations, better energy-efficient space conditioning appliances and auxiliary systems are installed in buildings that steadily lower their operational energy. However, using inefficient functioning energy systems in poorer nations negates these advancements. Due to several issues, such as a lack of information and awareness, expertise, high transaction costs, and a lack of regulation, energy-efficient buildings are nonexistent in these nations.

To conclude, four case scenarios have been created with the collected data and information about the plot area. The first step is to analyze the total material usage that is present in the area. Then, these materials are investigated in terms of recyclability ratios. Finally, an estimated overall analysis has been accomplished for the plot area. The next focus is to understand; how to reuse and recycle these c&d materials. A further investigation has been made into the roof's structure and elements. The non-recyclable materials have been detected and analyzed. In these 4 cases, it has been seen that the idea behind the C&D waste management is one of the most complex issues regarding recycling and reusing the current materials. There are various possibilities for recreating or retrofitting the roof structure. The first case is to establish reliable data about the total estimated debris creation from the current roof structure and eliminate the non-recyclable&non reusable materials from the equation. It was essential to understand how much of these used materials could be reused if the roof structure is renovated in its current form and design. The following three cases establish a roof design generally focused on green and blue roof systems for implementing a photovoltaic system.

In these scenarios, it has been seen that the more you put an additional material to the roof, the more c&d waste you will generate in the future. But the contradiction, in this case, is that there isn't a stable relevance between creating and adding extra elements which will be beneficial in the short and long term and not redesigning the roof structure at all and remaining as it is. The main problem in this equation is that the system must regenerate itself throughout time. It should adapt for its users and maintain a positive effect on the environment. So when we want to add solar panels to the roof, which is %100 beneficial in producing green energy and self-sufficiency, it does not have a positive side effect when considering C&D waste. So the study tried to establish the optimum level for waste production and creation dilemma. As for the green and blue roof systems, which both implement photovoltaic panels, these redesign ideas have a much more positive contribution to the users and the environment.

So we must think carefully and evaluate the actions we will take as architects. Therefore, these three cases;(including a green roof, blue roof, greenhouse, and solar panel systems) were analyzed delicately to understand if these renovation ideas will positively affect c&d waste management in the future. The conclusion is; that construction material has a significant role in reusability and recyclability. In each construction, it should be considered beforehand. Waste generation and sustainability should be in a delicate balance at all times. This paradigm between preserving and constructing a new structure will be strengthened in the future by examining the impacts of additional elements on waste management, such as legislation, public policy, product design tactics, and technology. The suggested framework has also looked broadly at waste management and the problems developing in this area. However, distinct waste types have unique traits and treatment strategies that are occasionally incompatible with one another. To be employed following the scope, requirements, and boundaries of each waste type, the suggested product-lifecycle framework should be adjusted and expanded. The proposed methodology also has to be tested using actual case studies to see how well product lifecycle data can be used to address problems with waste generation and recovery in various locations and nations.

- ANSI accreditation, https://www.ansi.org/accreditation/faqs.aspx#2 Regulation (EU) No 305/2011 CPR, http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=cel-ex-:32011R0305

- ISO, 1996, http://certifications.thomasnet.com/certifications/glossary/quality-certifications/iso/iso-14001-1996/

- Ahmed, R., A. van de Klundert, and 1. Lardinois. Rubber Waste, Urban Solid Waste Series, Vol.3. Amsterdam and Gouda: Tool, Transfer of Technology for Development and WASTE Consultants,1996.

- Beede, David N., and David E. Bloom, "The Economics of Municipal Solid Waste." The WorldBank Research Observer, Vol. 10, No. 2, August, 1995, pp. 113-150.

- Kreith, Frank, ed. Handbook of Solid Waste Management. New York: McGraw-Hill, 1994.
- Tchobanoglous George, Hilary Theisen, and Samuel Vigil. Integrated Solid Waste Management. Engi-neering Principles and Management Issues. New York: McGraw-Hill, 1993.

- UNEP-IETC, International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management. Technical Publication Series no. 6. Osaka/Shiga: UNEP International Environmental Technology Centre, 1996 (pp. 421-427)

- United States, Government of, Environmental Protection Agency. Decision Makers Guide to Solid Waste Management. Washington: US Environmental Protection Agency, 1989.

- United States, Government of, Office of Technology Assessment (OTA). Facing America's Trash: What Next for Municipal Solid Waste? Washington: OTA, 1989.

- Directive 2008/98/EC on waste (Waste Framework Directive), Article 3(13), http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:32008L0098

- European Commission Humanitarian Aid & Civil Protec-tion Report Brussels (2018). http://dgecho-partners- helpdesk.eu/partnership/start, 18.12.2018.

- The World bank_understanding poverty_solid waste management. September 23 2019. / What a Waste 2.0: A global snapshot of solid waste management to 2050.

- United nations / Before The Next Disaster Strikes: The Humanitarian Impact Of Climate Change

- Screening template for Construction and Demolition Waste management in The Netherlands V2 – September 2015

- Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives

- Díaz, Settele, and Brondízio, Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services - advance unedited version. 2019, IPBES Secretariat: Bonn.

- Williams, M., R. Gower, and J. Green, No time to waste: Tackling the plastic pollution crisis before it's too late. 2019, Tearfund: Teddington.

- EU Commission, Roadmap to a Resource Efficient Europe, European Commission, Brussels, Belgium, 2011.

- Directive 2008/98/EC on waste (Waste Framework Directive), Article 3(17), http://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:32008L0098

- Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste, Article 2(e), http://eur-lex. europa.eu/legalcontent/EN/ALL/?uri=celex%3A31999L0031

- Proposal for a Directive of the European Parliament and of the Council amending Directive 2008/98/EC on waste, Article 2(e), http://eur-lex.europa.eu/legal-content/EN/TX-T/?uri=celex%3A32008L0098

- G.A. Blengini, E. Garbarino / Journal of Cleaner Production 18 (2010) 1021–1030

- Barbaro, G. Rifiuti speciali non pericolosi da C&D: La gestione eco-efficiente in Italia. Archit. Sostenibile 2012, 31-5. Available online: https://www.architetturaecosostenibile.it/materiali/smaltimento-e-riciclo/rifiuti-speciali-non-pericolosi-ced-gestioneeco-efficiente-italia-760 (accessed on 14 April 2021).

- Deloitte. Screening Template for Construction and Demolition Waste Management in Italy v2. October 2015. Available online: https://ec.europa.eu/environment/pdf/waste/studies/deliverables/CDW_Italy_Factsheet_Final.pdf (accessed on 30 June 2021).

-Paleari, M.; Campioli, A. I Rifiuti da costruzione e demolizione:LCA della demolizione di 51 edifici residenziali. Ingegneria dell'Ambiente 2015, no 4.

- Roof beams and timber removal/Department of Environment, Climate Change and Water NSW 59–61 Goulburn Street, Sydney DECCW 2010/82 ISBN 978 1 74232 436 4 Published July 2010 © Copyright State of NSW and the Department of Environment, Climate Change and Water

- Roof beams and timber removal/Department of Environment, Climate Change and Water NSW 59–61 Goulburn Street, Sydney DECCW 2010/82 ISBN 978 1 74232 436 4 Published July 2010 © Copyright State of NSW and the Department of Environment, Climate Change and Water

- G. Camarini, M. C. C. Pinto, A. G. D. Moura, and N. R. Manzo, "Effect of citric acid on properties of recycled gypsum plaster to building components," Construction and Building Materials, vol. 124, pp.383–390, 2016.

- Industrial Internet of Things enabled supply-side energy modelling for refined energy management in aluminium extrusions manufacturing https://doi.org/10.1016/j.jclepro.2021.126882 0959-6526/© 2021

- A. Erbs, A. Nagalli, K. Querne de Carvalho, V. Mymrin, F. H. Passig, and W. Mazer, "Properties of recycled gypsum from gypsum plasterboards and commercial gypsum throughout recycling cycles," Journal of Cleaner Production, vol. 183, pp. 1314–1322, 2018.

- ISPRA - Higher Institute for Environmental Protection and Research National Center for Waste and Circular Economy

- Minimizing environmental impacts with clay roofing / https://www.constructionspecifier.com/minimizing-environmental-impacts-with-clay-roofing January 6, 2015

- WRAP. Plasterboard Case Study. International practice in plasterboard recycling: Denmark. Gypsum Recycling International A/S.

- Characteristics of Gypsum Recycling in Different Cycles Article in International Journal of Engineering and Technology · June 2015 DOI: 10.7763/IJET.2015.V7.794

- PVGIS ©European Union, 2001

- Tsoutsos, T., Frantzeskaki, N. and Gekas, V. (2005) Environmental Impacts from the Solar Energy Technologies. Energy Policy, 33, 289-296.http://dx.doi.org/10.1016/S0301-4215(03)00241-6

- Ellen MacArthur Foundation and McKinsey & Company, The New Plastics Economy 2016, MacArthur Foundation London.

- Bowyer. (1995). Wood and other raw materials for the 21st century. For Production, 45(2):17024

- S. Manfredi, R. Pant, D. W. Pennington, and A. Versmann, "Supporting environmentally sound decisions for waste management with LCT and LCA," The International Journal of Life Cycle Assessment, vol. 16, no. 9, pp. 937–939, 2011.

- M. Lennon, Recycling Construction and Demolition Wastes: A Guide for Architects and Contractors, Commonwealth of Massachusetts, Department of Environmental Protection, Boston, MA, USA, 2005.

- E. C. Directive, "Directive 2008/98/EC of the Eurpean parliament and of the council of 19 November 2008 on waste and repealing certain directives," Official Journal of the European Union, vol. 312, no. 3, pp. 3–30, 2008.

- Recycling potential in building energy renovation: A prospective study of the Dutch residential building stock up to 2050 https://doi.org/10.1016/j.jclepro.2021.126835 0959-6526/© 2021 The Author(s). Published by Elsevier Ltd.

- global plastics production 1950-2015 Source: Geyer, R., J. Jambeck and K. Law (2017), "Production, use, and fate of all plastics ever made", Science Advances, Vol. 3/7, p. e1700782, http://dx.doi.org/10.1126/ sciadv.1700782.

- Foldi L, Halasz L (2009) Környezetbiztonság. Com-plex KiadóKft, Budapest, Hungary.

- Padanyi J, Foldi L (2014) Environmental responsi-bilities of the military soldiers have to be "Greener Berets". Ecology Manage 2: 48-55.

- Hardesty BD, Good TP, Wilcox C (2015) Novel methods, new results, and science-based solutions to tackle marine debris impacts on wildlife. Ocean & Coastal Management 115: 4-9.

- Hopewell J, Dvorak R, Kosior E (2009) Plastics recycling: Challenges and opportunities. Philos Trans R Soc Lond B Biol Sci 364: 2115-2126.

- Eurostat 2015 material flow accounts and treatment of waste ec.europa.eu/eurostat.

- 2006 NRC Canada798Can. J. Civ. Eng. Vol. 33 Integration of Buildability Issues in Construction Projects in Developing Economies D TINDIWENSI Department of Civil Engineering, Makerere University P. O. Box 7062, Kampala, Uganda

- Wang Song, Liu Xinmin. "Based on the Theory of Complex Adaptive System, the Evaluation Model of Enterprise Supply Chain Is Established" [J]. Operation and Management, 2012, 115-116.

- Tan Yuejin, Deng Hongzhong. "Complex Adaptive System Theory and Its Application Research" [J]. System Engineering, 2001, 1-6.

- Shen L Y, Tam V W, Tam C M and Drew D 2004 Mapping approach for examining waste management on construction sites J. of Const. Eng. and Mngmt. 130 472-481

- Lotteau, M.; Loubet, P.; Sonnemann, G. An analysis to understand how the shape of a concrete residential building influences its embodied energy and embodied carbon. Energy Build. 2017, 154, 1–11.

- Azari, R.; Abbasabadi, N. Embodied energy of buildings: A review of data, methods, challenges, and research trends. Energy Build. 2018, 168, 225–235.

- Dixit, M.K. Embodied energy analysis of building materials: An improved IO-based hybrid method using sectoral disaggregation. Energy 2017, 124, 46–58.

- Ponomarev, P. Achieving Energy Efficiency in Buildings in Developing Countries. Bachelor's Thesis, California Polytechnic State University, San Luis Obispo, CA, USA, June 2006.

- journal of cleaner production volume 18, issues 10-11 july 2010 ISSN 0959-6526 doi:10.1016/j.jclepro.2010.01.027 Resources and waste management in Turin (Italy): the role of recycled aggregates in the sustainable supply mix Gian Andrea Blengini , Elena Garbarino

- A Holistic Sustainability Framework for Waste Management in European Cities: Concept Development Received: 22 May 2018; Accepted: 14 June 2018; Published: 26 June 2018 Sustainability 2018, 10, 2184; doi:10.3390/su10072184

- Techno-economic assessment of calcium sulfoaluminate clinker production using elemental sulfur as raw material https://doi.org/10.1016/j.jclepro.2021.126888 Received 20 November 2020
Received in revised form 22 February 2021 Accepted 23 March 2021
Available online 28 March 2021 Handling editor. Bin Chen

- http://dx.doi.org/10.1016/j.resconrec.2017.09.014 Received 12 September 2017; Accepted 12 September 2017 Resources, Conservation & Recycling 132 (2018) 190–203 Available online 27 October 2017 0921-3449/ © 2017 The Author(s). Published by Elsevier B.V. This is an open access article under the CC BY license (http://creativecommons.org/licenses/BY/4.0/).

- https://doi.org/10.1016/j.jclepro.2021.127003
0959-6526/© 2021 The Authors. Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

- ADAPTATION, MITIGATION, AND SMART URBAN METABOLISM TOWARDS THE ECOLOGICAL TRANSITION Riccardo Pollo, Matteo Trane section ARCHITECTURE ESSAYS & VIEWPOINT typology DOI doi.org/10.19229/978-88-5509-232-6/552021

- Waste statistics Statistics Explained Source : Statistics Explained (https://ec.europa.eu/eurostat/statisticsexplained/) - 08/12/2020 1 Data extracted in October 2020. Planned article update: April 2021.

- Received: April 2018 / Accepted: June 2018
© The Author(s) 2018. This article is published with Creative Commons license CC BY-SA 4.0 Firenze University Press. DOI: 10.13128/RV-22990 - www.fupress.net/index.php/ri-vista/

- DOI: 10.1596/978-1-4648-1329-0 © 2018 International Bank for Reconstruction and Development / The World Bank 1818 H Street NW, Washington, DC 20433 Telephone: 202-473-1000; Internet: www.worldbank.org

- The State of Victoria Department of Environment, Land, Water and Planning 2019 ISBN 978-1-76077-672-5 (Print) ISBN 978-1-76077-673-2 (pdf/online/MS word)

- journal of civil engineering and architecture volume 12, number 9, september 2018 doi:10.17265/1934-7359 Riccardo Pollo, Matteo Giovanardi and Andrea LevraLevron

- Department of Economic and Social Affairs Sustainable Development/United Nation UN https://sdgs.un.org/goals/

- Torgal, F.P.; Jalali, S. Eco-Efficient Construction and Building Materials; Springer-Verlag London Limited: London, UK, 2011.

- UNEP. 2018 Global Status Report: Towards a Zero-Emission, Efficient and Resilient Buildings and Construction Sector. 2018. Available online: https://www.globalabc.org/uploads/media/default/0001/ 01/f64f6de67d55037cd9984c-c29308f3609829797a.pdf (accessed on 25 January 2019)

- UNEP. Global Status Report 2017: Towards a Zero-Emission, Efficient, and Resilient Buildings and Construction Sector. 2017. Available online: https://www.worldgbc.org/sites/default/files/UNEP%20188_ GABC_en%20%28web%29.pdf (accessed on 2 February 2019).

- Dixit, M.K. Life cycle embodied energy analysis of residential buildings: A review of literature to investigate embodied energy parameters. Renewable Sustainable Energy Rev. 2017, 79, 390–413.

- Azari, R.; Abbasabadi, N. Embodied energy of buildings: A review of data, methods, challenges, and research trends. Energy Build. 2018, 168, 225–235.

- Dixit, M.K.; Singh, S. Embodied energy analysis of higher education buildings using an input-output-based hybrid method. Energy Build. 2018, 161, 41–54

- BS EN ISO 14040:2006+A1:2020 Environmental management. Life cycle assessment. Principles and framework / european standards

- Blue-green roofs with forecast-based operation to reduce the impact of weather extremes / https://doi.org/10.1016/j.jenvman.2021.113750 /Received 20 June 2021; Received in revised form 10 September 2021; Accepted 11 September 2021

- Feasibility of Combining Solar Panels and Green Roofs on the Activities and Recreation Center Final Report December 15, 2017 CEE 398PBL Kara Kessling, Abby Cohen, Jadon Jasso

- European commission The Environmental Implementation Review 2019 COUNTRY REPORT – ITALY

- CONSTRUCTION AND DEMOLITION WASTE AS A RENEWABLE RESOURCE FOR RECYCLED AGGREGATES: ANALYSIS OF ITALIAN CASE STUDIES
Alessandra, Diotti*, Sabrina, Sorlini*, Luca, Cominoli*, Giovanni, Plizzari*
* University of Brescia, Department of Civil Engineering, Architecture, Land, Environment and Mathematics, Via Branze 43, 25123 Brescia, Italy

- EU Construction & Demolition Waste Management Protocol September 2016

BIBLIOGRAPHY

- © 2021 International Bank for Reconstruction and Development / The World Bank 1818 H Street NW Washington DC 20433 World Bank, 2021. A Catalogue of Nature-based Solutions for Urban Resilience. Washington, D.C. World Bank Group

- Giordano, R.; Gallina, F.; Quaglio, B. Analysis and Assessment of the Building Life Cycle. Indicators and Tools for the Early Design Stage. Sustainability 2021, 13, 6467. https:// doi.org/10.3390/su13116467 Academic Editor: Andrea Pezzuolo Received: 30 December 2020

- International Journal of Scientific and Research Publications, Volume 2, Issue 10, October 2012 1 ISSN 2250-3153

- Cárcel-Carrasco, J.; Peñalvo-López, E.; Pascual- Guillamón, M.; Salas-Vicente, F. An Overview about the Current Situation on C&D Waste Management in Italy: Achievements and Challenges. Buildings 2021, 11, 284. https:// doi.org/10.3390/buildings11070284 Academic Editor: Łukasz Sadowski

- Date: October 2019 2.1: To raise capacity for better management of energy in public buildings at transnational level Work package: WP3 TESTING Activity: 3.4 Evaluation of test results Deliverable: 3.4.1 – CESBA MED SNT Generic Framework Responsible Partner: Andrea Moro, iiSBE Italia R&D

- EU Construction and Demolition Waste Management May 2018 Waste management practices municipal hazardous and ındustrial by john pichtel

- EUROGYPSUM, Environmental and Raw Material Committee. Factsheet on: What is gypsum? http:// www.eurogypsum.org/_uploads/dbsattachedfiles/whatisgypsum.pdf Archived 2013-12-02 at the Wayback Machine Retrieved 26 September 2013.

SITEOGRAPHY

- https://www.roof-info.co.uk/roofing-materials/epdm

- http://ec.europa.eu/environment/waste/target_review.htm Last update: 12/11/2021

- https://zerowasteeurope.eu/

- https://www.soils.org/aboutsoils/green-roofs

- https://www.idealista.it/en/news/financial-advice-italy/2019/02/26/2377-how-much-tari-tax-do-youhave- pay-italy-2019#:~:text=The%20Italian%20waste%20tax%20called,required%20to%20pay%20the%20tax.

- https://www.greenmatch.co.uk/blog/2017/10/the-opportunities-of-solar-panel-recycling

- https://www.cedgreentech.com/article/can-solar-panels-be-recycled

- https://architecturetoday.co.uk/sustainability-flat-roofing-part-1/

- https://www.singleply.co.uk/flat-roofs/fdt-rhepanol-pib/

- https://www.tporoofing.org/tpo-roof-recycling/#:~:text=Among%20the%20three%20single%2Dply, the%20process%20of%20TPO%20recycling.

- https://www.rubber4roofs.co.uk/blog/8-reasons-why-epdm-rubber-roofing-is-the-most-eco-friendly-roofing-system/#:~:text=8.-,100%25%20Recyclable,choice%20for%20the%20environmentally%20conscious.

- https://www.cedgreentech.com/article/can-solar-panels-be-recycled

- https://powercalculator.ibc-solar.com/

- https://www.greenmatch.co.uk/

- https://palmetto.com/learning-center/blog/how-much-roof-space-is-needed-for-solar-panels

- Intech Open Solar Panels and Photovoltaic Materials Edited by Beddiaf Zaidi (e-book)

- Recyclingportal.eu, Report: Waste transfer stations in different EU regions, 2009, http://www.recyclingportal.eu/artikel/22506.shtml

- https://www.thebalancesmb.com/wood-recycling-construction-2877760-

- http://geoportale.comune.torino.it/web/cartografia/cartografia-scarico

- MuseoTorino, https://www.museotorino.it/view/s/9a451a7c7deb4f-3181d632c4ab851422, consultato il 25/06/2021.

- https://gosmartbricks.com/all-you-need-to-know-about-brick-recycling/

- https://ihbconline.co.uk/caring/elements/roofCoverings/clayTiles/