reFAB

UrbanMining

MakerSpace

reFAB

UrbanMining MakerSpace

Architectural Engineering Graduation project

Research Paper

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INTECTURE

Contents

Abstract

The current paper represents the early stages of a research project whose ultimate objective is the integral design and construction of a, local-based, urban waste rehabilitation and product development facility that operates through consolidating communal engagement and educational progression in a pioneer fabrication program. The following analysis collates data, and comments on existing research, relevant reports and case studies in the topic of material reuse and computer aided design and manufacturing (CAM &CAD) with an intention of exploring the potential of divergent raw material input in the construction procedure through the exploitation of the emerging digital technologies and their employment in the architectural practice as an applicable respond to the recent environmental predicament. The investigation further expands and elaborates in the social impact of the ascending development of the new methods of design and construction, and its relevance to the deviation of the unconditional reliance upon the industrial production and the eventual transformation of the affiliated linear mentality of human activity into a novel socio-economical framework.

INTRO

Introduction

In a period that climatic change, raw material scarcity and energy resources depletion are crucial issues; flow, circularity and sustainable solutions constitute an increasing demand in almost every field of research. **"Reduce, Reuse, Recycle, and Recover"** is the sustainable guideline that has replaced the "Take, Make, Waste" attitude of the industrial age[1]. Despite this profound shift towards an environmental sensitive model, natural materials persist on being conceived by major part of the industrial production as sol form of resources. Furthermore to this exploitation of natural resources beyond their restoration capacity[2], environmental pollution has become a rampant issue following the linear mentality of a society where almost any facet of activity is inevitably accompanied by the production of waste. This situation is aggressively escalating as the rapid urbanization and population growth's major impact, making it requisite for society to adopt a more circular approach of operating.

Resent estimations indicate that cities consume 75% of the world's resources[3] and produce around 80% of our total carbon dioxide emissions[4] Predictions show that in 2050 the world's population will increase to 9.3 billion, from which 70% will be living in cities[5]. According to the calculations of the World Bank in 2012 cities generate about 1.3 billion tonnes of solid waste per year and this volume is expected to increase to 2.2 billion tonnes by 2025[6]. In addition future predictions of urban population increase are alarming and are respectively accompanied by a growing demand for materials and resources.

The building industry can be held accountable for a considerable share of this predicament as main natural resource consumer and refuge generator worldwide. More specifically, construction sector is responsible for a significant part of CO2 emissions, inorganic waste production and approximately 45% of the planet's raw material consumption, with well-known impacts on the environment such as global warming, ozone depletion, soil erosion, loss of natural habitat, toxins' release etc.[7]

As a result, the new generation of architects is being called upon to respond with sustainable future-oriented designs and adaptable solutions. Meanwhile, digital advancements and current research on the field of innovative manufacturing technologies indicates that the integration of such tools in the architectural process in terms of design and construction is capable of transforming the building industry radically. This being said, main aspiration of this paper is to investigate the potentials of introducing disused processed elements as a substitute raw material input to the computer aided manufacturing (CAM) process.

More in specific, having as main drive the current ecological crisis, intention of this investigation is to carry forward the development of genuinely novel methods constrained by the material parameter and the understanding of building as a wasteless process mediated from adopting a circular mentality and utilizing new architectural tools that are able to account for off-the-shelf products and discarded materials. A new way of producing, with ultimate motive to mobilise people to take matter at their own hands and act upon, and for, their environment, by setting the foundations of a dynamic approach in the conformation of the urban fabric which bares qualities that augment the ability of evolution. According to the current's research viewpoint exploiting the refuse for construction purposes is an imperative contingency in order to reduce the need of natural environment exploitation; moreover incorporating these elements as an integral part of digital fabrication promises to contribute substantially to the increasing effort for alternative production methods in a direction of building a viable future.

Cities consume **75%**
of the world's resources

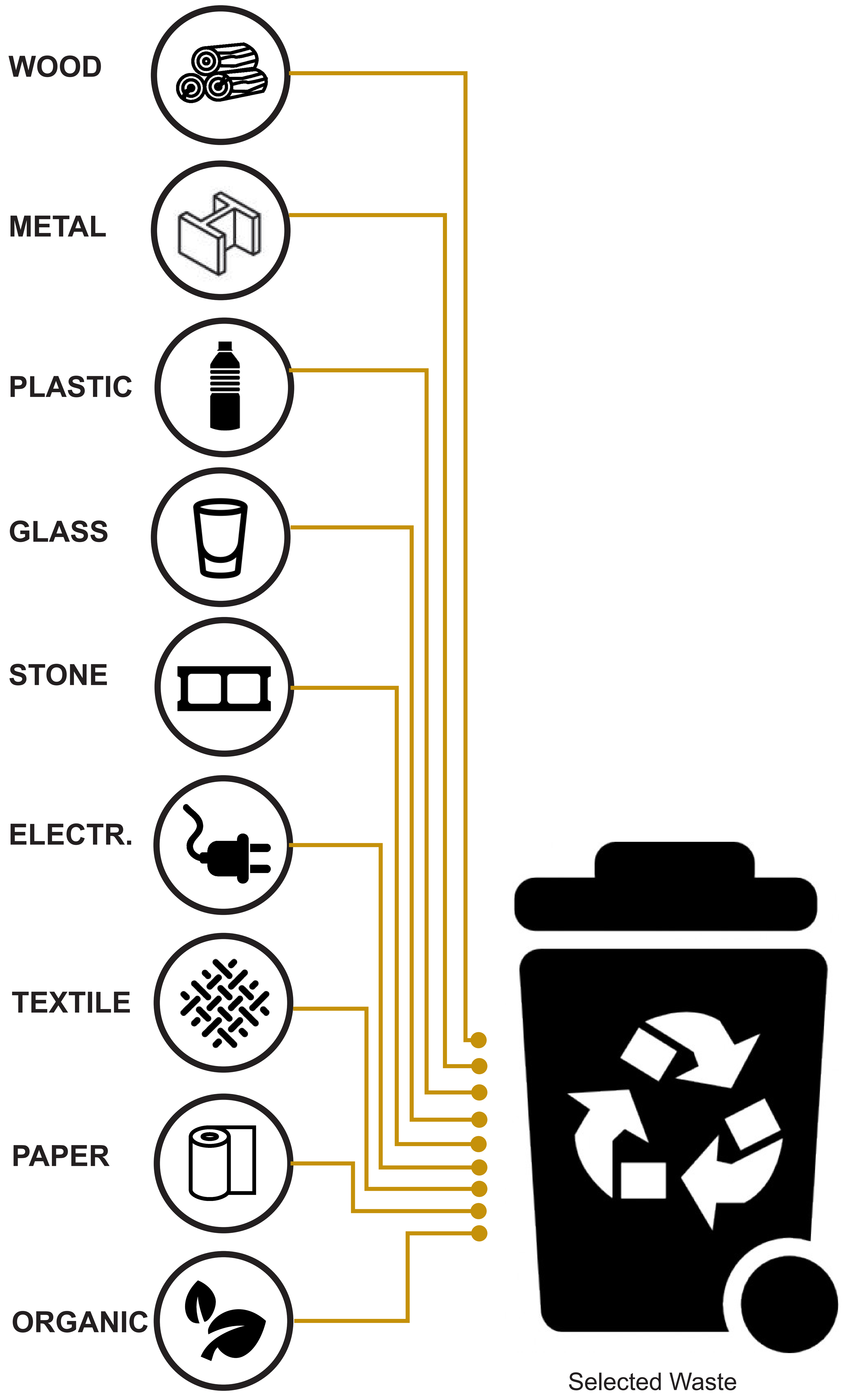
Cities generate about **1.3B ton**
of solid waste per year

Construction sector is responsible for **45%**
of the planet's raw material consumption,

[1] Building From Waste, Recovered Materials in Architecture and Construction, Dirk E. Hebel, Marta H. Wisniewska, Felix Heisel, 2014
[2] A.Leonard, The Story of Stuff: The Impact of Consumption on the Planet, Our Communities, and Our Health – And How We Can Make It Better. New York City, USA: Free Press, 2010
[3] D. Nunes, Critérios para Avaliar a Sustentabilidade na Vizinhança ao Nível dos Bairros. Attainment of Master Degree in Civil Engineering, Instituto Superior Técnico, University of Lisbon, 2009
[4] United Nations Human Settlements Program, State of the World's Cities 2012/13. Nairobi: UN-HABITAT, 2013
[5] Department of Economic and Social Affairs Population Division, 2015_. World Urbanization Prospects , New York: United Nations, The Revision 2014
[6] Daniel Hoornweg and Perinaz Bhada-Tata, What A Waste, A Global Review of Solid Waste Management, 2012, No. 15
[7] United States Environmental Protection Agency, Global Greenhouse Gas Emissions Data, 2014 https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data + OECD, Material Resources, Productivity and the Environment. OECD Green Growth studies. Paris: OECD Publishing, 2015http://dx.doi.org/10.1787/9789264190504-en

Waste material types

that can be recycled and participate in building construction



Objective

Objective of the graduation project is the design of an exemplar local-based manufacturing facility constructed from salvaged materials that operates through collecting urban refuse and immediate to access materials. Disposed elements which can, if elaborated in proper manner, comprise an integral part of the raw material reserve in a perpetual loop of an advanced manufacturing practice. A transcending process that allows disused materials to become again part of the city life, by offering affordable products and elementary infrastructure that respond to the community's needs, and simultaneously the self-efficiency, development and replication of this autonomous spatial configuration into an adaptive global network.

The urban waste fabrication labs, reFAB, constitute a generic, novel production framework accommodated in a smart, integrally designed construction that is attempting to adjoin the merging, future-oriented practices of recycling and innovative manufacturing in a metabolic social model that will create new job positions and promote its principles through an educational, environmental directed context. A collective sustainable infrastructure committed to communal aggregation and depended on alternative economic correlations that operates through urban mining in a local scale and regenerates in global level by employing advanced tools of communication and production.

The constructed from refuse lab units operational program includes the collection, storage, classification and refinement of selected disused materials, with an ultimate intention of resurrecting them through pioneer fabrication methods into everyday products and vernacular urban infrastructures. This modular network of constructions, able to grow and reproduce, and remaining consistent to circular economy's equivalent functional principles, intends on constituting a physical interpretation of the production procedures for which it is created, with main intention to augment social engagement by inspiring and motivating people to get involved in inherent practices.

The urban laboratory, managed by the community and equipped with advanced digital manufacturing technologies and an open-source regulated data library, will offer professional opportunities and recruit volunteer labour and expertise by organizing workshops, in a direction of creating an evolutionary, self-developing construct that promptly confronts the environmental challenges. In this context new professional opportunities can emerge, and participants will have the potential of interacting in a didactic manner, exchange knowledge, learn in practice how to operate advanced technological equipment and exploit the 'new' raw material resourse in order to cover collective and individual needs, and eventually transform their neighbourhood in a spirit of solidarity and cooperation.

Thematic Research Inquiries

- Research on salvaged materials capable of participating in digital fabrication processes and their properties and limitations
- Research on the approach of optimizing the control of disposed material logistics
- Research on existing online platforms that can connect with, and facilitate the operation of, an open-source regulated data base within the topic of material, reuse and construction?
- Investigation on materials and fabrication methods that can respond sufficiently to the general requirements of designing and constructing a refuse rehabilitation and advanced manufacturing laboratory?
- Research on complemetary spatial and operational frameworks of production
- Research on the refuse refinement and rehabilitation methods required of the materials preceding advanced fabrication processes
- Inquiry on the additional tools required in order to process and amend salvage materials preceding the stage of digital fabrication and potential construction utilizing the advanced technologies
- Study on the ground of optimization on alternative methods to digital fabrication, in regard to refuse elements with deficiency in being employed in construction through the advanced production processes

Overall design intention

The composition of a theoretical generic framework of salvaged materials rehabilitation methods through the employment of parametric design and computer aided manufacturing, as means of generating a smart, integral design of heterogeneous materiality that responds sufficiently to the implementation of a sustainable and self-developing spatial infrastructure that constitutes an exemplified paradigm of a pioneer production system.

Research Question

Which refuse type of materials can be substantially employed in digital manufacturing methods and which rather can be utilized with alternative methods as means of formulating a consistent spatial framework of metabolic mentality?

Relevance

In a period of environmental challenges, raw material scarcity and energy resources depletion are crucial issues; future oriented solutions constitute an increasing demand in almost every field of research. In respond to the ecological predicament the current investigation intents on utilizing the advanced production methods through the employment of refuse as the new raw material source in building construction. Moreover, the project's objective is the design of a collective, local-based, sustainable spatial framework of production, constructed from salvaged materials, that operates through interactive cultivation in advanced production methods of metabolic mentality.

METHODS

Methodology

The multidisciplinary process of integrating waste elements in architectural design through computer aided design and manufacturing technologies required a manifold analysis in the subjects of material reuse, advanced fabrication methods and user's intimate interaction with the production process. A practice based research, accompanied by an investigation on literature, selective existing research, several reports and recent publications, as well as interviews, references and case studies analysis of innovative construction methods that are able to activate alternative materials as future building components, was a necessary step in order to respond to these demanding research inquiries.

Methods of research on the subjects of material reuse in construction and advanced fabrication processes are based on:

1. Practice based research

1.a. Intervention and provocation

[Through former projects and precedent work in the topic of material reuse, collective work and participation in design]

1.b. Experimentation

[Workshops & precedent experience on digital fabrication and on-site construction]

1.c. Interviews

[Foteini Setaki from TheNewRaw & Vasiliki Sklivaniti researcher at TNO institute in Delft]

2. Literature & case study based research

[including preceding research, reports, web search, diagrams formulation etc.]

The methodology according to which the current research paper has been developed, is roughly dividing the investigation in two sections:

The **first** part is a general overview on the subject, indicating the problem in hand and the objective of the project, including research questions and relevance to the posed issue, as well as the program definition and context identification and the **second** part composed by two major chapters of refuse materials rehabilitation and digital manufacturing.

Program Definition

The development of reFAB lab's operational program was accomplished by taking into consideration the variety of parameters and principles that designate the need for this pioneer framework, and an analysis of the functional elements that formulate existing spatial infrastructures that operate through cooperative production and interactive cultivation in advanced manufacturing processes, with main representatives the FabLab Network and the relevant to the project's location in Amsterdam, Makerversity.

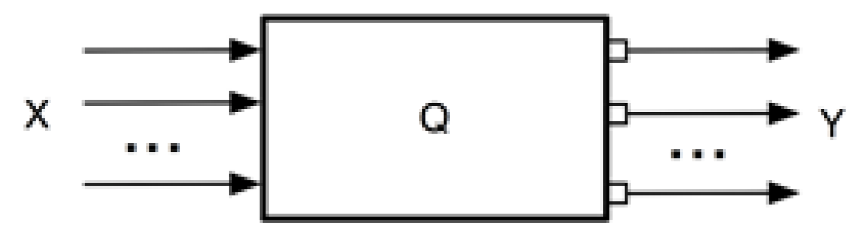
Choice of Context

The context inquiry develops through a solid argument designating the selection of the area of intervention on the account of need in the pronounced generic framework. Evidently, small scale residential areas in developing urban environments, with significant necessities in elementary infrastructure, limited access to advanced manufacturing technologies, and a redundant amount of accumulated waste, demonstrate significant needs in a metabolic infrastructure able to absorb and transform refuse into value. However, the place that would promote the development of the reFAB network through the agency of the first showcase implementation led the investigation in substituting the intended location in regard to the parameters of funding, supplementary functional programs and required research platforms which can provide disused material inventories. In such way, the context analysis guided the first urban salvaged materials rehabilitation through advanced manufacturing technologies unit's materialization in a currently developing area, destined for innovative interventions, Marineterraine in Amsterdam.

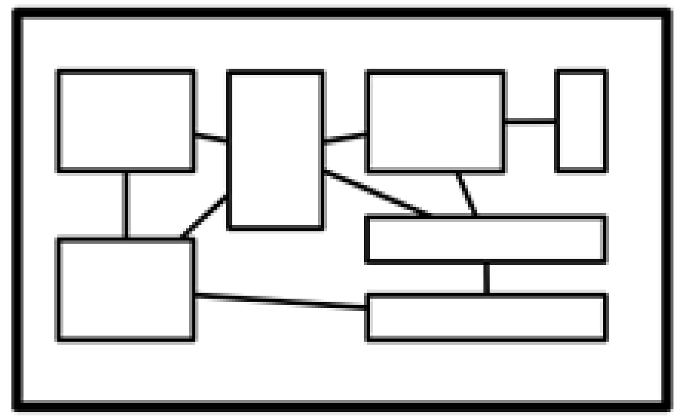
Fundamental Principles of Systems Architecture

The citation of basic assumptions defining a system, constitutes in the comprehension of the current analysis, in regard to structure and methodological approach, a beneficial and constructive frame of guidelines and reference

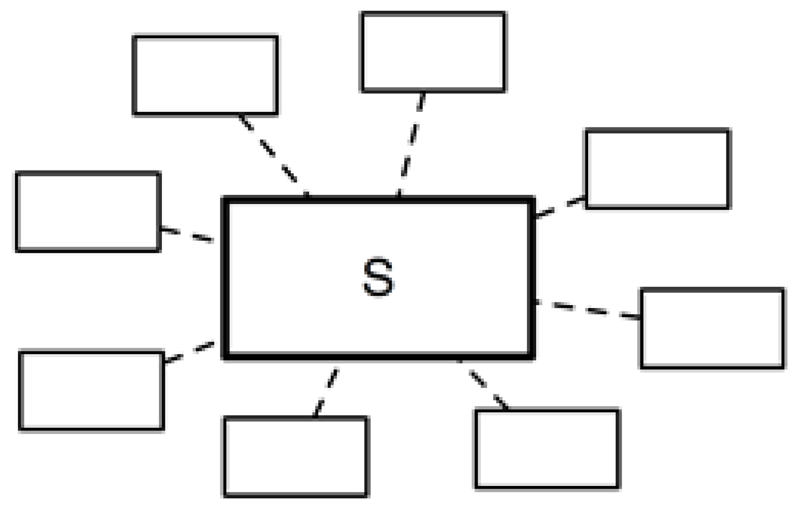
1. Representing real objects as systems
An object performing a function and defined in a certain district by its inputs, outputs and an internal face



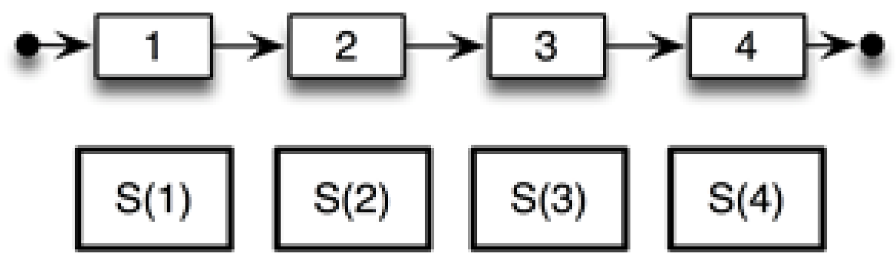
2. A system can decompount into a set of smaller systems
The set of systems cannot be understood when not integrated into the whole system



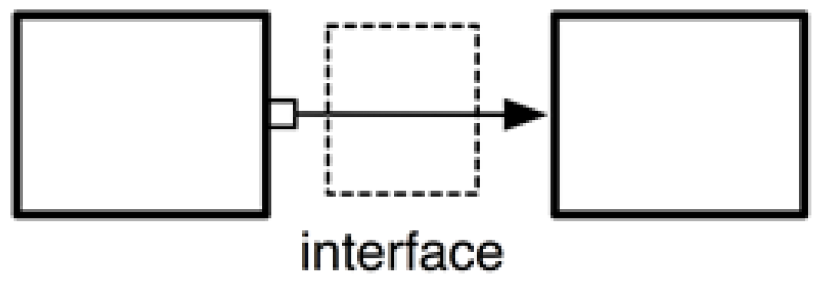
3. A system must be considered in interaction with other systems
An object interacting with its environment



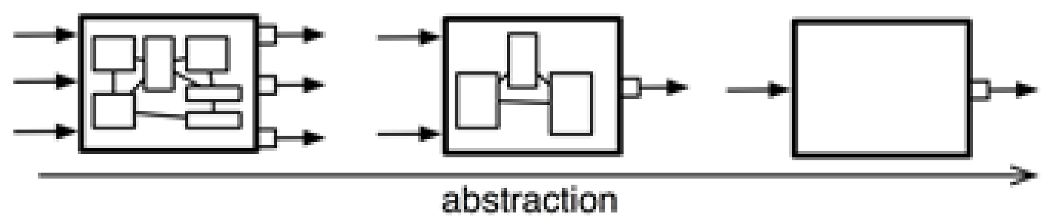
4. A system must be considered through its entire lifecycle
From its design and composition until the decomposition and recycle of it



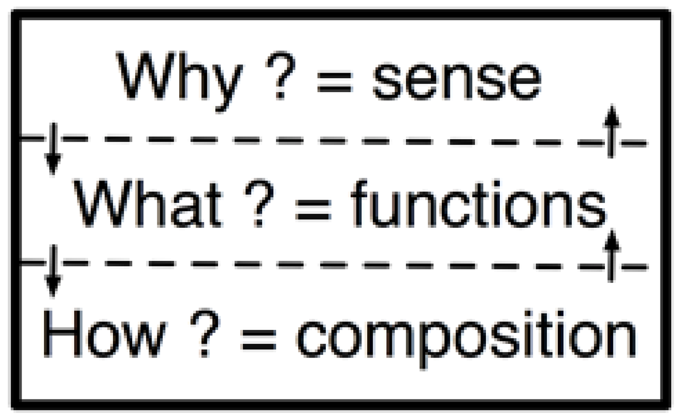
5. A sysrem can connect to another through an interface
The interface will model the properties of the connection



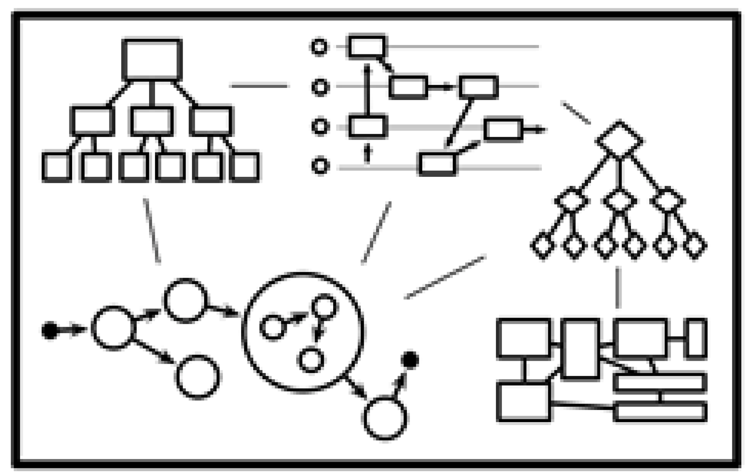
6. A system can be considered at various levels of abstraction
The conceptual simplification allows taking into account only the relevant to a process properties and performances



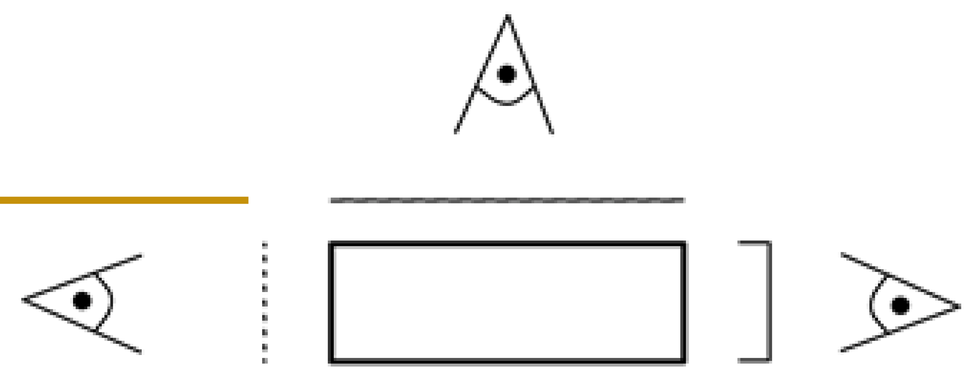
7. A system can observed according to several layers
The most common of these being: sense, function, composition



8. A system can be described through interrelated models with certain semantics
As properties, structure, condition, behaviour, data etc.



9. A system can be described through various viewpoints
The point of view corresponds to different concerned actors



Taking advantage of the potentials computer aided manufacturing can facilitate the development of a smart integral system that can correspond to the current needs of users while respectively is able to answer to environmental challenges, wastage, different functions and future demands. "Systems Architecture is a response to the conceptual and practical difficulties of the description and the design of complex systems." By employing "…a generic discipline to handle objects (existing or to be created) called "systems", in a way that supports reasoning about the structural properties of these objects…"*. Spatial and structural flexibility in this sense is established as a significant design parameter which facilitates the ability of the sustainable framework to cover different needs and adapt and survive through time in a variety of plots and different uses.

Source of marginally converted index and diagramatical representations: Boris Golden, What is Systems Architecture

*https://www.lix.polytechnique.fr/~golden/systems_architecture.html

Main Analysis Structure

Following the introduction, a general overview of the posed issue of the imminent environmental developments and the subsequent intention of society to redirect the existing models of operation into a future oriented scheme that will have a major impact in industrial production processes, constitutes a theoretical background before arriving to the next two main sections of this discourse. Focusing in the building industry, the current debate is attempting, by analyzing the potential of employing divergent salvaged materials in computer aided manufacturing, with a conviction of comprising the future of production processes, to utilize the outcomes of the investigation as tools of design for the construction of a sustainable, local-based framework that will operate through circular processes by introducing these principles into practice.

The investigation unfolds through an attempt to designate 'waste' as a territory, and the aftermath of exercising alternative definitions, in an effort to restore the disused processed materials' ability to be widely acknowledged as an unlimited raw material resource.

The current approach continues by elaborating on the potential of incorporating the refuse as a new material input in advance production technologies in accord to respective researches in the topic of the sustainable mentality behind the utilization of computer aided design and manufacturing (CAD &CAM) in architecture practice; an advocacy stemming from the capacity of integrating the material parameter in early stages of the process, and the forehand optimization potential in calculations of time, cost and methods of production.

Thereafter, follows an appraisal of the socio-economic impact of metabolic mentality in design and construction practices through argumentation and proclamation on open-source software and regulated platforms, user's participation in design, DIY production processes and personal fabrication with main reference the unfolding phenomenon of the Fab Lab network, and its province and evolution potential in developing territories; a subject directly inherent to the current proposal's potential of development into a generic, sustainable spatial framework of production with educational intentions, that operates through collective effort and the employment of pioneer production tools.

Refuse Rehabilitation

The paper pursues on revealing the disused processed materials' emerging potential of establishment as integral part of the building production through a variety of material examples composed by refuse, cited on a table board with detailed descriptions of origin, required elaboration, technical properties, potentials of application and relevant evaluation according to criteria such as availability, reusability, structural efficiency, cost of rehabilitation etc.

This section additionally includes two interviews from researchers in the topic of recycling and digital fabrication, and two case studies analysis which encounter refuse elements as an important raw material reserve. Henceforth, the paper cites a case study of a precedent project of my own along with a rundown and assessment of a lecture by the collective architecture association Rotor in the topic of material reuse and deconstruction. The latter citations result in some design considerations in regard to the rehabilitation of salvaged materials in the architecture practice, an attempt that can be significantly facilitated by on-line research platforms and open-source data bases, and a valuation of certain material types' recycling capacity.

Correspondingly, substantial challenge comprises the capability of employing the refuse through DIY fabrication procedures to meet the demanding requirements of a material rehabilitation lab design. Hereof, the research elaborates in the prospective considerations of design in accord to preconditions provided from the Environmental Health & Safety Department of North Carolina.

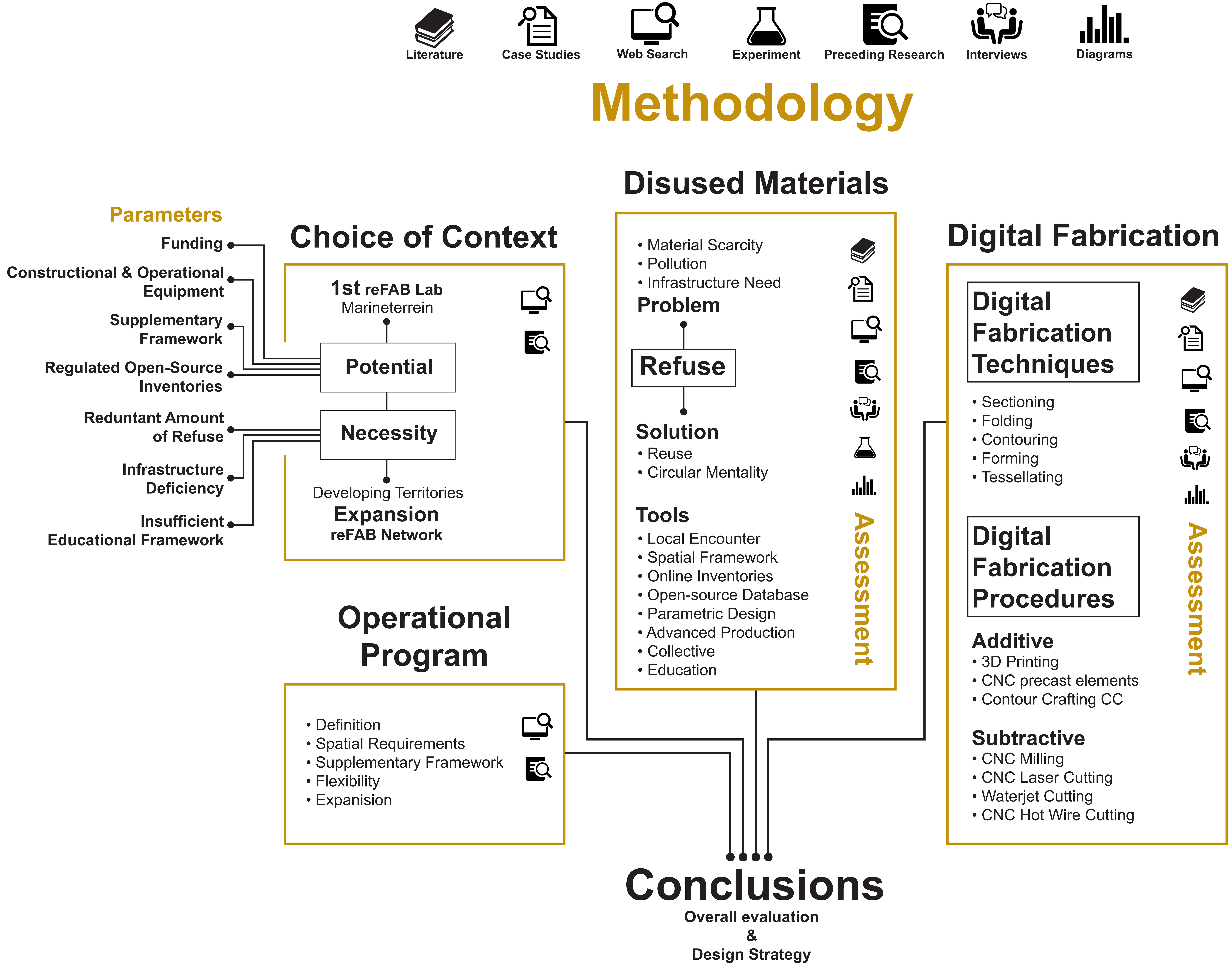
Digital Fabrication

The next section is devoted to the analysis of the main digital fabrication techniques and processes accompanied by table boards with technical data, application potentials, general evaluation and the consequent capacity of the innovative tools to incorporate specific types of refuse as raw material input; an appraisal on the emerging technologies that can be employed in architectural design and construction in regard to metabolic mentality.

Due to the scarcity of paradigms employing refuse in building construction through computer aided manufacturing, the complementary case studies included in this section remain as references to the digital fabrication techniques and are subjected to elemental evaluation, with the exception of the Fab Lab House example, implemented in Barcelona, which is comprehensively analyzed. However, in accord to the analysis of the processes' potentials, this investigation anticipates to develop a framework to this regard.

Concluding, the investigation attempts through a general overview of the above considerations and refuse material assessment through spider diagrams to answer to the main research inquiry about the potential of certain types of refuse materials to be substantially employed in digital manufacturing methods without industrial elaboration and a consequent suggestion of digital tools and techniques to this matter, and those that would more efficiently rehabilitated and return to the production stream with alternative methods as means of developing a smart, integral design influenced primarily by the material parameter and composed from divergent, interchangeable heterogeneous components depended on various parameters as (program, context, material availability and technical properties, digital tools etc.). A consistent framework of metabolic mentality building construction.

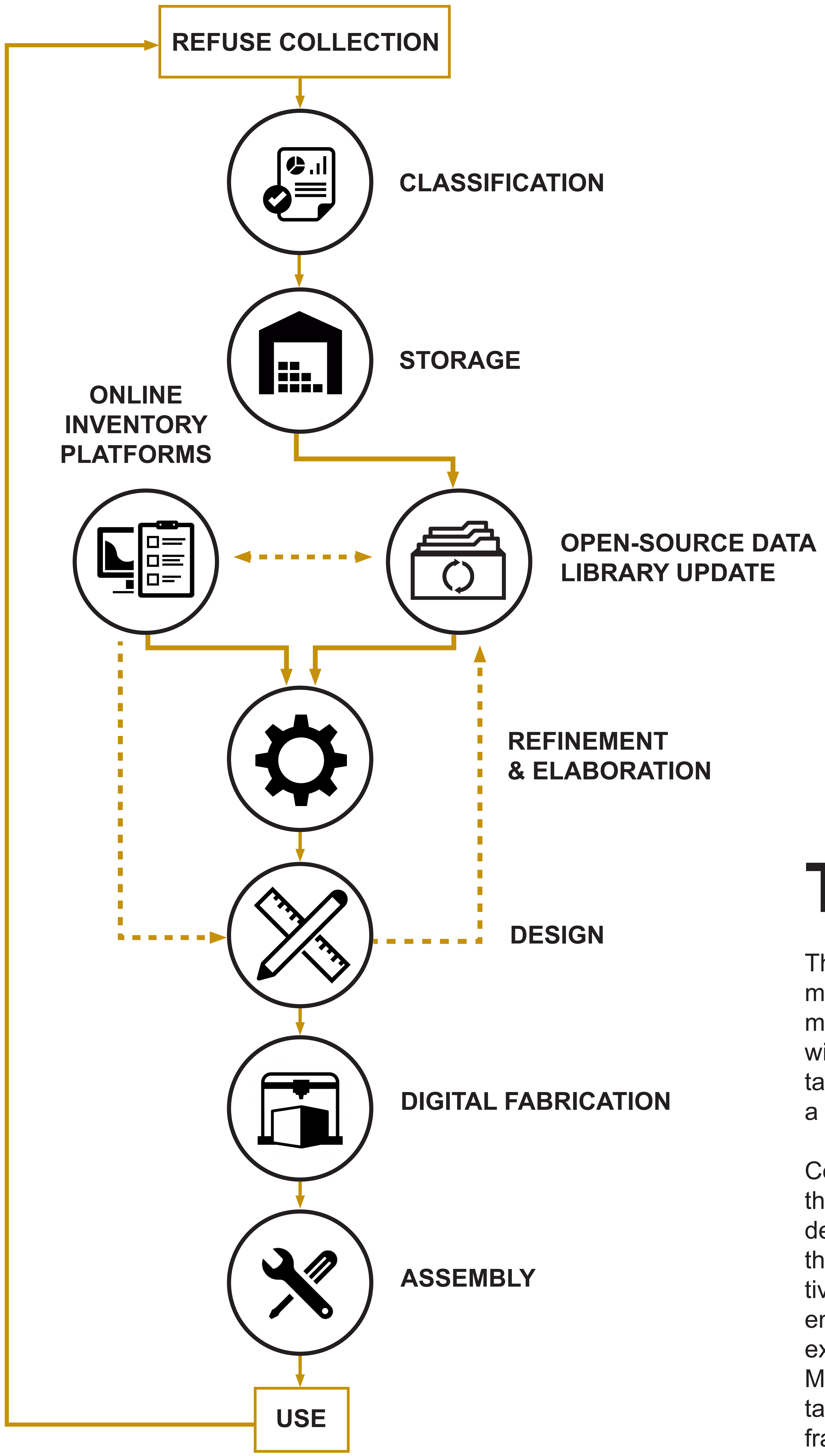
Methodology



PROGRAM

reFAB Facility's Operating Program

Digital fabrication lab units constructed from refuse materials can collect, store, classify and refine selected waste and resurrect them into useful urban constructions. This network of constructions, able to grow and reproduce, and remaining consistent to its functional principles, intends on constituting a physical interpretation of the production procedures for which it is created, with main intention to inspire and motivate people to get involved in inherent procedures.



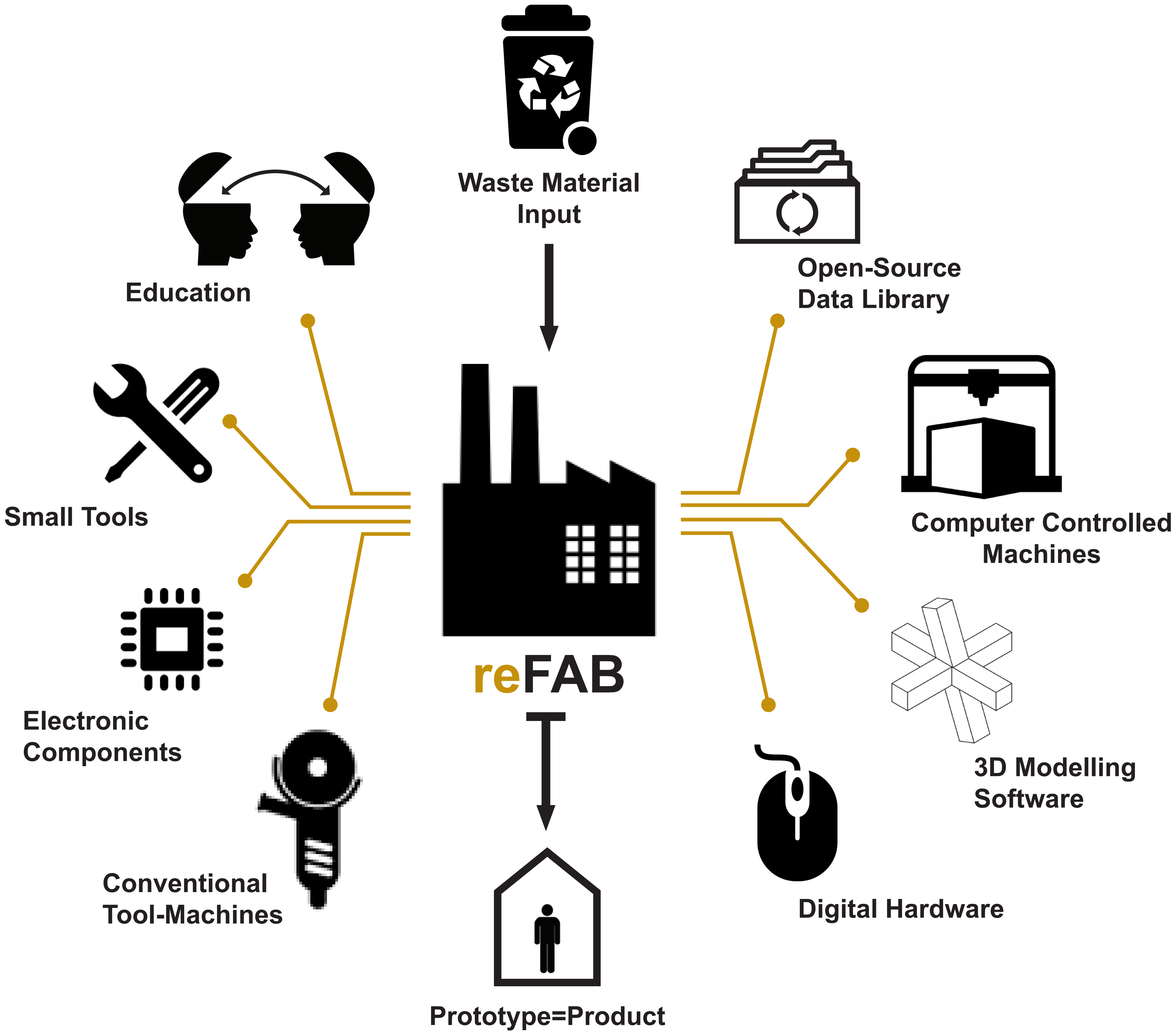
The program

The establishment of the operational program of the urban mining fabrication labs was the primal preoccupation of this project and the consisting framework of this investigation's development. In this manner, each of the under analysis subjects in this paper is mutually interrelated with the program constituting this generic infrastructure. The metabolic character of this sustainable system implies an adaptable and modular construction that is capable of undertaking a variety of functions that are required for concluding a loop in the promoted new economy.

Considerable part of the effort is contributed to the crystallization and actual embodiment of the principles defining the pioneer framework of reFAB in a versatile multiuse operational condenser. On the account of this condensation, the research was directed through reference to the operational components of analogous existing spatial models of co-working and interactive cultivation in the innovative production technologies, these being the unfolding phenomenon of Fab Labs (spatial indications from Fab Academy's floor plan layouts) and a relevant exemplification of collective workshop located in the context of Marineterrein in Amsterdam, Makerversity. The integration, in the complementary makerspaces program, of a supplementary functional element of unlimited input, the refuse rehabilitation, in regard to a production framework has the potential to weaponize the operation.

reFAB Lab's Operational Components

An urban laboratory, managed by the community and equipped with advanced digital manufacturing technologies and an open source data library, will offer professional opportunities and recruit volunteer labor and expertise by organizing workshops, in a direction of creating a sustainable self-developing framework. In this context people are able to interact in a didactic manner, exchange knowledge and learn in practice how to operate advanced technological equipment and work with raw materials in order to cover collective and individual needs, and eventually transform their neighborhood in a spirit of solidarity and cooperation.



Permanent-stable spaces

Makerspace [250m²] Work platform the working space will include adaptable working stations and selves and mobile tables, adequate empty space for assembly and conventional material elaboration

The main lab consists of three operational spatial configurations:
- **Waste Elaboration & Rehabilitation Space [80m²]**
- **Multipurpose Workshop Space [90m²]**
- **Advanced Manufacturing Space [80m²]** CNC Room [60m²] & 3D Printing Room [20m²]

Computer Room [100m²]

- **Offices [40m²]**
- **Common area [60m²]**

Material Repository [400m²]

- **Storage Room [250m²]** potential of existing building stock refurbishment
- **Waste Disposal Containers [150m²]**

The Material Repository is a binary spatial arrangement divided in two sections. The first section constitutes a restricted to public refuse storage space of classified salvaged materials in different categories according to type, dimensions and technical characteristics, refined and not, which can be utilized for circular production. The second spatial configuration is engaged for discarded unwanted material disposal from the adjacent framework of Makerversity, the residents of the neighborhood and the broader city area.
The latter configuration refers to an arrangement of a certain number of, open from above, waste containers that can be ideally interrelated and directly connected with the main repository facility with the intention of an immediate absorption and classification.
Each of the disposal containers, part of the intended to design fragment, is designed and constructed through the utilization of the material type intended to be disposed, as showcase of the emerging employment of disused processed materials in computer aided manufacturing.

Auxiliary Spaces [60m²]

- **Kitchen & Living Room [25m²]**
- **Toilets [35m²]**

Temporary- adaptable spaces

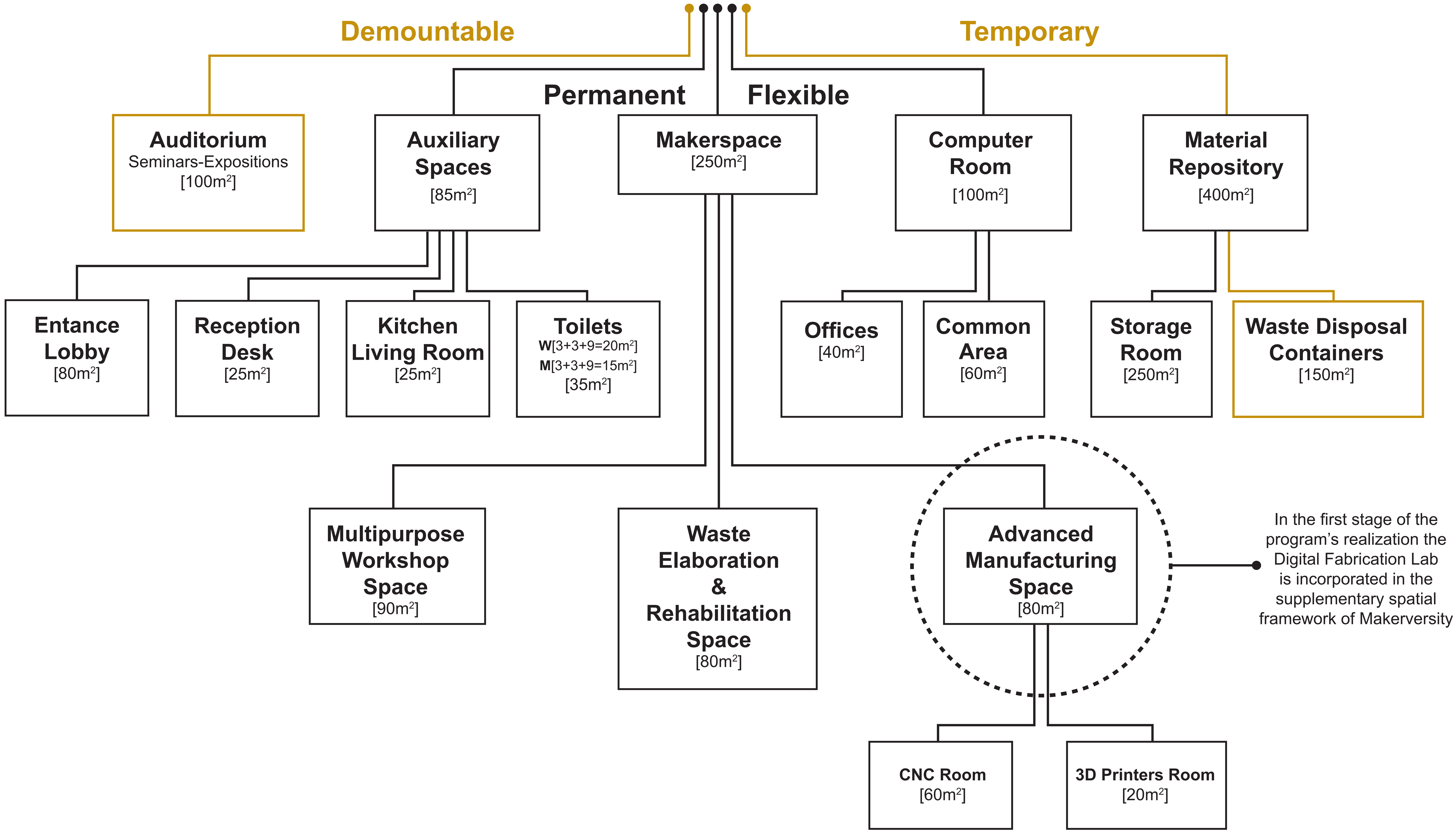
Auditorium [100m²]

The Auditorium constitutes an amphitheater-like spatial configuration that is intended for conferences, assemblies, presentations, expositions etc. The space is open to public and does not operate through a daily based program, in such manner, is subsequently the most probable space to be periodically adjusted spatially and structurally in regard to different functions, climate and cultivation on the pioneer production methods purposes. A space that will consistently address to innovation in construction through periodical transformations and self-exposition.

Annual Workshop

An annual workshop is intended to be customly organized in order to expand, transform or optimize the temporary section of reFAB. During this event individuals, students and working groups from various fields of institutional and professional sectors are invited to participate in experimental building construction. In such manner, the participants will have the opportunity to cooperate, interact and exchange knowledge in the topic of alternative methods of production with disused materials and additionally learn how to operate conventional and advanced manufacturing tools in a collective spirit, as a crucial element of the contemporary societal evolution.

reFAB Spatial Program



Start the reFAB...

1. Prepare your knowledge background on the topic
Investigation on the subjects of material reuse and digital fabrication
Current research
Fab Foundation site and online [about, debate forum, tutorials database etc.]

2. Find host agency
2.1. Ownership
2.2. Spatial framework: • Existing stock
• Heritage restoration and possible spatial extension
• Demountable spatial framework

Recommended
for the following reasons:

- 1st project
- refuse absorbtion
- educating process
- showcase potential

3. Secure funding
Municipality
UN subsidies
Institutional Frameworks etc.
Raise capital though precedent reFAB labs

4. Select your partnerships
Necessary employment: Chemical Enginner Architect Engineer Software Developer
Optional Employment: Industrial designer Mechanical Enigineer and many more.

5. Find and prepare context
The location of implementation of the reFAB lab has to respond to both of the following factors: Necessity and Potential. In respect to these parameters the potentials of consent by and accessibility to the community are high. The site preparations includes the following steps:
• Stimulate awareness
Inform and motivate your partners and local community on the necessity of the project's realization in local and global level
• Identify supplementary frameworks [operational and spatial]
• Search for the new raw material resources [landfills, depositories, second-hand suppliers, scavenger's collection etc.]
• Formulate inventories
• Inform the developing open-source database and online inventory platform

6. Equip, implement and commission the reFAB lab

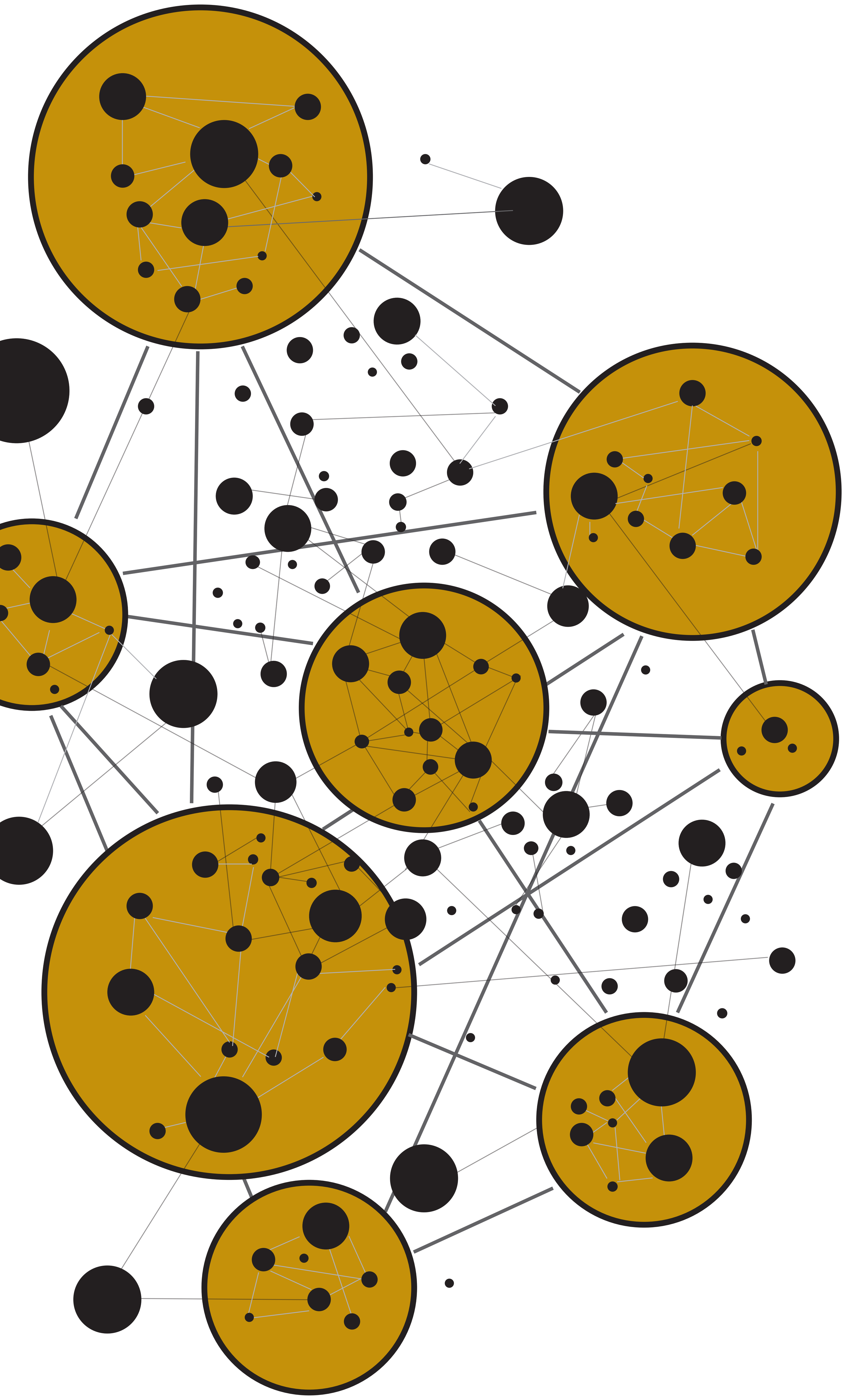
7. Train your partners and future trainers
Educate the people that will work there on technical and management level

8. Identify first projects
The local preconditions that affected the context selection are able to supply immediate answers to this regard. 'Start with local problem solving' and continue by gradually integrating to the global network of reFAB labs and have access and contribute to a wide range of projects

9. Do it

...reFAB Network Expansion

These guidelines are essential and complied to the consistent set up of Fab Lab Community (http://cucfablab.org/get-started/start-your-own-fab-lab), however due to the operational framework the requirements are developed and optimized accordingly.



ReFab Network Development

After certain period of the initial reFAB unit's establishment and operation, certain fund can be concentrated with the intention of the urban mining space development and intensification into a generic global framework. Below follow some specific indications of a preliminary operation that the initial reFAB unit and, optionally, any newly generated module-unit could be undertaken with in regard to the expansion of metabolic mentality through the reFAB network

• Concentration of fundamental capital through the lab's operation and interested stakeholders. The pursuit capital can be accessed in approximately 30-35.000 euros; including basic digital manufacturing equipment with an approximate cost of 10.000 euros according to indications provided by the Fab Foundation* and supplementary costs to initiate the construction of an elemental framework of reFAB's operation, with an intention of gradual expansion, around 25.000 euros, in condition of reused materials employment in the process and utilizing existing structural and/or operational framework (supplementary operational facilities, existing building stock refurbishment and integration, shipping containers etc.)

• Inquiry and investigation of the context where the impending implementation of the next lab will be realized

• Supplementary operational/or and spatial framework inquiry

• Research on disused materials (refuse and second-hand) resources available in the territory of intervention and inventory formation. The creation of an interactive on-line regulated platform incorporating the descriptions of material type and origin is essential for the control of the logistics

• Preliminary layout and design of the prospective infrastructure providing an elementary framework to the new participants to step on, and aiming in the captivation of stakeholders

• The permanent personnel requirements for the elementary operation of reFAB lab attributed in an architect, chemical engineer and a software developer. A mechanical engineer's participation in occasions can be essential.

*(http://cucfablab.org/get-started/start-your-own-fab-lab/)

CONTEXT

Context

The Chicken and the Egg Affair

A build entity with such program will seemingly be more sufficiently incorporated in a context of small scale urban environments, ideal case being the residential neighborhoods of developing territories, with significant necessities in elementary infrastructure, advanced manufacturing technologies deficient accessibility, and most importantly a redundant quantity of accumulated refuse, controversial to the amount of MSW production, in behalf of insufficient or even absent absorption mechanisms of this accumulating predicament. The Multilateral Investment Guarantee Agency of the World Bank informs that despite industrial estates should by located in areas far away from residential neighborhoods unfortunately, in many low- and middle-income countries, industrial facilities are often located proximately to populated areas, where the luck of waste treatment and disposal infrastructure and the negligence of isolating potentially hazardous processes, results in critical community and environmental impacts.[1]

In such a way, and in respect to the potential areas provided by the Intecture studio the context originally selected was the ascending cultural capital of Indonesia, Bandung.

Having the above as driving force, the refuse material rehabilitation lab network reFAB, comprised by units constructed from salvaged materials will be able to adsorb and rehabilitate the waste of residential regions and resurrect them into every day products and vernacular infrastructure of relative spirit.
Taking into account the iteration of these units, as means to a network formation, and the essential reliance upon the material parameter which can result in structures with divergent qualities, without a necessary implication of detachment from the surrounding environment, the project can be consistently encompassed among the generic associated architecture. In this sense locality and engagement to context are determined by the climate, the availability of resources, the material disposal and the constant altering of the social component. A local-based spatial framework that can be implemented globally.

Generic Associated Architecture (GAA) is structured as a group of physical objects interacting with the material flow by a set of constraints determining the material flow trajectories.[2]

A build entity with such program will seemingly be more sufficiently incorporated in a context of small scale urban environments, ideal case being the residential neighborhoods of developing territories, with significant necessities in elementary infrastructure, advanced manufacturing technologies deficient accessibility, and most importantly a redundant quantity of accumulated refuse, controversial to the amount of MSW production, in behalf of insufficient or even absent absorption mechanisms of this accumulating predicament.

Initial Area Of Focus

Bandung City:
Area: 167,7km2
Population: 2,6 million
Density: 15.000/km2

Bandung Subcenters: Recommended areas of intervention

Intensevely developing cities with reduntant quantity of waste

Mumbai - India

Bandung - Indonesia

Lagos - Nigeria

Hong Kong - China

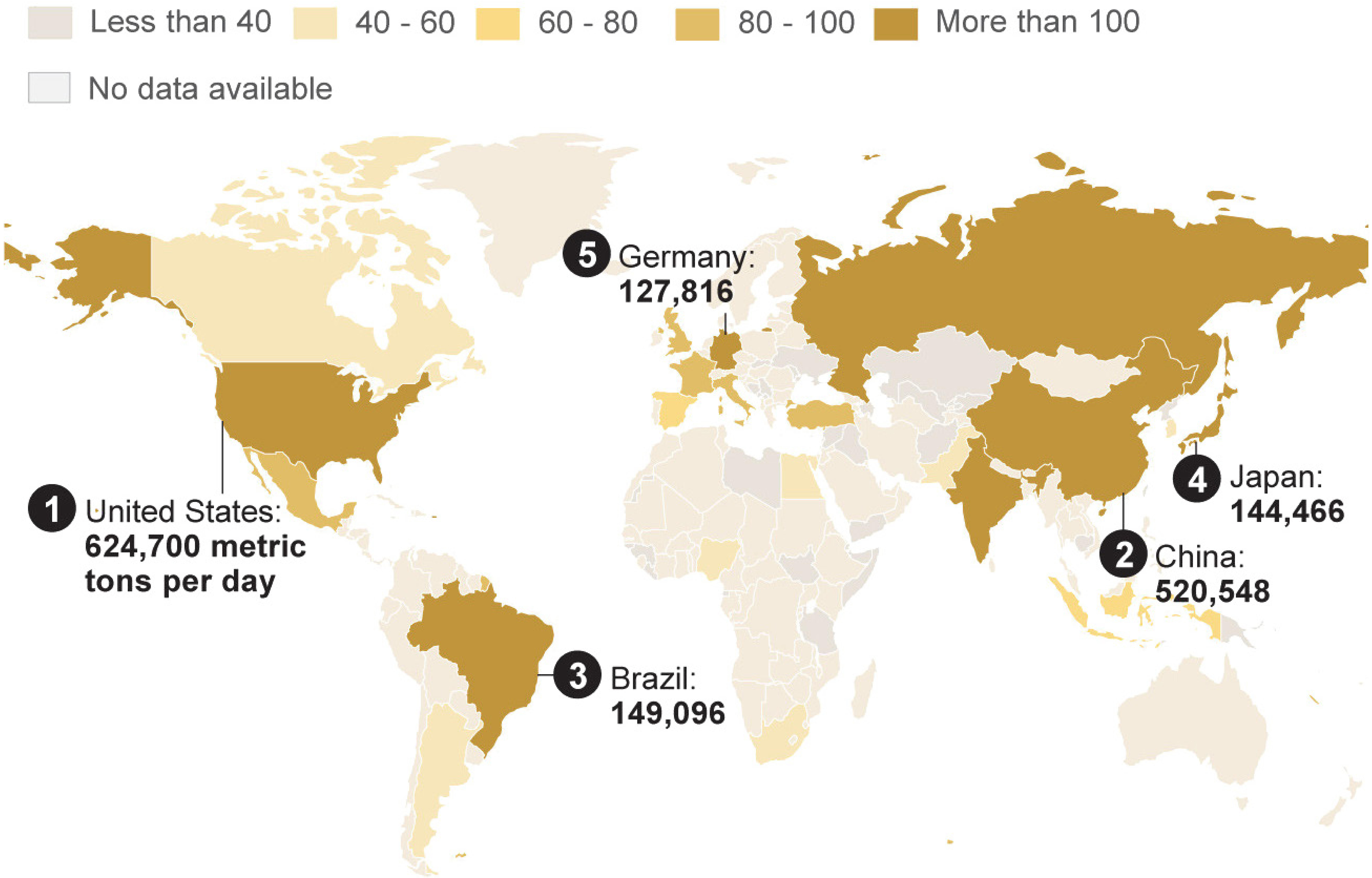
Rio de Janeiro - Brasil

[1]http://www.worstpolluted.org/projects_reports/display/91
[2]IGI Global, International Publisher of Information Science and Technology Research (http://www.igi-global.com/dictionary/generic-associated-architecture-gaa/4282)

Who Generates the most Waste?

Metric tons of solid waste generated each day*

(In thousands)



*Figures are from a 2011 report that compiled data from earlier years.

Source: World Bank, Angelica Quintero/ @latimesgraphics

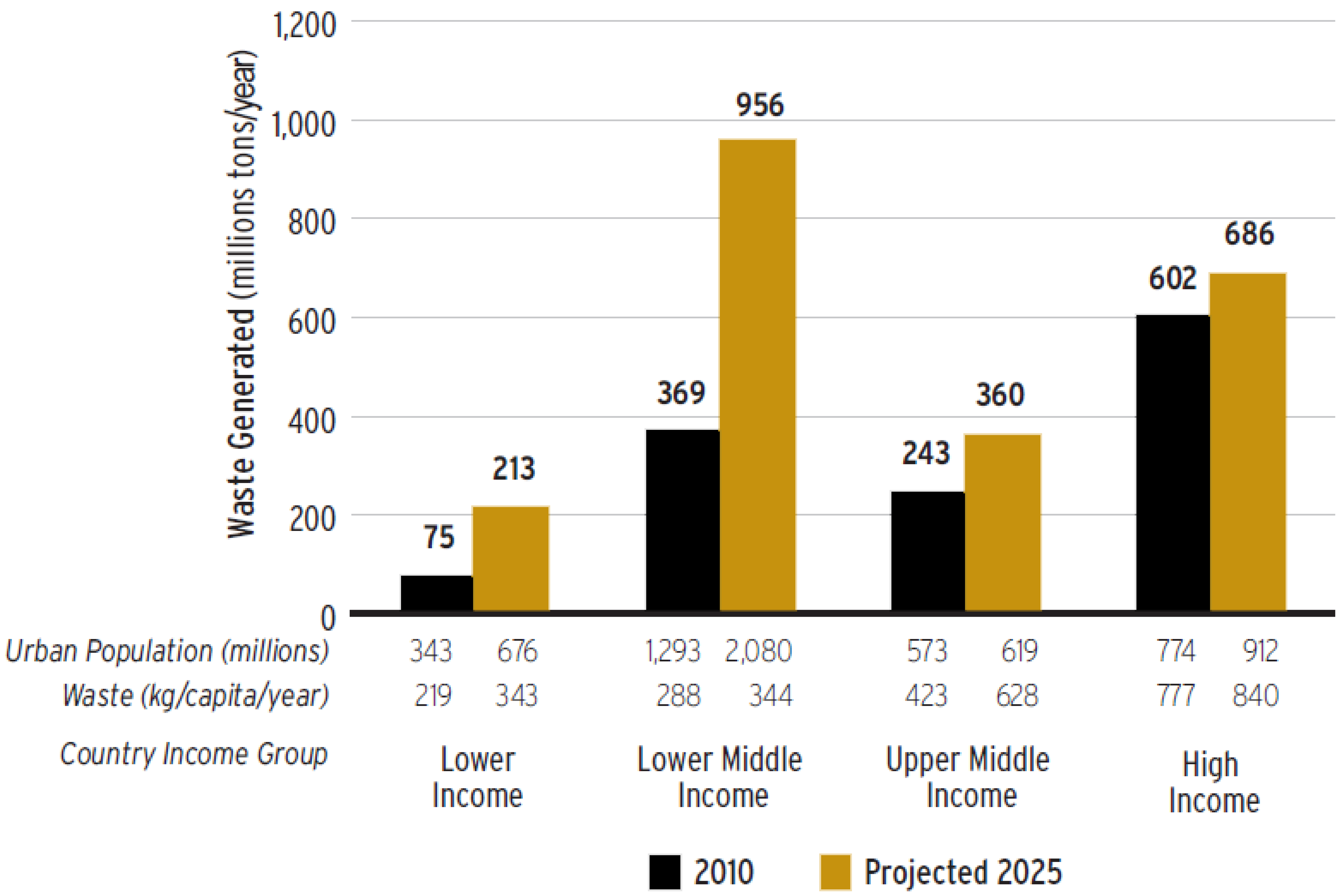
‘...residential neighborhoods of developing territories, with significant necessities in elementary infrastructure, advanced manufacturing technologies deficient accessibility, and most importantly a redundant quantity of accumulated refuse, controversial to the amount of MSW production, in behalf of insufficient or even absent absorption mechanisms of this accumulating predicament’

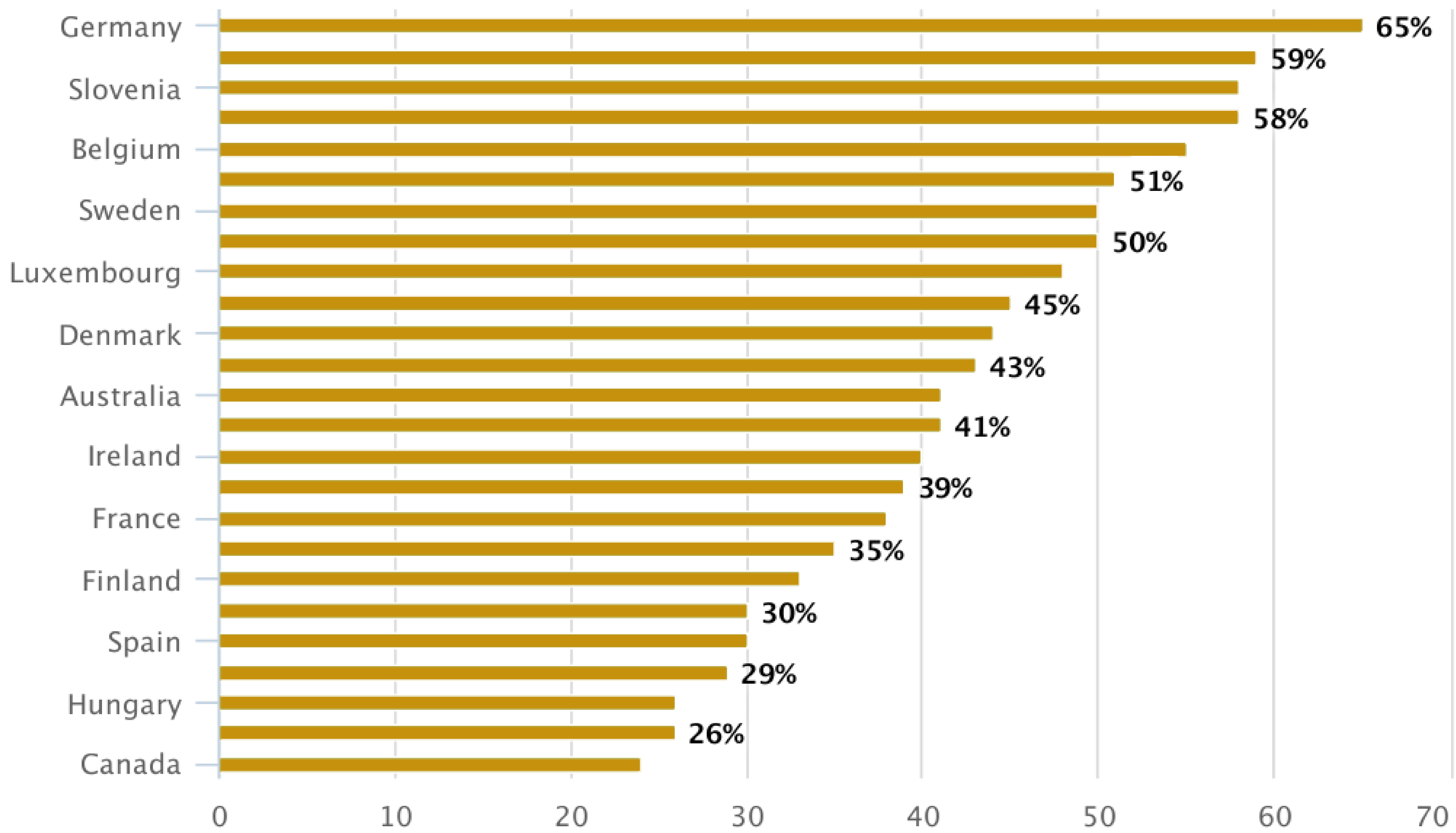
Urban Waste Generation By Income Level

The methodology for calculating 2025 projections for the urban municipal solid waste generation were made by factoring the expected population growth and GDP*, estimated per capita waste generation. The projections by country were calculated based on the level of expected GDP (high, upper-middle, lower-middle and low-income) and an average range of MSW generation based on the specific income level.

*GDP per capita is a measure of a country's economic overall output that accounts for population.

Source: Daniel Hoornweg and Perinaz Bhada-Tata, What A Waste, A Global Review of Solid Waste Management, No. 15, 2012





Countries with the most recycling rate
Source: http://www.city-data.com/blog/4693-waste-recycling-composting/

The generic nature of such a construction signifies an indirect relevance with the context, often not easy to define, and in the same time significant effort of investigation and design is concentrated in the demand of immediate accessibility to the new raw material variable resources.

"Generic architecture is a desire to create something that is not new, not unique but something that could work. A building that can be situated anywhere on the planet, a design that is interchangeable." (Luuk Verlint 2009)

The chicken and egg affair reflects the complicated criteria emerging from the **potential** of realizing such a project in a specific context, in respect to funding, infrastructure, competent methods of controlling material logistics and required equipment, against a location's actual **necessity** in the aformentioned framework. In other words, the on-situ implementation of the project without the necessary framework to support its construction is a versatile subject. How is it possible to realize this otherwise autonomous, sustainable and self-developing system without initial input? "Financing personal fabrication in underserved countries is too direct a goal for traditional basic research funding, and too speculative for conventional aid organizations or donors."(Gershenfeld 2005)

As stated in the beginning intention of the project is the generation of a diverse materiality integral design from waste that responds sufficiently to the implementation of a future-oriented spatial framework. The reFAb's structural system will represent a physical translation of the cause of its implementation. Therefor the lab with an intention of being consistent to this discipline requires to respond with its design and construction to the essential principles, tools, methods, heuristics and practices that have been originally set-grounded.(system)

However, the integration of heterogeneous salvaged components in a structure implies many interrelations and hides recursive levels of coordination, from where derive great difficulties in maintaining a unified vision of the system's overall design. (from system)
In other words, when the designer is not capable of controlling the material logistics in terms of location of extraction, type, quantity and dimensions the design process can be considerably, if not indefinitely, suspended. In respond to this a supplementart framework of existing research platforms and the advanced production equipment is in demand.

"Financing personal fabrication in underserved countries is too direct a goal for traditional basic research funding, and too speculative for conventional aid organizations or donors."
(Gershenfeld 2005)

[1]http://www.igi-global.com/dictionary/generic-associated-architecture-gaa/42825
[2]https://luukverlint.files.wordpress.com/2009/10/essay-pdf.pdf

The context identification for the implementation of the initial reFAB unit has been suspended for a significant period of time since it was depended variable parameters and driven by inconsistencies that led in preserving scepticism on regulating the actual location of the project's realization.

The solid argument of this selection was subsequently not determined by the requisites of an areas' infrastructure or the projects relevance to the latter, rather the availability of existing inventory platforms of disused and second hand material in stock, and an infrastructure with supplementary function that facilitates the construction and complements the demanding operational program of reFAB with the potential of reciprocity and spatial association. Thus, the required location directly influenced by the presence of a framework that has the capacity to advocate to these essential preconditions through the assistance in multiple facets of realization, such as initial funding, spatial infrastructure, raw material logistics and advanced technological equipment.

On that account, the efforts of investigation did not concentrate in search of the needs of a specific context, but more likely to the inquiry of a location that can sustain the implementation of the first unit of a self-developing network. In other words, in the case of the first egg of this project, the site was defined through potential and not necessity; **Not 'what is not there' but 'what is there'** and how could it be exploited.

This being said, the projects potential of realization would dramatically increase through implementing the initial configuration in an alternative context as the Marineterrein in Amsterdam which constitutes a representative to the above specifications location, comprising an area designated for innovative interventions that can respond sufficiently in terms of auxiliary infrastructure and existing refuse materials data-bases. Makeversity, comprises an establishment with essential advanced technological equipment that operates with a consubstantial program to reFAB and the respective principles of co-working and education that is located in the pronounced location; a sanctioned supporting framework of inherent mentality and supplementary operation. In addition, the collective architecture studio SuperUse has developed an on-line disused and second-hand material inventory (Harvestmap*) that refers to the broader area of Netherlands providing the essential for the reFAB's construction and operation intelligence.

In these lines, the current project's context analysis is finally employed in Marinneterrein in the city of Amsterdam.

Accordingly, corresponding to the Fab Lab Academy (worldwide network of Fab Labs) expansion phenomenon the possibilities of a consequent evolution of the reFAB network, considering the notable similarities in principles, operational framework and areas of intervention of these generic programs, are substantial. Moreover, in regard to the evident distressing policy of establishing industrial infrastructure where land and labour is most affordable, the critical environmental developments find their most bitter expression in the context of developing territories. Taking the above into account, is legitimate to ponder about the potential of the reFab project to supplement the Fab Lab Network by adjacent implementation or building expansion; a cooperation resulting into a reciprocal welfare for both parties in program and infrastructure, constituting an overall sustainable socio-economic framework of collective circular production. However, in the premises of the current investigation this denouement inhabits only as reference and won't be developed further.

General overview of the build enviroment in Amsterdam city

'...in regard to the evident distressing policy of establishing industrial infrastructure where land and labour is most affordable, critical environmental developments find their most bitter expression in the context of developing territories.'

***Harvestmap** is an online marketplace for redundant and second hand materials. Harvestmap allows companies or individuals to make an inventory of their supply of materials, components or even buildings to superusers. All materials, ranging from small quantities to continuous flows of (industrial) leftovers are represented. Registration and participation allows you to share your own supply, provide tips to the community and find available resources in your neighbourhood or the surroundings of a project. Harvestmap is under continuous development as we learn how to improve the platform, making sharing resources even more simple.

M A K E R V E R S I T Y

Makerversity is collective association that is operating through constructing and running its own spatial framework, which combines co-working space consisted by workshop facility and the required equipment, and program learning activities for young people as means of inspiring the next generation of creative and practical minds. Main aspiration of the organization is to bring together people of different creative and technical backgrounds that will have the opportunity to play an active part in the program and interact by exchanging experience, expertise and knowledge, with an ultimum intention of eventually increasing the diversity within the creative industries.

Main Operational Program

Work

Desk or studio workspace for your business in London and Amsterdam

Make

Access to digital and traditional machinery, tools, and making workshops

Inspire

Give back to the next generation through our learning and support programmes

Pricing for Joining the Collective

Flexible Membership

€175 per month

- Hot desk, in our co-working space
- 60 hours access to making workshops

Full Time Membership

€300 per month

- Dedicated desk
- Desk storage and workshop storage
- Full time workshop access

Stamp Card

€156/€312/€468 per card

- Access to workshop facilities
- Cards available for 5, 10 or 15 days
- Compulsory Health & Safety Induction with first card: € 45

Spatial Program

- Permanent Workspaces
- Event Spaces
- Studio Spaces
- Fabrication Facilities
- Prototyping Facilities
- Business Support
- Cultural Programme

Current Area of Focus
Marineterrein in the city of Amsterdam

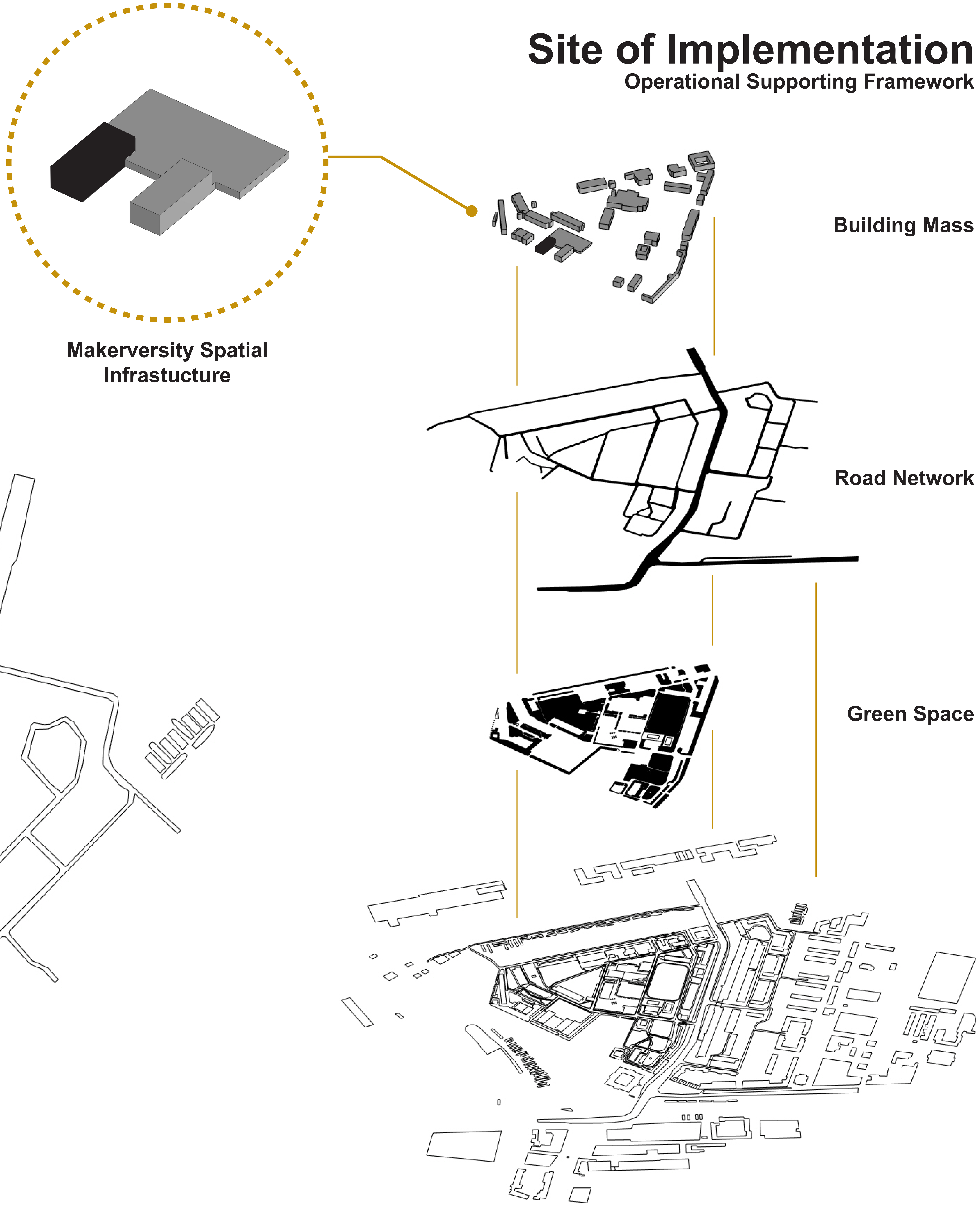
Empty Space
There is wide availability empty space [consisting more than 70% of the total area] as ground for intervention

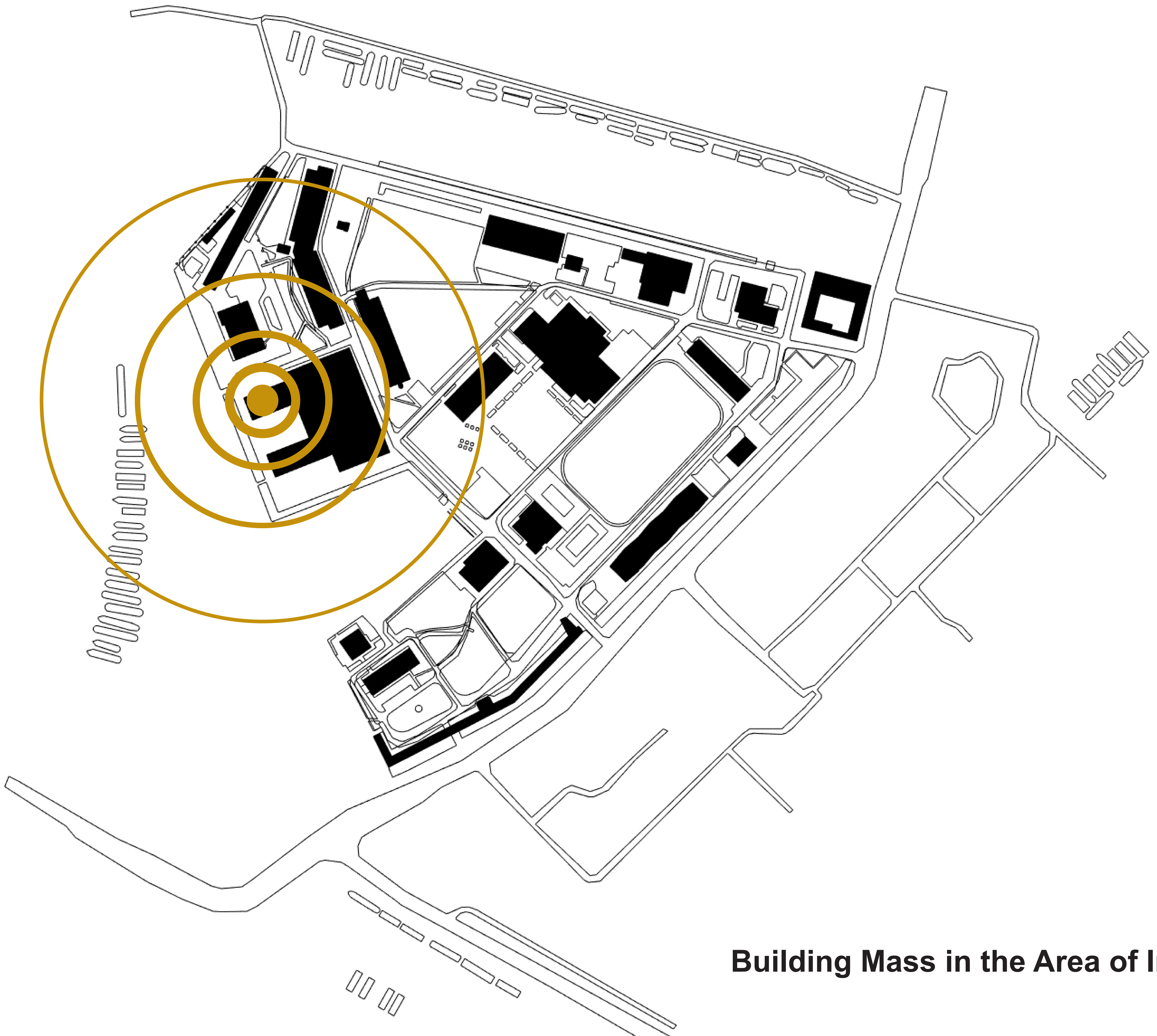
Marineterrein

Marineterrein is a particular location in the early stages of a gradual transition from a military complex to a developing public district and a remarkable ground for innovative interventions that can essentially contribute to the city of Amsterdam, giving the profile of an area where 'things happen'. The first part of the site has opened to public in 2015 is the region of historical value Voorwerf. The general area has a considerable existing stock of vacant buildings and sites, which are managed by the Bureau Marineterrein Amsterdam, with intended objectives to exploit the potentials of Marineterrein to develop into a self-sustainable area with smart infrastructure that could provide energy to additional parts of the city.

Site of Implementation
Operational Supporting Framework

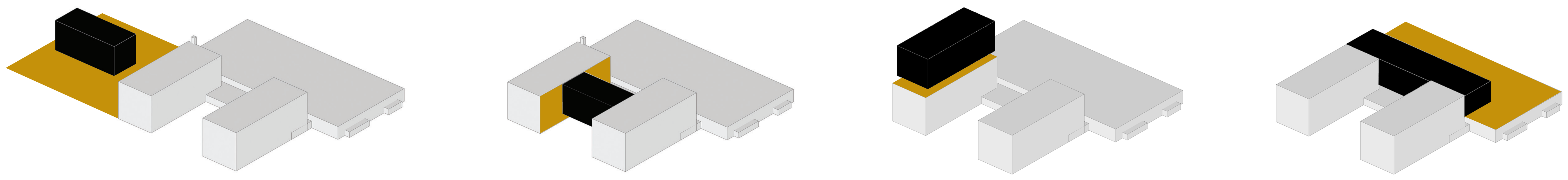
According to the legal planning framework, in respect to the real estate market developments there is no established designation plan and major construction initiatives are suspended, while the area's vision is estimated to develop in the next 10 years' time. Any potential implementation in this period will be taken into consideration in a case-by-case basis, according to whether a project is competent to positively contribute into the desired direction, on which grounds the detention can be interrupted. Along these lines, despite the discouraging condition of the market, Marineterrein has the unique possibility to evolve in slow pace, making room for events, experimental thinking and temporary uses based on community initiatives that can be accommodated to available sites and vacant building stock. Due to the strategic location of the context, the marine area has great potential to transform in a 'new cultural and urban hub'. These advancements increase the popularity and attractiveness of Marineterrein, and propagate the area to be a place of communication and innovation.



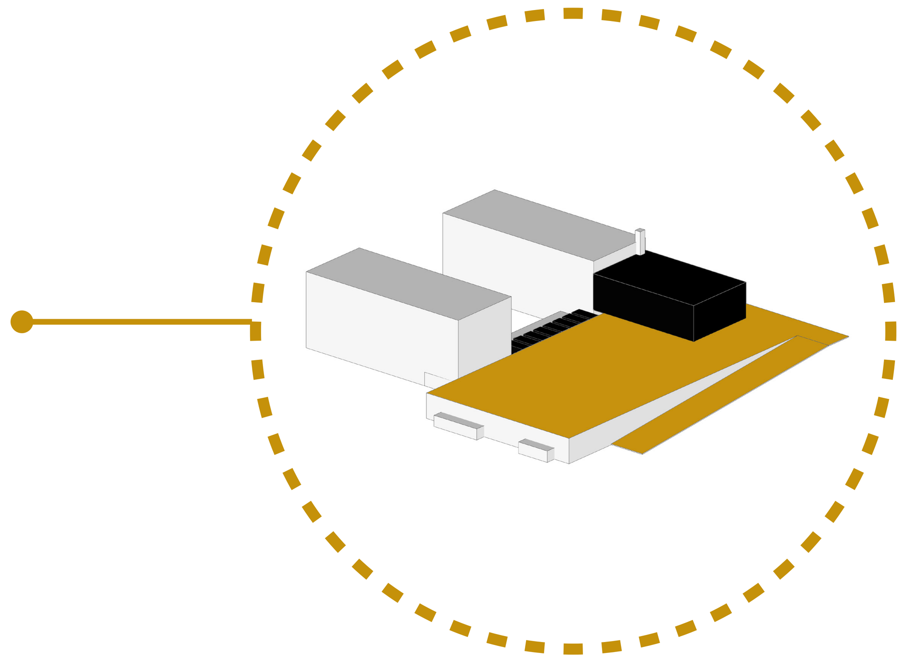


Building Mass in the Area of Investigation & Location of Interest

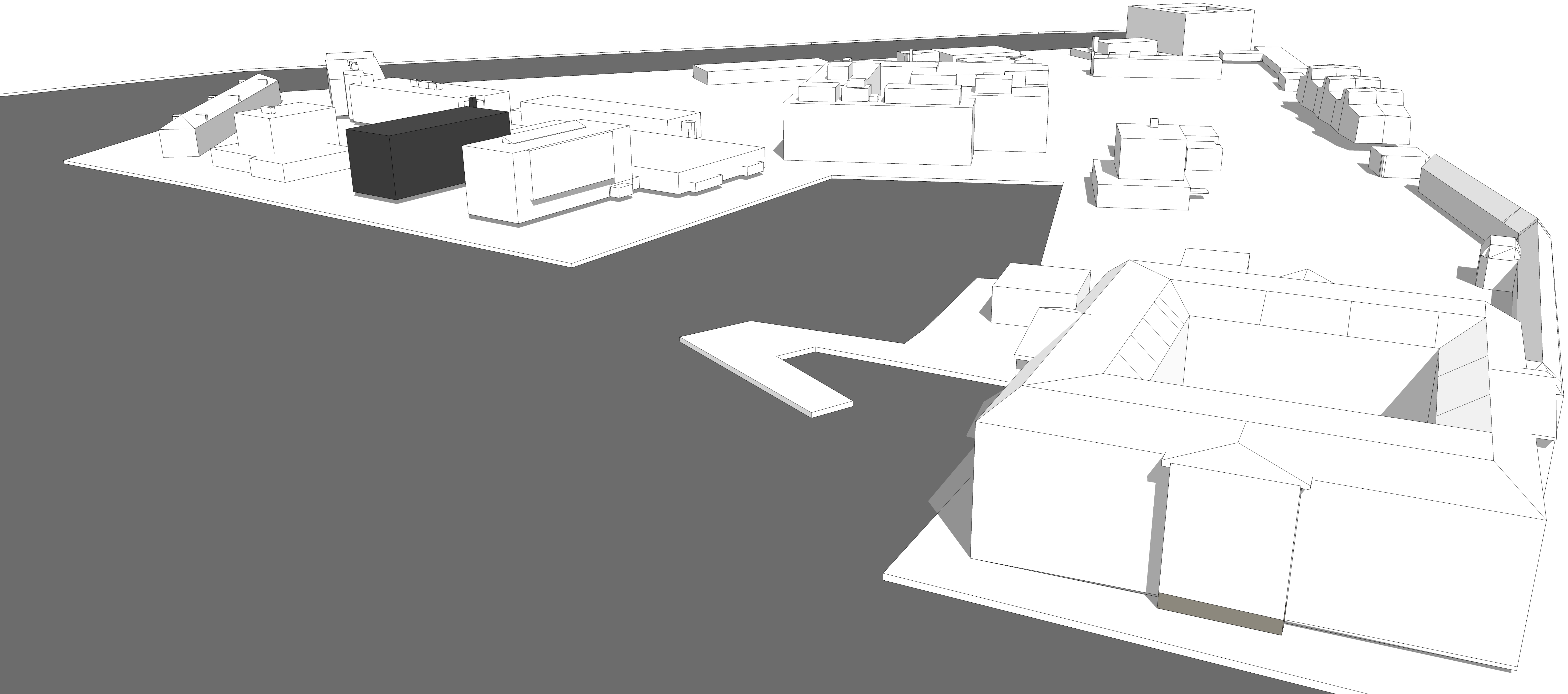
reFAB Main Infrastructure Setting



Independent Structure | **Infill Intervention** | **On-top Expansion** | **Low Volume Expansion**



Potential Intervention



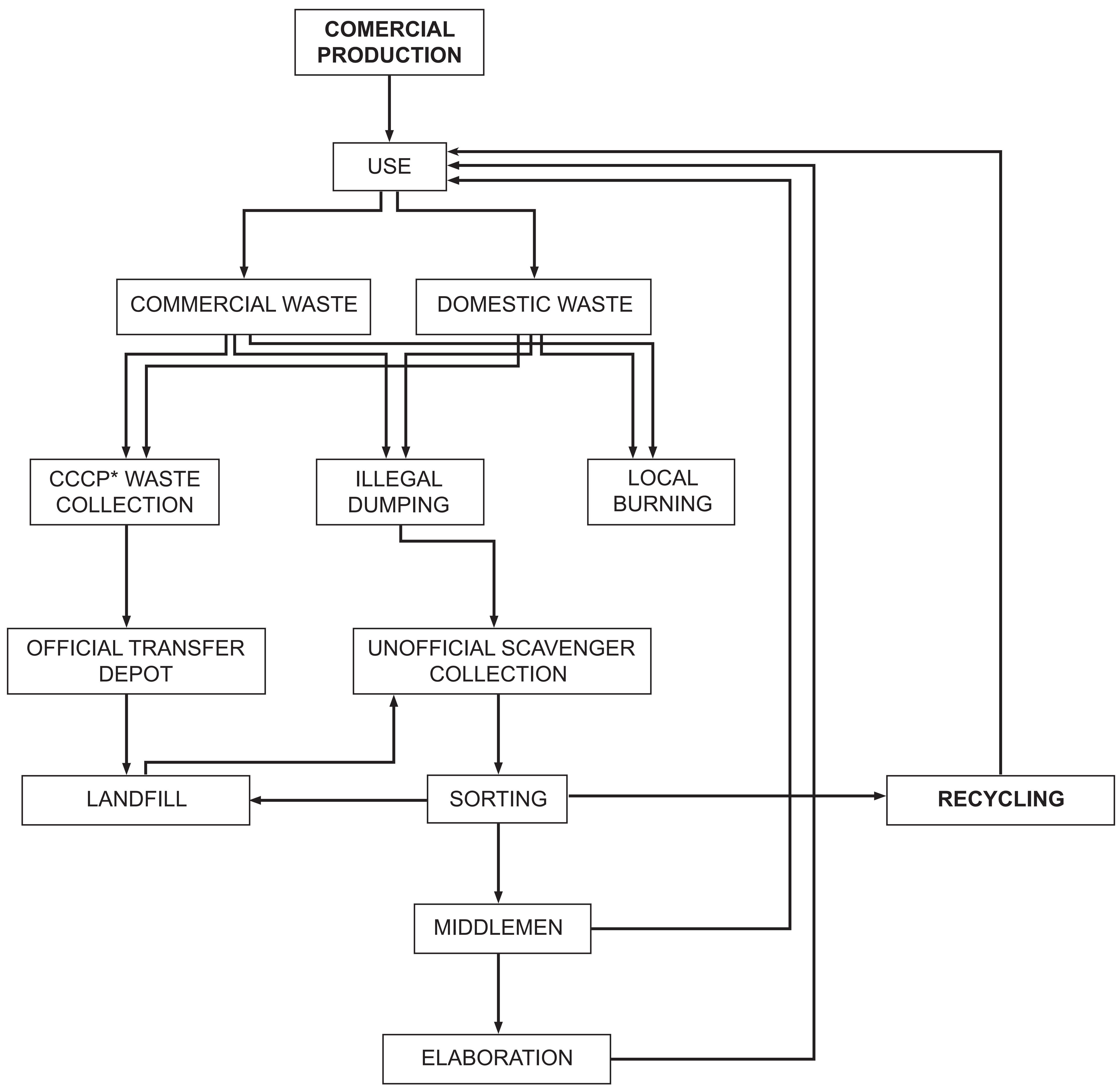
Marineterrein is an environment where innovations contribute to the development of the city. In order to create the right conditions for such an evolution, the site has been divided in three main areas:

1. **Marine Area**
2. **Waterpark**
3. **Innovative Workshop**

The Marineterrein constitutes one of Amsterdam's innovative spatial workshops with international perspective. The "Innovative Workshop" domain will be integrated with dwelling development and infrastructure of private institutions and collectives that operate experimental processes in the field of sustainability and energy.

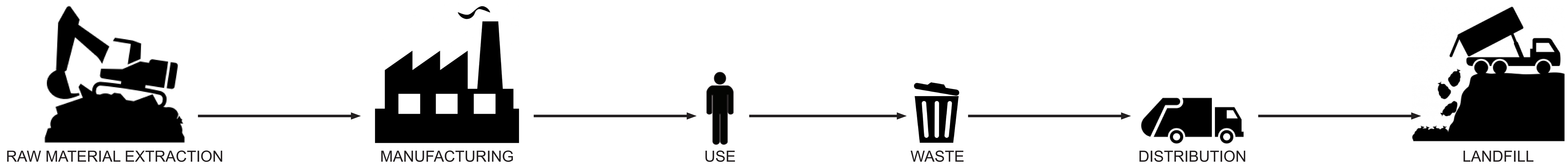
REFUSE

Typical Waste Flow



What is Waste?

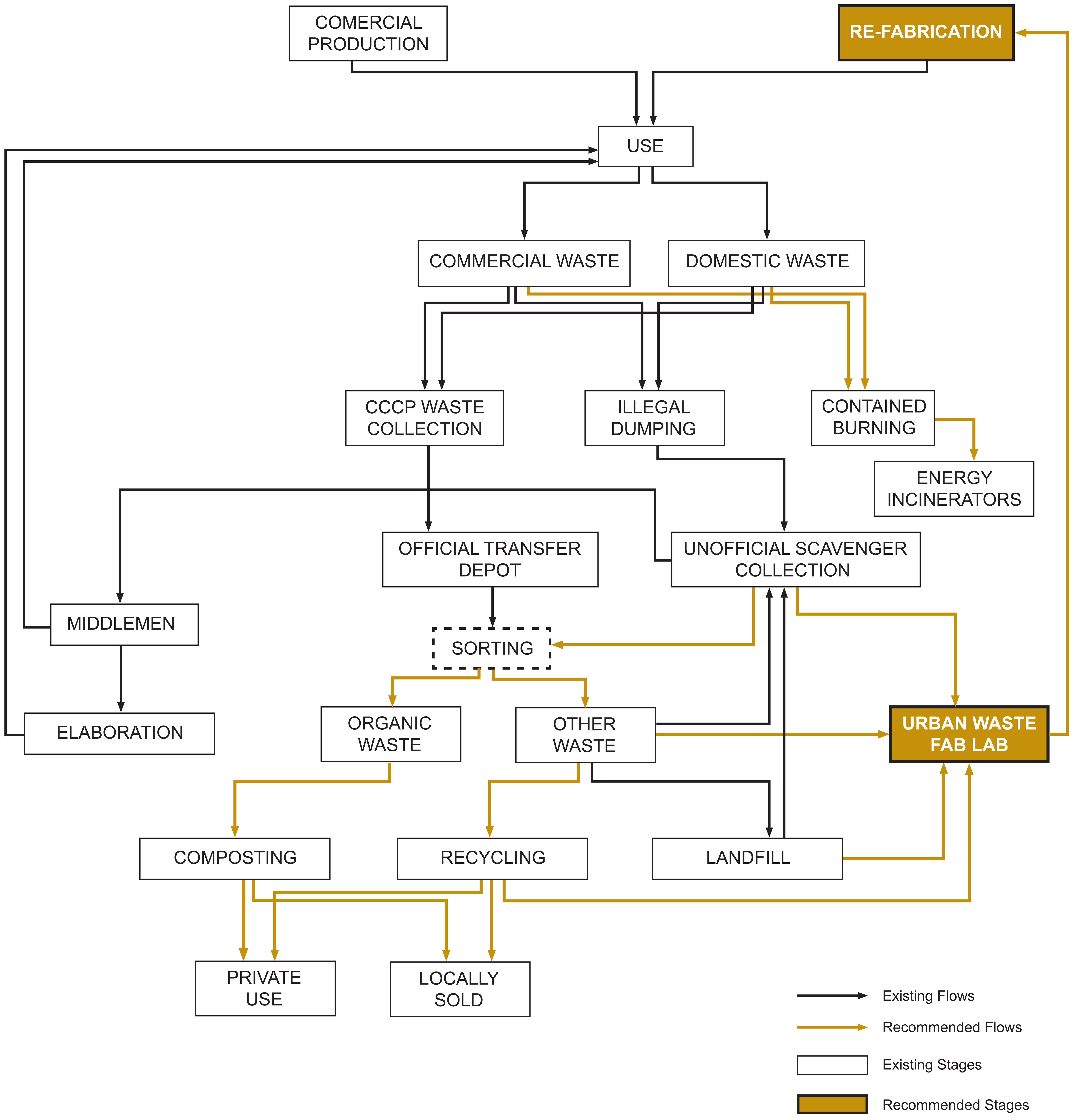
Until recently the notion of production was intimately accompanied with the concept of waste; almost any form of activity with raw material input and elaboration method, including energy consumption, is attached with the production of waste. But what is actually waste? The word waste is an output of linear processes for resources exploitation, this being: **extract, manufacture, consume and discard**[1]**;** and has been considered so far as the discarded by-products or unwanted goods that have fulfilled, or not, their production reason, thus no longer necessary. There exactly lies the most significant challenge; to alter a social perception, from the definition of this construct to the very essence of it; to actually kill the word waste. The added value of refuse is being finally set under public consent. According to Future Cities Laboratory (ETH Zurich) research platform, where intensive research on advanced manufacturing technologies and alternative building materials is being conducted, the participants are motivated to "…develop ideas on how design can play an important role of activating waste as a building material in future cities planning. The abundance of refuse is the essential hypothesis of the research."[2]



Extract, Manufacture, Consume & Discard

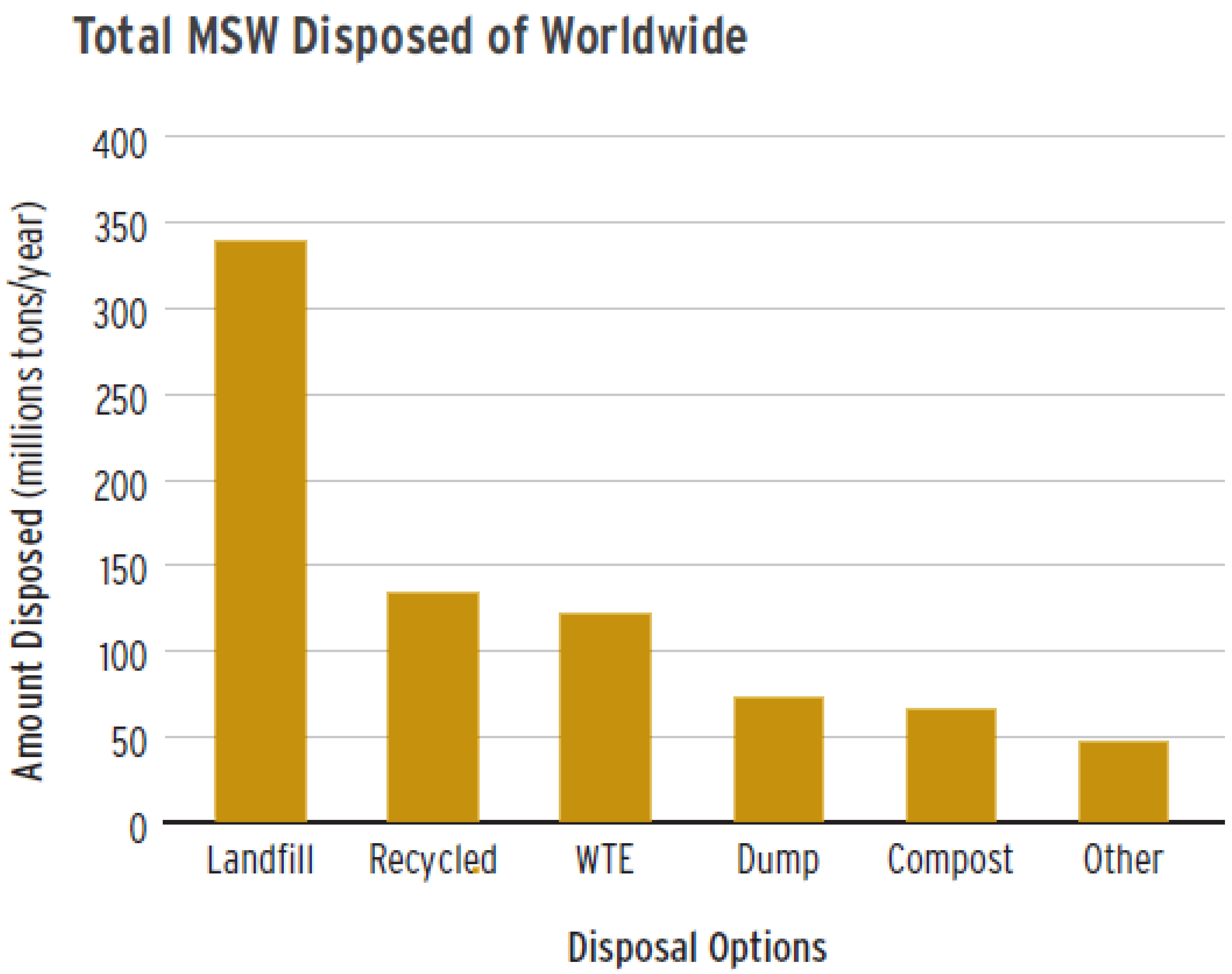
[1]A.Leonard, The Story of Stuff: The Impact of Consumption on the Planet, Our Communities, and Our Health – And How We Can Make It Better. New York City, USA: Free Press, 2010
[2]http://www.fcl.ethz.ch/research/archipelago-cities/alternative-construction-materials/constructing-waste.html
*CCCP: Central City Cleaning Department

Suggested Waste Flow

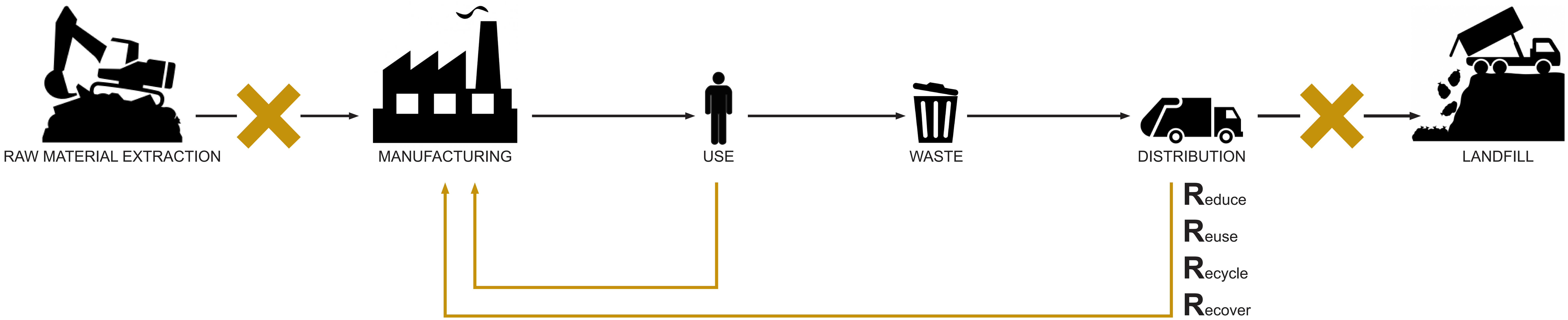


Main objective of this investigation is to carry forward a circular mentality of incorporating disused processed components back in the production stream as a significant growing raw material resource. This kind of metabolic assimilation where no element should be considered as waste is coming along with great environmental and socio-economical reverberations that "threaten" to have major impacts on the building industry by altering the linear mode of production drastically; and this being the exact reason for its so far obstructiveness and retardation.

There exactly lies the most significant challenge; to alter a social perception, from the definition of this construct to the very essence of it; to actually kill the word waste



Total Municipal Solid Waste (MSW) disposal worldwide
The graph indicates the current annual global MSW disposal for the entire world. The chart was provided by the World Bank in 2012 and the estimations are only approximate values, given that the data is from various years.
Source: Daniel Hoornweg and Perinaz Bhada-Tata, What A Waste, A Global Review of Solid Waste Management, No. 15, 2012



Urban Mining & Recycling

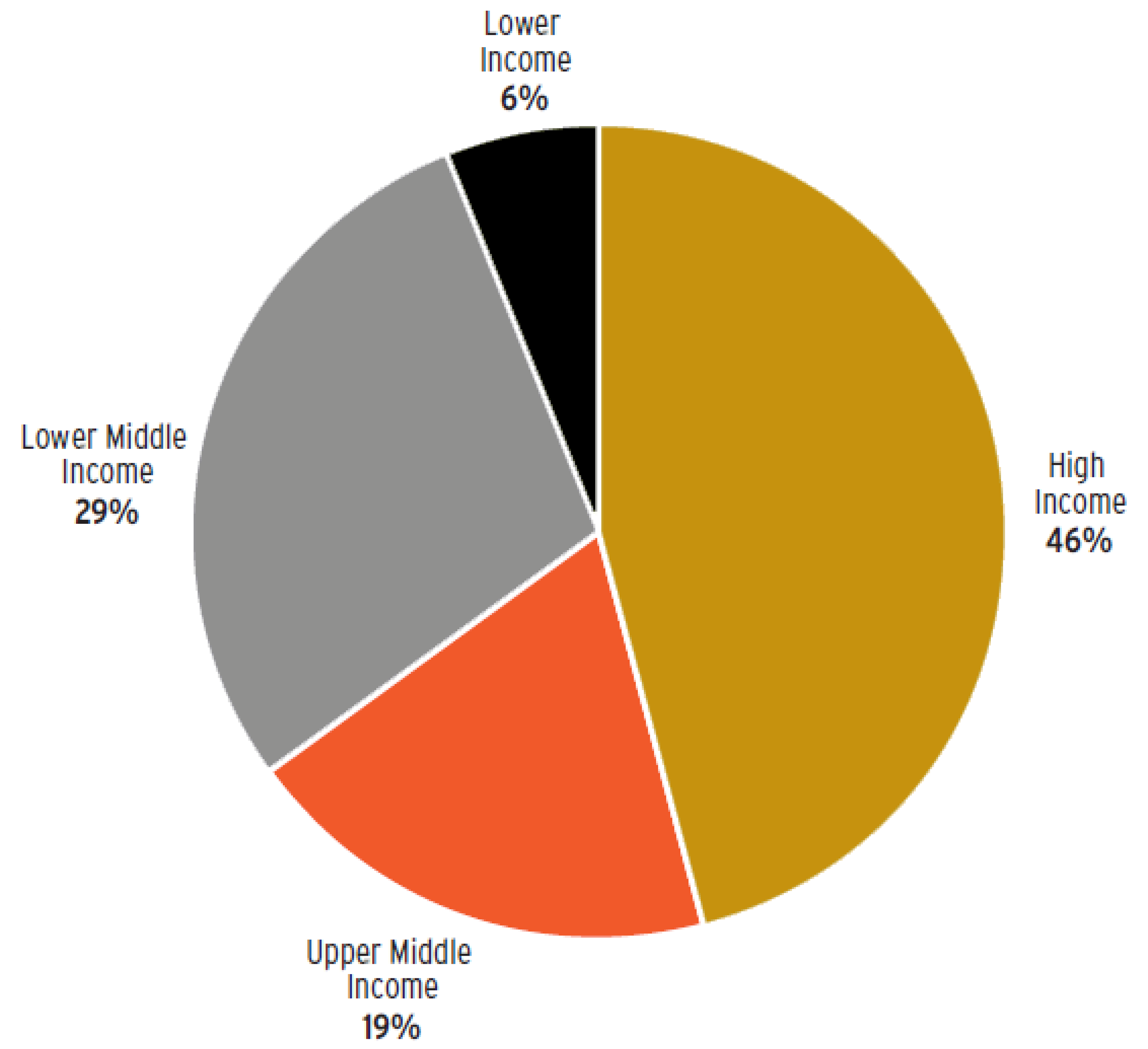
Pie Charts indicating estimations on MSW

[provided by the World Bank]

Source: Daniel Hoornweg and Perinaz Bhada-Tata, What A Waste, A Global Review of Solid Waste Management, No. 15, 2012
*Countries are classified into four income levels according to World Bank estimates of 2005 GNI per capita.
High: $10,726 or above
Upper middle: $3,466-10,725
Lower middle: $876-3,465
Lower: $875 or less

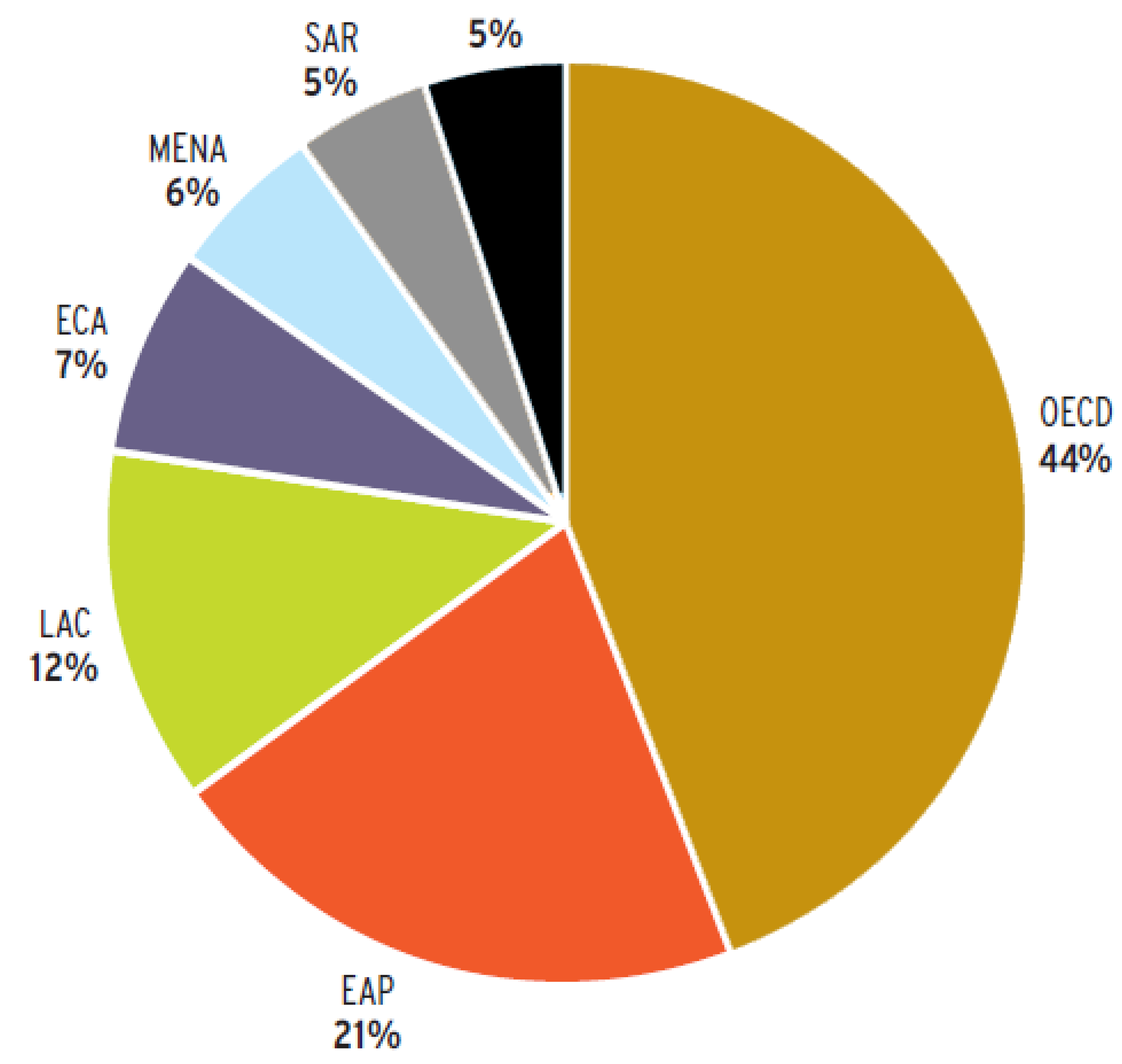
Waste Generation by Country Income Level*

High-income countries produce the largest amount of solid waste per capita, while low income countries produce the least. Although the total percentage of waste generation for lower middle income countries is presented higher than that of upper middle income, this outcome is an apparent function of China's inclusion in the lower middle income group, the average per capita waste generation amounts for the various income groups reflect the income level of the countries.The chart represents the global waste production according to income. (see Figure 2).



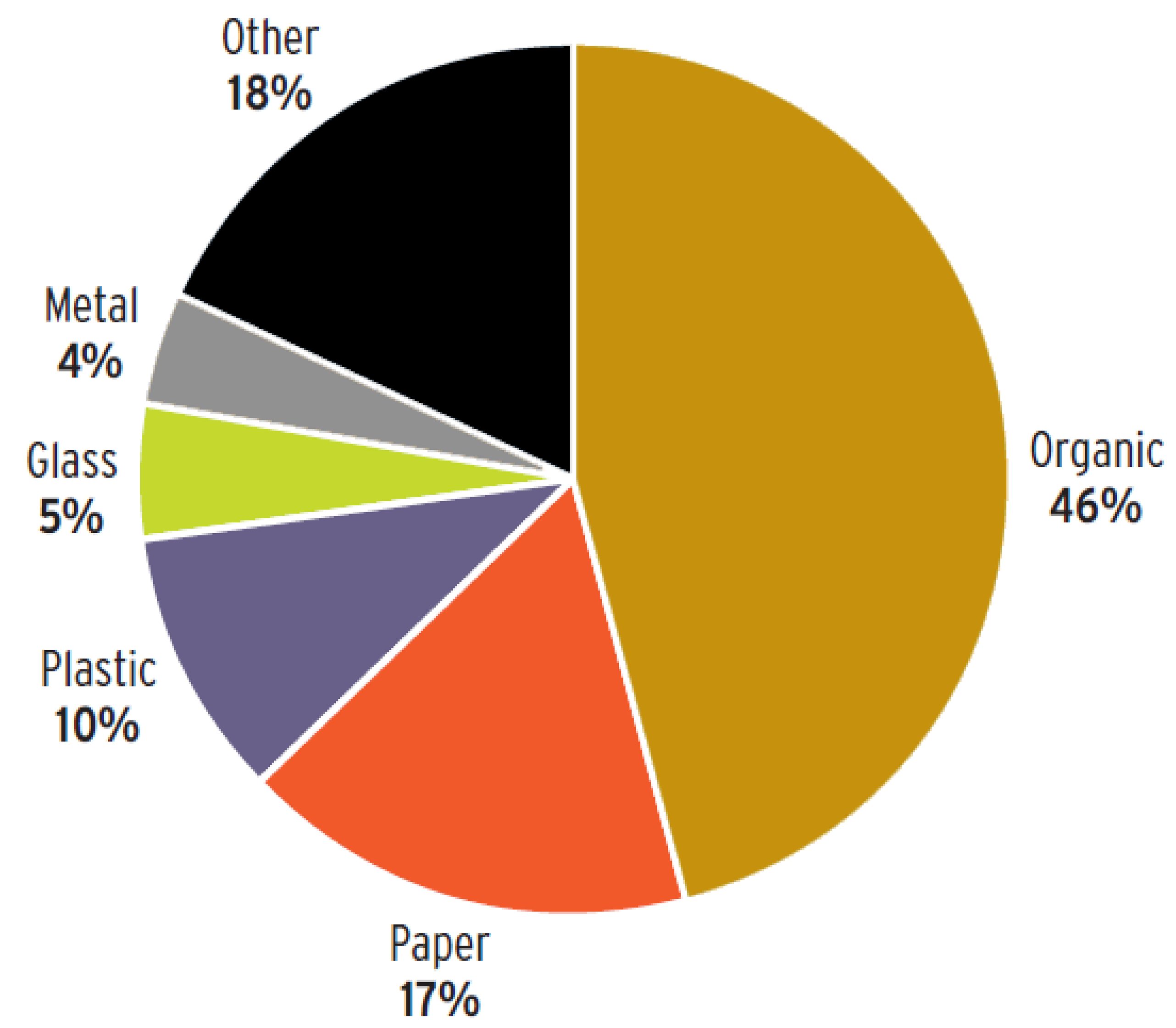
Waste Generation by Region

Waste generation varies as a reaction of affluence, however, regional and country differences can be significant, as can generation rates fluctuate in various scales, i.e. within the same city. The pie chart illustrates the regional classification of waste production as estimated by the World Bank in 2012.



Global Solid Waste Composition

The pie chart represents the Municipal Solid Waste composition worldwide approximately estimated through data sets from various years, provided by the World Bank in 2009. As the graphic reveals organic waste comprises the majority of MSW, followed by inorganic refuse as paper, metal, other wastes, plastic, and glass.



Material Elaboration & Refinement processes

preceding the digital fabrication

- **Separation–Classification**
- **Parametric Design**
- **Cleaning**
- **Cutting-Shredding**
- **Furbish**
- **Heating**
- **Melting**
- **Cooling**
- **Compressing**
- **Additives**
- **Casting**
- **Other amendments**

On the side are provided symbols of refuse material elaboration processes necessary for the assessment of rehabilitation in the following investigation

CASE STUDIES IN MATERIAL REUSE

Plastic Bags Brick

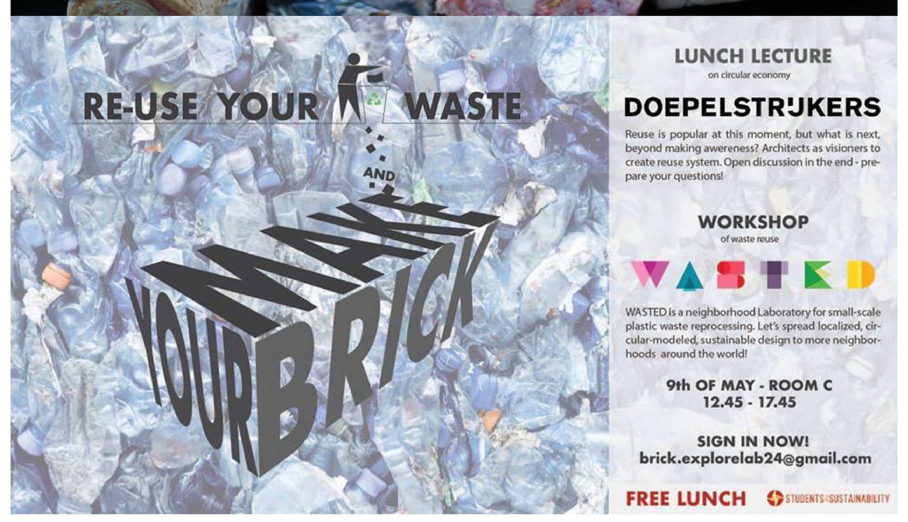
• 100% recycled
• Waterproof
• No glues & chemical in the production process
• Wide availability of raw material
• Recyclable
• Household equipment
• Easy to produce

Make your Own Brick

Wasted workshop's sample of a dissected brick produced by reused plastic bags type HDPE

Explore Lab had organized the workshop 'Make your own (recycled) Brick' for a sustainability symposium. The workshop consisted by a lunch lecture from Doepel Strijkers and a recycling workshop with WastedLab. Wasted is a neighborhood Laboratory for small-scale plastic waste reprocessing.

The workshop's main objective was to urge the participant students of TUDelft integrate in their design mentality a more circular approach through the exploitation of waste materials by means of learning how to incorporate used plastic as a building material resource. A short informal lecture on the impacts of plastic in the natural enviroment and subsequently to people, the different types of plastic and basic properties and considerations on reuse, and some references on alternative approaches on plastic rehabilitation were followed by the actual process of transforming waste plastic bags in an elementary building component in practice. Eventually, as it turned out, the actual procedure of composing a brick, by plastic proved to be a very simple, straightforward proccess.



Ingredients

The process of making a solid plastic brick 100mm3 involves:

• a wooden box and
• a table for sorting waste bags
• a scale to measure the amount
• a plastic bucket
• a steel mould
• a clam
• a pair of welding gloves
• a specially coated (tefal) cooking pot
• a conventional oven
• 850gr plastic bags type 4[LDPE]

Making Process

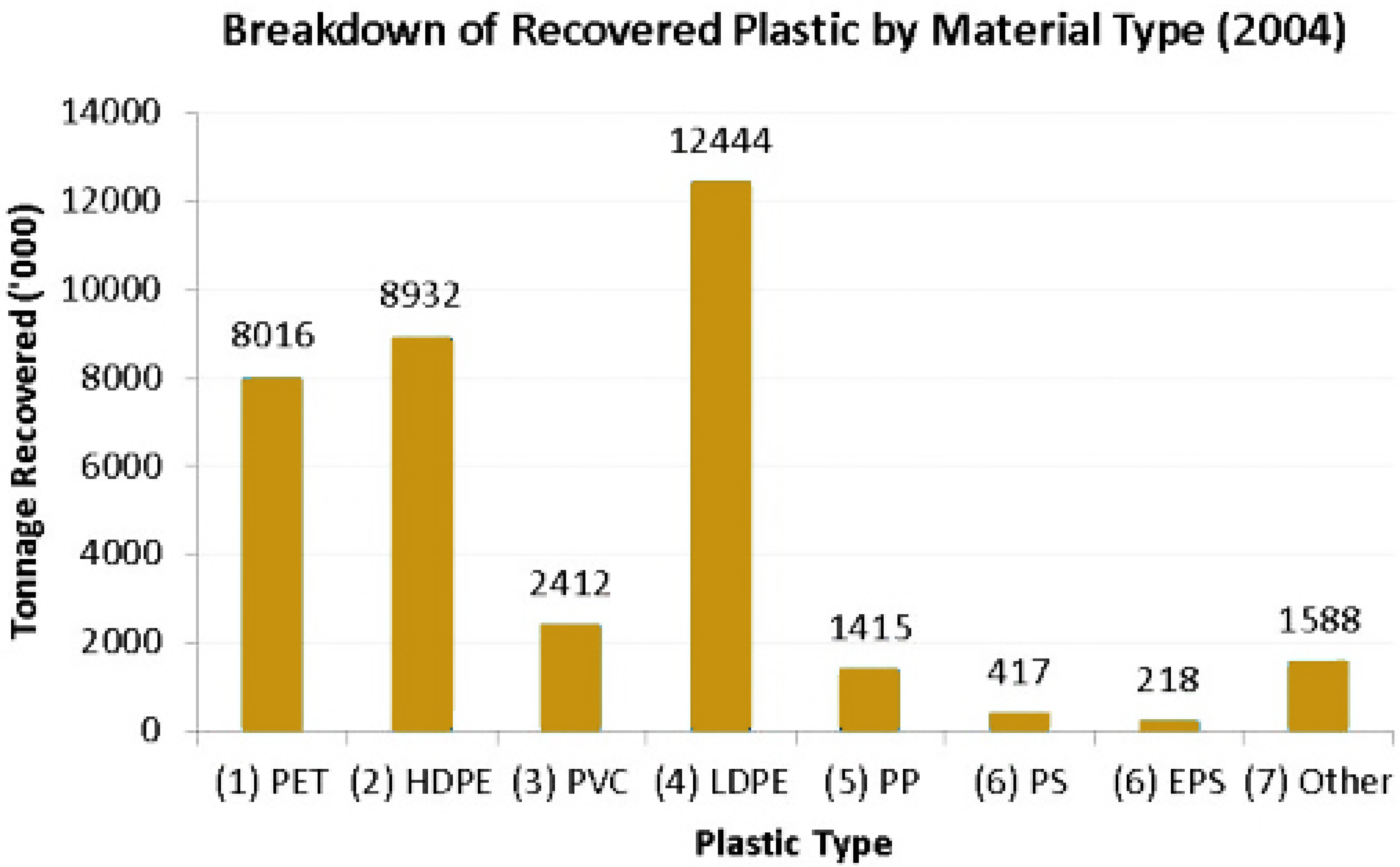
The process involves a wooden box and table for sorting the waste plastic bags, a scale to measure the amount. After concentrating the desired amount of plastic bags they can be put all together in one bag and then into the specially coated pot. After pre-heating the oven one can put the pot inside and wait for around 30'. When the bags have melted properly, one has to put out the, clay like consistent, plastic mass which can be handled easily with welding gloves, and put it into the steel square mould. After putting the clay into the mould, the latter is placed in the custom made press. When the mould is fully pressed it is clammed and put into one of the black buckets which is filled up with water to cool down.

Know Your Plastics

Plastic constitutes an endless refuse material resource and a highly pollutant element. The material although it contributes to approximately 10% of the overall discarded refuse worldwide, due to the deficiency to be naturally decomposed contributes to the persistence of plastic debris in certain environments. As a result, plastic has covered approximately 88% of the planet's ocean surface (National Academy of Sciences, 2014[1]), a number that is progressively ascending. In addition to this predicament, used plastic constitutes a very underestimated product with extremely low value compared to other recycled materials such as metal, wood, glass or even paper, while in reality the material comprises a large and unlimited raw material resource. This being said, and considering the ability of the disposed material to easily reform and regenerate, plastic constitutes a significant object of interest in the current investigation. Many different types of plastic exist that they can be roughly divided in seven categories, according to their chemical composition that is defined from their precursors, process of polymerization and added ingredients.

Type	Name	Description	Examples
1 PETE	Polyethylene Terephthalate [PET]	usually clear or green, sinks in water, rigid, glossy	soda bottles, peanut butter jars, vegetable oil bottles
2 HDPE	High-Density Polyethylene [HDPE]	semi-rigid, usually sinks in water, cloudy colored plastics	milk and water jugs, bleach bottles
3 PVC	Polyvinyl Chloride [PVC]	semi-rigid, glossy, usually sinks in water	detergent,/cleanser bottles, pipes
4 LDPE	Low-density Polyethylene LDPE]	very flexible, usually floats in water	6-pack rings, bread bags, sandwich bags
5 PP	Polypropylene [PP]	semi-rigid, low gloss, usually sinks in water	margarine tubs, straws, yogurt containers, reusable food storage containers
6 PS	Polystyrene [PS]	dull appearance, floats in water	styrofoam, packing peanuts, egg cartons, foam cups
7 OTHER	Other PC Polycarbonate	often brittle, glossy and clear, usually sinks in water	reusable water bottles, baby bottles

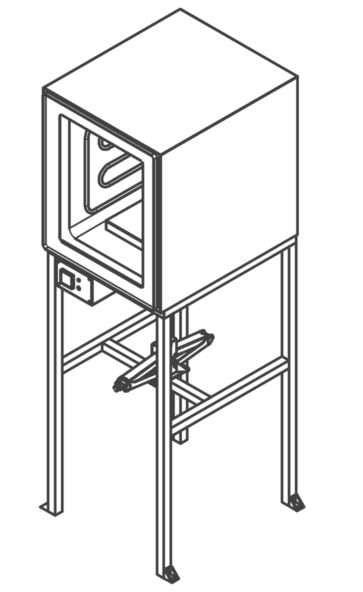
Table board converted from source: https://www.mygreentraveler.com/product-category/gt/ & Recyclingtips.info



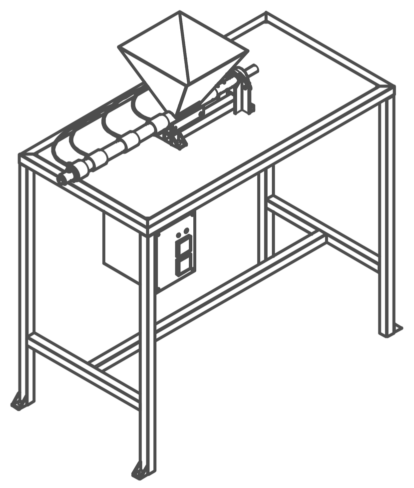
A total of 32,442 tonnes of plastic was recovered in 2004. This graph shows a breakdown of that plastic by type. Graph adapted from Plastics NZ (2005)

D.I.Y. Construction Manuals of Plastic Recycling Machines

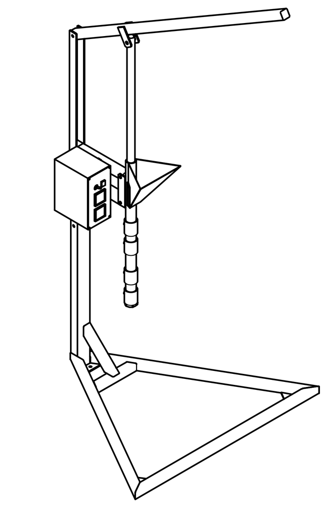
Source: Blueprints and instructions provided open-source by Dave Hakkens through his website PreciousPlastic



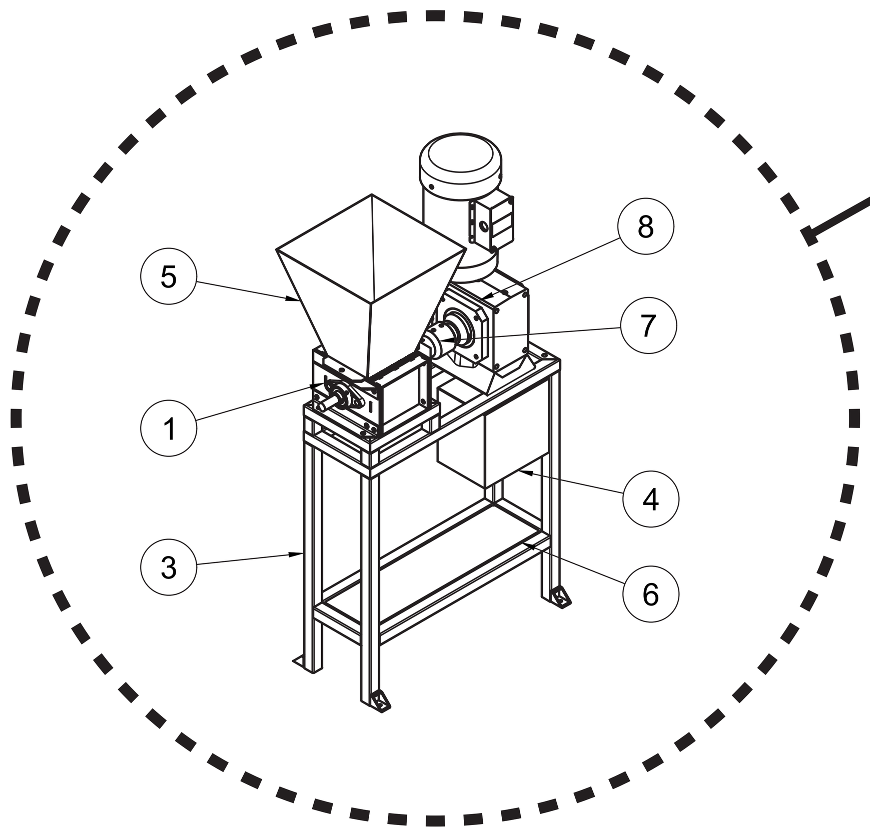
Compression



Extuder

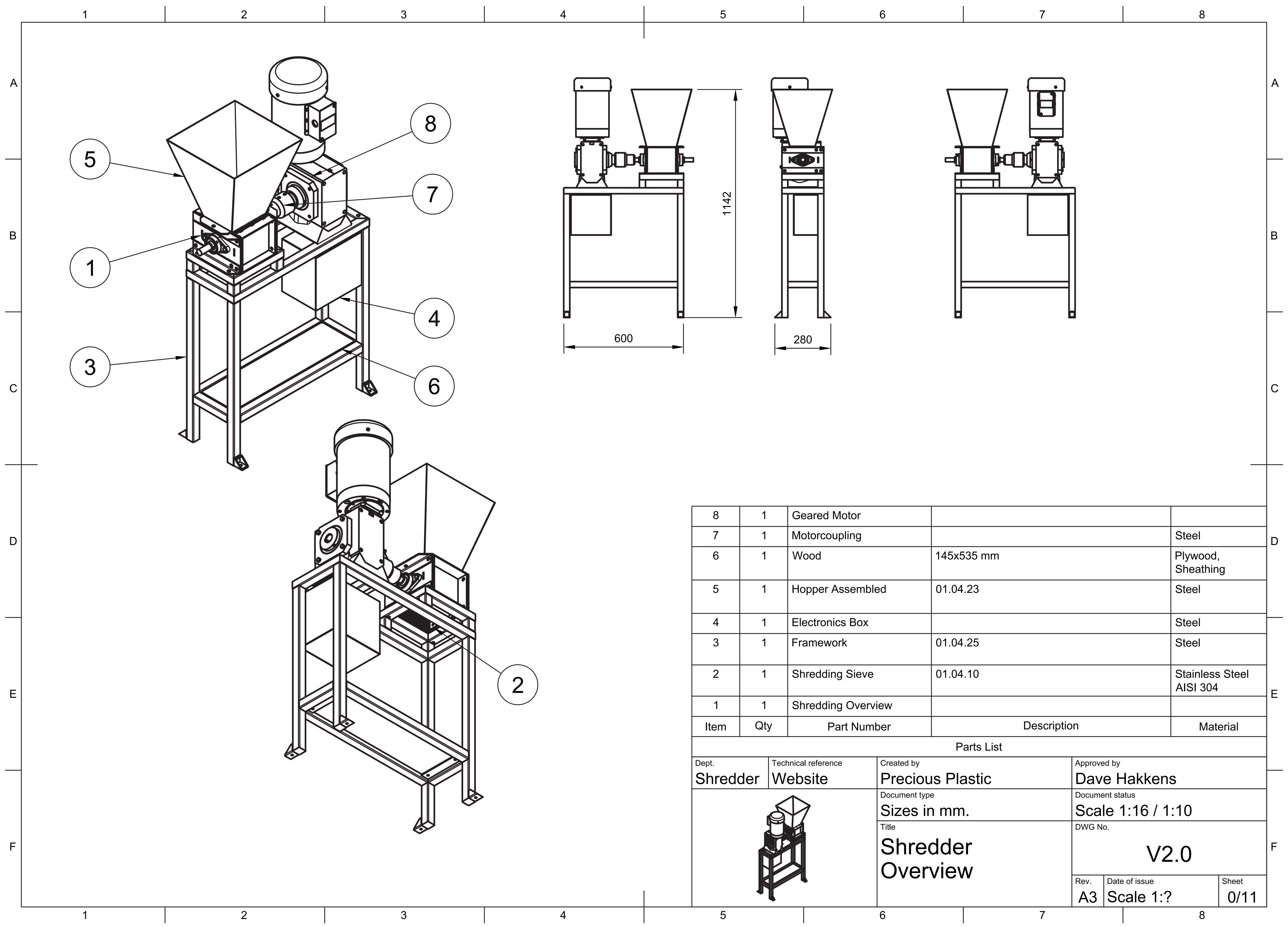


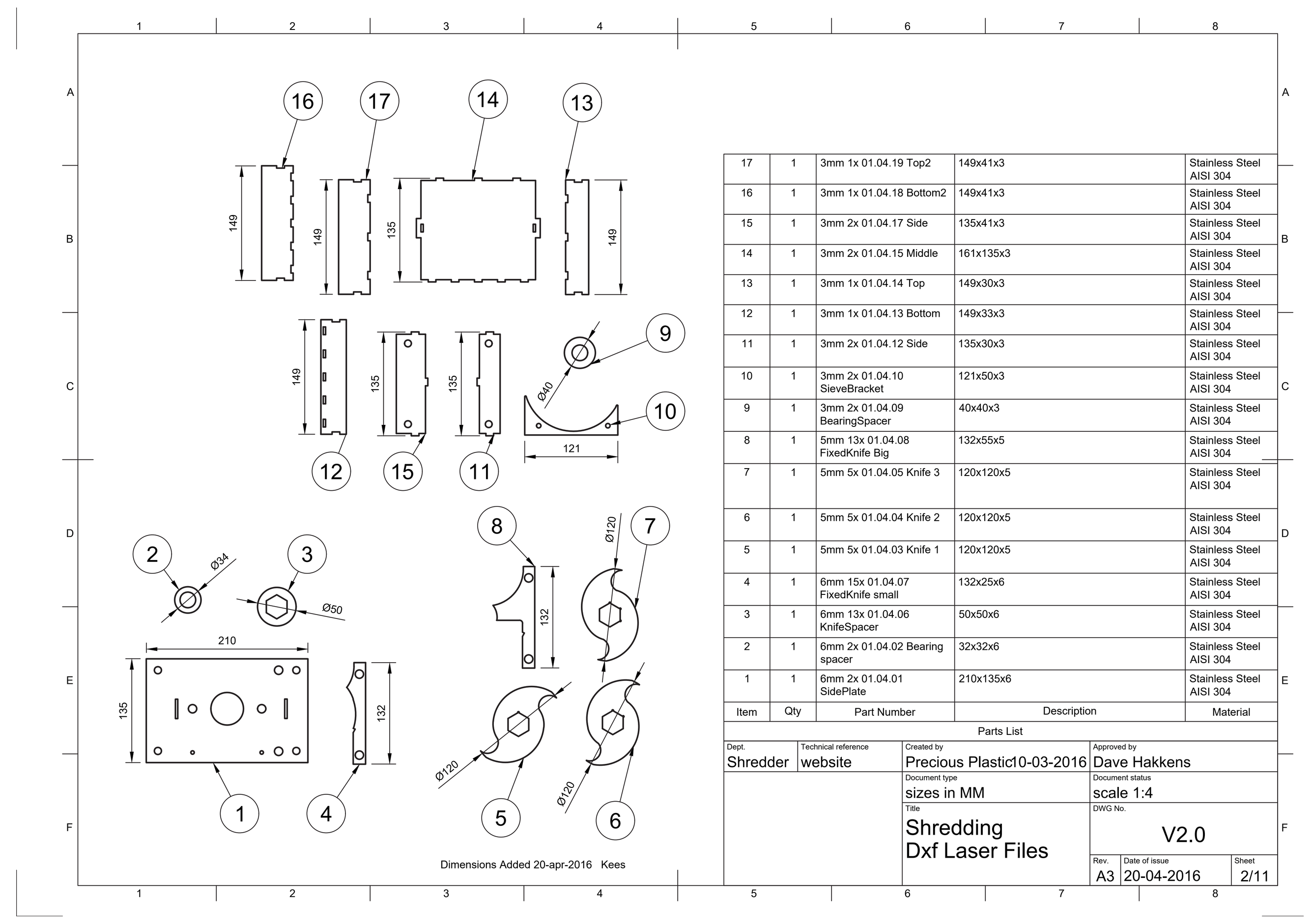
Injection



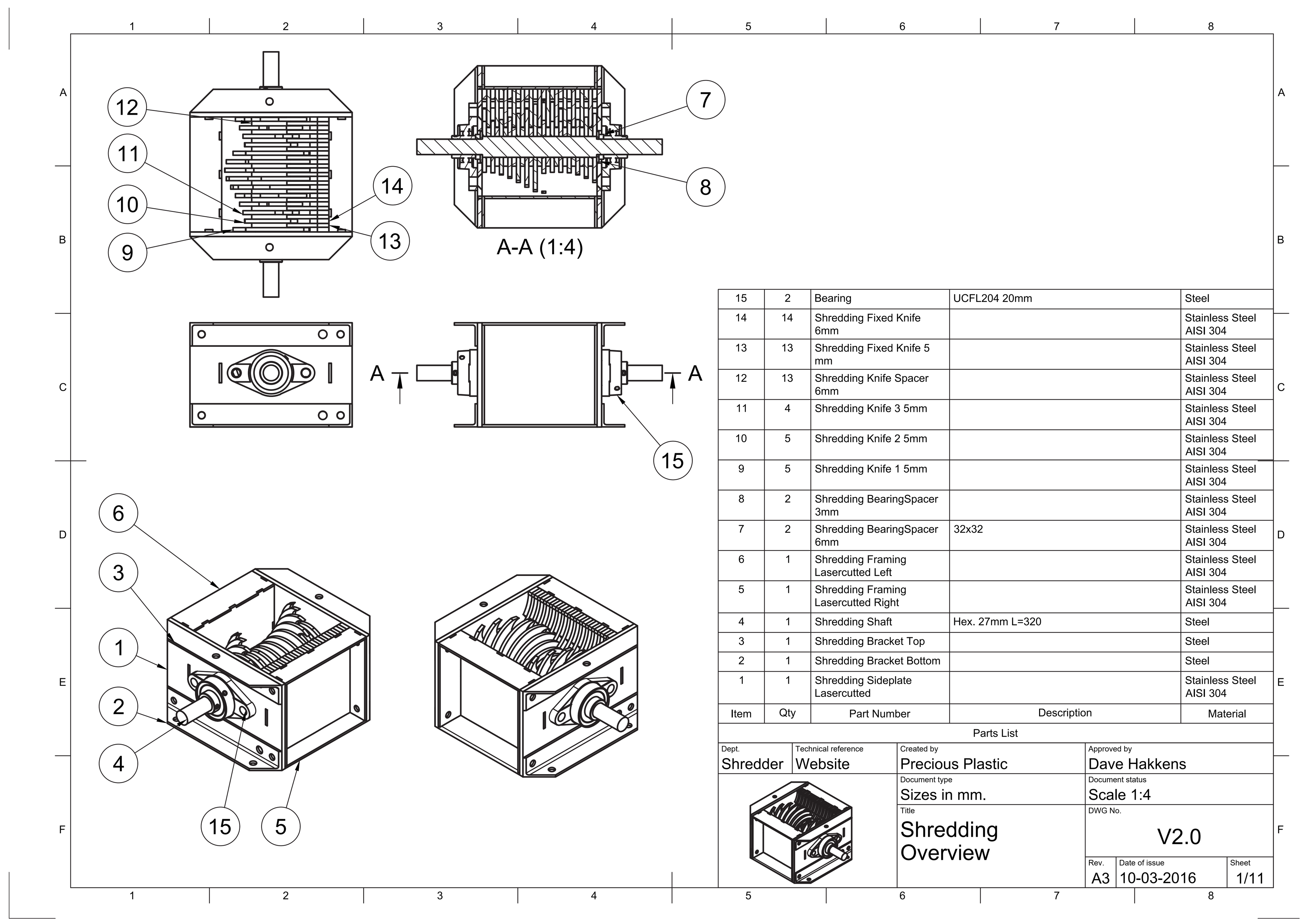
Shredder

D.Hakkens in his website Precious-Plastic encourages the visitor to learn how to build his or her own equipments for plastic recycling, by downloading for free his open-source manuals. The manuals are consisted by instructional videos, photos, detailed structural designs, in CAD and PDF form, and digital fabrication files of these, easy to build in your home or through your neighborhood craftsman, recycling tools. Additionally, the site urges the user to optimize or adjust the designs according to their needs and disposes its own forum where people can adress their queries or observations and suggest their improvements on the construction of these tools.

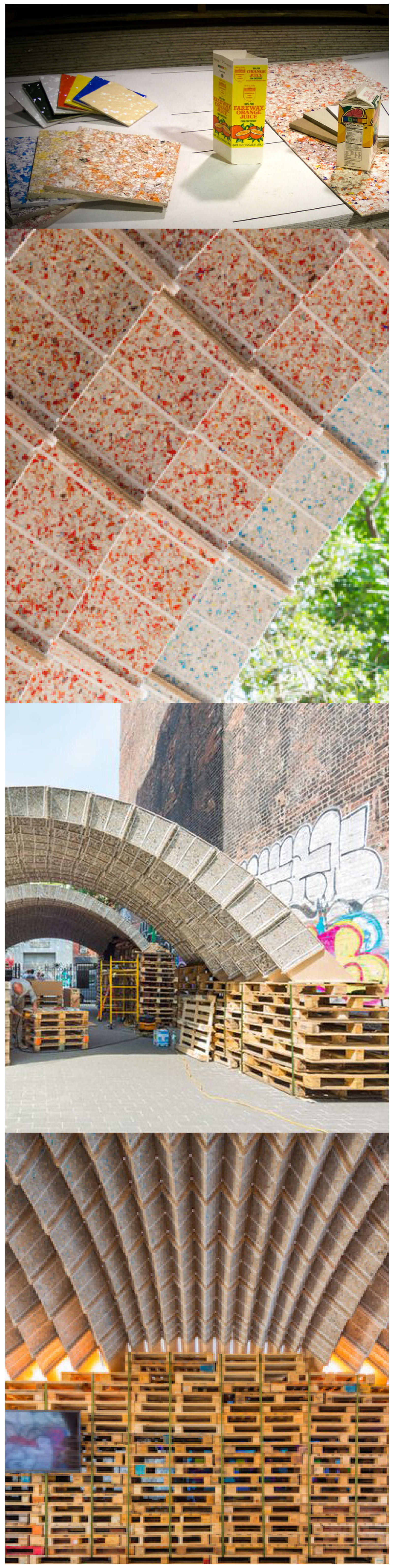




Digital manufacturing technologies can provide an essential framework for the construction of the reFAB lab through collective unskilled labor without the overall, otherwise unavoidable, commitment to industrial production, and augment the prospective operational sustainability, autonomy and self-development of the establishment by supplying the innovative tools which democratize the ability of future consruction in an operational framework of circular metabolism. This being said, the reFAB facility will be able to insure and **facilitate the production of the suplementary required equipment** for the elaboration and recycling of the refuse materials preceding the digital fabrication and many of the necessary conventional work furniture and tools, through the employment of the advanced manufacturing tecnologies. In other words, the digital tools will generate the rest of the tools.



ETH Ideas City Pavilion



At the IDEAS City Festival 2015 in New York City ETH Zurich participated with the designed and construction of a pavilion using as main material resource discarded beverage cartons. In order to recycle such a product, the laminated layers require to be separated through a process that demands a high water and energy consumption. Instead the ReWall Company in order to exploit the potential of the product as a valuable raw material resource, uses an alternative recycling procedure by shredding the material and pressing boards intended for interior cladding made out of 100% beverage cartons.

Although ETH's team by parametrically designing a shape that adheres to the forces' flow and transfer the stresses between the structural components, the structure was able to allow the employment of a non-standard, weak material. In this manner the recycled panels were utilized as sol structural element for the pavilions composition, without the application of glue or additional non-recyclable elements. The dry-assembled vaulted structure due to the double curvature and triangulations, provided the a stable and safe shell made only from beverage packages. To ensure an adequate connection of the discrete blocks, a pre-stressed cable, running inside the blocks through the whole length of the arch, was used. The arches are also structurally connected with each other through each block.
The recovered product produced from paper, polyethylene and aluminum due to the initial intended use is additionally totally waterproof.

Case Studies Conclusions

ETH Ideas City Intervention

• A designer can find **alternative utilization of the technical advantages** stemming from the original use of a product (exploiting the laminated layers of the beverage carton for the waterproof capacity of the infrastructure)
• Through the exploitation of computer aided design a designer can integrate the material and variable parameters in early stages of the process and have optimal results; moreover facilitate the **employment of non-standart building components** in design and construction

Wasted Workshop

• **Knowing your refuse material's technical properties** and limitations is a necessary precondition before attempting to incorporate it in a production process
• The plastic rehabilitation in elementary building material composition can be a **very simple, DIY proccess**.
• The **tools** required in such a process can even be consisted by **every day, household equipment**
• Optimization potential in the mounting process (dry assembly or mortar)

The Material
ReWall
Naked Board

• 100% recycled
• Waterproof
• Mold resistant
• No glues & chemical in the production process
• Recyclable

INTERVIEWS

Interviews in Regard to the Subject of Material Reuse & Digital Fabrication

In an informal meeting with Foteini Setaki, a TUDelft researcher in Architecture's Building Technology division, conducting an investigation on acoustics and additive manufacturing and co-founder of The New Raw*, a short discussion took place around the topic of the potential of refuse materials' integration in digital manufacturing.

The conversation mainly expanded in a general overview of the current's research pursuits according to the three main layers of systemic analysis: 'Why, What, How', and the emerging possibilities, as well as the decelerating determinants, of employing digital fabrication in larger scale, vernacular realizations of the architecture practice. Additionally, significant part of the content of this interaction advocated for the assets and indicated the drawbacks of the efforts on redirecting the refuse through architectural design back in the production process, in general level and on personal experience based evaluation. Along these lines, and taking into consideration that the relatively recent shift towards circular thinking is still in an immature stage of development, the incorporation of refuse as a raw material input in a building process adjacent to computer aided design and manufacturing (CAD & CAM), appears to constitute an evidently multidisciplinary procedure with a wide variety of promising outcomes, influential parameters, blur points and ground for investigation.

During an interview from Vasiliki Sklivaniti, researcher at TNO institute in Delft, an extended discussion took place about the emerging possibilities of waste materials and by-products being included as main ingredients in the building material composition. In addition, Sklivaniti filled with a spirited will the supplementary following questionnaire:

• What is your work about?

At the moment I am doing my Erasmus Internship at research institute TNO in Delft. My expertise is in Structural reliability group and specifically in materials team, of the department. The project I am currently working is about Geopolymers. Nothing to do with plastic as many people think at first, but building materials made from byproducts and waste. The project focuses on the creation of a new recipe of geopolymers and the examination of two durability problems that we also find in cement, Alkali silica reaction and sulfate attack.

• How do you consider waste?

'Waste' means any substance or object which the holder discards or intends or is required to discard; according to the 2008/98/ec Official Journal of the European Union 22.11.2008 DIRECTIVE

It can also be described as an environmental problem, but also an economic loss deriving from consumption and production patterns.

CRA states that "solid waste" means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities.

By-product is a substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste. Only if the following conditions are met: (a) further use of the substance or object is certain; (b) the substance or object can be used directly without any further processing other than normal industrial practice; (c) the substance or object is produced as an integral part of a production process; and (d) further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impact. 60% of the waste generated consisted of mineral waste and soil, largely from construction and demolition activities and mining.

• Can you name relative components developed and their so far application?

The name 'geopolymers' was first introduced in 1976. They can be used as inorganic building materials, as coatings and as adhesives in ceramic concrete.

Geopolymers consist of 2 parts; first part is the precursor which can be ashes, slag and clay. In general the precursors are rich in Si, Al. The second part is the activator. The activator is a solution of waterglass, alkalis such as Na, K, Mg and water. According to the mix design that is chosen they are mixed in different proportions, according to a standard, and curing in the preferable temperature.

*The New Raw is a creative practice that explores the merging fields of digital fabrication and material resourcing. Main intention is closing loops by introducing digital fabrication technologies in the recycling process of discarded materials. In this manner, the team explores what design can offer towards the subjects of waste-overproduction and material misuse. The New Raw was founded in Rotterdam in 2015 by Foteini Setaki and Panos Sakkas.

As we can understand there are many factors that play a significant role to the final product and its characteristics concerning mechanical properties, durability, time to dry, water resistant, cost and sustainability. So far they are used in: • Decorative stone artifacts, arts and decoration.
• Cultural heritage, archaeology.

• What is the product you are developing now?
Geopolymers from metakaolin, slag, NaOH and water-glass. Metakaolin is a clay material and slag derives from the ferronickel production industry. When mixing the ingredients monomers monomers start to form and the geopolymerization reaction starts and finally the strong binders (geopolymers) are formed.

• What are the advantages and disadvantages compared to the former developed products?
The geopolymers have a different performance according to the different precursors, activators, different mix designs and different curing temperature. If we try to select and identify some common characteristic that describe geopolymers is that they are sustainable strong binders, they are fireproof, they perform better than cement in compressive and they have higher resistivity to acids. Also they have bigger setting time compared to cement and concrete when curing at 20oC.
The greatest advantage that makes them so popular in scientific communities is that they are sustainable by terms of using byproducts and waste. Don't forget that they are also described as Low-CO2 cements and concretes.
The greatest disadvantage is that they are in a very early stage of research. There are not yet standards to describe the mix design, the proportions that are used globally, and this doesn't make them a product for the market yet.
In terms of cost according to the mix design they can be more or less expensive than the former products. Concerning the durability description they are performed some accelerated tests to try to describe the state of geopolymers in years and in different conditions. There not some clear results yet, but after the end of my internship the scientific community will be richer on this topic.

Interview & Questionnare Assessment

• The adoption of the word 'waste' is an outcome of linear mentality of production, it is discouraging, condemning, doesn't reflect the shift to an ecological social model and cannot claim a position to metabolic thinking, hence preferably is to be avoided.

• In the current socio-economic framework waste & byproduct composites do not necessarily imply cost-effective production methods

• There are certain time frames in respect of refuse composites life circle's assessment to be provided, and ground for optimization for the new production approaches

• Geopolymers mixed with byproducts composites, in the same manner with a large variety of waste originated products, are in the eraly stages of development, thus, not yet standartized and efficiently tested to meet formal technical requirements and enter the market

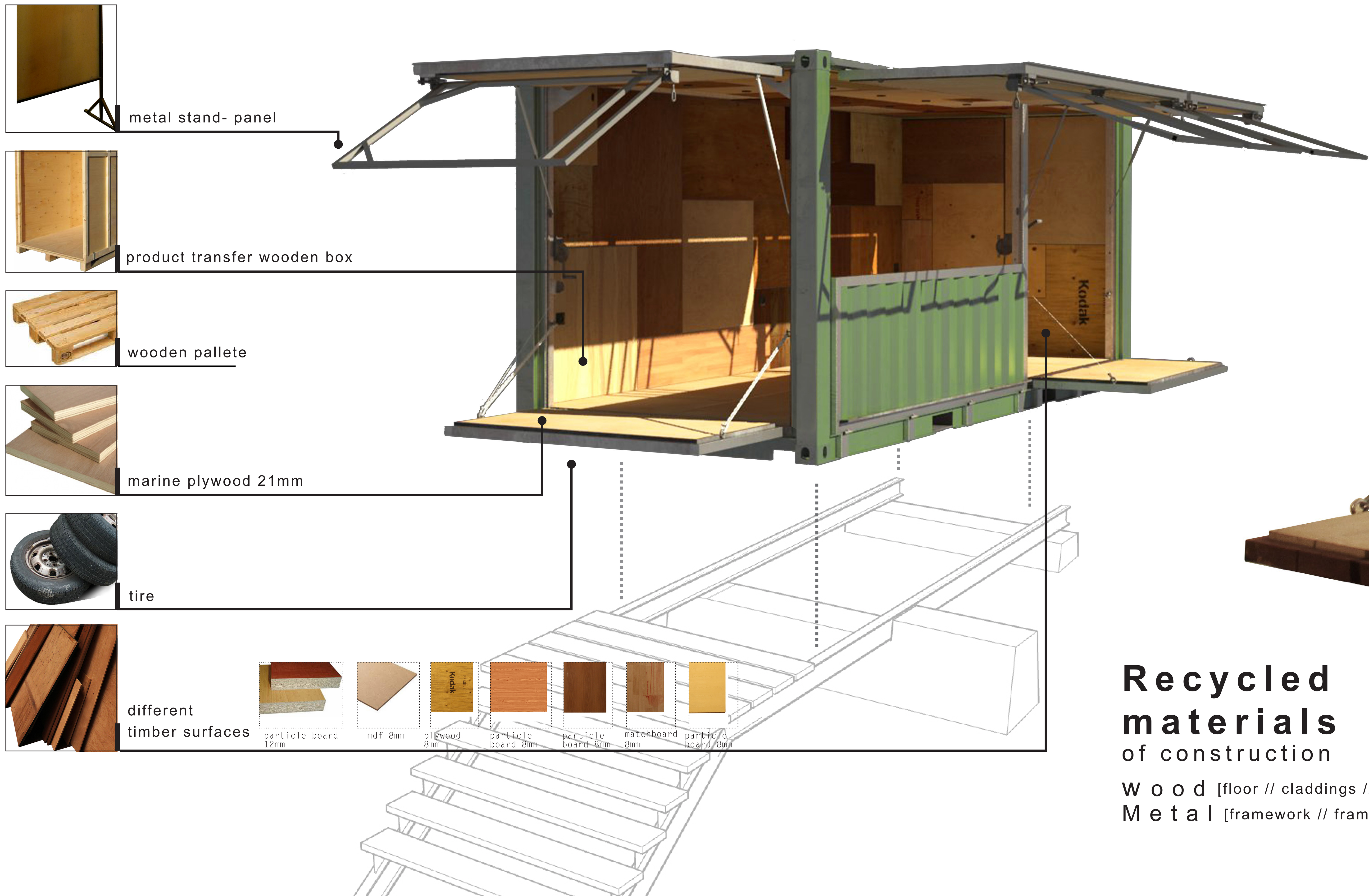
• Despite the closed material loop mentality has been one of the main concerns of the innovative research being conducted in the advanced fabrication methods, this architectural approach remains in an elementary level of development and facing a long road ahead

The Container Project Case Study

Abstract

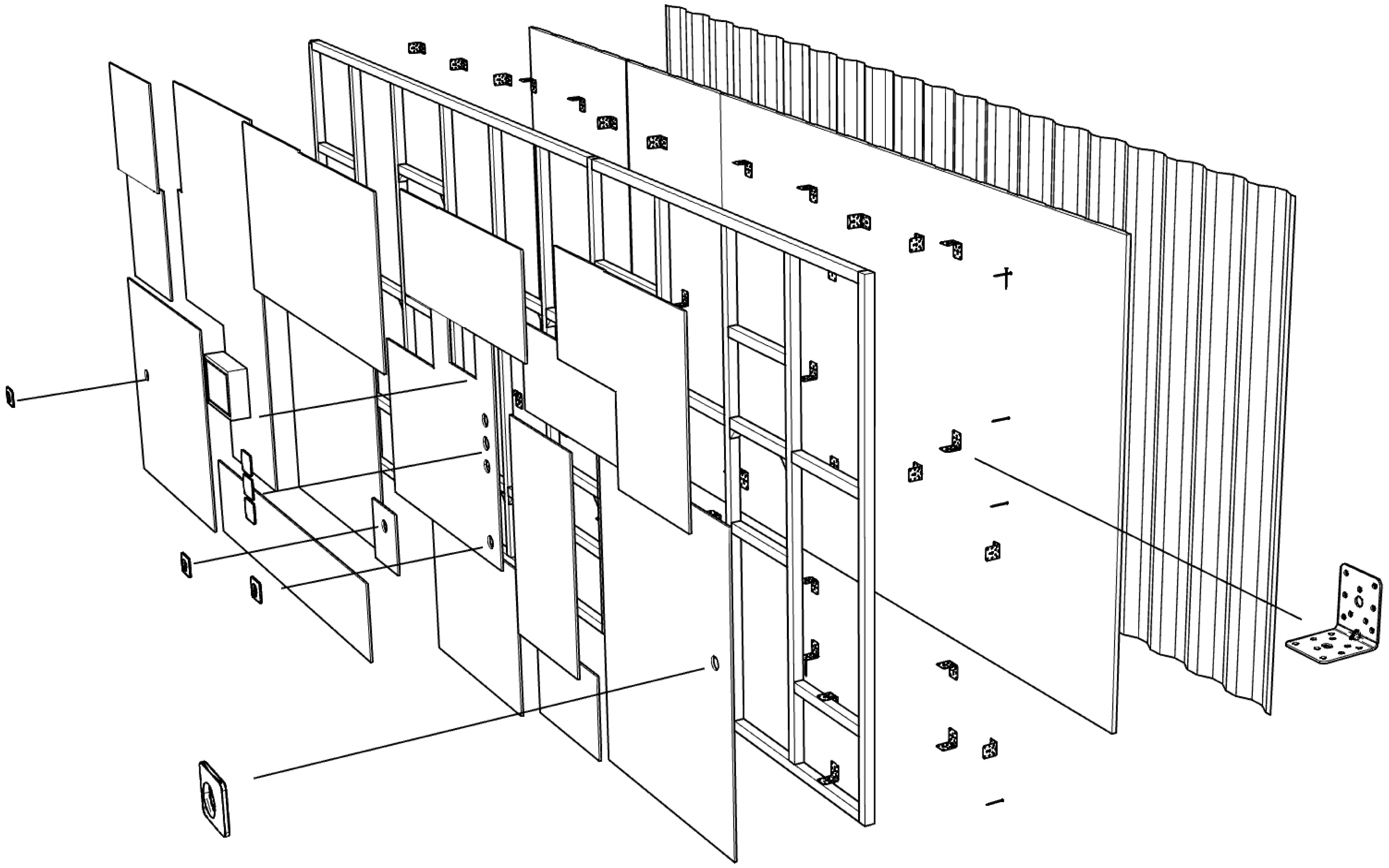
The Container Project constitutes the realization of our graduation project (C. Grivokostopoulos, P. Lianos) in the National Technical University of Athens NTUA (2014), which sprung from an intention of comprehending the idea of inert urban space along with the significance of it in a context of a densely populated metropolis in crisis. The situation of the plot under study was further stressed by the observed inadequacy of the community to appropriate within the statutory frameworks the remaining space in a way that qualitatively embodies the idea of the public realm. Our research on the designing tools that would be able to facilitate this kind of urban void reactivation and public space retrieval, led us focusing on a metabolic mentality of urban mining and minimal interventions able to evolve over time. Modular urban constructions that would be sufficient to mobilise people to act upon their environment. In this view, we decided to exploit an immediate to access raw material resource, the refuse,as well as weaponize our method of approach through utilizing a micro-organism, compared to the building mass that surrounds it, that vitalizes, through piggyback use, and comes front to specific needs of the users, in other words a 'parasite': A module unit-intruder locally grafted onto a suitable arrangement of spare space, able to evolve and alter gradually the existing morphology and the previous inertia of the site. The park Navarinou, a prime example of such a site, began to form by the residents initiative and the 'world' of Exarchia, and now is one of the first occupied outdoor conformations in Athens that, despite the odds, manages to function for seven years self-organized, giving the neighborhood a new meeting and interacting site, and a green relief. The needs of such an area for storing materials and tools and hosting the events and assemblies through which it operates, as well as the will to expand the circle of users in which it refers to, led, through our consultation and cooperation with members of the regular assembly of the park and neighborhood, to the design and the actual implementation of a temporary construction, by reusing and transforming an old container into a small self-organized multispace. A social cafe able to accommodate events and projects - such as workshops, discussions, financial aid practices etc. – organized by the local assembly and respective social groups.

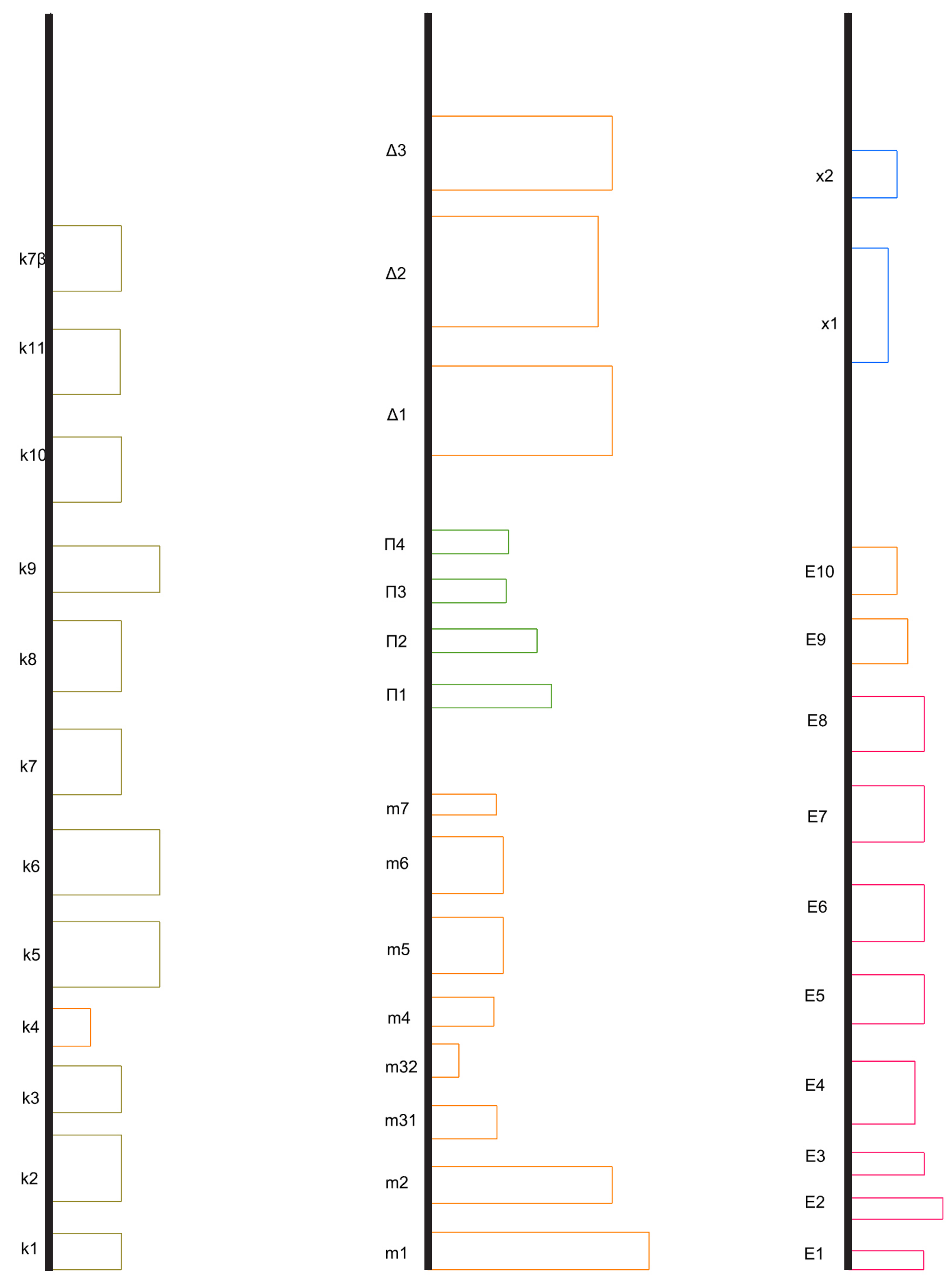
Whereas, fundamental decision was the development of a smart integral design that corresponds to the current needs of the users and is able to respond to different functions and future demands. moreover in the specific case, due to limited accesibility to manufacturing equipment, fund resources and working hands, the shift to waste material exploitation as raw material input and the recruit of volunteer labor were fundamental perconditions.



Recycled materials
of construction

W o o d [floor // claddings // sunshade // furniture]
M e t a l [framework // frames //furniture]



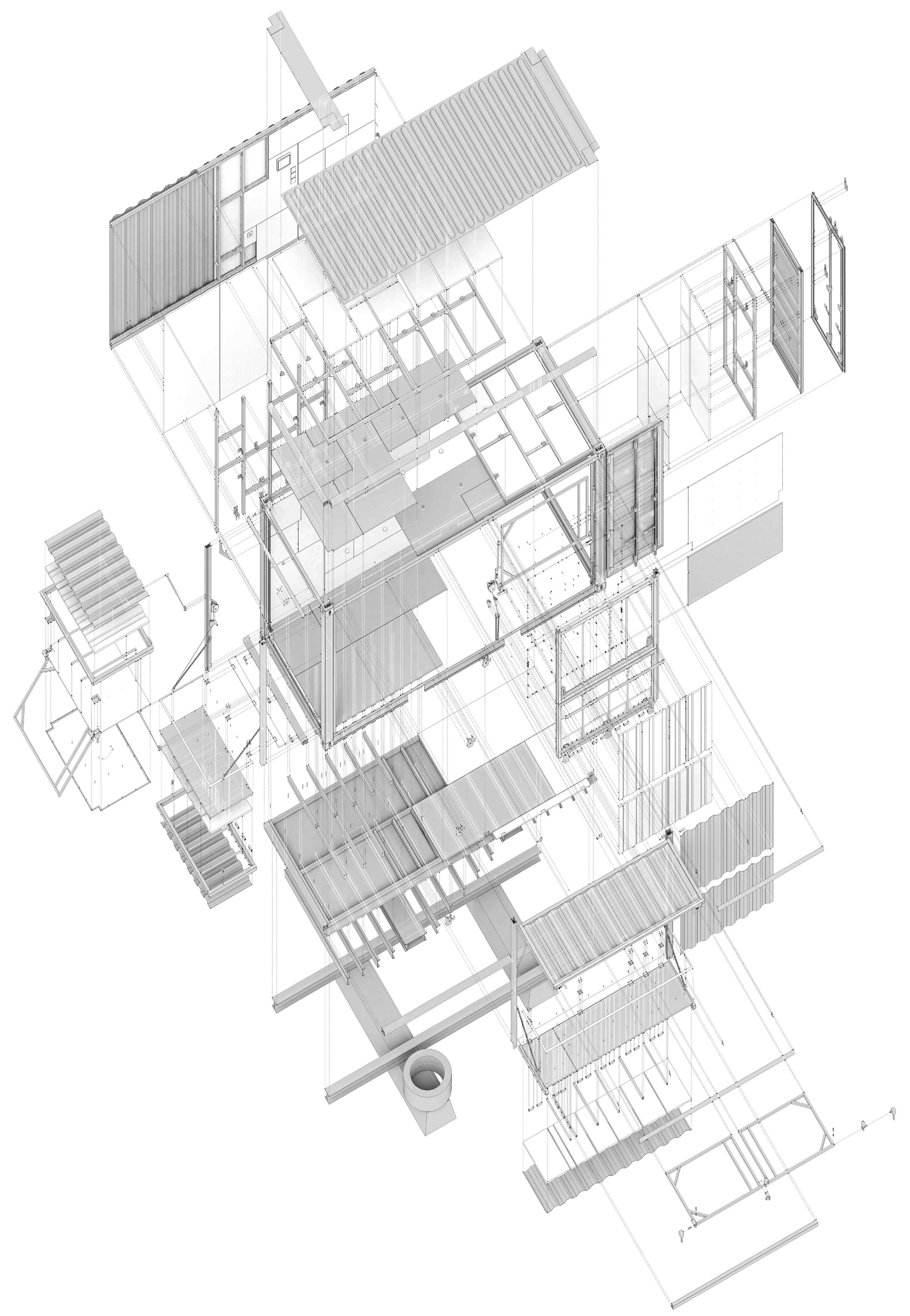


Patchwork

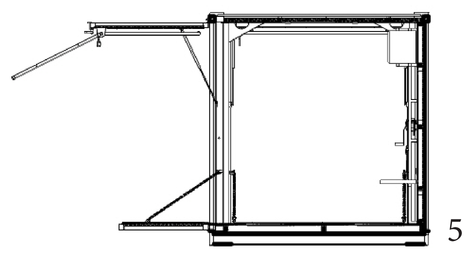
Timper sheets classification

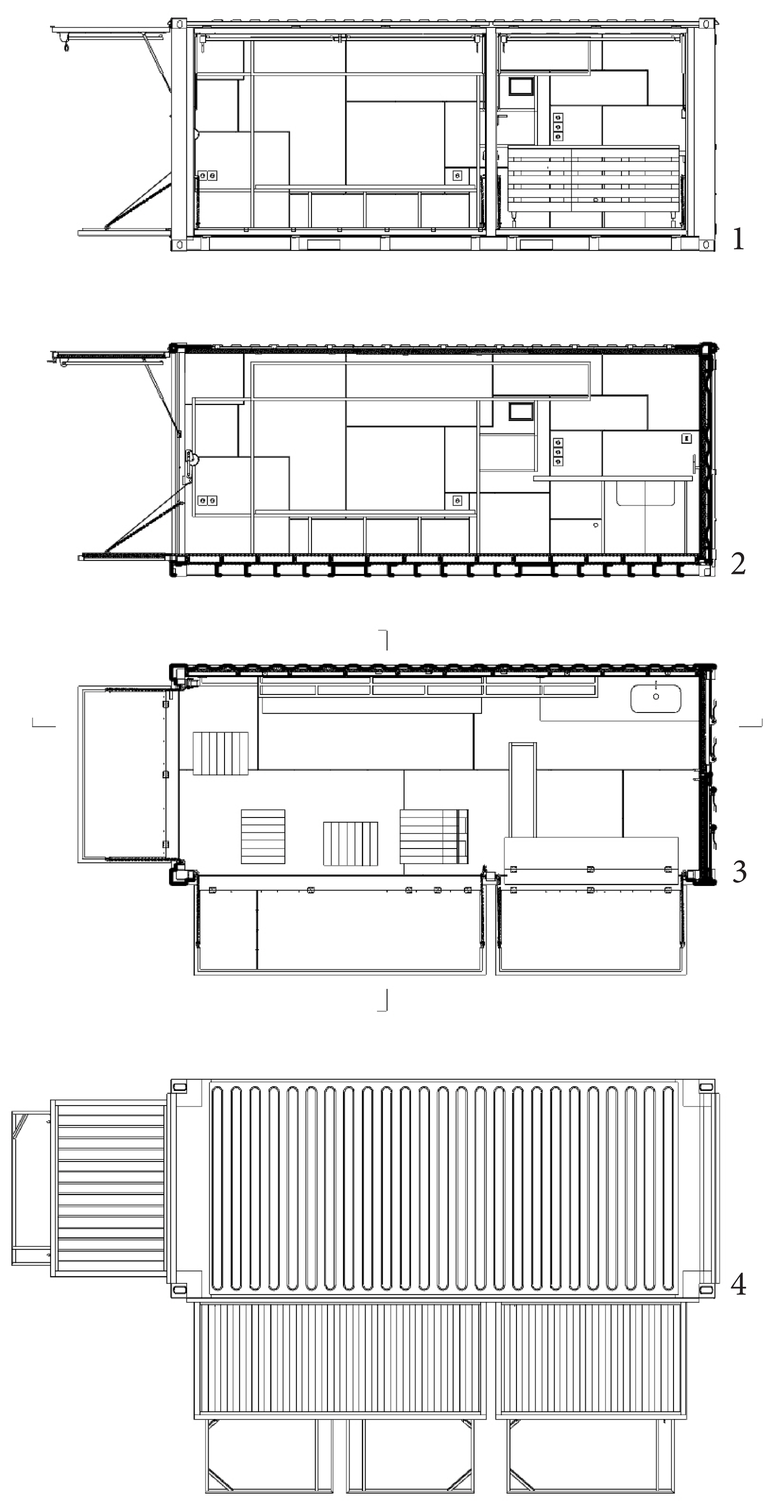
according to type of wood & dimensions

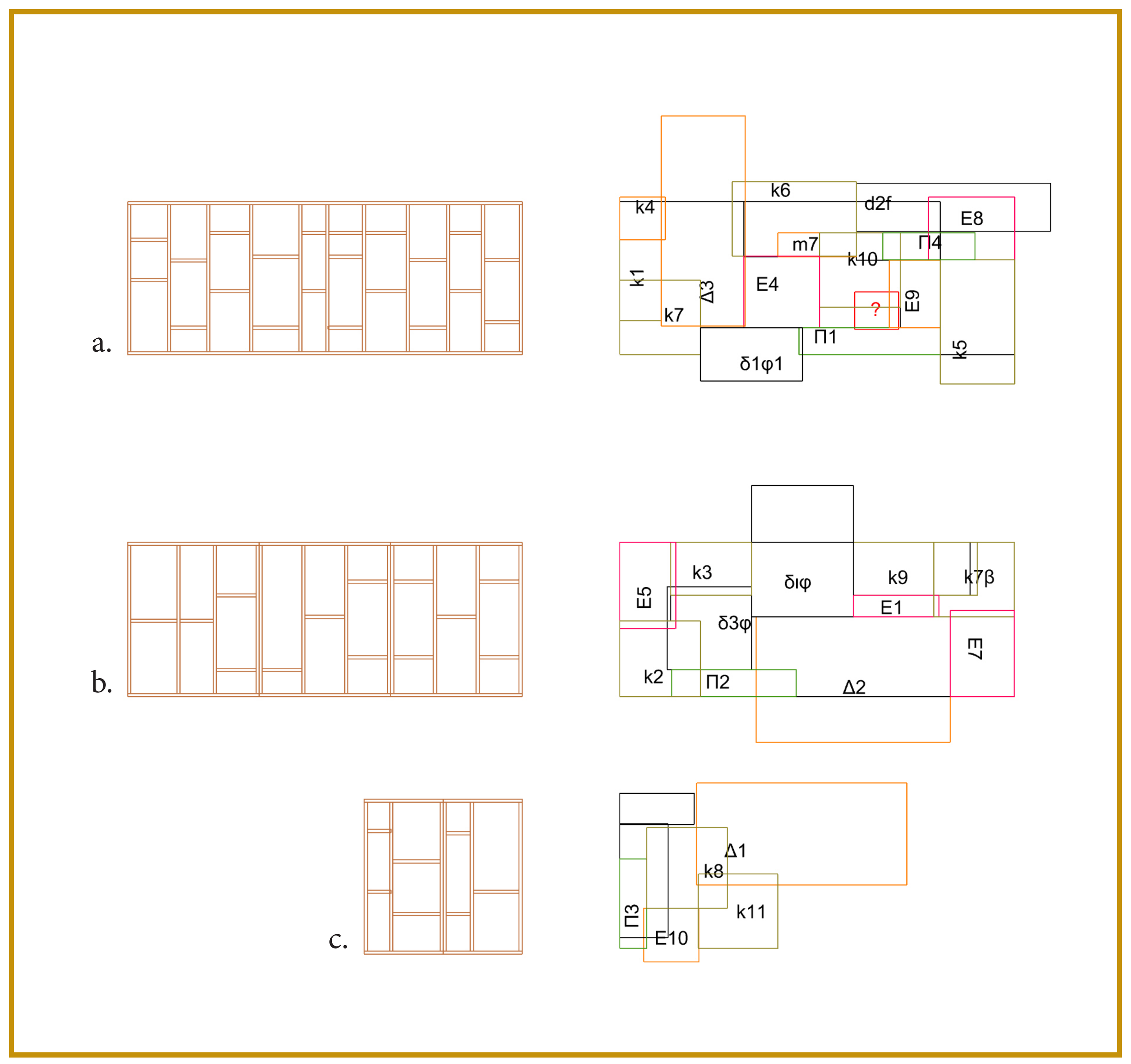
k: plywood 8mm, 9mm & 12mm
m: particle board 8mm, 15mm & 20mm
π: coated mdf 8mm
Δ: mdf 8mm & 12mm
E: chinese plywood 8mm
x: particle board 8mm



1. Front Elevation
2. Longitudinal Section
3. Floor plan
4. Elevation from above
5. Vertical Section

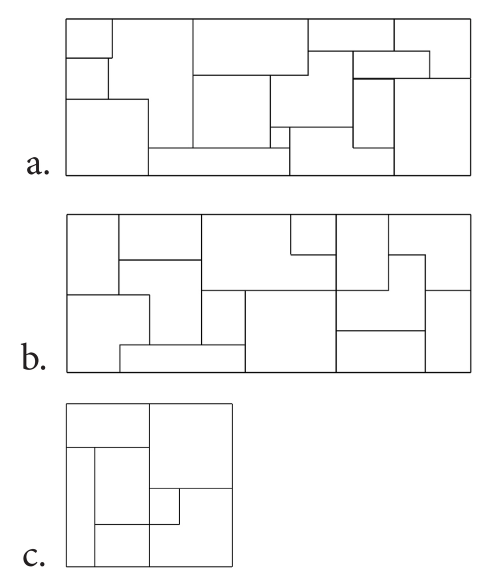






Timber frame formation according to the parchwork's composition

a. Back Wall
b. Sealing
c. Doors

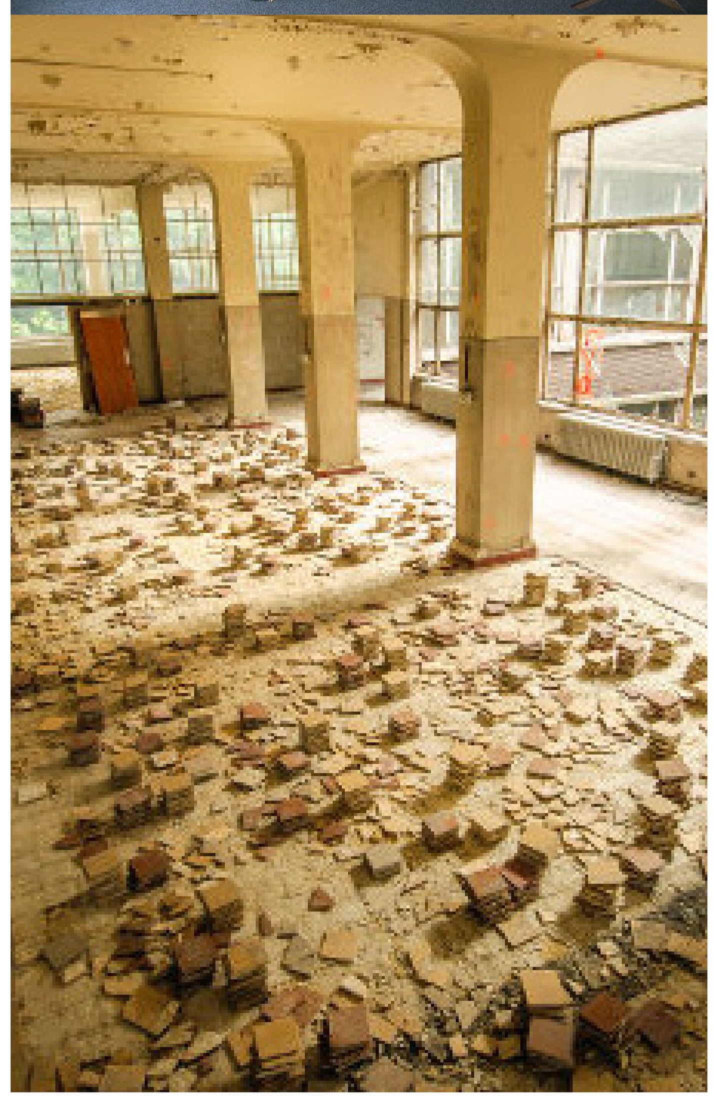


Fundamental Criteria of Patchwork Composition

- Minimum scraps
- Moisture affected spaces
- Durability





Concluding the assessment of this lecture I would like to cite some very instructional guidelines that, in my opinion and personal experience, should regulate any framework of a material rehabilitation project in the architecture practice as provided by the Rotor collective association:

- **Escape the plot dogma; one project at the time**
- **One can be responsible of his own agenda**
- **One should find ways to combine different claim of paradigms as means to create a personal agenda and way to operate**

VISITING PROFESSORS 2016-2017

PUBLIC LECTURE

ROTOR ON DECONSTRUCTION

THURSDAY 11 MAY 12:45 - 13:45 OOSTSERRE BK CITY

Rotor

'Founded in 2005, Rotor is a collective of people with a common interest in the material flows in industry and construction. On a practical level, Rotor handles the conception and realization of design and architectural projects. On a theoretical level, Rotor develops critical positions on design, material resources, and waste through research, exhibitions, writings and conferences.'

Rotor Deconstruction is a project of the Rotor collective that is established on a 10 year research on material flow in the construction sector, and has great potential of constituting an independent cooperation in the near future. Objective of the program is to organize the dismantling and commerce of the valuable construction elements from buildings that are to be subjected in transformation or demolition. The sale takes place through an online platform where detail descriptions of the items and their origin are provided.

A substantial contribution to my experience in the valuation and clarification of emergent problematics in employing disused materials in architecture practice was through a lecture that took place in the Architecture faculty of TUDelft by Rotor team. The discourse was initially and justifiably absorbed by the definition envelop of the word waste once more as means of providing ground of the lecture content to unfold. 'But what is actually waste?' Is it just defined by a moment the user decides he or she doesn't anymore need a component? According to Rotor the notion of waste is actually contextual and can occur from early stages of an elements' lifecycle. Hereof I have to quote that by principle of this investigation and the intended advertisement of precondition of the metabolic mentality, following the paper's precedent definition of 'waste' this dissertation attempts on using the word scarcely as possible. Already during production stream is wide familiar that occurs a redundant amount of refuse and by-products during the making process. Over and above, components are discarded as not competent in fitting the industry's or responsible factors' established criteria in amounts that cannot be considered negligible.

For clarity purposes I will separate the refuse into these 3 rough categories of:
- During-production unusable remains or byproducts
- After-production waste
- Post-consumer waste

The appraisal of interpreting reuse is coming to a person when he or she recognizes value and designation to a component that has been considered at a certain point as waste. The lecture further expanded on some of the problematic parameters of reusing materials in architecture practice acknowledging the market value adjacent to commercial risk and the control of the logistics to affect the equilibrium the most; in which case a consistent management and exposition of the whereabouts of refuse coming along with an establishment of an inventory can provide immense probabilities of the materials' rehabilitation.

After the debate was occupied by the impurity of 'sustainability' today, once again the unit of language and not the actual perception of it, that is to be attributed mainly to a United Nations manifestation that initiated 3 decades ago in an attempt to "formulate aspirational goals for the world community" and in the name of environmental urgency.

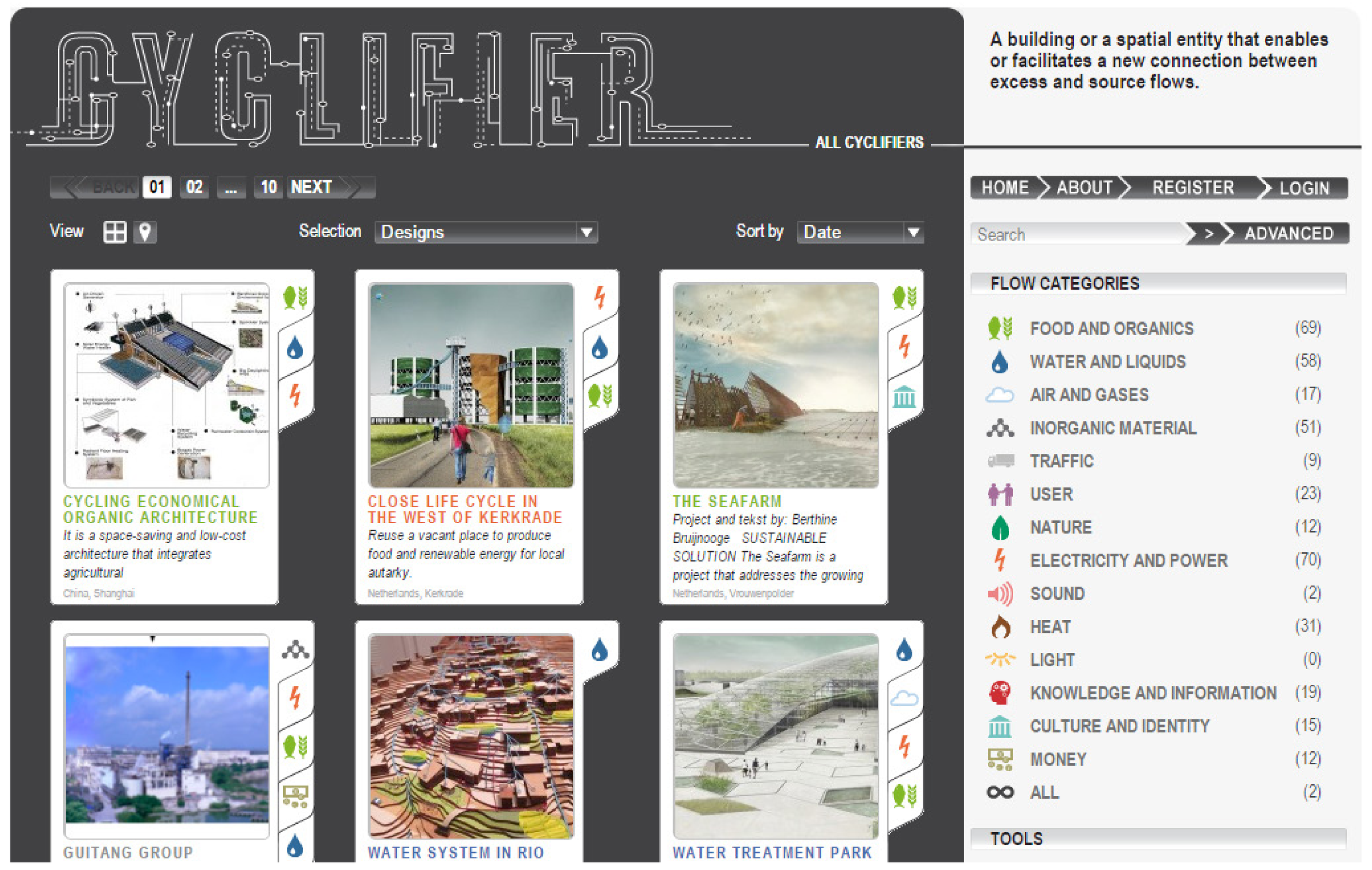
Sustainability: "..is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

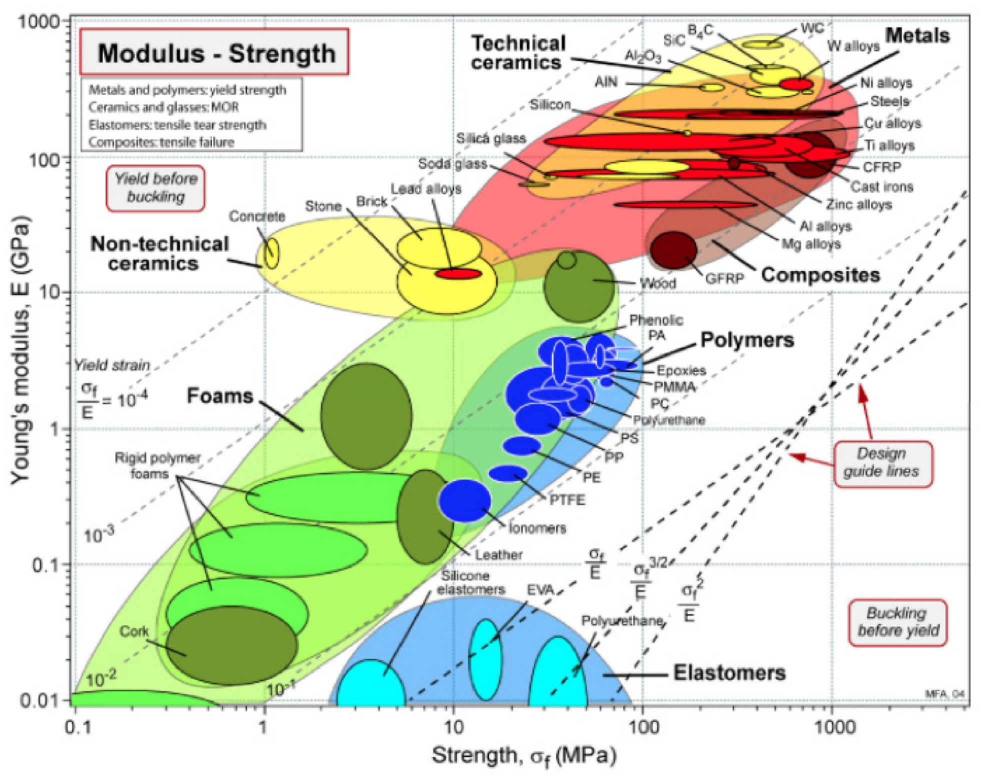
An additional interesting approach was Rotor's reflection on the increased burden of this sentence stemming from the words 'future' and 'needs' which seem to undermine any decision making process in regard to the fact that these needs do not yet exist thus being obscure, and weaponize the meaning of sustainability.

On-line Data Platforms

within the Topic of Material Reuse & Construction

Material Property chart indicating Technical Modulus - Strength ceramics AlN Metals and polymers yield strength
Ceramics and glasses Elastomers tear strength Composites tensile etc.





1. Harvestmap is an online marketplace for redundant and second hand materials. Harvestmap allows companies or individuals to make an inventory of their supply of materials, components or even buildings to superusers. All materials, ranging from small quantities to continuous flows of (industrial) left-overs are represented. Registration and participation allows you to share your own supply, provide tips to the community and find available resources in your neighbourhood or the surroundings of a project. Harvestmap is under continuous development as we learn how to improve the platform, making sharing resources even more simple.

2. Cyclifier is an online community of enterpreneurs, companies, designers, architects and everybody else who is interested in or contributes to innovations that contribute to local exchange and production. The site allows you to post items at various scales within the reuse-topic. All examples of small commodities, furniture, interiors, buildings and reuse on urban scale are welcomed. Next to exhibiting applications, the platform promotes the development of knowledge on the subject by starting up discussions, adding historical background and allowing usercomments.

3. CES Selector is a PC application that enables materials experts and product development teams to find, explore, collate and apply materials property data

4. Opalis is an online inventory of the professional sector in salvaged building materials around Brussels. This site is intended for all contractors, architects and building owners who wish to work with reuse materials. You will find: An updated directory of professional resellers, materials, practical tools and documents.

A Few Words about Wood

Wood is one of the most often reused materials in building construction by means of urban interventions, temporary installations, furnishing and small scale structures due to its wide availability, easy and fast application in construction, dry assembly potential and aesthetics. Reusing wood in its 'natural' state though, implies as precondition a minimal elaboration, if none, confined in, dimensions adjustment and scraps removal through severing, carving, and finish. Additionally, wood has a relevant short life cycle compared to other material, and most often as refuse is not standardized in type or dimensions, a major influential parameter in design with limited control of logistics, can be pest-infected, have various forms of corruption and its remaining days our counted. Thus, employing wood as raw material input, not in the form of lesser quality composite, back to the production stream is an ambitious aspiration if the initial structural properties are intended. Although, wood as fiber composed element can be easily transmuted, mainly through industrial elaboration, in a wide range of products and find various applications in building construction through the production of countless familiar industrial composites. In fact, fiber cellulose composites have become an emergent market product in respect to the natural resource depletion and the distressing ecological situation.

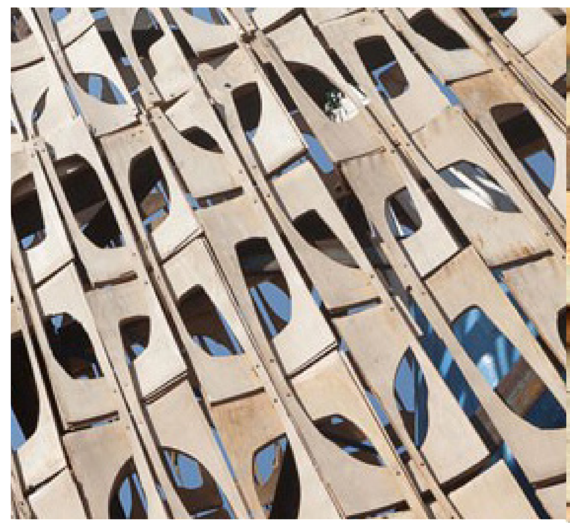
In **conclusion**, used wood, in its natural form, is most probable to retrieve its place as an integral part of building construction mainly through conventional equipment and refinement processes in paneling by heterogeneous types of timber (patchwork). As far as to the concern of the current investigation, wood's re-employment as raw material input in advanced manufacturing production is achievable and worthwhile only through its industrial of-the-shelf composites and not through urban mining processes.

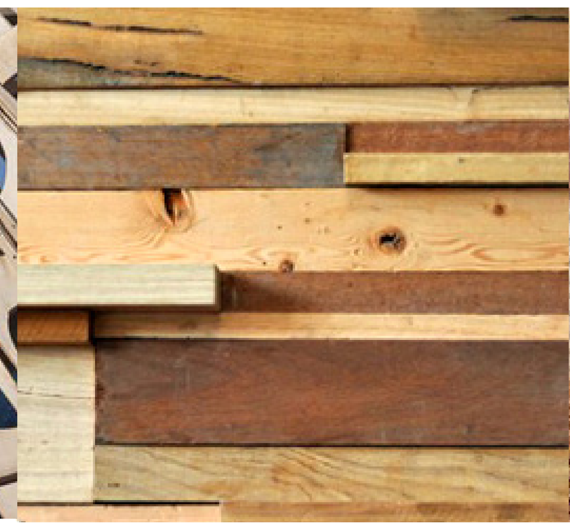
Common Salvaged Timber Types


Sheets


Beams and planks

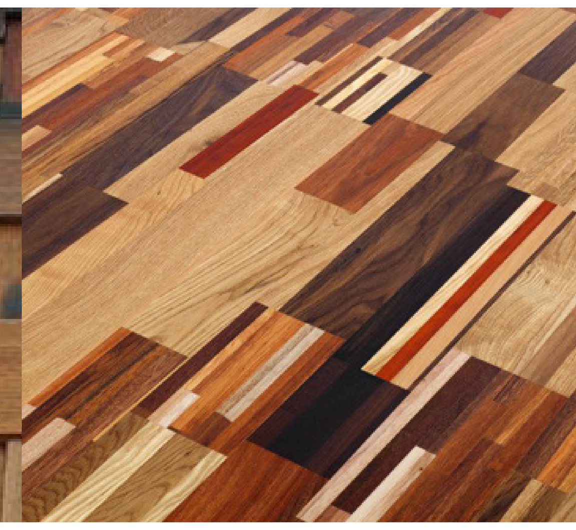
Patchwork Methods


Regular pattern of skateboard manufacturing scraps


Irregular pattern of variable size & thickness timber strips

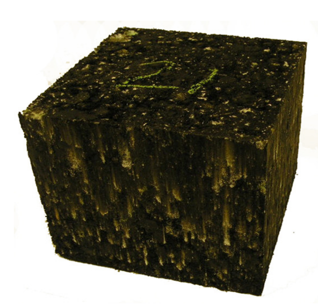
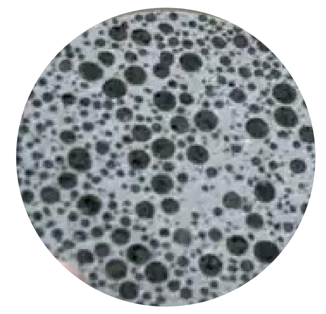

Polygon regulated pattern of same thickness components

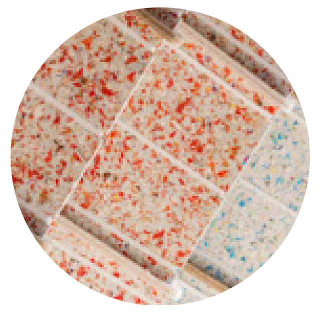
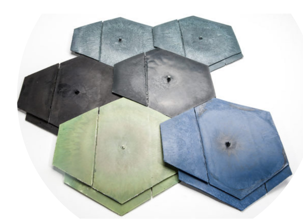

Cubic regulated pattern of certain dimension categories components


Irregular pattern of variable size, but same thickness timber strips


Regular pattern of variable size, but same thickness timber strips

Urban installations from Raumlabor collective in the first two images & own project in the last image
Source: http://raumlabor.net/

	ECOR	Paper Waste Brick	Bagasse Particle Board	Newspaper Wood	Bitublock	Fly Ash Cement	Self-Healing Concrete	Clay & Slag Brick	Stonecycling Brick
									
Developed by	Noble Environmental Technologies	Spain's University of Jaen	Universities of India	Vij5 and Mieke Meijer	Dr. John Forth	UNKN	Bacterial Mineral Precipitation, TUDelft	TNO, Delft	Tom van Soest
Waste Origin	cardboard, newspaper, office paper, discarded wood chips, residual agricultural fibers including Bovine Processed Fiber (BPF), kenaf, oat, coffee, coconut, and other waste fibers	paper waste and by-products of the paper industry and waste water purification	sugar mills by-product	newspapers	recycled glass, incinerated sewage sludge ash (ISSA), quarry fines, MSW Incinerator bottom ash (MSWI BA), construction and demolition waste and other recycled aggregate	fine powder which is a byproduct from burning pulverized coal in electric generation power plants, a residue left at the end of the coal combustion process	construction market and micro-organisms laboratory development	clay material and slag deriving from the ferronickel production industry	demolition sites
Composition	100% Bio-based material converted from waste cellulose fiber, pressure, and heat	paper waste and waste from water purification, mixed in a ceramic blend(clay) and pressurized	bagasse fiber residual pulp from sugarcane	Newspaper and a type of adhesive (UNKN)	mix of coarse, fine and filler particles, ratios dependent on the feedstock material and desired product properties	fly ash and Blast Furnace Slag (BFS) mixed with lime and water it forms a compound similar to Portland cement	concrete in addition to microfibers and calcium carbonate precipitating micro-organisms	geopolymers from metakaolin, slag, NaOH and waterglass	pulverized recycled building materials (not provided composition)
Application	interior, furnishings, signage, displays, packaging, consumer products, artwork, storage, shelving etc.	conventional building construction	core material for laminated floors, replacing high-density and expensive wood fiberboard	panelling, furniture and interior equipment	load and non-load bearing construction units such as concrete and clay based building blocks	loadbearing construction and all building purposes	ideal for sewer, underground retainers for hazardous waste etc. building purposes	loadbearing construction and all building purposes	both interior and exterior applications on building construction
Waste Comp. Availab.	●●●●●	●●●●●	●●●●○	●●●●●	●●●●●	●●●○○	●●○○○	●●○○○	●●○○○
% Waste Composite	●●●●●	●●●○○	●●●●○	●●●○○	●●●●●	●●○○○	●○○○○	●●○○○	●●●○○
Manufact. Facility	●●●○○	●●○○○	●●●●●	●●●●○	●●○○○	●○○○○	●○○○○	●●○○○	●●○○○
Structural Efficiency	●●●○○	●●○○○	●○○○○	●●●○○	●●●●○	●●●●○	●●●○○	●●●●○	●●●○○
Thermal Insulation	●●●○○	●●●●○	●●●○○	●●●●○	●●●○○	●●●○○	●●●○○	●●○○○	●●●○○
Acoustic Insulation	●●○○○	●●●○○	●●○○○	●●○○○	●●●○○	●●●○○	●●●○○	●●○○○	●●●○○
Fire Resistance	●●●○○	●●●●●	●●○○○	●●○○○	●●●○○	●●●●○	●●●●○	●●●●○	●●●●○
Waterproof Efficiency	●●●●○	●●●●○	●○○○○	●●●●○	●●●●○	●●●●●	●●●●●	●●●●●	●●●●●
Cost Effective	●●●○○	●●●●○	●●●●○	●●●○○	●●●○○	●○○○○	●○○○○	●●○○○	●●○○○
Optimiz. Potential	UNKN	optimized through alternative, green products as sewage sludge, brewing by-products, olive, producing biodiesel etc.	mix with pMDI resin as a bonding agent and wax as dimensional stabilizer for laminated floor and furniture applications	UNKN	possible future changes due to product quality protocols may make current potential waste inputs more attractive	optimum amount of fly ash varies not only with application, but also with composition and proportions in the mixture	development of capsules with properties to survive the mixing process and release the healing agent	concerning durability description accelerated tests are required to estimate the material behaviour in its lifecycle	UNKN
Additional Estimation of the Product	+ no toxic adhesives, additives, formaldehyde, or other sources of off-gassing + bonds well with virtually any adhesive, coating, treatment, laminate or veneers + 75% lighter than conventional panels	+ requires less time of baking than conventional bricks - poor in mechanical strength - adhesion and forming difficulties following the production procedure	+ manufacturing process on a commercial scale + substitute for wood + lightweight	+ resemble the aesthetics of real wood	+ low carbon footprint and high recycled content generate price advantages + the adaptable process conditions appears highly suited to a wide range of wastes and the more inconsistent nature of waste characteristics - Heavy metals may be present in some of the aggregate wastes.	+ contains various heavy metals and toxic elements which are usually allowed to disperse in the atmosphere or is dumped in a landfill - Fly ash is a pozzolanic material, expensive replacement for Portland cement	+ self-repairs cracks in concrete structures + substantial savings, especially in steel reinforced concrete	+ utilizes by-products + low condensation in CO_2 - early stage of research - cost related uncertainty	+ meet today's industry requirements and can be used for both the interior and exterior of buildings + produced from various types of waste, and combined in different ways to create new colours, textures, shapes and sizes

	 Saw Dust & Rice Husk Building Brick	 Rice Husk Ash Concrete (RHA)	 Fungi-brick	 Recycled Glass Brick	 Replast Brick	 Beverage Carton Brick	 Polli-Brick	 'Pretty Plastic' Tile	 Plastic Bag Brick
Developed by	UNKN	India	Mycologist Philip Ross	Japan's GRC, Beecycle, Kingston	Byfusion	ReWall	Miniwiz	Materia	Carter Zufelt, Wasted
Waste Origin	fine powder which is a byproduct from burning pulverized coal in electric generation power plants, a residue left at the end of the coal combustion process	by-product of burning the outer shell of the paddy that comes out as a waste product during milling of rice	corn stalks, hemp, and mycelium grow into solid objects in about five days with no added energy (can be composted at the end of the installation)	hydro-thermally solidified materials from breaking down glass waste into sand grade	all kinds of plastic from landfills and recycling facilities	beverage carton packages from landfills	plastic bottles from landfills and recycling facilities	locals who separate their waste, through WASTED and through visitors, who can bring plastic instead of a ticket when entering FabCity	milk containers, tupperware, oil/shampoo/detergent bottles, and mainly plastic bags
Composition	cast from fluorogypsum binder/plaster using saw dust, rice husk and exfoliated vermiculite	rice ash as admixture for concrete	chopped-up corn stalks, hemp, and mycelium	30-70% pozzotive glass replacing sand as admixture to cement	mix of shreded unsorted plastics	shreded and pressed material of 100% beverage cartons (paper, polyethylene and aluminum)	mechanically recycled plastic of type PET from drinking bottles	sorted, washed, grinded and moulded recycled plastic of type PET, HDPE and PE	plastic bags of type HDPE
Application	bricks, flooring tiles and plastering	special concrete mixes, high performance concrete, high strength, low permeability concrete	interior and exterior application on building construction	bricks, tile blocks, floor materials, outdoor furniture	interior and exterior application on building construction	initially intended for interior cladding, but also various exterior applications	panelling, interior and exterior application on building construction	panelling slates and tiles, interior and exterior application	brick for interior and exterior application
Waste Comp. Availab.	●●●○○	●●●●○	●●●●○	●●●○○	●●●●●	●●●●●	●●●●●	●●●●○	●●●●●
% Waste Composite	●●●○○	●●○○○	●●●●○	●●●○○	●●●●●	●●●●●	●●●●●	○○○○○	●●●●●
Manufact. Facility	●●○○○	●●●○○	●●●○○	●●●○○	●●●●●	●●●○○	●●○○○	●●○○○	●●●●●
Structural Efficiency	●●●●○	●●●●●	●●●●●	●●●●○	●●●●○	●●○○○	●●●●○	●●●●○	●●●●○
Thermal Insulation	●●●●○	●●●●○	●●●●○	●●●○○	●●●●○	●●●○○	●●●●○	●●●○○	●●●○○
Acoustic Insulation	●●●○○	●●●○○	●●●○○	●●●○○	●●●●○	●●●●○	●●●○○	●●●○○	●●●○○
Fire Resistance	●●●○○	●●●●○	●●●●○	●●●●○	●●○○○	●●○○○	●●●●○	●●●○○	●●○○○
Waterproof Efficiency	●●●●○	●●●●○	●●●●●	●●●●○	●●●●●	●●●●●	●●●●●	●●●●●	●●●●○
Cost Effective	●●●○○	●●●○○	●●●●○	●●●○○	●●●●○	●●●●○	●○○○○	●○○○○	●●●●○
Optimiz. Potential	further studies on fire resistance and standardization, also addition of waste lime sludge may add economy	study on applications of RHA as repair mortars, coatings and soil stabilization	dial in different material properties of the bricks by changing variables, tune the material for permanent structures	integral pigment can be applied to the mix to further enhance the brick, by offering more design possibilities	improvement of product's production method and appearance for promotion reasons	UNKN	UNKN	UNKN	further ways of interlocking process and moulding shapes in regard to the need of assembly
Additional Estimation of the Product	+ lightweght + FG binder is cheaper than the lime and cement binders	+ carbon neutral green product + reduces the consumption of cement due to blending + considered a class apart from all other mineral admixtures due to its unique microstructure and the resultant benefits in concrete and its multi various application possibilities	+ 100% organic and compostable + stronger, pound for pound, than concrete + super-strong, water-, mold- and fire-resistant + grown and formed into just about any shape	+ artificial super-light aggregate + approximately 95% of coal Btu energy equivalent is saved + endless aesthetic possibilities	+ requires no adhesives + LEED certification + 95% lower greenhouse emissions (GHG) compared to concrete block + flexibility in shape - in some cases need additional support - appearance	+ no additional adhesives + waterproof due to its initial intended production reason - low mechanical strength	+ the 3D strong self-interlocking structure without chemical adhesives + translucent + 1/5 of standard curtain wall systems + lightweight + UV protection + scratch-resistant and easy to clean - process economically efficient in mass manufactured on-site	+ chemical resistant + lightweight + scratch resistance - moderate UV resistance - not renewable	+ HDPE has a high strength-to-density ratio, is widely accessible, and can be found in an abundance of colors + very simple production process - not yet applied and tested in building construction

The evaluation of the properties of each recovered material composite has been made with main criteria in accord to its application potential, in comparison with the other recycled products, and in regard to the evaluation of data provided from their developer, eco-friendly carriers and general web resources

Laboratory
Design & Construction Guidelines

"Floor and Base Materials: Floor materials should be non-absorbent, skid-proof, resistant to wear, and resistant to the adverse effects of acids, solvents, and detergents. Materials may be monolithic (sheet flooring) or have a minimal number of joints such as vinyl composition tile (VCT) or rubber tile. Floor materials should be installed to allow for decontamination with liquid disinfectants and to minimize the potential spread of spills.

Walls: Wall surfaces should be free from cracks, unsealed penetrations, and imperfect junctions with ceiling and floors. Materials should be capable of withstanding washing with strong detergents and disinfectants and be capable of withstanding the impact of normal traffic.

Ceilings: Ceilings such as washable lay-in acoustical tiles (Mylar face with smooth surface or equivalent) should be provided for most laboratory spaces. Open ceilings are acceptable provided minimal ducting and piping is present and all exposed surfaces are smooth and cleanable.

Windows and Window Treatment: Windows should be non-operable and should be sealed and caulked. Window systems that use energy-efficient glass are recommended. Treatments should meet all functional and aesthetic needs and standards.

Doors: Vision panels are recommended for all laboratory doors. In laboratories where the use of larger equipment is anticipated, wider/higher doors should be considered. Laboratory doors should be recessed and swing outward in the direction of egress. Door assemblies should comply with all appropriate codes. Biosafety Level 2 (BSL-2) laboratories should have doors that are self-closing and have locks.

Door Hardware: Laboratory doors are considered high-use doors. All hardware should be appropriately specified to withstand this type of use. Light commercial grade hardware will not be specified. All appropriate hardware to meet security, accessibility, and life safety requirements should be provided.

Module/Bay Size: The dimension of the structural bay, both vertical and horizontal, should be carefully evaluated with respect to the laboratory planning module, mechanical distribution, and future expansion plans. Because of the importance of the laboratory planning module to functional and safety issues, the laboratory planning module should be considered as the primary building module in multi-use facilities.

Equipment Pathway: The potential routing or pathway for the addition or relocation of heavy equipment should be reviewed and identified during the design phase.

Hazard Communication Signage: Each laboratory should have a signage holder for prominently displaying hazard communication information at the entrance door. Individual labs should have signage holders that are consistent with the type used by other laboratories within each department or building.

Flammable Chemicals and Waste Storage: Flammable-chemical storage cabinets should be placed in each laboratory and meet applicable fire safety requirements. Flammable storage cabinets should not be located near exit doorways, stairways, or in a location that would impede egress. Space should be allocated in each laboratory for storage of chemical waste."

The primary requirements for the design of laboratory are mainly in regard to the creation of a safe and spatial accessible environment for the personnel to conduct their work to. An additional design objective is maximum flexibility for safety reasons and as to allow the potential of learning processes. The health and safety percussions should be carefully evaluated and integrated to the design wherever feasible.

Main Requirements of Building Design

- Preferably noncombustible construction
- Clear segregation between offices and lab
- In case of utilization of natural gas, an automatic shutoff valve is required

Design Considerations

- Auxiliary spaces as storage room, kitchen, toilet are required
- The workstations should designed as flexible as possible in order to accommodate different functions and the whole range of body dimensions
- Working surfaces and walls should be mechanically strong, smooth for cleaning purposes and impervious to chemicals. Any penetrations for electrical, plumbing and other necessities should be completely sealed
- Shelf lips should be provided for the bookshelves
- A sink for hand washing should be provided

Finishes & Materials In Architectural Design

The design method and material features required for the construction of a lab, that can be exposed to chemicals (in this case additives, adhesives, melted materials and their reactions), are depended on various characteristics such as durability, precision and smooth cleanable surfaces, which can contribute in the facilitation of maintenance, and pest infection, as well as the creation of comfortable productive and most importantly safe working environment. The material finishes must be resilient to the corrosive activity of disinfectants and other chemicals that participate in the laboratory's operation. The selection of materials and design of penetrations are also unconventionally influenced by the fire safety building regulations.
Bellow, follow some fundamental design guidelines for architects and engineers, in regard to materiality and function of the main composing elements of a building, as provided by the Department of Environmental Health & Safety of the University of South Carolina, USA:

Substantial challenge comprises the capability of employing the refuse through DIY fabrication procedures to meet the demanding requirements of lab design. Even though the construction guidelines of a conventional maker-space do not present to expand further than basic safety protocols, proper ventilation requirements, spatial accessibility and work space flexibility, the elaboration of variable types of waste materials including polymers and the adjacent chemical adhesives in material composition concludes in troublesome directions of 'how to build a laboratory' in regard to safety provision, high-end slick building materials, mechanical strength and general quality of construction. Hereof, the research elaborates in the prospective considerations of design in accord to preconditions provided from the Environmental Health & Safety Department of North Carolina, USA and spatial indications from Fab Academy's floor plan layouts.

Waste Lab Recommended Construction Elements

Floor
- non-absorbent
- skid-proof
- resistant to wear
- washable
- monolithic or minimum joints (large paneling components)

Walls
- no unsealed penetrations
- mechanically strong
- no imperfect junctions with ceiling and floors
- washable

Ceilings
- washable lay-in acoustical tiles
- smooth surfaces

Sources of data: -Laboratory Design & Construction Guidelines, University of South Carolina, Department of Environmental Health & Safety, 2010
-Laboratory Safety Design Guide, Environmental Health & Safety Department, updated 2015

FABRICATION

Relevance of Material Rehabilitation in Digital Fabrication

The advanced fabrication technologies are innovative production methods based on iteration which have great potential of launching a new mentality by activating the refuse as integral elements of the raw material reserve, even initiate efforts of a precycling mentality*[1] by providing components capable of obtaining a forehand afterlife, said differently: processed materials anticipating to be re-used.

Additionally, recent developments on computer aided manufacturing (CAM) demonstrate a significant tension of incorporating these innovative tools as integral part of the design and construction procedures, while digital fabrication has indicated great potential of enhancing circular processes and completing material loops. More specifically, the on-going research on developing and integrating digital technologies to the current architectural perception and production procedures ''…promises substantial contributions to sustainability and productivity, while at the same time enabling completely new forms of architectural expression''[2].

The Material Parameter

Data permutation between design and construction has always been a reciprocal process. Furthermore, today the designer is able to exploit the new representation and production methods through a process genuinely constrained by the material parameter. The design of digitally fabricated architecture is exploiting the leverage of being informed by the methods and material of construction in very early development stages. "…perhaps never more so than now, when digital media and emerging technologies are rapidly expanding what we conceive to be formally, spatially, and materially possible."[3] Obtaining this knowledge of materiality and fabrication techniques in such early phases of the design process can deliver great optimization potentials on calculating the cost, energy and material consumption of a project.

All the efforts of investigation however until recently have been complied in a technical calibration between digital representation and actual implementation in respect of structural and performative assessments. The overall evaluation of advanced technologies abilities to ecological contribution still remains in elementary level. '' The multidisciplinary nature of integrating digital processes remains a key challenge to establishing a digital building culture. In order to fully exploit the potential of digital fabrication, an institutional and funding environment that enables strong interdisciplinary research is required. Traditionally separated disciplines such as: architecture, structural design, computer science, materials science, control systems engineering, and robotics now need to form strong research connections''[4]

The New Economy

In like manner, the terms digital fabrication seem to abstain from vernacular implementations and remain in the collective consciousness as elite, futuristic fruitions. This predicament is preserved and promoted by current business and educational models that are depended on fragile economic correlations, and seem incompetent to adapt and survive in the new industrial status quo. Thus, significant percentage of the building industry is still holding strong foundations in formerly elapsed production processes that fail to respond sufficiently to the current requirements for productivity and sustainability.

However, innovative digital manufacturing advancements are gradually passing the new regime from the web into the physical word, promoting the transformation of industrial production processes through personal manufacturing. The most interesting part of this advancement is that small fabrication is flourishing in far distant corners of the world, utilized by developing communities; mass customization is one step closer to common practice and large scale implementations not far from reality.

Despite the respectable intentions though of institutional carriers and the substantial benefits of their research, in reality, the luxury of attending these educational programs and participating in innovative research on advanced manufacturing technologies is seemingly not realizable or for everyone available. Developing countries which are estimated to have the highest rates of population growth, urbanization and subsequent construction necessity, thus justifiably facing the most significant manifestation of environmental pollution, are the least prepared to confront it, awaiting for external assistance. In specific, more than half of the global population, that is to say around 3.9 billion people, are concentrated in urban settlements which occupy roughly 2% of the planet's surface.[5]

[1]*Precycled projects are the ones that strive to use an off-the-shelf product that can be reused after its use as an architectural installation. [Christopher Beorkrem, Material Strategies in Digital Fabrication, 2013]
[2]https://www.ethz.ch/en/the-eth-zurich/global/eth-global-news-events/2016/12/eth-meets-you-at-the-aaas-2017-in-boston/DigitalFabrication.html
[3]Lisa Iwamoto, Digital Fabrications, Architectural and Material Techniques, p.004, 2009
[4]https://www.ethz.ch/en/the-eth-zurich/global/eth-global-news-events/2016/12/eth-meets-you-at-the-aaas-2017-in-boston/DigitalFabrication.html
[5]Department of Economic and Social Affairs Population Division, 2015_. World Urbanization Prospects , New York: United Nations, The Revision 2014

The Fab Lab Network

Evidently, the launch of the Fab Labs (Digital Fabrication Laboratories) by the professor at MIT and the director of MIT's Center for Bits and Atoms Neil Gershenfeld in December of 2003, and the widespread development of this phenomenon in far distant territories of the planet has indicated that due to increasing requirements for substantial immediate answers to local needs, advanced production equipment in underdeveloped communities seems to be needed the most; or as he wisely put it: "…some of the least developed parts of the world need some of the most advanced technologies."

Personal Fabrication

In respect to the relatively recent transition from mainframes to personal computers (PC's), the accessibility of advanced manufacturing technologies to ordinary people in the form of personal fabricators (PFs) is gradually becoming more evident. With the proper combination of digital tools, anyone can find open-source, download, further develop and optimize blueprints and technical descriptions of any product and construct it already emancipated from industrial dependence. A condition that signifies the emergence of a new deliberated economo-societal model.

"In a world of open-source software, ownership of neither computers nor code alone provides the basis for a proprietary business model; what's left is the value added to them by creating content and delivering services... Similarly, possession of the means for industrial production has long been the dividing line between workers and owners. But if those means are easily acquired and, and designs freely shared, the hardware is likely to follow the evolution of software." (Gershenfeld 2005)

"..if the market is just one person, then the prototype is the product." (Gershenfeld 2005)

The first fab lab was set up by a team led by Sherry Lassiter at the South End Technology Center, in inner-city Boston and the second in the town of Sekondi- Takoradi, on Ghana's coast in 2004. Since then, over 100 fab labs have been implemented everywhere, from South Africa to Norway, from downtown Detroit to rural India, forming a worldwide network.
"When the cost of high-quality resources for design and prototyping becomes very low, these resources can be diffused very widely, and the allocation problem diminishes in significance. The net result is and will be to democratize the opportunity to create." (Hippel 2005)

Democratizing Production

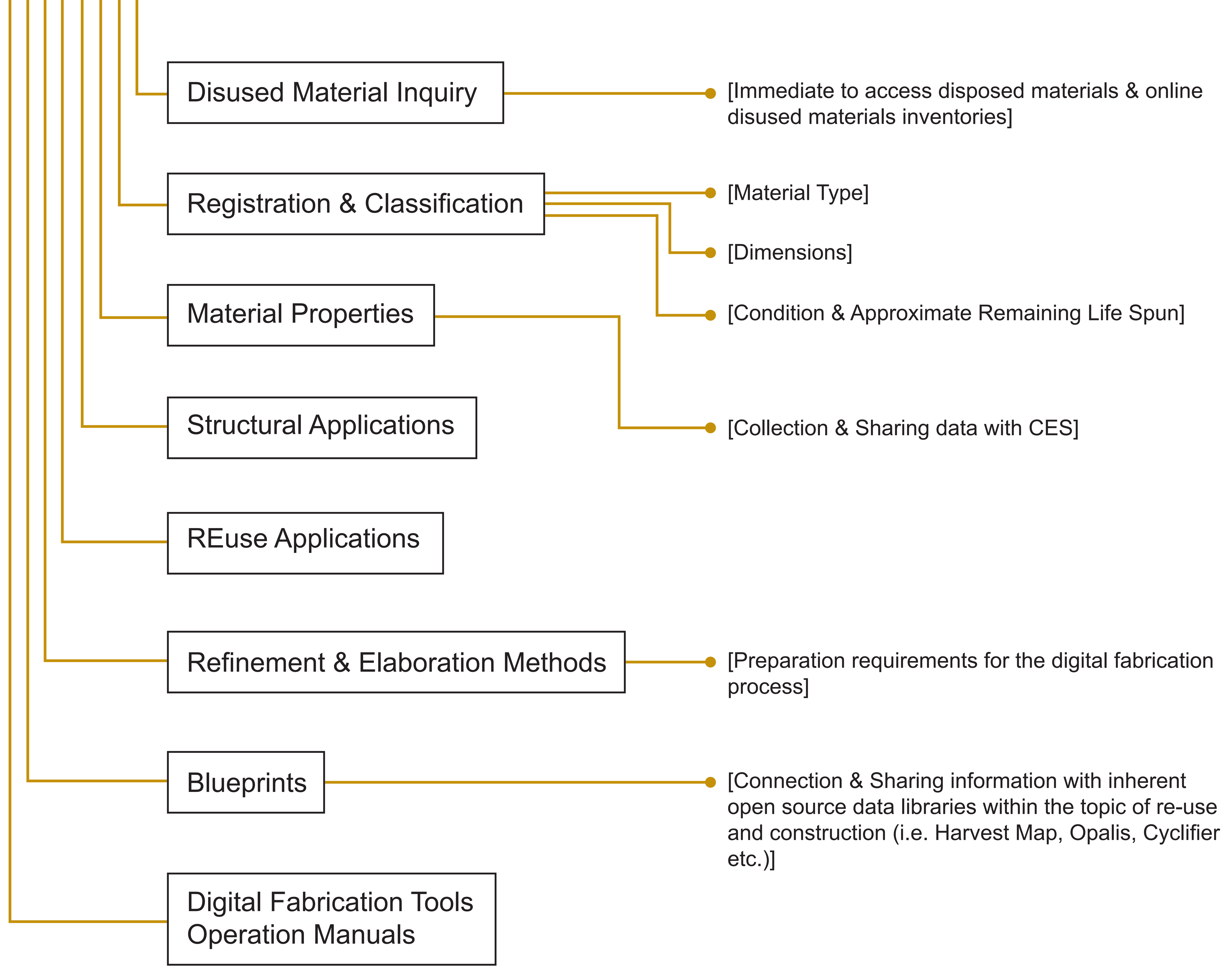
This democratizing access to advanced manufacturing technologies brought forward another prospering aspect of exploiting the innovative means of production, personal fabrication; "… a larger 'maker movement' of high-tech do-it-yourselfers…". Local needs demand local responds. Significant necessities in elementary infrastructure and deficient accessibility in manufacturing technologies are adequate reasons to motivate users to reclaim their tools of production and the driving force of a new societal development. In the context of collective fabrication laboratories people are able to interact in a didactic manner, exchange knowledge and learn in practice how to operate advanced technological equipment and work with raw materials, as a means of covering communal and individual needs, and eventually reforming their habitat in a spirit of solidarity and cooperation.

"The Fab Academy seeks to balance the decentralized enthusiasm of the do-it-yourself maker movement and the mentorship that comes from doing it together. After all, the real strength of a fab lab is not technical; it is social."

[1]Neil Gershenfeld, Fab: The Coming Revolution on Your Desktop--from Personal Computers to Personal Fabrication Paperback, 2007

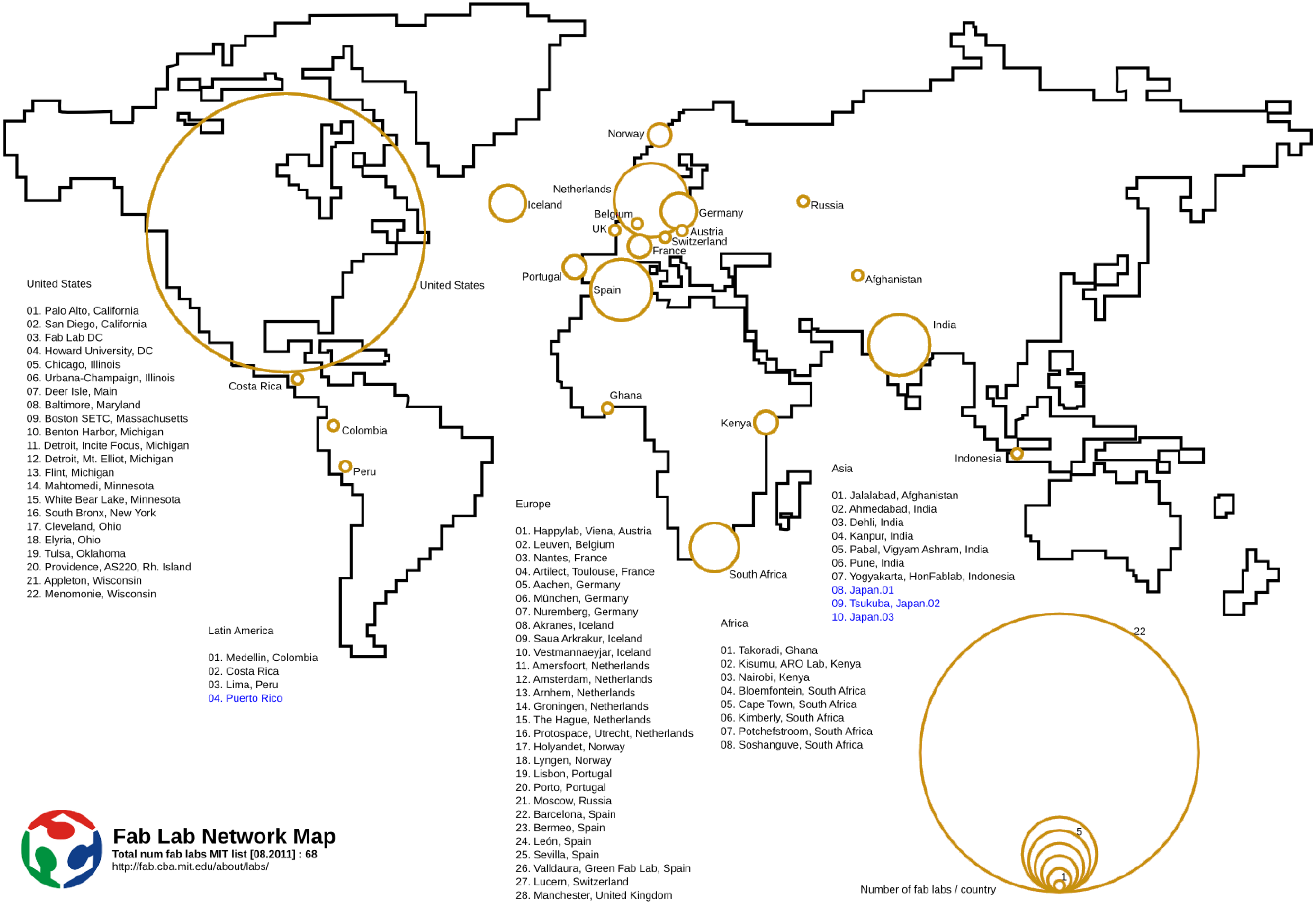
Refuse Material Digital Library

Open-Source & Regulated Database



ABOUT:
The **Waste Material Digital Fabrication** platform intends on developing as an online open-source regulated database that allows users to register and classify the incoming waste materials in the depository network of Waste Refinement & Farication Labs according to their type, size and condition; additionally the platform aims in facilitating the D.I.Y. design and construction of prototypes-products intented for personal use, by connecting and sharing information (i.e. properties data, available materials' locations and blueprints) with inherent open source data libraries within the topic of material, re-use and digital fabrication (i.e. CES, Harvest Map, Opalis, Cyclifier etc.).

"In a world of open source software, ownership of neither computers nor code alone provides the basis for a proprietary business model; what's left is the value added to them by creating content and delivering services... Similarly, possession of the means for industrial production has long been the dividing line between workers and owners. But if those means are easily acquired and, and designs freely shared, the hardware is likely to follow the evolution of software."
(Gershenfeld 2005)



Fab Lab Network

Participation in Design & Construction Processes

This paper is, yet again, attempting to bring forward a significant topic of the architectural debate the past decades, that of the user's participation in design. Hence, important matter in the design process is the different stages of involvement that the user, in this case often identified also as maker, is allowed or better motivated to intervene.

Having acknowledged the ambiguous position of architecture in a society of over-production and over-consumption, and participation in the design process as an important parameter of the architect's engagement to context, a complicated equation formulates between design threw intimate consultations with the local community, and a careful investigation of the existing patterns and all the forces at play. In order to ensure a sufficient estimation of the problem, the actual issue being negotiated here is that building with foresight can reach a certain point of advancement and offer partial responds, which, frequently, is not adequate to ensure the future development of a project without compromising the needs of a community for the days to come, no matter how properly the initial procedure has being carried out.

Under such scope adaptable, autonomous systems[1] are a highly debated topic that reflects distinctly today's architecture tendency on alternative, down to earth, applications of bottom-up design and closed material loops. These words become more meaningful when accompanied by an inadequacy of society to fulfil its needs and appropriate within a statutory framework the inert urban space in a way that qualitatively embodies the idea of a future oriented public realm.

Digital processes and mass customization bring forward a new relevance to the architects position and users participation in decision making, design and eventually construction. Personal fabrication is a rising (r)evolution that "… will allow individuals to design and produce tangible objects on demand, wherever and whenever they need them. Widespread access to these technologies will challenge traditional models of business, foreign aid, and education."[2]

Embracing the development of exploiting digital tools, that have ability to provide elementary infrastructure in the latent urban space, is an approach whose primary aspirations correspond not only in technical issues but reflect the flexibility of a new architectural intervention model and most importantly a shift to a general democratizing production method, through direct involvement of the user in primary applications of construction, by consistently addressing the subject in different stages of the process. A rising opportunity for society to reclaim control of the technology intended to better life.

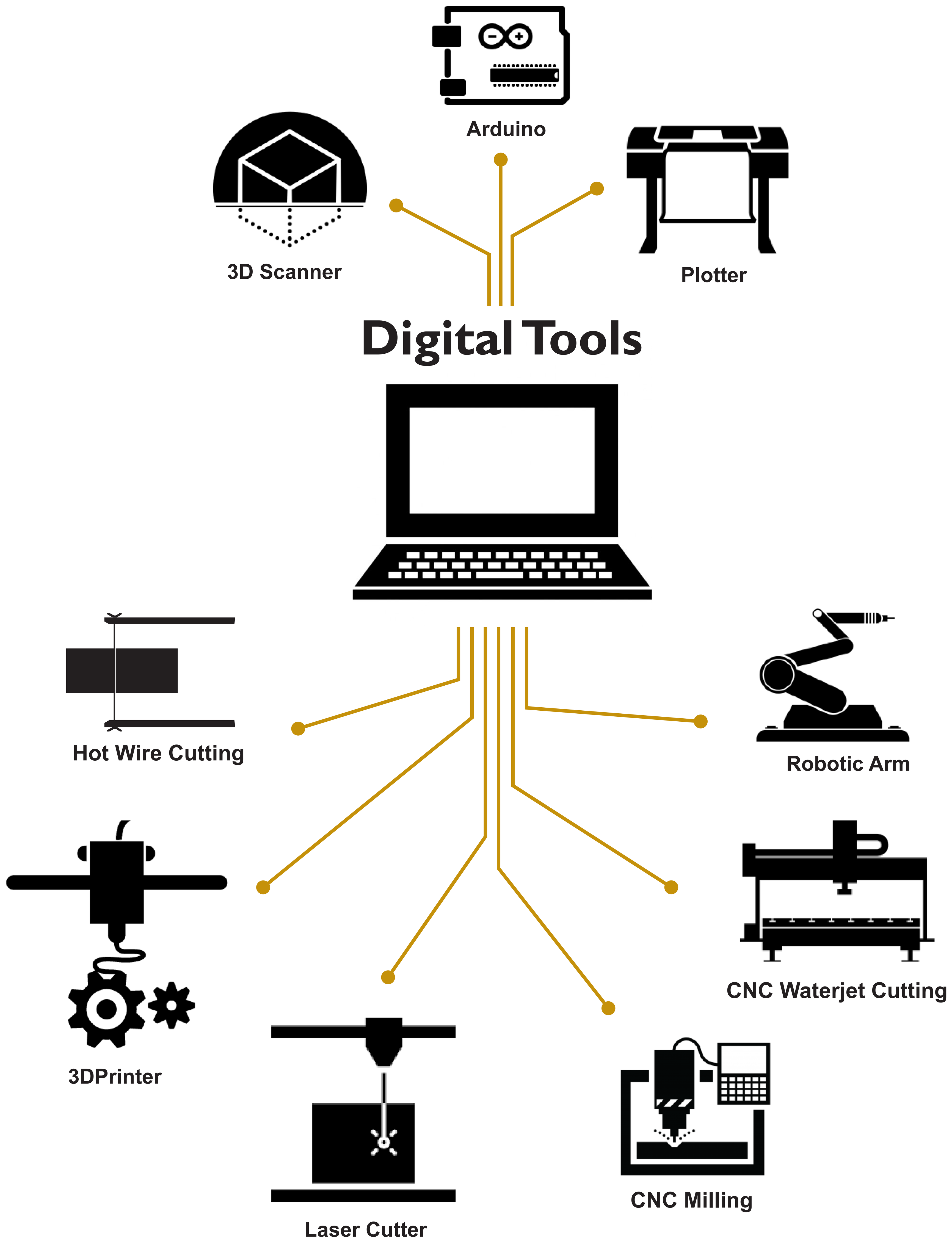
Closing, society is standing on the threshold of environmental crisis and the building industry faces significant challenges in construction due to the current ecological developments. The new manufacturing abilities have indeed great potential to facilitate the production of environmental oriented implementations that can render open systems which embrace custom change and optimization through time, research and experience of use; "… in order to build adaptably we must try to build…with the greatest perfection technically available..."[3] Digital tools are capable of providing a supporting framework which facilitates the ability of exploiting the latent space of the city and the immediate to access materials, which supplies, efficiently in a broader spectrum of sustainability. The aftermath of such developments can positively influence productivity and in addition create new professional opportunities inside and outside the industrial premises, resulting in important societal changes. "Better ways to build things can help build better communities."[4]

Digital revolution has occurred, and has developed within a new social model with intense democratizing potentials; we are now anymore digital natives. The new state of affairs consists of processes, ultimately, preeminent by flexibility of a moral measure between the inside and outside statutory frameworks intervention, through direct involvement of the user in primary applications of architecture. An effort to restore the immediacy in practice and the designer's need for reconciliation with the natural environment and the public user; primary aspirations of a process that contributes to the community an infrastructure for a better tomorrow.

[1]'Systems Architecture is a generic discipline to handle objects (existing or to be created) called "systems", in a way that supports reasoning about the structural properties of these objects.'_https://www.lix.polytechnique.fr/~golden/systems_architecture.html
[2]Neil Gershenfeld, How to Make Almost Anything _The Digital Fabrication Revolution, 2012
[3]Christopher Beorkrem, Material Strategies in Digital Fabrication, 2013
[4]Neil Gershenfeld, How to Make Almost Anything _The Digital Fabrication Revolution, 2012

Advanced Manufacturing Technologies

The following diagram includes an estimation of all the necessary digital fabrication equipment required for the adequate functionality of the Urban Mining Laboratory reFAB which are likely similar to the requirements of the regular FabLab founded by Neils Gershenfeld.



Digital Fabrication Techniques

- Sectioning
- Folding
- Contouring
- Forming
- Tessellating

Digital Fabrication Procedures

Additive

- 3D Printing
- CNC precast elements
- Contour Crafting CC

Subtractive

- CNC Milling
- CNC Laser Cutting
- Waterjet Cutting
- CNC Hot Wire Cutting

Digital Fabrication Techniques

Sectioning

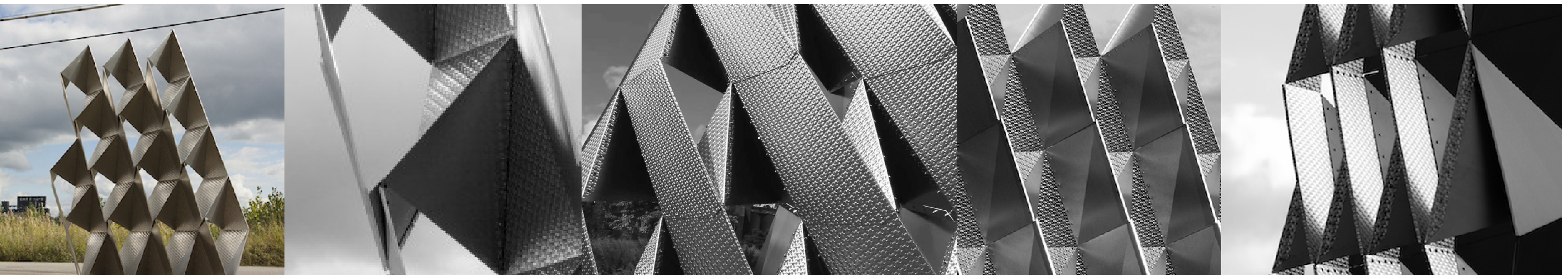
The technique employs multiple orthographic projections, usually produced by subtractive technologies, in the formation of a series of profiles, the contour of which creates a geometry. Sectioning can be utilized as a effective method to compose complex surfaces and structure concurrently.

Reference: The provided reference is a clean showcase of sectioning as means of apprehending the essence of the technique. The project is temporary installation designed by a student team led by the Assistant Professor in the Kent State University of Ohio, Bill Lucak, and is an attempt to demonstrate the potential of parametric design and digital fabrication methods to generate a complex geometries through the succession of a multiple series, of radially placed in this case (not parallel), plywood CNC cut vertical profiles. The limitations in dimensions of the standardized sheets of plywood were overcome through connecting the struts of the segmented smaller components by joints, thus forming a ribbed installation.

Tessellating

Tessellation in digital fabrication is the technique according to which identical or diversified geometries are collected or designed to formulate a united pattern on a plane without gaps or overlaps. In architecture practice the technique materializes through tiling and 'digitally defined mess patterns' (Iwamoto 2009).

Reference: This project is performed by students at the University of Stuttgart together with the Institute for Computational Design (ICD) and the Institute of Building Structures and Structural Design (ITKE), and constitutes an exemplified interpretation of the tessellating technique by means of computer controlled design and fabrication. The modular lightweight construction is composed by polygonal prefabricated plywood plates linked together at the edges by finger-joints which are commonly used in carpentry, providing a system with high loadbearing capacity. This parametrically optimized shape and joining system has the potential of wide application in custom geometries.



Folding

This origami based technique utilizes a flat surface to compose a three-dimensional one through folding, in such manner this method grants a two-dimensional material the capacity to form space and retain its initial properties.

Reference: 3xLP is a representative to this category project by Christopher Romano and Nicholas Bruscia which attempts through the employment of parametric design and digital fabrication to bring forward the potential of a thin leaf of rigitized stainless steel to be utilized, in absence of framing, in order to form a dynamic, standalone and sharp designed curtain wall. In this manner, the design intents on exploiting sheets of material through texture and a folding approach as means of creating a robust geometry without framing and additional components.

Contouring

Contouring is cumulative subtractive method adjacent to carving that shapes three-dimensional geometries through the consecutive deduction of a surface's material.

Reference: Jeremy Ficca's CNC Panels is an ideal example of contouring, also mentioned in Iwamoto's book 'Architectural and Material Techniques', that reveals the potential of utilizing only two-dimensional CAD drawings in subtractive technologies (CNC router) it order to generate a succession of iterated surface forming a three-dimensional sculpture. This project attempts through contouring techniques to customize common and emerging materials on various levels in regard of deriving in aesthetic formations.

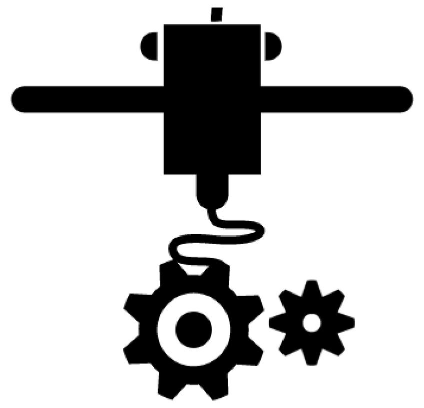
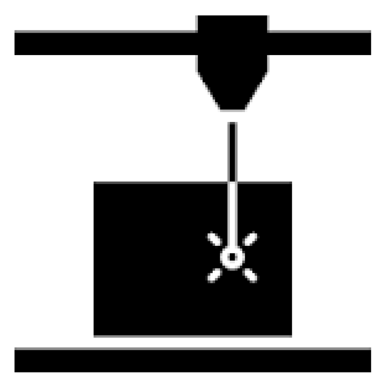
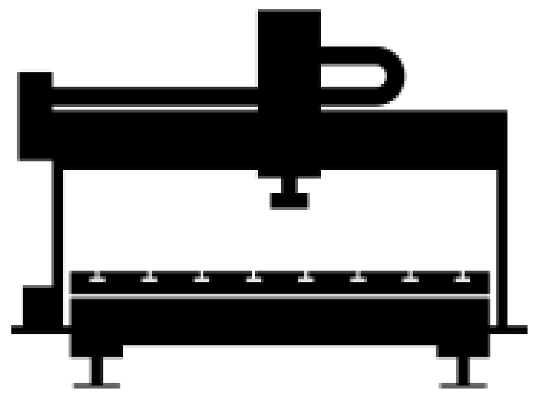
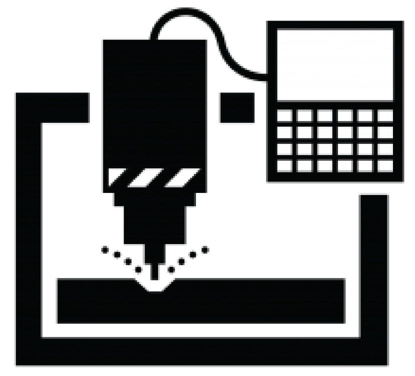
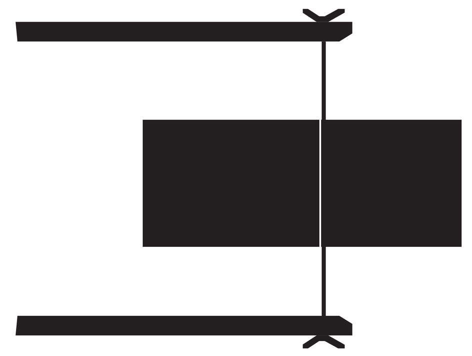
Forming

The technique can employ both subtractive and additive methods to produce moulds as means of generating multiple components. Forming is an economically efficient and one of the least waste producing digital fabrication methods.

Reference: The showcased project is an exercise performed by students of the Institute for Advanced Architecture of Catalonia, Iaac, where the team is employing a representative implementation of the forming technique through the construction of CNC milled EPS moulds as means of creating a trilateral symmetry design of "Topography Faces". The concluding final pattern formed by matching the 3 different faces of numerous tiles allows through its topographical surface the flow of water. This is a good scenario to reveal the potential of utilization of a foam material treated by milling to provide ceramics the ability to compose complicated geometries.

Digital Fabrication Technologies

Overview & Evaluation

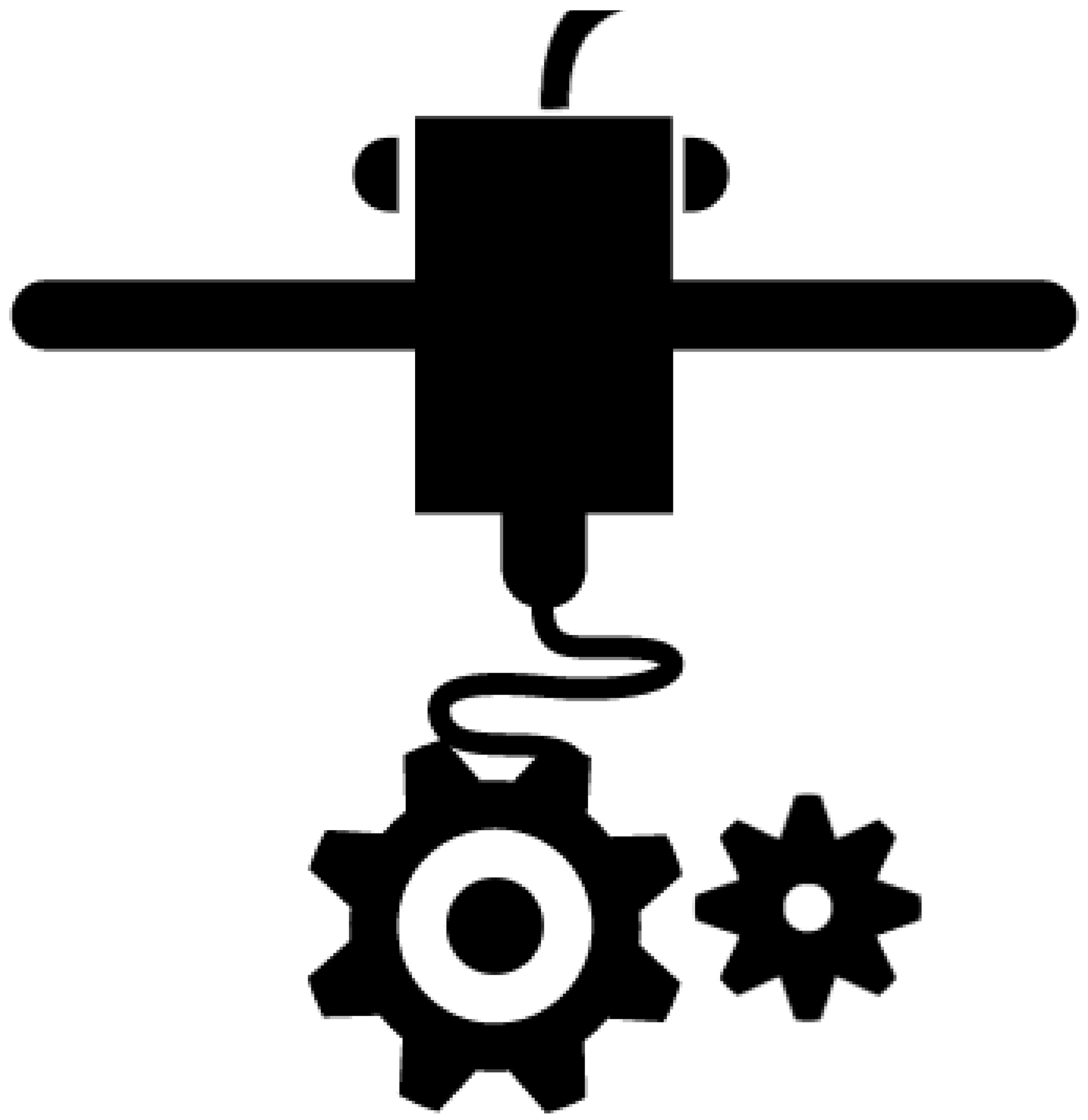
	 3D Printing	 CNC Laser Cutting	 CNC Waterjet Cutting	 CNC Milling	 Hot Wire Cutting
Advantages	+ Waste plastic utilization + No waste are produced + No molds + Material variety + Form freedom	+ Precision + Demountable + Bearing structure ability + Engraving ability + Lightweight + Customization + No adhesives and joinery re-quired	+ Demountable + Bearing structure ability + Customization + Thick material cutting ability	+ Demountable + Customization + Engraving + Software variety + No adhesives and joinery re-quired	+ Form freedom + Customization + Large volume geometries + Lightweight
Disadvantages	- Not demountable - Not bearing	- Waste production - Energy consumtion - Speed - Limited size components	- Water consumtion - Speed - Waste production	- Waste production - Limited size components	- Difficulty in waste utilization - Not demountabe - Short material variety - Waste production - Not structural
Materials	• Plastic • Concrete • Ceramics • Aluminium	• Plywood • MDF • Metal • Plastic • Cardboard • Various depended on machine	• Wood • Plastic • Foam • Ceramics • Metal • Paper	• Wood • Metal [Various & Aluminium] • Cardboard	• Polystyrene • Styrodure
Waste Material Input	• Plastic [transformed through a melting and extrusion process to a new polymeric filament] • Ceramics	• Metal [transformed though melting pro-cess into a new sheet] • Plastic [transformed though melting process into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	• Metal [transformed though melting pro-cess into a new sheet] • Plastic [transformed though melting process into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	• Metal [transformed though melting pro-cess into a new sheet] • Wood [in the case of solid panel or by tramsforming wood in a by-product]	Rare cases of integrating a waste product
Energy Consumption	Depended on machinery and material	100kW	37kW & depending on pump	18kW	Depended on machinery and material
Material Thickness	Approx. 6x6m printing size	max. 400mm	max. 350mm	Approx. 250mm	Depended on the wire structure
Dig.Fabrication Speed	Depended on machinery and material	max. 300m/min	max. 35m/min	Approx. 10m/min	Depended on machinery and material
Finish Independency	●●○○○	●●●●○	●●●●●	◉○○○○	●●●○○
Overall Production Speed	●●●●○	●●●○○	●●○○○	●○○○○	●●○○○
Waste Production	●○○○○	●●●●○	●●●●○	●●●●○	●●●●○
Mat. Emb.Energy Economy	●●●○○	●○○○○	●●○○○	●○○○○	●●○○○
Sustainability	●●●●○	●●●○○	●●●○○	●●●○○	●●○○○
Material Variability	●●●○○	●●●●○	●●●●○	●●●●○	●○○○○
Waste Mat. Integration	●●●●○	●●○○○	●●○○○	●○○○○	◉○○○○
Waste Pre-elab. Independ.	●●●○○	●●○○○	●●○○○	●●○○○	◉○○○○
Product Recycling Capacity	●●●○○	●●○○○	●●○○○	●●○○○	●○○○○
Demountability	●○○○○	●●●●●	●●●●●	●●●●●	●●○○○
	3D	**2D**	**2D**	**2D + 3D**	**2D + 3D**

Sources: The data of the table board have been provided by M. Hauschild & R.Karzel's book 'Digital Processes', N. Remmerswaal and A.Koff's research papers and estimation based on personal investigation on computer aided manufacturing (CAM).

Basic Types of 3D Printing Technologies

Overall Estimation of 3D Printing

The process of 3D printing resides in **additive manufacturing** technology that was developed in 1980's. Additive fabrication is a process by which 3D objects are produced by the consecutive deposition of material in layers. Currently the process is employed in rapid prototype development and has a wide application in industrial production. However, today, this innovative method of production is still in the **early stages of exploitation** for manufacturing purposes and has still a lot of ground to cover before it compensates for an overall specter of construction without being assisted by other technologies, and constitute a long-range assembler.



	Operating Tool	Input Material	Form Develop.	Application	Advantages	Disdvantages
1. FDM (Fused Deposition Modeling)	heat	plastic	thermoplastic filament is heated and extruded through a nozzle that deposits the molten plastic in X,Y (layer by layer)	product development and rapid prototyping in small business and education	+ fabrication of robust parts reliably and quickly + cost-effective + most common	◉
2. SLA (Stereo-lithography)	UV-laser beam	photosensitive liquid resin	exposing a layer of photosensitive liquid resin to a UV-laser so that the resin hardens and becomes solid (layer by layer)	jewelry industry and cosmetic dentistry for creating castable molds	+ smooth surfaced objects with extreme detail	◉
3. DLP (Digital Light Processing)	special projector	photosensitive liquid resin	exposing a layer of photosensitive liquid resin to a UV-laser so that the resin hardens and becomes solid (layer by layer)	proffesional use, movie projectors, cell phones, and also for 3D printing	+ speed + robust pieces with excellent resolution	◉
4. SLS (Selective Laser Sintering)	laser	powdered material	laser selectively sinters a layer of granules, which binds the material together to create a solid structure	product development and rapid prototyping in a wide range of commercial industries	+ wide range of materials (nylon, glass, and ceramics as aluminum, silver, steel)	- expensive high-powered lasers & limited-run manufacturing of end-use parts
5. SLM (Selective Laser Melting)	laser	powdered material	uses a high-powered laser beam to fully melt metallic powders into solid three-dimensional parts	aerospace or medical orthopedics industry	+ parts with complex geometries and thin-walled structures, with hidden channels	- expensive
6. EBM (Electron Beam Melting)	electron beam	powdered material	a computer-controlled electron beam under high vacuum fully melts the metallic powder	aerospace parts and medical implants	+ exciting	- currently very slow and very expensive
7. LOM (Laminated Object Manufacturing)	laser or knife	adhesive coated paper, plastic or metal laminates	uses layers of adhesive-coated paper, plastic or metal laminates, fused under heat and pressure and shaped by a computer controlled laser or knife	aerospace parts and medical implants	+ accuracy + most affordable and fastest 3D printing + large parts + full color	◉
8. BJ (Binder Jetting)	combination of materials	powder based material and a bonding agent	the binder is extruded in liquid form from a printhead and acts as an adhesive between powder layers	aerospace parts and medical implants	+ ceramic, metal, sand or plastic + full-color	- medium resolution and rugged prints
9. MJ (Material Jetting / Wax Casting)	heat	wax	molten wax is deposited onto an aluminum build platform in layers using several nozzles that sweep across the build area	customizable jewelry	+ detail	- very fragile and should be handled carefully

Subtractive Manufacturing Technologies

CNC Laser Cutting

The process utilizes a high-power laser to separate sheets of material by directing the output according to a desired shape supplied by 2D drawings. The process has a wide application in the architecture practice for modeling purposes, although is **not recommended for building construction** due to speed and cost compared to other CNC technics.

CNC Milling

The milling process is removing material by the passing of a computer controlled motor head that is rotating. This technology has the potential of creating complex geometries through multi-axial equipment that can approach the object from almost any angle. General disadvantages of this technic are the speed and ability of the machine to reach internal corners due the milling heads radial. More specifically to this investigation the process has relatively **limited waste material input ability**.

CNC Hot Wire Cutting

The desired components shape in this process is provided by the movement of a heated, through electrical current, metal wire. The hot wire can be mounted on multi-axe robotic arm for the production of more complicated geometries. Major disadvantage of this technic is the material input (foam) which in the case **reused materials can't have an actual application**.

CNC Water Jet Cutting

The water jet process is, mainly, an industrial method of separating materials by the utilization of high-pressure jet of water. The water jet can cut material without interfering with its inherent structure. The process has a wide range of material input, although, it is employed mainly for the production of sensitive to heat materials and machine parts. Water jet cutting is a relatively **slow and cost related process** and similarly to the other CNC processes has **not great potential for variety of refuse material input** due to the luck of standardization in the desposed material reserve.

Overall Estimation of Subtractive Manufacturing

Subtractive manufacturing in digital fabrication is a process in which a piece of a raw material is cut by a computer controlled tool (sharp rotating tool, laser, waterjet etc.) in predesigned shape. The process is precedent to additive and can employ **a variable material types** (aluminum, steel alloys, brass, copper, softwoods and hardwoods, thermoplastics, acrylic, modeling foams, machining wax) and has a **wide application** in cutting sheets of materials, but also in the construction of 3D objects by successively chipping away parts from a solid block of material. An important advantage of this technic for the present investigation, is the abitity of subtractively produced components to be **dry assembled** in the overall construction, thus, being demountable and flexible in adaptation, weared parts replacement and demounting capacity. In addition, compared to the most common additive manufacturing technologies, subtractive methods have the ability to **allow moving parts** in a construction through the production of living hinges.

Assessment [Subtractive]

- ⊕ **Wide application in construction**
- ⊕ **Variable raw material types**
- ⊕ **Demountability**
- ⊕ **Mass customization**
- ⊖ **Limited refuse material input**
- ⊖ **Waste producing method of production**

Assessment [Additive]

- ⊕ Complete product production from scratch
- ⊕ Robust three-dimensional forms
- ⊕ Rapid prototype development
- ⊕ Requires only the necessary material
- ⊕ Polymeric materials integration
- ⊖ Potential of accumulating errors
- ⊖ Limited capacity of heterogeneous materials
- ⊖ Limited demountability

Additive Vs Subtractive

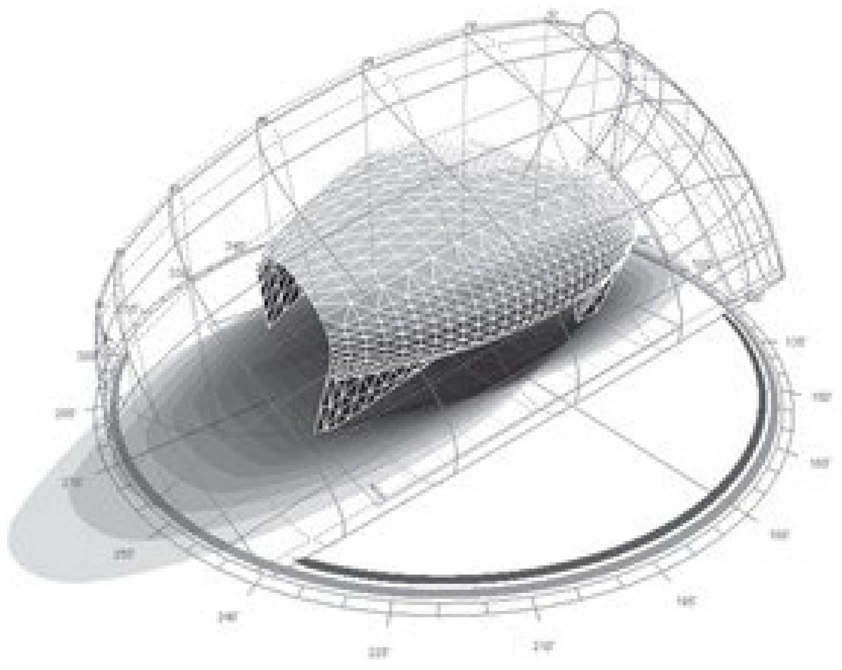
Disadvantages of Additive Manufacturing

• They can produce relatively robust forms, though the product's size is dependable, thus limited, to the dimensions of the nozzle's (print head) supporting structure. A condition affects signifficantly the 3D printing technology's employment in architecture
• The printing process has the potential of accumulating errors
• The product is produced complete, however the ability of integrating heterogeneous materials in the same process is limited
• The product is not demountable
• The process is slow compared to other digital controlled methods of manufacturing

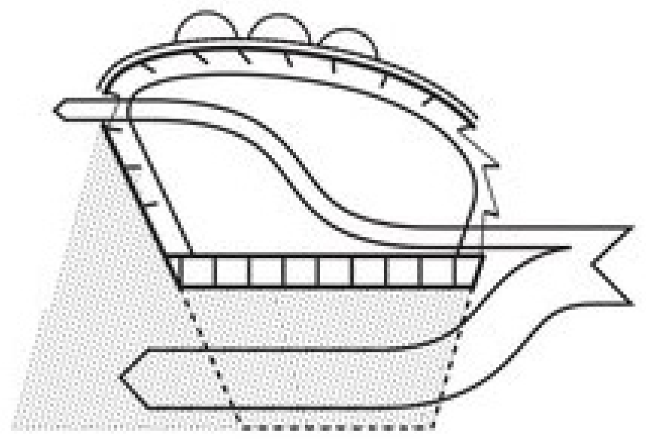
Disadvantages of Subtractive Manufacturing

• Main deprivation of subtractive manufacturing to additive, is that deducting tools require amount of material minimum the size of the product, hence constituting an improvident and highly waste producing process with by-products often not easy to recycle. In regard to the current investigation's approach, where by-products can be embedded as raw material input in a circular production process, refuse doesn't necessarily constitute a problematic parameter; however, in the case of certain material types, as wood and no-sinter*able elements, the above issue entangles variable considerations.

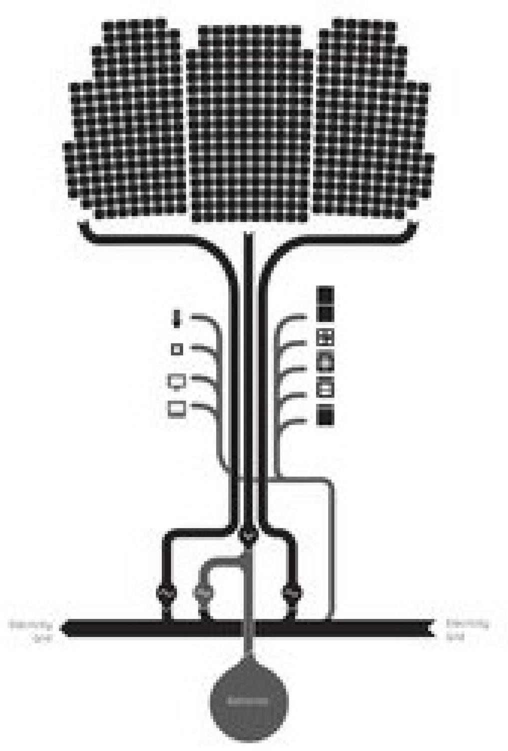
The Fab Lab House Project



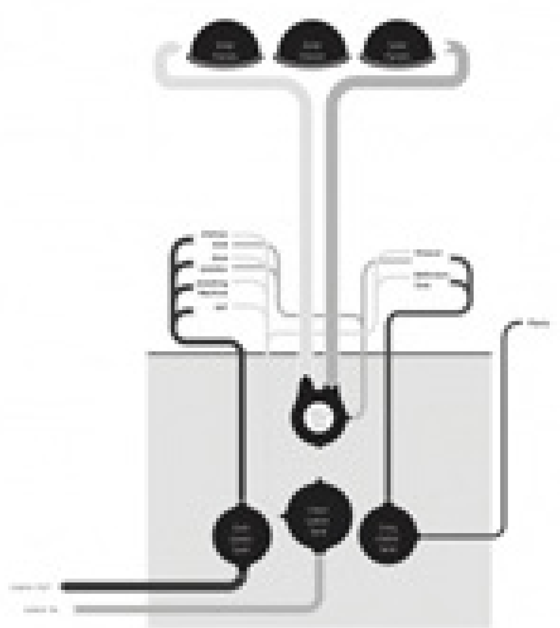
Parametric Form Development
The form is parametrically regulated according to energy consumption



Climate Scheme
The design uses the of the resources (sun, water, wind) of the enviroment to create a microclimate



Tree Development
The structure is developed in a tree like model, where the top ‘leaves’ (PV panels) captivate the solar energy and transmit it to its ‘roots’ (accumulator) to be stored and return as electricity when necessary



Passive Structure
The dwelling uses passive systems of climate control

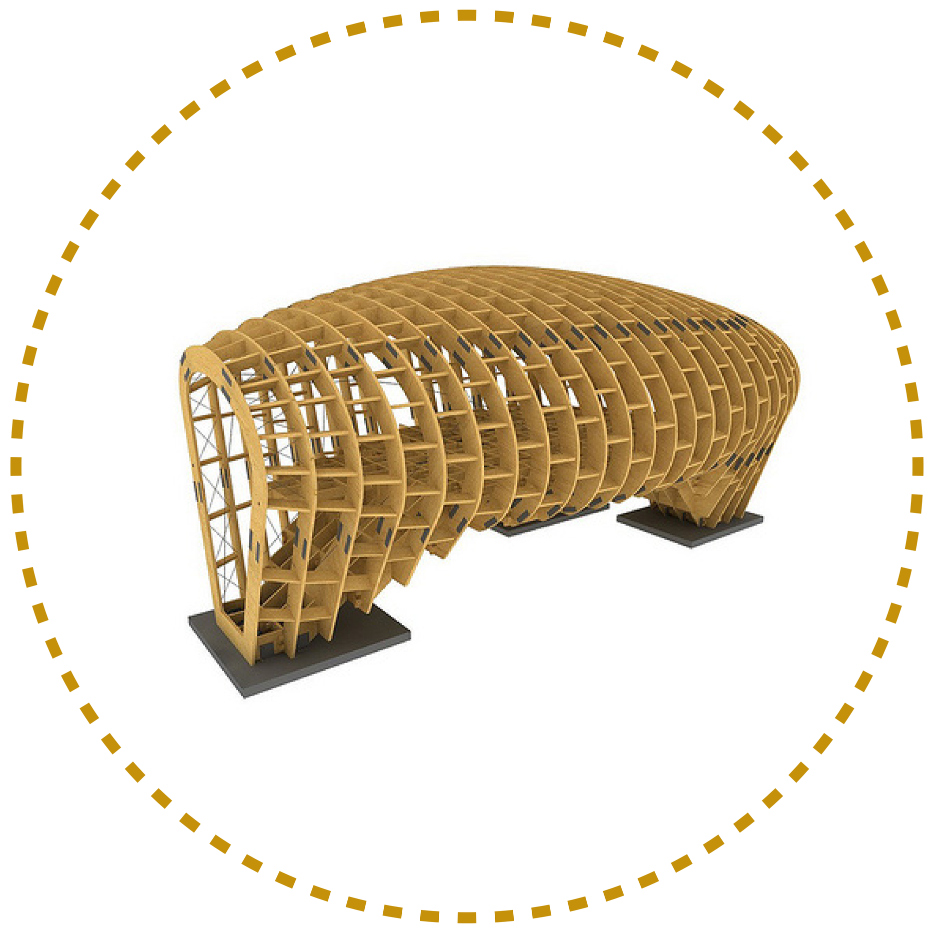
Case Study Relevance

The Fab Lab House project, designed and constructed by a team of architects and developed by the Institute for Advanced Architecture of Catalonia in Barcelona (Spain), the Center for Bits and Atoms of MIT and the Fab Lab Network, along with a group of private firms. This reference project is an exemplified case study paradigm, that has great potential in facilitating this investigation in regard to the intention of employing computer aided design and manufacturing in the implementation of an integral, sustainable spatial framework. The mentioned project is related to reFab not only in regard to the approach of design, but the imminent relevance to fundamental principles and intentions, program and parameters of construction, and collective work and multiple determinants coming together in pursue of this undertaking realization.

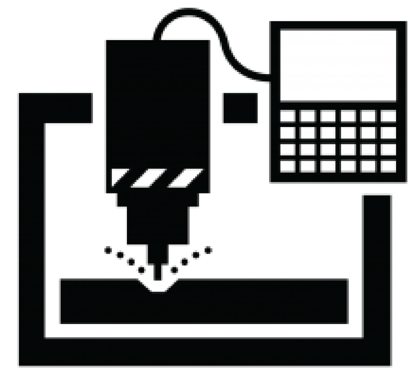
Sustainable Design

According to IAAC and the Fab community the dwelling is a self-sufficient structure that responds to high environmental oriented requirements and is capable of producing twice as much energy as it consumes. In addition the Fab Lab House incorporates advanced manufacturing technologies that can provide tools and everyday objects by using the processes utilized in the general design of the space.

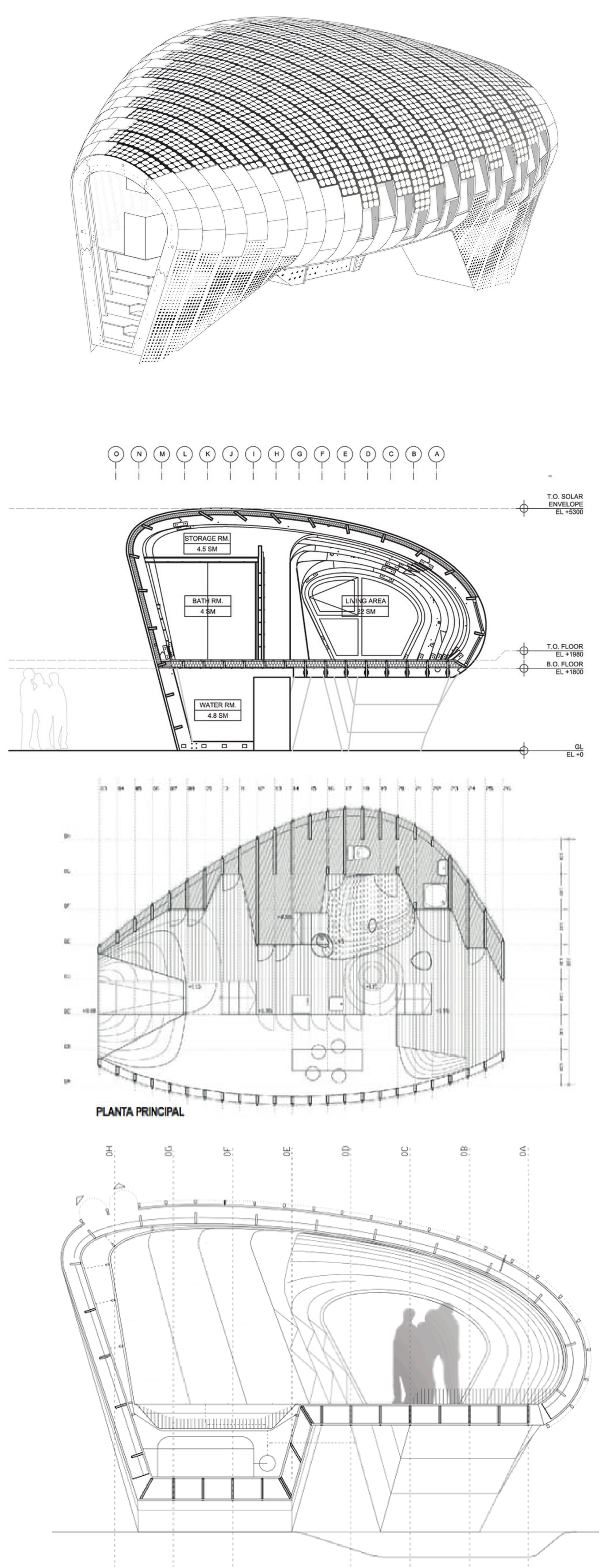
The Fab Lab House Construction Process

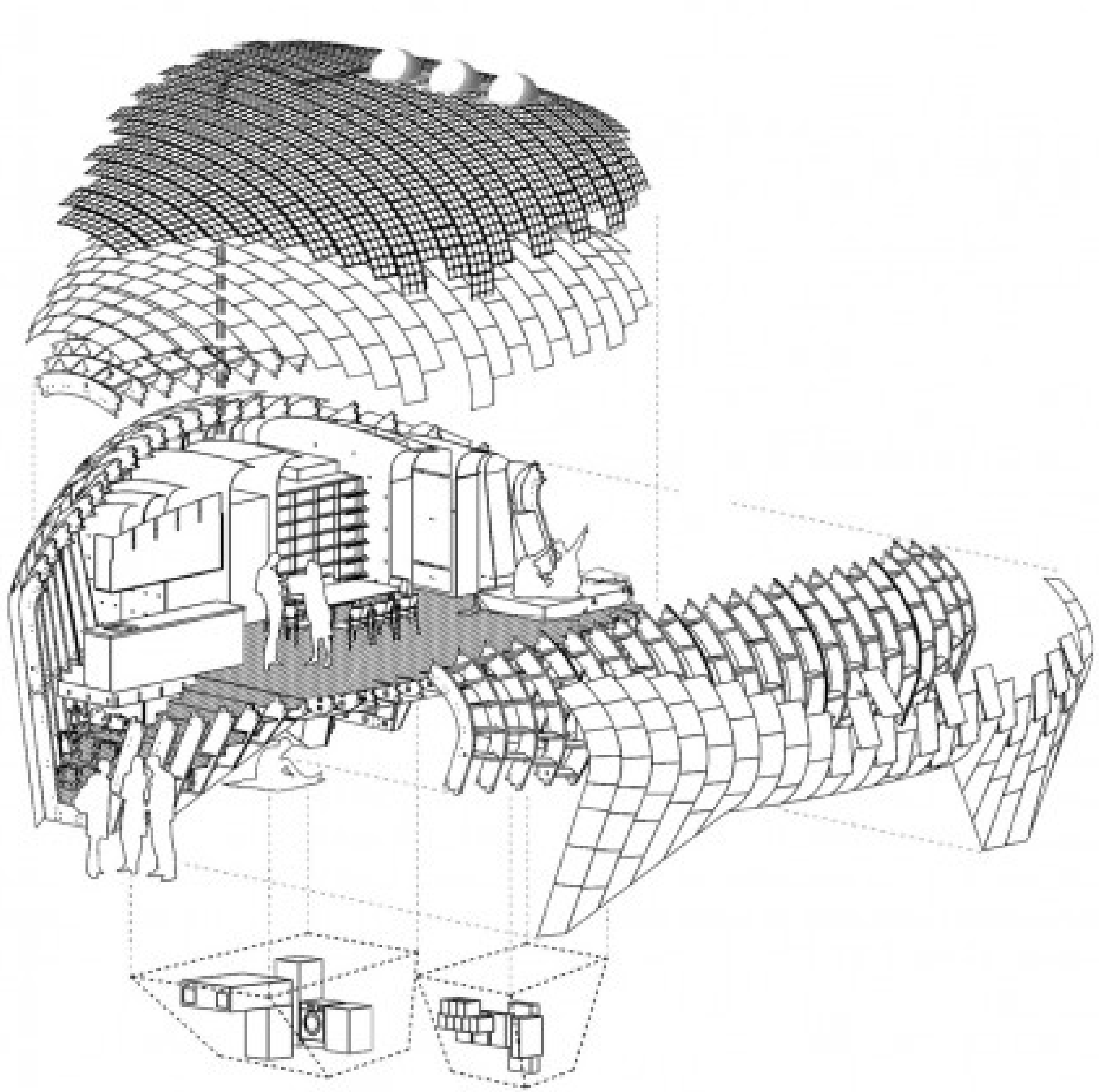


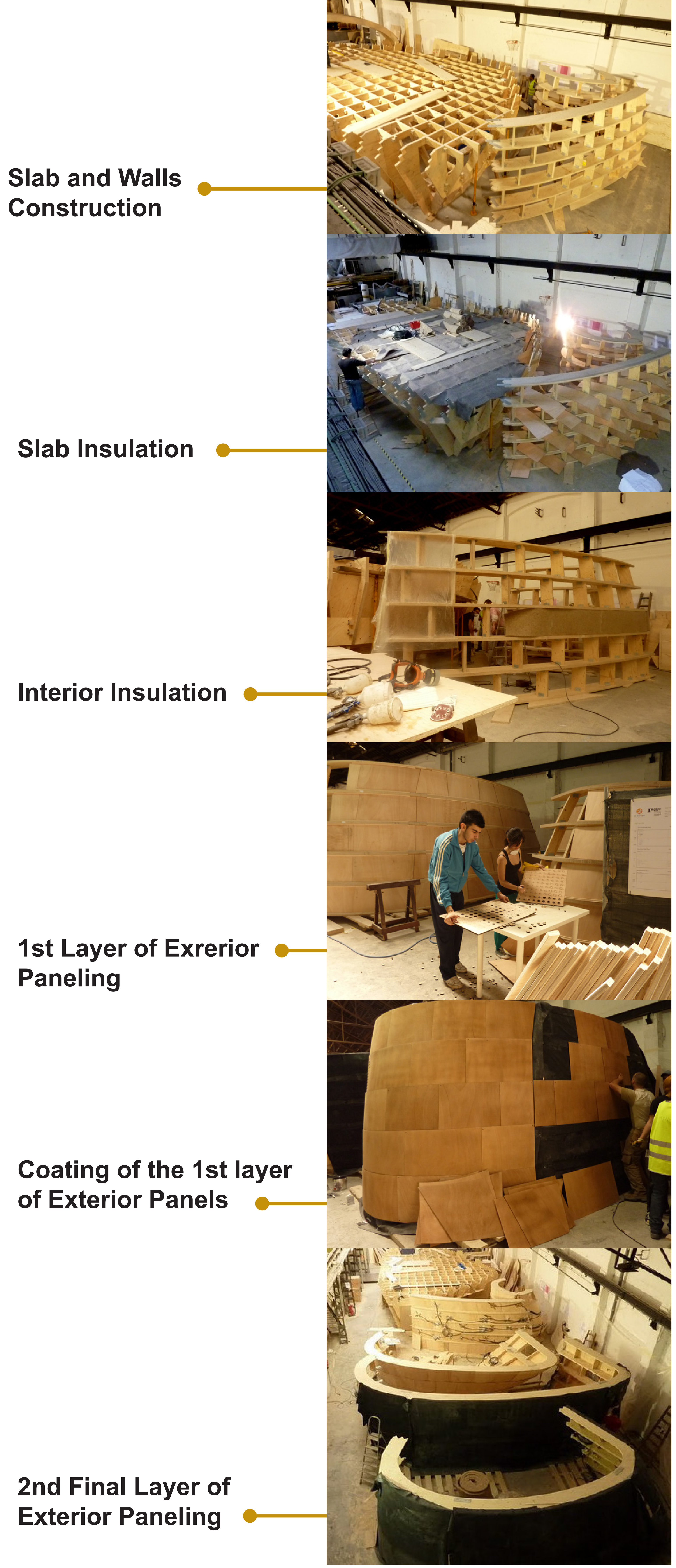
The methods for constructing this integral design were mainly based in CNC subtractive technologies. The design was parametrically developed through a hybrid application of sectioning, since it utilizes the successive orthographic projections of the geometry only in one direction, instead of the common two for this process (x, y). Hence, the design method as means of connecting the parallels series of plywood ribs, utilizes small scale plywood plank components gaping the residual void between the sections, with a jointing system of small metal brackets. The reason for this entanglement, in my opinion, occurs in accord to the conjunction of two parameters: alternating the series of the vertical small connections so that the dressing paneling's intersections don't concur, and not using the double amount of vertical plywood ribs in regard to the first, as means of material economy.



Digital Fabrication Tools:
- **CNC Milling**
- **Laser Cutter**



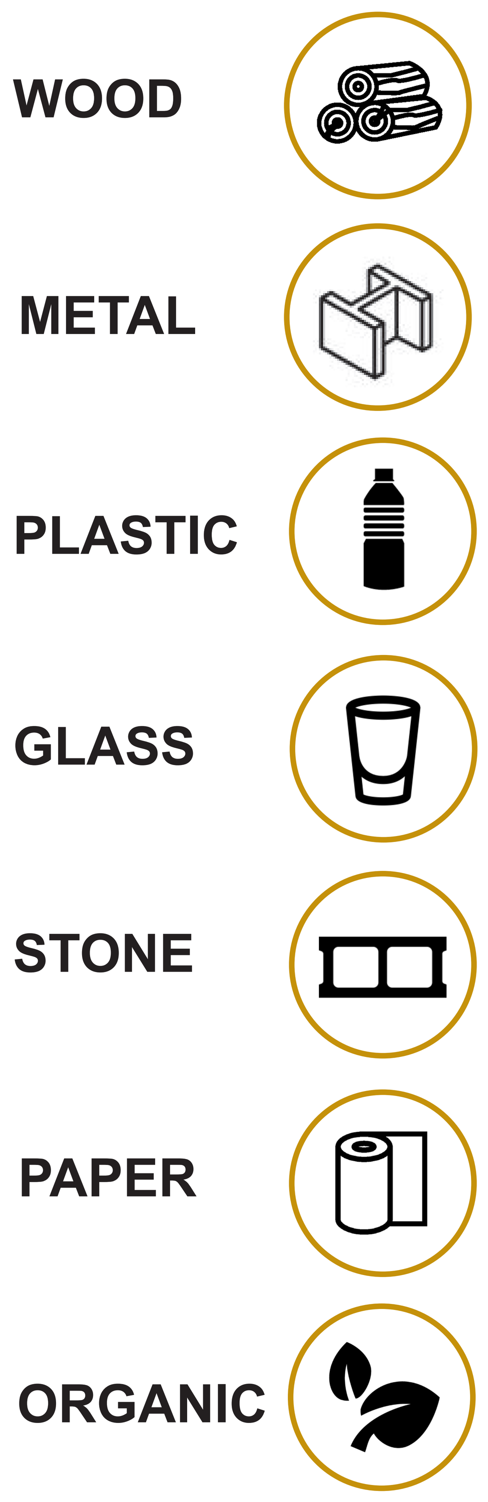




CONCLUSIONS

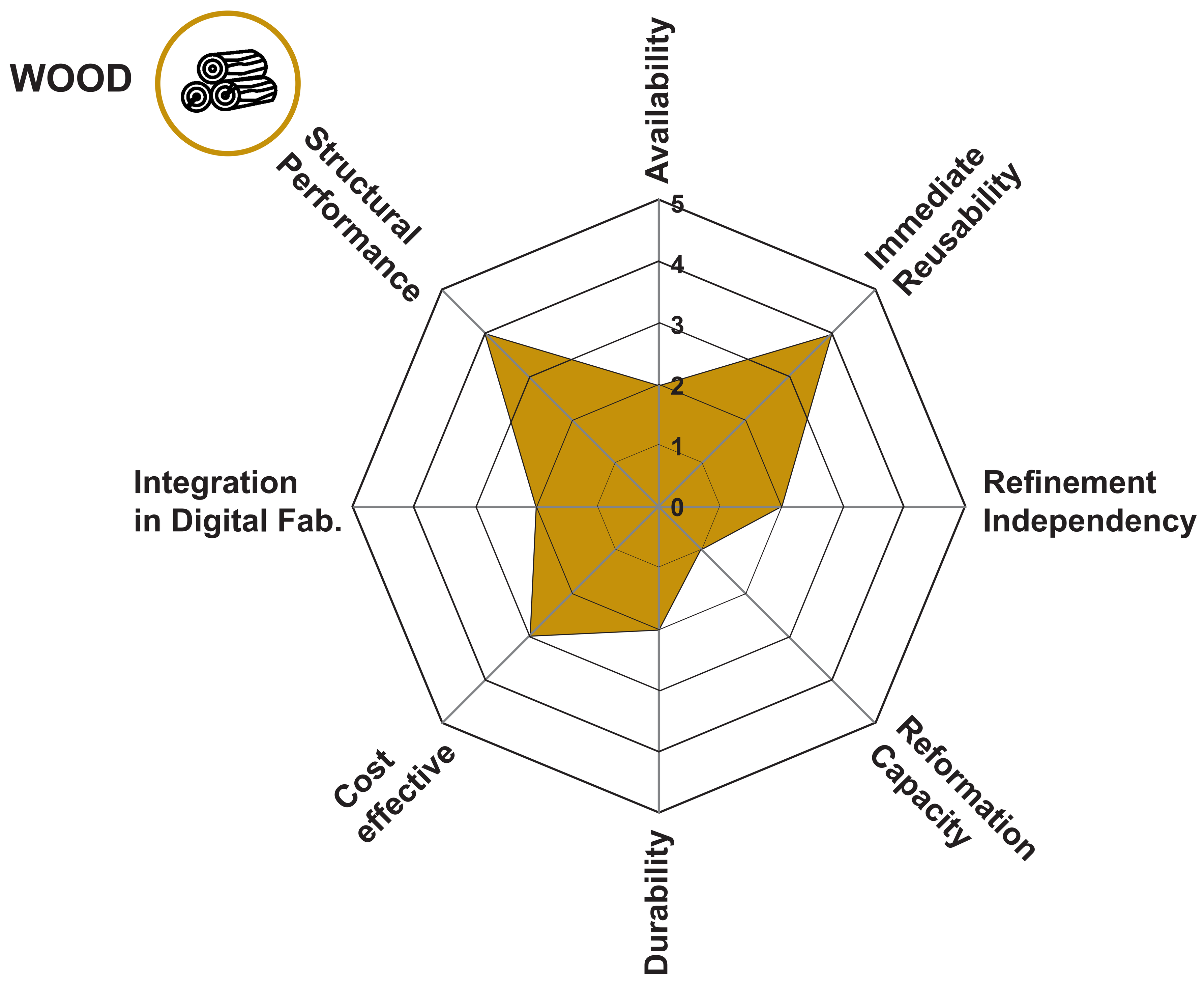
Refuse Employment in Building Construction Assessment

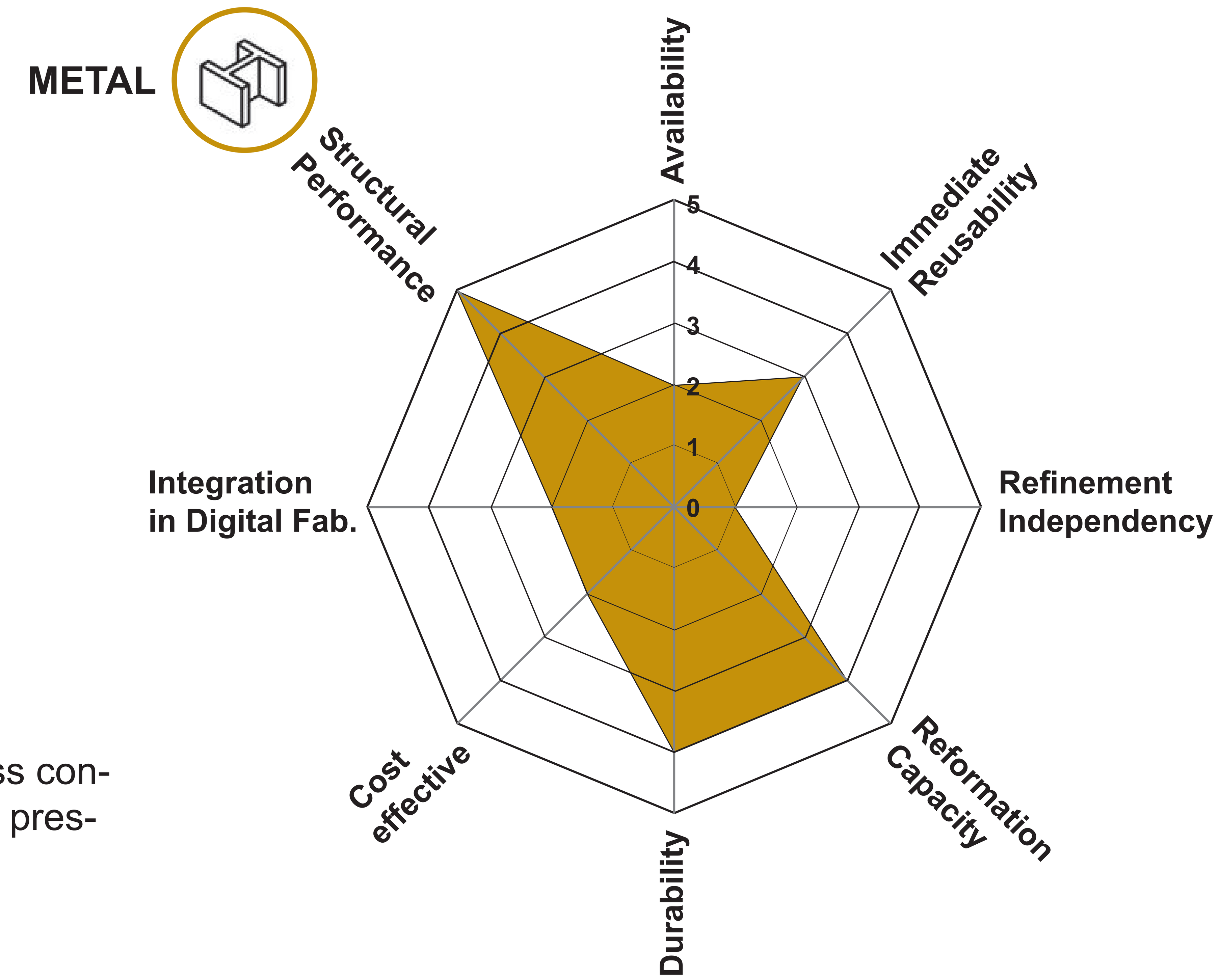
General overview & potential of integration as raw material input in digital fabrication



Below follow some spider diagrams of seven of the most common employed in building construction refuse materials' valuation in regard to the following criteria:

- **Availability**
- **Immediate Reusability**
- **Refinement Independency**
- **Reformation Capacity**
- **Integration in Digital Fabrication**
- **Durability**
- **Cost effective**
- **Structural Performance**



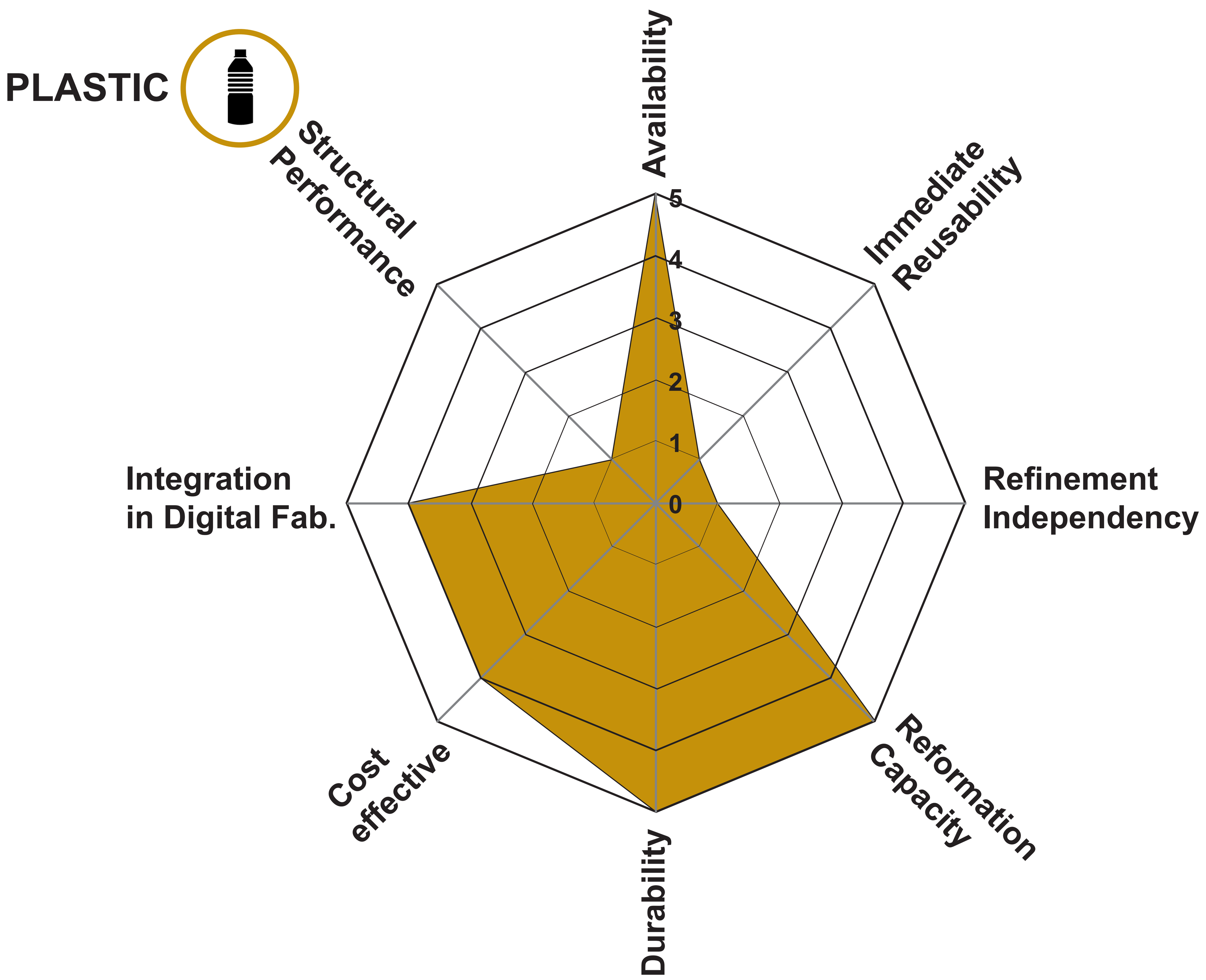


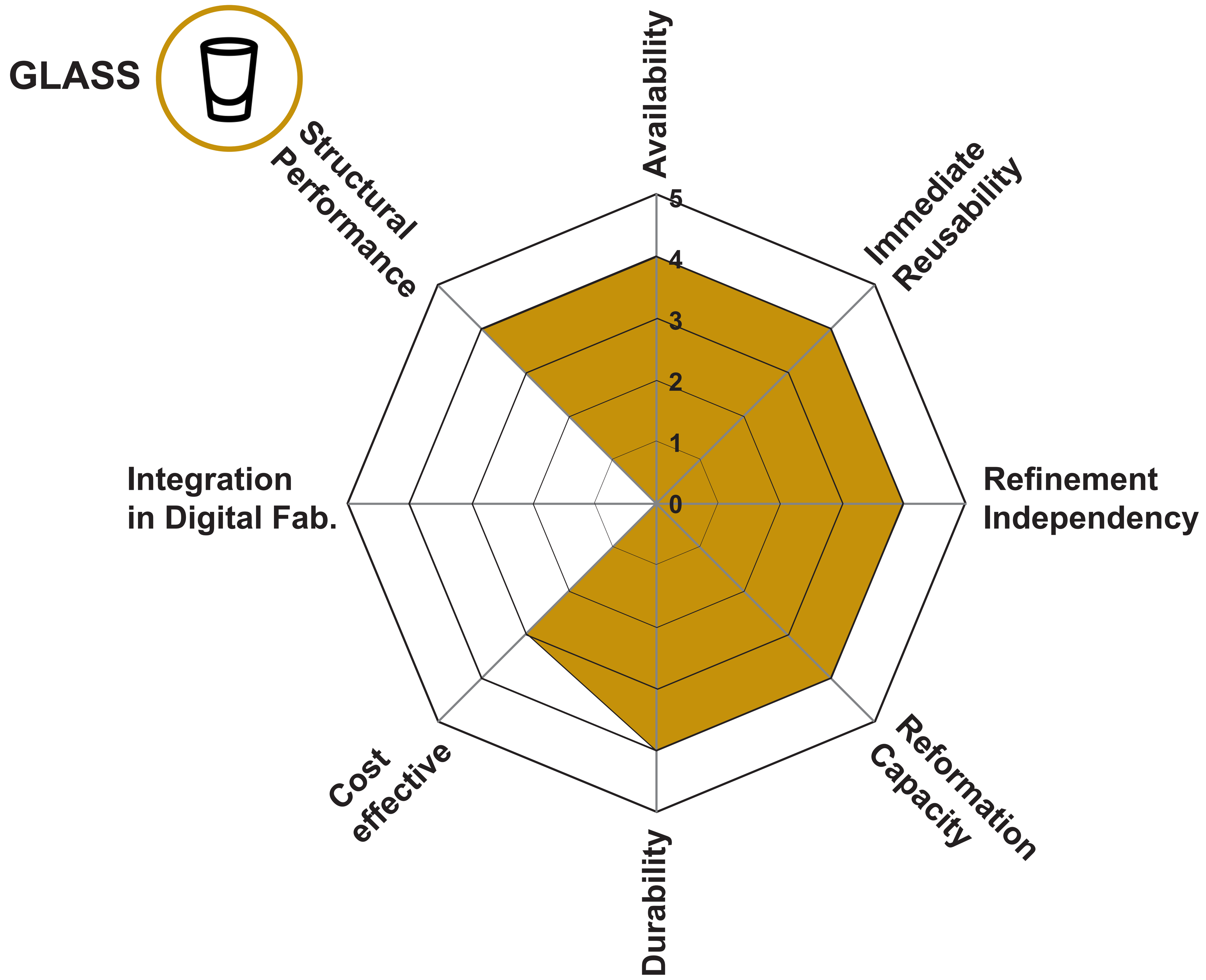
Wood can be rarely extracted from landfills and conventional refuse reserves, although can be very frequently reclaimed through construction sites, neighbourhood's disposal, scavenger's collection and online inventories. The material has the advantage of immediate application in construction with few amendments like severing, burnish and varnish, constituting an economic option of reuse, although is not easy to be reformed according to potential requirements without industrial elaboration and often its remaining days are counted. The possibility of integrating refuse wood in digital fabrication can occur only through subtractive processes and is a troublesome process (analysed in previous chapter), although due to its good structural performance, recyclability, demountability and aesthetics as alive material, wood should not be discarded from any rehabilitation effort.

Metal is respectively to wood, a material than can be recovered mainly through specific locations and inquiry methods due to its high value and great structural performance. Metal is a versatile material that can occasionally be utilized in construction with few amendments, most often, though, the material requires an overall reformation through sintering* and moulding, usually through industrial process, but also DIY elaboration is feasible with 'easy to make in your garage' tools (furnace, moulds etc.). The potential of employing disposed metal in digital fabrication is only possible if the above processes have been preceded, then the material can be utilized by almost any of the advanced manufacturing tools, although 3D printing technologies that can allow metal as raw material input are extremely cost related and have main application in industrial production, such as Direct Metal Laser Sintering or SLS, LOM, BJ etc. (see 3Dpinting technologies table board). The overall estimation is that incorporating refuse metal in digital fabrication frequently requires industrial pre-elaboration, especially in the case of structural purposes and not just panelling. Concluding, metal either as an off-the-shelf product or disposed material definitely retains high value, as an efficient structural element with wide application in construction, expensive and scarce in the natural reserve, recyclable, demountable and with aesthetic potentials.

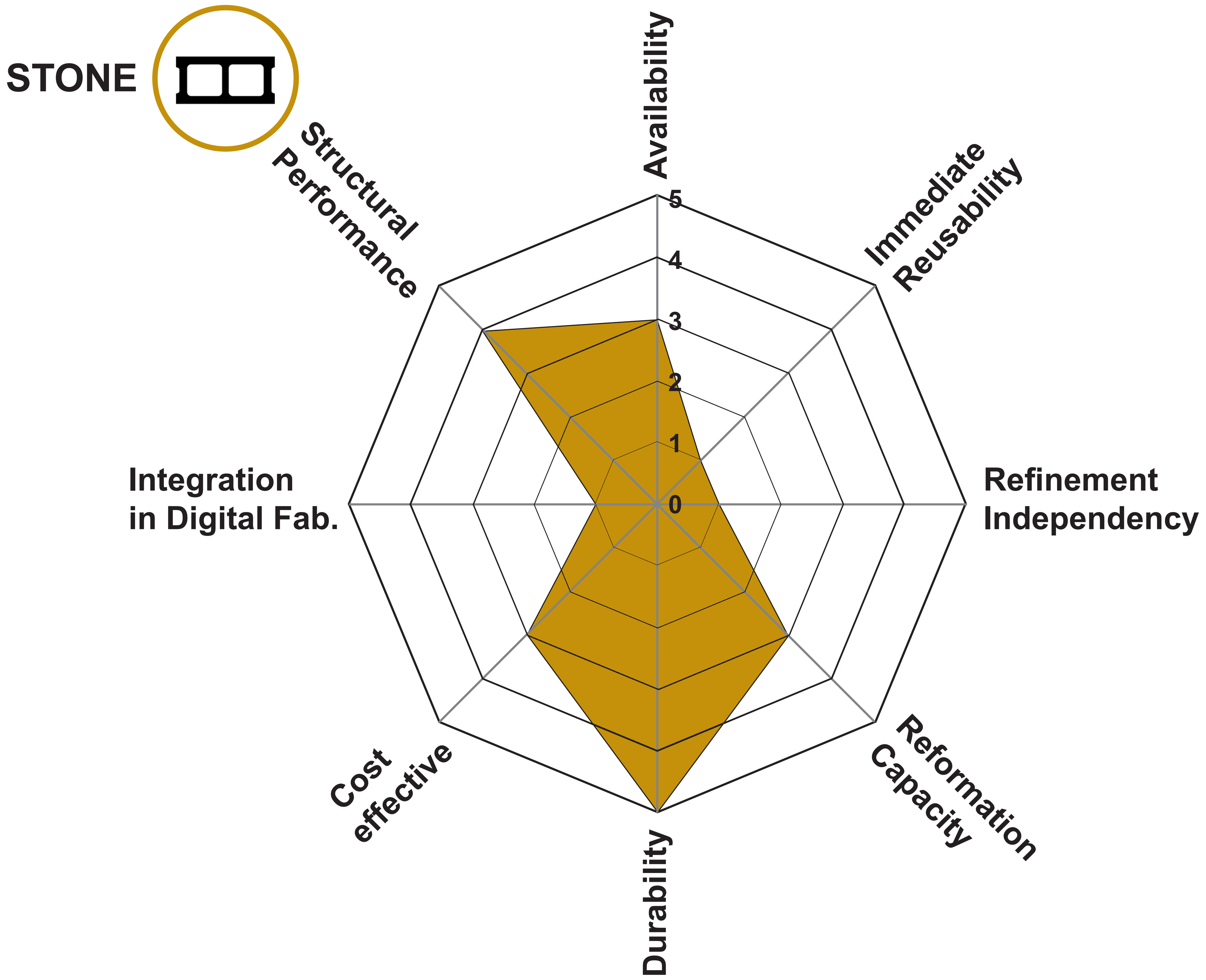
* Sintering is a method of creating objects from powder. The process consists of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquefaction.
Sources: http://encyclopedia.thefreedictionary.com/sintering
https://en.wikipedia.org/wiki/Sintering

Plastic constitutes an endless refuse material resource and a highly pollutant element that cannot be naturally decomposed and has covered approximately 88% of the planet's ocean surface (National Academy of Sciences, 2014[1]). The specific refuse has mainly insulating properties and moderate structural abilities, mainly restrained in panelling, tilling, sealing and joinery. The material usually requires rehabilitation and can be easily reformed, through DIY tools and processes, in readymade products and raw material input in digital fabrication technologies, mainly through its reformation into a new polymeric filament as 3D printers FDM (Fused Deposition Modelling) and BJ (Binder Jetting) raw material input, comprising the most efficient, enduring and wide available material for recycling.



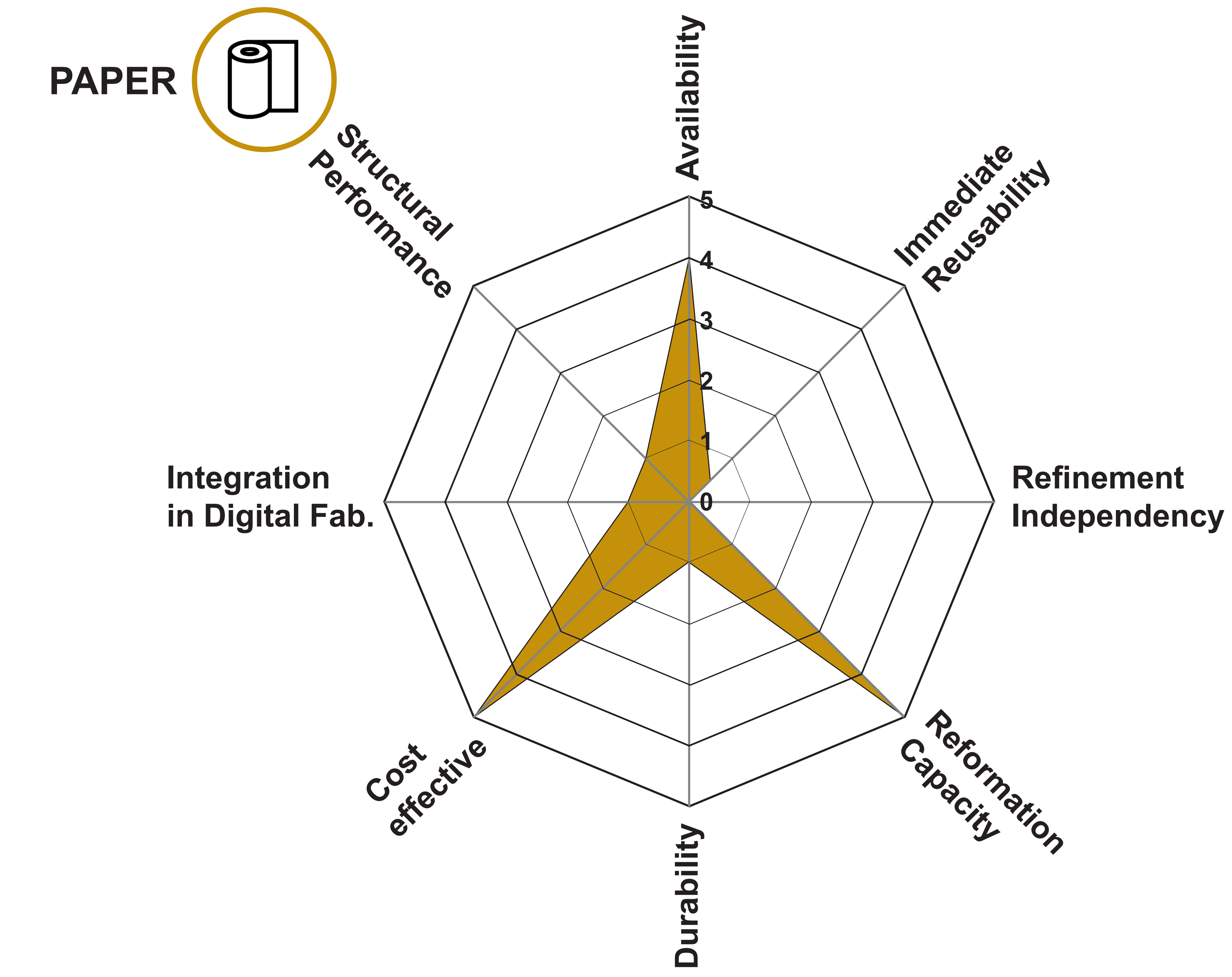


Stone as salvaged material is mainly available through building demolition and transformation sites, and online inventories (Opalis). Stone is a natural material, thus not harmful for the environment. The recovered material when in good condition, meaning still standardized, can be immediately incorporated in the building process, offering good structural performance and esthetical results. However, despite being one of the most common utilized materials in building making for many centuries, due to the current shift of events in a new metabolic mentality and future oriented production processes, the requirements in construction reflect good insulating properties, flexibility, temporality and demountability as main parameters to consider; hence, considering the redundant amount of existing building stock and permanent infrastructure, stone is not anymore recommended for major utilization in the urban fabric formation. Although, recycling of any material remains an endeavour that should not be discouraged in any case.

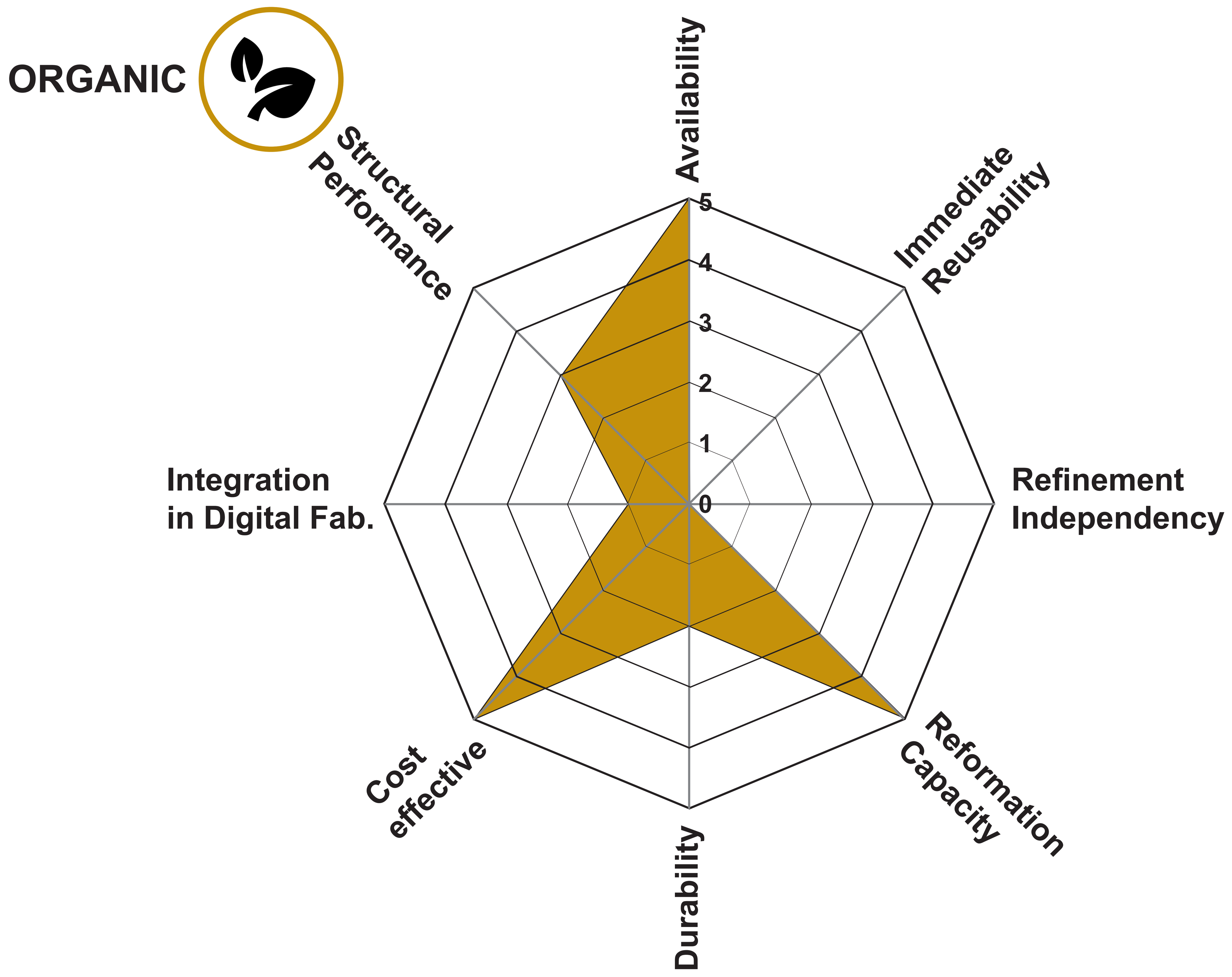


Glass is also a commonly salvaged and recycled material, and the last decades has found considerable immediate applications in building processes with reused materials, that is to say vernacular infrastructure (dwellings), urban installations and experiments in alternative building methods. The material has good structural properties, and in thickness can endure significant bending stresses (more than steel), is light permeable and beautiful. Although, the material's application in building construction is immense a as screen component, the structural advantages of the material are yet not fully exploited, with few exceptions due to the considerable difficulties in the production process, which are mainly attributed to deficiencies in accomplishing the required thickness for structural application due to parameters as the time of the sintered material's solidification and more. Innovative research is conducted to this regard, of glasses structural application in construction, by academic institutional carriers (i.e. TUDelft PhD researcher Faidra Oikonomopoulou), and private organizations. The potential of glass employment in digital fabrication is a quite troublesome subject that provides significant ground for investigation by itself, and won't be included in the premises of the current research paper.

1. http://www.pnas.org/content/early/2014/06/25/1314705111.full.pdf+html?sid=379d3657-ed7d-44ad-88ba-97f6af9bb2aa



Paper is a fibre composed element originated by wood and is widely available in households, recycling facilities etc. The material lately has started claiming position in the building sector due to the emerging potential of fibre composed elements in construction and has met wide application in temporary installations and emergency infrastructure solutions. Paper composed elements have limited structural capacity and usually find application in panelling or sound insulation with rare exceptions (see Shigeru Ban work, Wikkel House etc.), although mixed with other materials paper is able to create strong bonds and offer great structural properties. However, relevant processes are currently depended in industrial production due to proper mechanical equipment, and potentials of assessing the exact material's proportion analogies, technical requirements and life cycle.



Organic refuse consists of countless disposed elements and by-products, and is estimated to constitute 46% of the global waste composition according to the World Bank's estimation in 2012, that is to say by far the most disposed material by any other. However, the ability of organic refuse to be immediately, naturally decomposed puts the material in the bottom of the environment polluting elements list. However, in respect to the intensive research on alternative construction materials, certain disposed organic waste, mainly fibre composed and by-products, are also investigated as a viable option in circular production processes.

Conclusions & Design Considerations

in regard to material reuse in architecture practice

Attending an extensive investigation on material reuse in the building process, and a personal estimation of problematic variables that surfaced on my own project's previous implementation, below follow some parameters that can substantially influence the design process:

1. The design and construction with disused materials carries a strong possibility of developing into a time consuming procedure subsequent to a variety of reasons, the most important, according to my opinion, can be mentioned as:

- No sufficient control of the logistics the discarded components are claimed-arrive in your possession
- Elaboration and refinement methods required in order the waste elements to return in the production processes as raw materials
- Difficulties and retardation in design due to insufficient knowledge of the available raw materials. Even with certain knowledge of location, types and quantity of material the designer is unable to estimate beforehand the quantity and type necessary until the completion of design
- Such projects, most commonly, constitute small scale interventions or temporary installations, a condition that is attributed mainly to community's immediate requirement for elemental infrastructure, substantial funding obstacles and experimentation on innovative building processes stemming from an environmental consciousness. Along these lines such projects are usually implemented through collaborative and collective effort resulting from communal and voluntarily participation. How positive and socially healthy as this developments as it may be, it is very common that the majority of subjects participating in such procedures have elemental or absent knowledge of handicraft and building construction methods. In this sense, the realization of a project depended on unskilled labor can prove to be a time consuming and patience demanding process.

2. One other parameter that requires a designer's attention, when the utilization of refuse material is intended, is that frequently during the design and construction process an adjustment and simplification of the initial design, construction details and building methods can be in demand, according to the material availability, the available resources and in order to facilitate its fabrication or assemblage by handiwork and unskilled labor.

3. Considering the above parameters, a physical model production, comprises a problematic, troublesome occupation; a redundant, extremely time consuming, waste producing and inconsistent step in regard to the process's original set of principles. Admittedly, this limitation incommodes in significant level the project's visualization, as well as the estimation of calculating the cost, time and material parameter of the project, and general synthetic process of design. Although this equation's major determinant are the logistics, the potential of a model's realization is additionally affected in significant level by certain parameters as the degree of standardization of the materials anticipating to be reused, before or after being submitted to the required refinement and elaboration procedure, the forehand knowledge of exact type, dimensions and quantity, and the level that they can be considered as a 'raw' material resource.

More specifically, the ability of waste material to transform into a really novel raw material can affect the ability of the material to be represented and the actual preservation of a project's vision. I.e. the plastic potential to be assimilated and transformed through a melting and extrusion process to a 3D printer's raw material input (a brand-new polymeric filament), next to a timber's element incapacity to regenerate, where most common technique of integrating waste wood in construction, that does not refer to industrial transformation into lesser quality timber based materials, is the patchwork of variable timber types and sizes. In the latter occasion of ignoring the condition, type and dimension of the material intended to be used in construction constitutes its representation through modeling almost impossible. However, such a restrain urges the designer to interact, formulate or participate in working groups that can contribute to the feasibility of experimenting and actually implementing through collective effort and a 'trial and error' procedure, this type of projects.

4. A most notable aspect of the difficulties of utilizing the refuse in architecture practice often accrues due to program or scale of a project. In major projects and when working for a 'big' client, the components intended to be reused cannot respond adequately to the end of life regulations and the technical descriptions required by the stakeholders and/or the statutory framework the construction is taking place. This usually occurs due to the cost of demounting and logistics, the incapability or cost of the embedded effort in assessing the remaining life spun of an element, and most often the stakeholders' aesthetic expectations when waste elements are placed side-by-side to brand new, slick, off-the-shelf building components. The latter, due to raw material scarcity and the current shift to an environmental sensitive model that increases the demand for sustainable construction, has triggered a gradual, nevertheless important, transformation of the client's perception of waste. This being said, the overall shift of society to a metabolic mentality and the refuse materials' wide public acceptance still have long way to go constituting for the new generation of designers an intriguing challenge.

Below follows a differential equation recently provided to me in a lecture given at the Architecture faculty in TUDelft by the Belgian studio Rotor in order to designate the reusability of a building component:

Reusable if:
Cost of
(demount + logistics) * risk < market value

- **Time consuming process**
- **Deficient control of logistics**
- **Material rehabilitation required preceding construction**
- **Inadequate life-cycle assessment**
- **Complications in large scale implementations**
- **Material insufficient respond to technical regulations**
- **Salvaged materials competing off-the-shelf products**
- **Physical model making is often problematic & redundant process**
- **Co-working & participation supports realization**
- **The necessary unskilled labor influence schedule & design method**

Reusable if:
Cost of
(demount + logistics) * risk < market value

Source: Rotor's lecture in TUDelft , May 2017

The design, through material reuse, considerations are conclusions mainly derived from the Container Project case study and the Rotor's lecture in TUDelft, among many other resources and case studies in the topic of material rehabilitation that influenced this investigation.

Patchwork Case Study Conclusions

The attempt of applying heterogeneous element types in the same construction process (patchwork) can generate several complications mainly in regard to certain criteria that influence design, as the logistics, the effort to avoid material wastage resulting from scraps of the process of re-employing salvaged, not standardized elements in a unique pattern, in addition to complications resulting from the different technical properties of the variable material types that have to be taken into account in respond to specific construction requirements according to function and climate; i.e. different material types have different behavior in regard to mechanical strength, durability according to type and preceding life cycle,moisture, general insulation properties and potentials of interior or exterior application. Managing these restrictions during design of a small construction constitutes a troublesome but intriguing and feasible process, although in large scale implementations these preconditions can be impossible to regulate. The above process requires a high level control of logistics and formulation of inventories that can increase the potential and efficiency of salvaged elements' rehabilitation, material classification according to technical features and dimensions, and design through multiple parameters. Taking additionally into account that significant percentage of a raw material's embedded energy is consisted by the factor of transportation, which increases carbon footprint, a platform that is capable of dispensing data about the quantity, type, price and material location constitutes a fundamental condition that needs to be integrated into a sustainable system of production. In these lines, considering the above criteria in early stages of design through the employment of parametric software has great potential of realization and optimization of the process.

- **Research on material reserves**
- **High level control of logistics required**
- **Formulation of inventories**
- **Classification of heterogeneous materials according to type & dimensions**
- **Construction criteria assessment**
- **Employment of parametric software in the design process**
- **Straight forward prototyping**
- **Advanced manufacturing methods employment**

Conclusions on the Digital Fabrication Techniques

Resulting the analysis on digital fabrication techniques and the Fab Lab House case study, according to the current investigation's approach sectioning and tessellating are the most efficient methods of employing computer aided manufacturing in vernacular implementations in architecture practice. Significant asset of the two techniques constitutes the capacity to provide sufficiently both structure and surface.

Sectioning has proven over time to be a sufficient technique able to provide high mechanical strength structures, insulation and waterproof capacity in simple and very complex geometries (double curved surfaces) in regard to its wide application in the construction industry for airplane and ship manufacturing. While tessellating obtains the significant advantage of not necessarily being depended on an additional supporting framework by employing a parametrically optimized geometries arrangement and smart integrated joining systems.

ETH's installation in Ideas City Festival utilizes a construction technique adjacent to tessellating in digital fabrication, although the current application's method inconsistency to the overall principles of the technique derives, in my opinion, from the recomposed from refuse weak material panels' insufficiency to form mechanically strong connections and an overall load bearing structure without a certain overlap that is defined by a parametrically optimized design in accord to the flow of forces.

In addition, the case of the Fab Lab House indicates that hybrid applications of techniques according to specific criteria can facilitate an economy driven process, moreover by applying such parameters through computer software can provide optimal results in terms of design composition, climate scheme and material management.

As discussed, the design of digitally fabricated architecture is exploiting the leverage of being informed by the methods and material of construction in early development stages. Taking this into account, the employment of parametric design in any attempt of material coming first in construction is a precondition of a smart, integral process. Furthermore, utilizing this reciprocal process of a genuinely constrained by the material parameter design provides an actual potential of incorporating almost any of the refuse material types analysed in this investigation through the above technics.

Sustainable Assessment on Digital Fabrication Technologies

Conclusions [additive]

3D printing consists a revolutionary advancement in the computer controlled manufacturing and in such manner, the **waste resulting subtraction process of production had a great potential of no longer being required**. A possitive aspect of exploiting additive fabrication in the current project is that the method utilizes thermoplastics (PLA, ABS, nylon etc.); hence the capacity of integrating **waste plastic as raw material input**, through the conversion of the element in a new polymeric filament is an important asset. Additionally, by definition 3Dprinting requires **only the necessary material** the product consists of, without the production of waste.

Conclusions [subtractive]

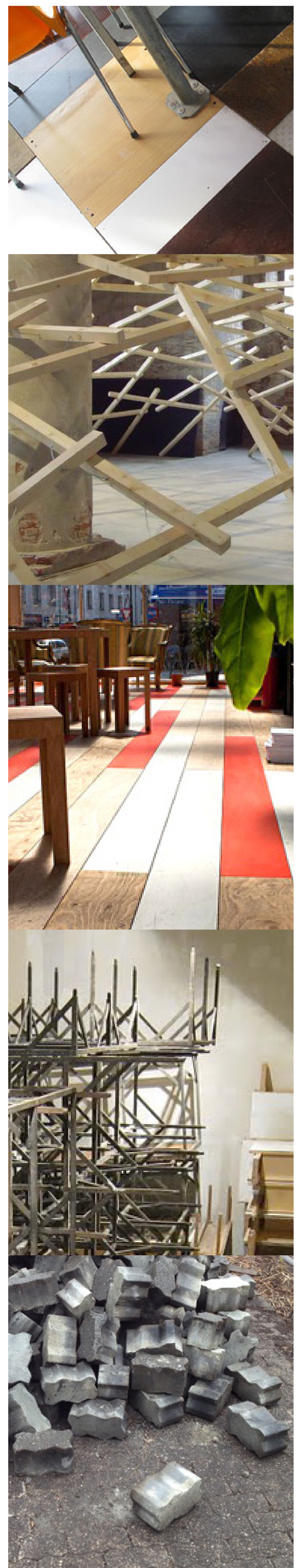
Subtractive methods have considerable disabilities towards the intention of employing certain types of refuse as integral part of the raw material reserve in advanced production technologies; wood which is one of the most common utilized elements by CNC hardware, and in the same time one of the most frequently recycled materials, constitutes the most representative in this category, in regard to the lack of this disposed material type in standardization and deficiency in reformation into a new product without industrial elaboration. However, with perseverance on the accumulating stock and systematic classification of these materials according to type and dimensions, by utilizing parametric design the incorporation of these materials in digital fabrication is not out of reach.
Despite, the above aggravation, CNC technologies obtain the leverage of fabricating components intended for demountable construction, which in the architecture practice of metabolic mentality is an asset not to be disregarded.

Reference Projects

Agenda of projects, collective aggregations and architecture studios with referense to the topic of reuse and urban intervention, that have been employed as source of case studies, data, methodology and inspiration, with the conclusive definitions of what their work or vision is about, as provided through their on-line platforms

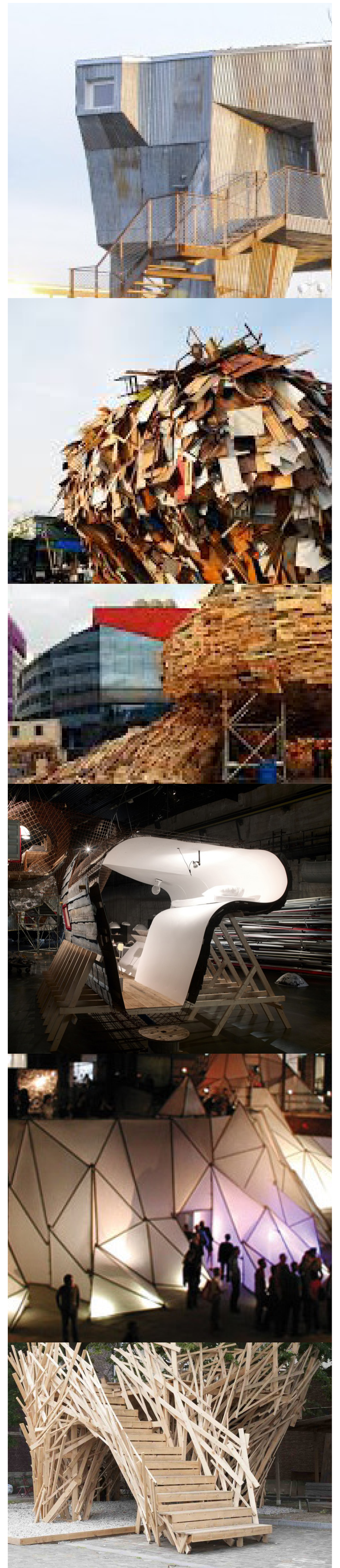
Rotor

Founded in 2005, Rotor is a collective of people with a common interest in the material flows in industry and construction. On a practical level, Rotor handles the conception and realization of design and architectural projects. On a theoretical level, Rotor develops critical positions on design, material resources, and waste through research, exhibitions, writings and conferences.



Raumlabor

Raumlabor is a community of interests located in Berlin that pursues common goals and content in architecture. As a result, Raumlabor is not a company (and therefore not a GbR or GmbH), but project-related working groups which find the appropriate legal form, as a rule a project-related GbR, whose partners are the contractors. With a strong belief to the complexity of society their projects constitute a more substantial approach through small scale spacial proposals deeply rooted in the local condition

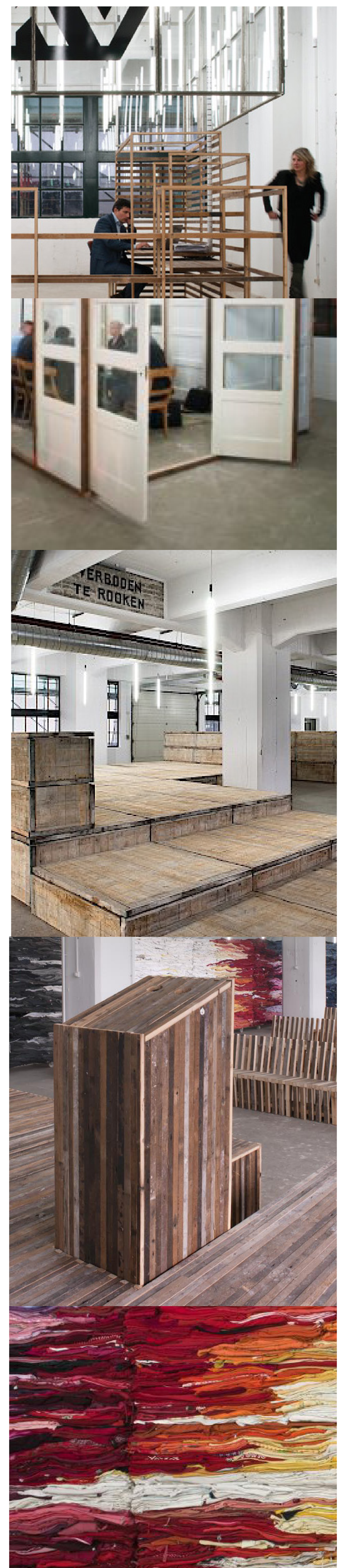


SuperUse

Superuse Studios was founded in 1997 by Césare Peeren and Jan Jongert and has become a pioneer in the field of sustainable design. The firm is renowned nationally and internationally for its innovative design approach as well as for providing 'open source' methods and tools to the design community. All with the aim to make effective use of frequently wasted resources and energy.

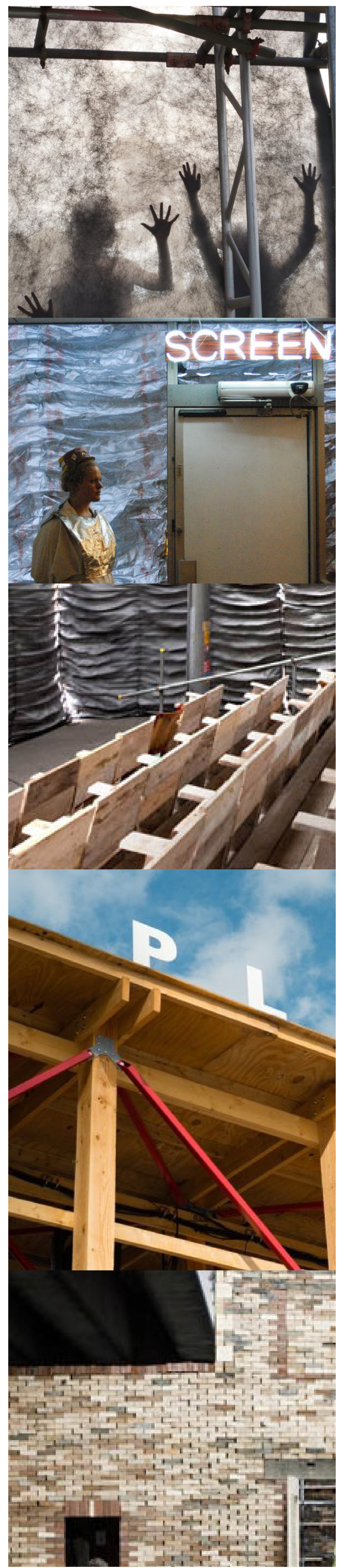
Haka (Doepelstrijkers)

HAKA is a recycle office in Rotterdam designed by the architecture studio Doepelstrijkers and built out of waste materials by ex-detainees, the HAKA Recycle Office creates both ecological as well as social return on investment. The HAKA building is living Lab created in 2009 by Doepelstrijkers studio, was designated as a campus for clean-tech activity, a 'Living Lab' for companies, institutions and authorities in the field of water and energy innovation.



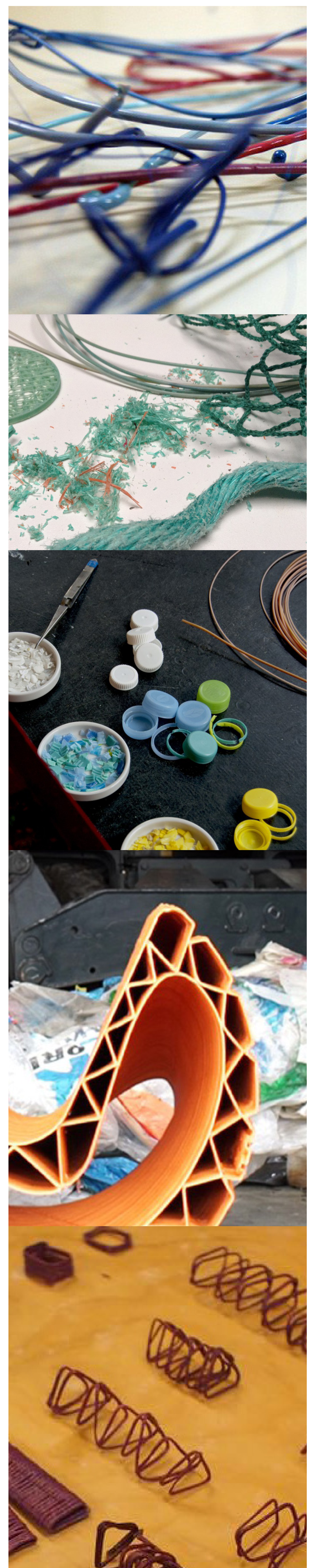
Assemble

Assemble are a collective based in London who work across the fields of art, architecture and design. They began working together in 2010 and are comprised of 18 members. Assemble's working practice seeks to address the typical disconnection between the public and the process by which places are made. Assemble champion a working practice that is interdependent and collaborative, seeking to actively involve the public as both participant and collaborator in the on-going realisation of the work.



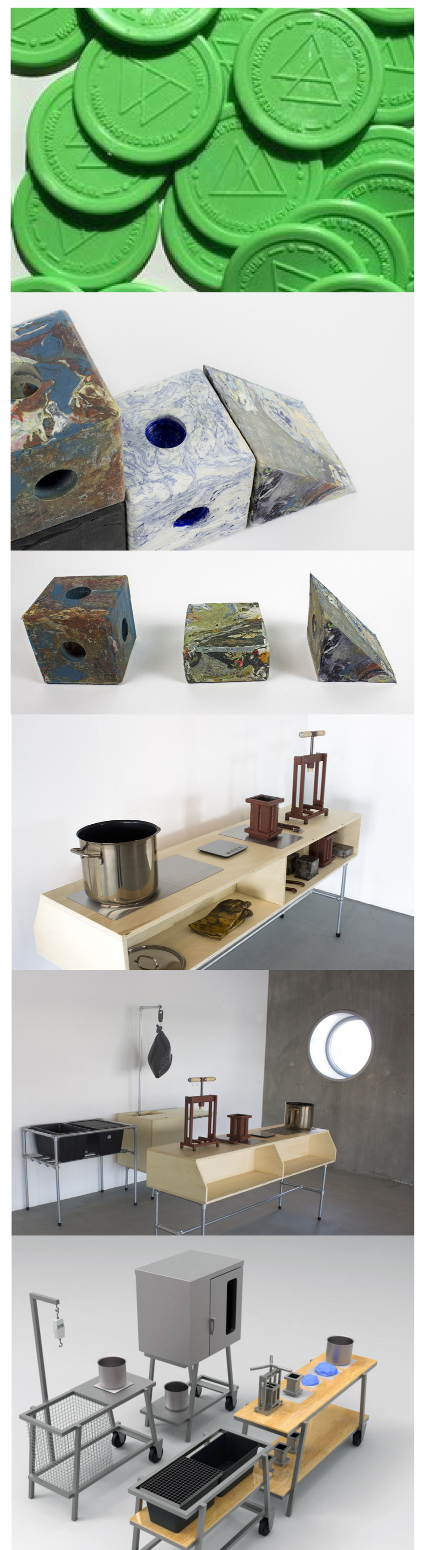
The New Raw

The New Raw is a creative practice that explores the merging fields of digital fabrication and material resourcing. Main intention is closing loops by introducing digital fabrication technologies in the recycling process of discarded materials. In this manner, the team explores what design can offer towards the subjects of waste-overproduction and material misuse. The New Raw was founded in Rotterdam in 2015 by Foteini Setaki and Panos Sakkas.



Wasted

Wasted is a neighborhood Laboratory for small-scale plastic waste reprocessing located in Amsterdam Noord. The company's main objective is to transform trash into useful components working with the community, for the community using innovative operational approaches; i.e. education packages, workshops, opensource documents and plastic waste utilized as local currency with a reward system.



Precious Plastic

Precious Plastic is a project of Dave Hakkens resulted on website, where a solid version of machines for plastic reuse, instructional videos, and blueprints shared opensource for free. A complete package that enables people to start recycling.

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