FROM NON-EXTRACTIVE TO POST-EXTRACTIVE ARCHITECTURE

GEOGRAPHIES OF WASTE

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I hereby undertake that this digital version of the Master's Thesis will be printed without any further changes or additions and hand-delivered on Tuesday 28 June before 4pm together with the presentation visual material to the Master's Secretariat (MSH 2nd floor).

Name: Simona Popova

Signature:

Contents

Part I : Non-Extractive Architecture. On designing without depletion

How was this possible ?

human activity
materials
resources
supply chains
externalities

Barcelona Pavilion. Mies van der Rohe. Photograph by @Gili Merin

“In the place of energy efficiency, we propose to consider externalities as a metric of sustainability.”

“Architecture’s externalities do not necessarily take material form”

1.1 What is Non-Extractive Architecture ?

The term of non-extractive architecture first appeared in 2021 as the title of book and a live research residency project, at the Palazzo Zattere in Venice, Italy, that was launched by Joseph Grima and his studio Space Caviar. The project is examining and redefining the role of architecture and the architect, him/herself within the society today.

What if we understand architecture as form of connection between natural and man-made environment? What if we challenge and redesign our economy in favour of ''integration, circularity, durability and social resilience through the towns and cities we build''? (Grima, 2021)

What if we shorten the material supply chains and make them more ''visible and participatory rather than invisible and often exploitative''? (Grima, 2021)

''Non-Extractive Architecture engages individuals within and outside the field of architecture to create an open platform through which the current role of architecture can be debated, and new paths can be defined to leverage its potential as a positive force in shaping the future of a landscape.'' (Grima, 2021)

Volume 1 of the project is a collection of all the relevant practices that exist out there that are related to/following the principles of non-extractive architecture, all through their distinct positions and discourses.

...

Non-extractive architecture **rethinks the responsibility of the architect's role and explores externalities and side effects of material economies and supply chains in the building environment.** It is a practice that acknowledges the multiple impacts of human activity and more specifically related to architecture and construction practices, on the planet earth. It realizes the fact that r**esources on the planet are not limited and advocates for change of the architectural practice and education, for change of our economic system and for policy-making and a more interdisciplinary approach to practice.**

Non-extractive architecture looks at sustainable practices beyond, energy efficiency, beyond timber construction, beyond designing with materials that are recyclable. Of course, all these strategies are incredibly important and valuable, on to designing architecture that is more environmentally friendly and responsive, however, we need to take a step further and **look at architecture as a practice that its dependent on a set of resources, a set of supply chains, a set of practices and their relationship with the community.**
In consequence of the **exhaustion of the term ''sustainability''** we need to come up with **new vocabularies to speak about these strategies.**

It is important to acknowledge **construction as an additive process,** that in order to respond to a need and provide resources or services, they have to come from somewhere else. **Every additive process or human activity results with a consequence somewhere else and produces amount of waste. Furthermore, these processes are intertwined with certain labor practices. All these activities and practices are extractive and exploitative in a certain way. Following this argument the project begins with one general question: ''Is it possible to imagine architecture that is non-extractive, non-exploitative''?**
Architectural and Construction practice has to acknowledge the consequences and take responsibility for its actions. **In both practice and education, we have to develop strategies that go beyond ''circular design of the materials'', ''energy efficiency''. The discourse of non-extractive architecture allows us to explore all these questions and opens up many different possibilities.**

LANDSCAPES OF EXTRACTION. MODIFYING THE PHYSICAL ENVIRONMENT TO REACH OUR GOALS.

“For thousands of years, humans have modified the physical environment by clearing land for agriculture or damming streams to store and divert water. As we industrialized, we built factories and power plants. While these modifications directly impact the local environment, they also impact environments farther away due to the interconnectivity of Earth’s systems.”

@National Geographic Resource Library 2022

Landscapes of Extraction

Photographs @tomhegen

Photographs @tomhegen

1.2 State of the Art Research

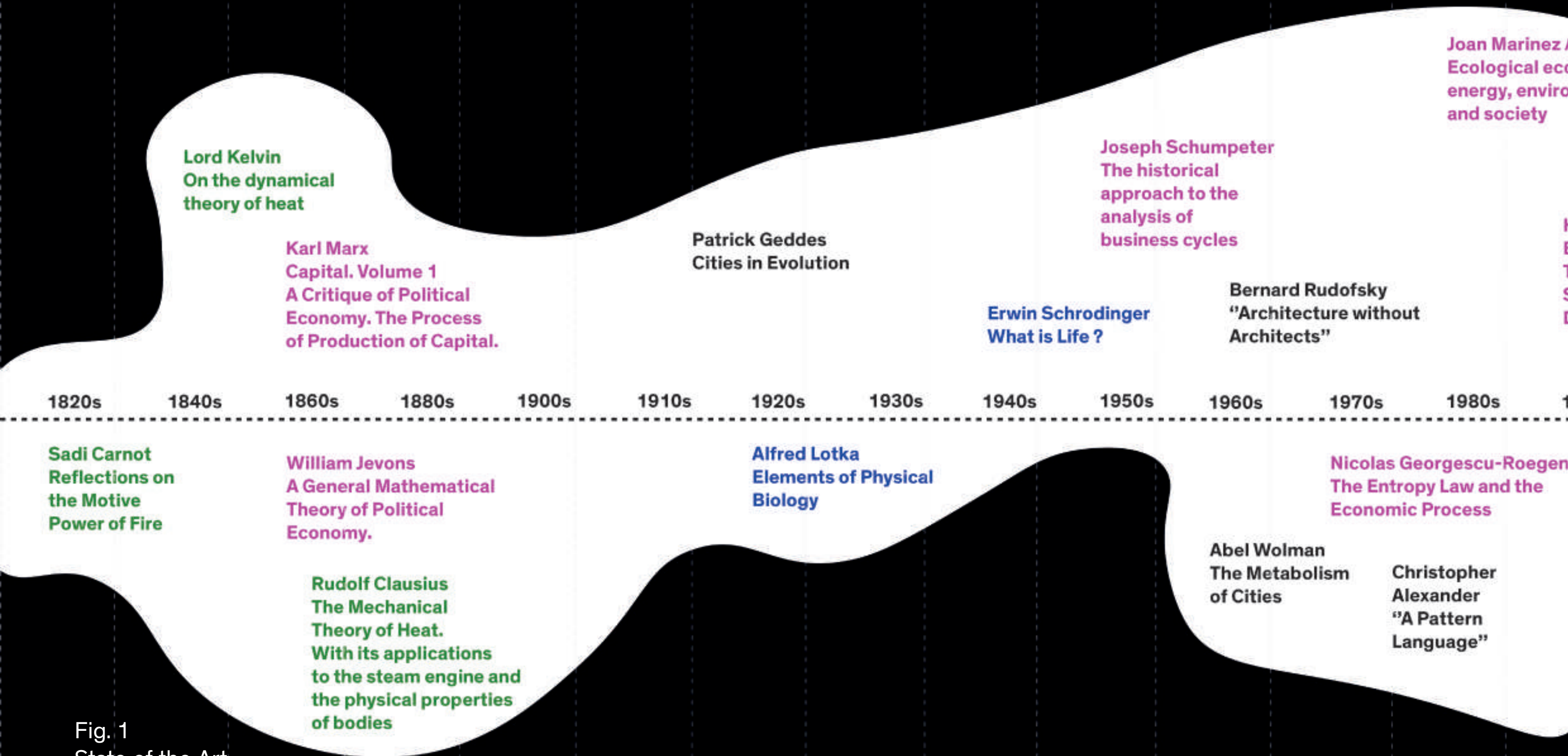
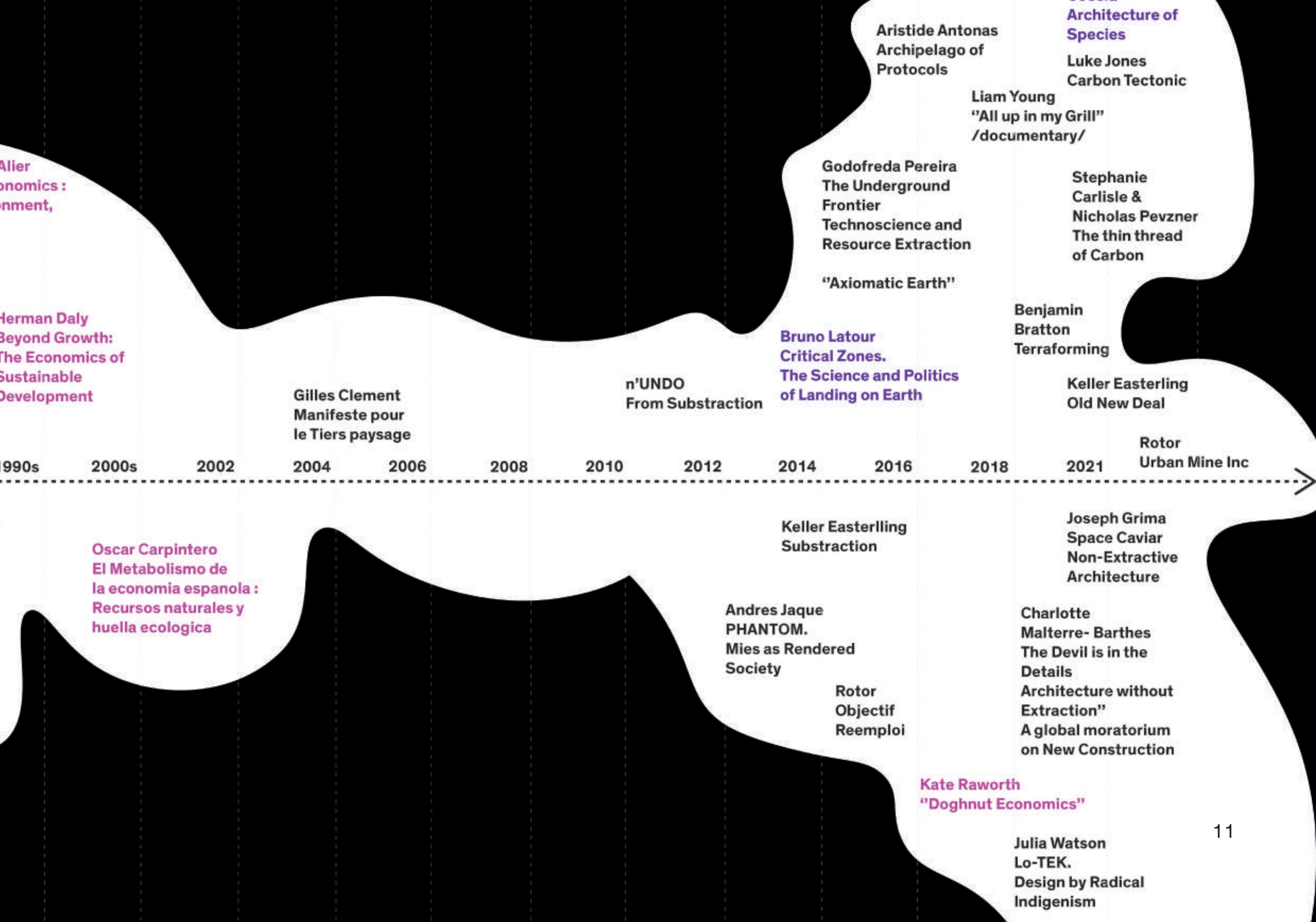


Fig. 1
State of the Art
Timeline



Architecture of
Species
Aristide Antonas
Archipelago of
Protocols
Luke Jones
Carbon Tectonic
Liam Young
"All up in my Grill"
/documentary/
Alier
onomics :
onment,
Godofreda Pereira
The Underground
Frontier
Technoscience and
Resource Extraction
"Axiomatic Earth"
Stephanie
Carlisle &
Nicholas Pevzner
The thin thread
of Carbon
Herman Daly
Beyond Growth:
The Economics of
Sustainable
Development
Benjamin
Bratton
Terraforming
Bruno Latour
Critical Zones.
The Science and Politics
of Landing on Earth
Gilles Clement
Manifeste pour
le Tiers paysage
n'UNDO
From Substraction
Keller Easterling
Old New Deal
Rotor
Urban Mine Inc
1990s
2000s
2002
2004
2006
2008
2010
2012
2014
2016
2018
2021
Keller Easterlling
Substraction
Joseph Grima
Space Caviar
Non-Extractive
Architecture
Oscar Carpintero
El Metabolismo de
la economia espanola :
Recursos naturales y
huella ecologica
Andres Jaque
PHANTOM.
Mies as Rendered
Society
Charlotte
Malterre- Barthes
The Devil is in the
Details
Architecture without
Extraction"
A global moratorium
on New Construction
Rotor
Objectif
Reemploi
Kate Raworth
"Doghnut Economics"
Julia Watson
Lo-TEK.
Design by Radical
Indigenism

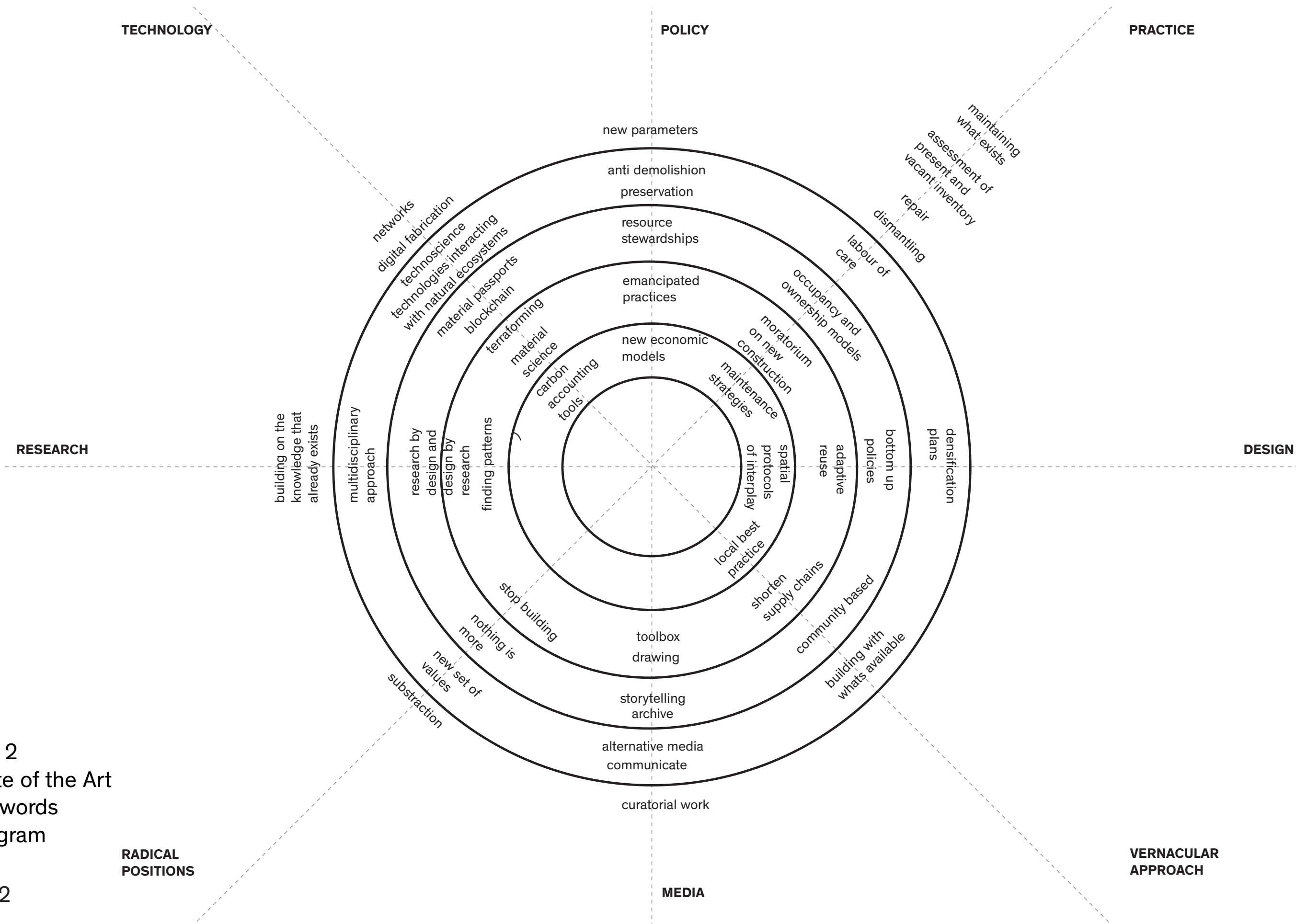


Fig. 2
State of the Art
Keywords
Diagram

State of the Art Analysis

The two diagrams were developed in the context of the discourse of Non-extractive architecture. We can argue that the notion/term of **''Non-extractive architecture''** can be considered as part of the ''NEW WAVE'' of discourses around sustainability, even though **all of the issues, concepts and strategies that it addresses, that are related to extraction and exploitation of material and immaterial resources, and the creation of externalities, have been existing for a while.**

Following the argument that all concepts around the topic of Non-extractive architecture have already been invented, it was an interesting exercise to **position the relevant non-extractive practices and positions on a timeline, analysing their relations and tracing the authoritative state of the art back in history.**
The diagram (fig 1.) highlights the state of the art from several different disciplines : In black are the ones practicing within **Architecture, Landscape and Urbanism;** In pink are the ones within the field of **Economics;** In blue are the ones from **Physics and Biophysics ;** In green are the ones from **Engineering and Thermodynamics**, and last but not least, in purple are the ones from **Social Sciences.**

The second diagram (fig2.) was developed as part of the state of the art research for my master thesis. After looking deeper into the work of the relevant/authoritative state of the art from the previous diagram(fig 1.) **I have structured their positions within different themes and by using key words, to help me shape my own position within the Non-Extractive Architecture Discourse.**

The themes that I have observed during my analysis were exploring the **relationship between research and design practices, where we can argue that the two are deeply related within the notion of research by design and design by research.**

Another aspect that I have found interesting is that most positions are calling for **either Technological or a more Vernacular approach to practice.** Considering the society in which we live today, and looking towards the future, we can argue that **there is no way that we will live in a world that wont be highly technological, however there is also no way to build an attainable technological framework, without it being socially sustainable.**
The different state of the art discourses addresses the need for radical positions within practice and question what are the media and tools that we can use to communicate these ideas and more importantly, what policies will have to be adapted to enable these ideas to be translated from theory into practice.

The following pages present a short analysis of a selection of 4 State of the Art positions from the timeline that were the most relevant ones for building my position within the discourse of Non-extractive Architecture.

One interesting name that appears, in the 1970s , whose discourse was later on related to the notion of "degrowth" is the one of Nicholas Georgescu-Roegen – an environmental economist that was the first one to explain economy as an extractive process through the second law of thermodynamics. When addressing "sustainability", which is a term to be questioned and examined within our practice today, we are often concerned with energy efficiency. Georgescu-Roegen argues that the material extraction and resources are fundamental aspects to be considered and questioned for the future production, even more than energy. If we ask ourselves : "Is a non-extractive way of building really possible ?", the discourse of Georgescu Roegen really gives an interesting position on this. In reality, no, it is not possible or compatible within the current economic system, to achieve a non-extractive way of building. And this is proven through the second law of thermodynamics...

The laws of thermodynamics state that:
Law 1 : Energy is always conserved
Law 2: Its quality to do anything useful tends to decrease in an isolated system/an isolated system is the universe/

However, in an open system/for example, every living being on earth is an open system/ or closed system /planet earth is a closed system/ additional energy can come in which can reduce entropy within the system. But it does so by the expense on an entropy sometimes out of the system!
When related to Economy, the second law of thermodynamics states that: Materials can be recycled, however they cannot be recycled a 100% because this will require too much energy

-Energy cannot be recycled at all
-All physical processes convert low-entropy energy and materials into high-entropy wastes
-The structure of any physical good/product degrades over time and energy inputs are needed to counteract this
-A decrease in entropy in one place, means a larger increase somewhere else /externalities/ (fig3) and (Fig4)

Georgescu-Roegen's discourse, even from 1970s, challenges the current economic system that we live in, by covering all the energy, material and labour dimensions that non-extractive architecture addresses today.
To conclude, there are many other practices and disciplines outside the Volume and outside the architectural practice, that address, directly or indirectly the topic of non-extractive architecture.If we look deeper into their work, we can argue that there are certain points of connection (for example, in discourse, a certain theory explored or a certain case study that they worked on) where everyone is related to one another and create one complex network of ideas, knowledge and discourses, to be critically analysed and strategically linked towards shaping a more socially, economically and environmentally resilient practice of Architecture.

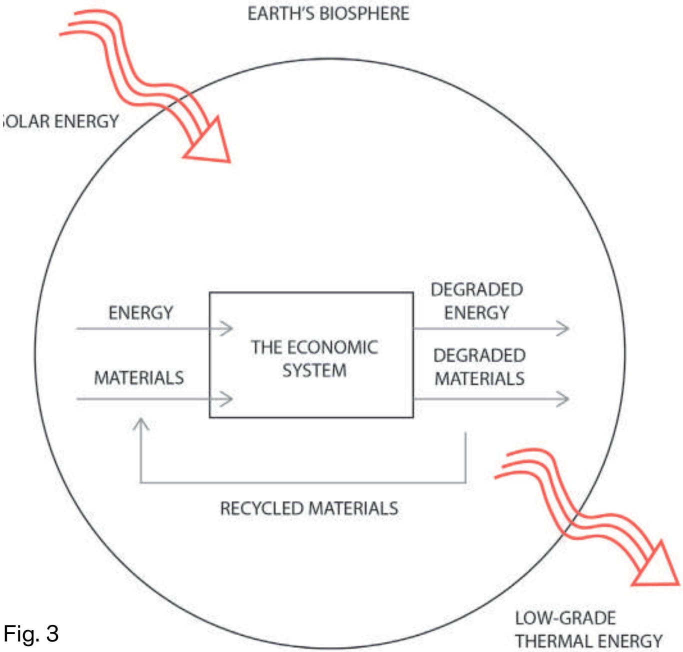


Fig. 3
Economy as an extractive process. Flows of Materials and Energy within the Economic System

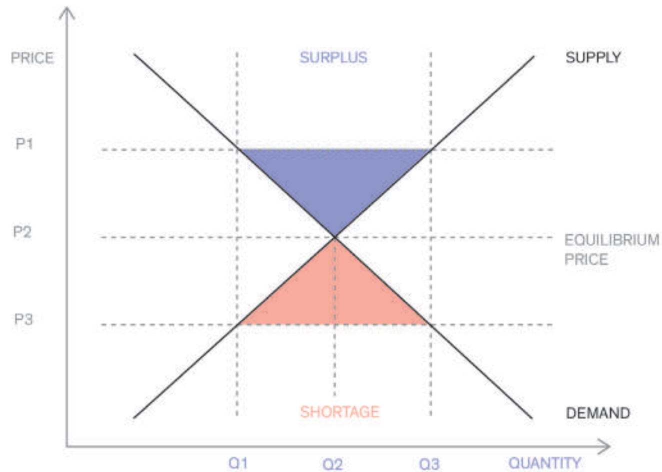


Fig. 4
The Economic System Diagram.

Joseph Grima and Space Caviar |

An approach towards Non-Extractive Architecture | Research by design and design by research

EARTH 1 / Salt Marsh

Interview: Feifei Zhou in conversation with Rhiarna Dhaliwal and Connor Cook

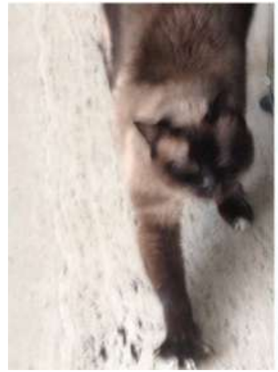
Feifei Zhou, co-editor of Feral Atlas in conversation with Rhiarna Dhaliwal and Connor Cook

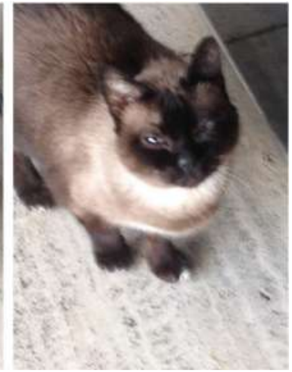
Within the current context how does the role of our the architect change ? Rethinking responsibility...

Details of the installation and moments of the workshop Syntropic materials. Towards a polyculture of materials and knowledge by Eugenia Morpurgo

Images : @Blog. Non-Extractive Architecture

Andrés Jaque
PHANTOM. |
Mies as Rendered Society |
A hidden context





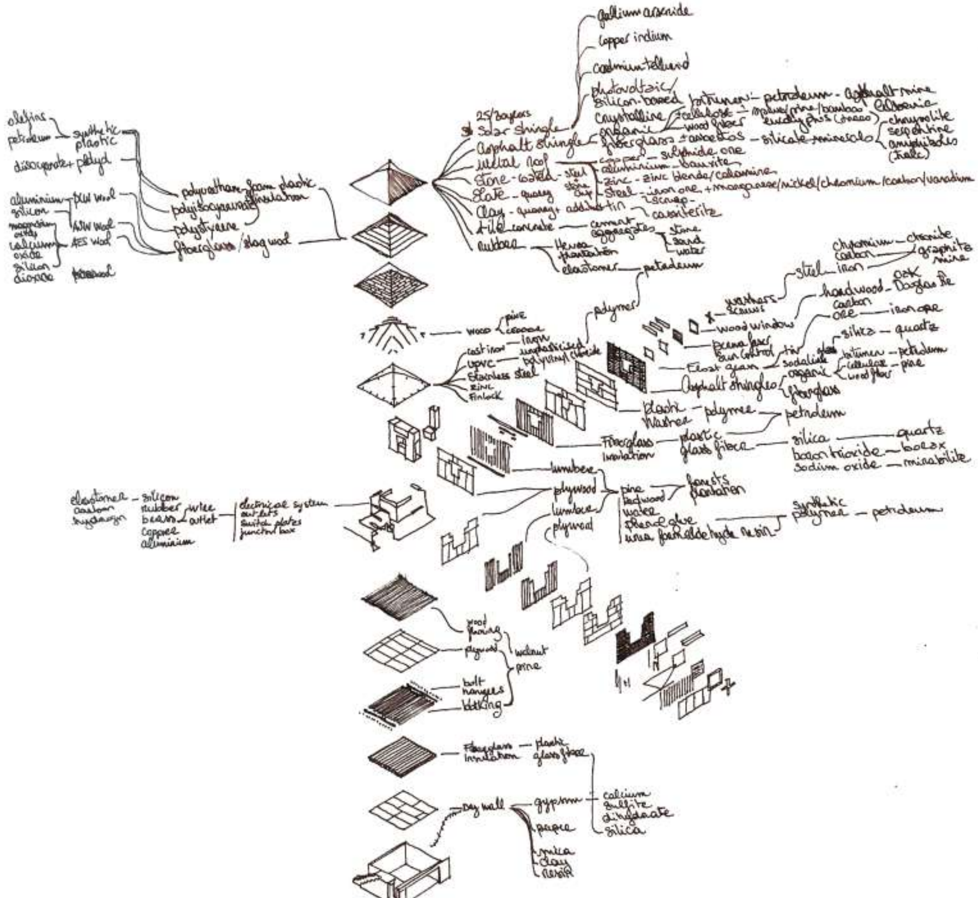
Finding patterns | A hidden context | “Looking underneath the surface” .

@An exhibit of all the objects found in the basement of the Barcelona Pavillion.

Mies van der Rohe.
Nationalgalerie.
Berlin
@Bauwelt 2020

Photographing the
“extractive” technical
basement.

Charlotte Malterre-Barthes. Material World | Scales of Extraction | A global moratorium on new construction



The discipline is in need of radical positions | A drastic change in construction protocols | Stop building ? Drawing by @Charlotte Malterre-Barthes. Scales of Extraction.

Courses

Material World

"Who is it that the Earth belongs to?" Bangstad, Sindre, and Nilsen Torbjørn Tumyr. "Thoughts on the Planetary: An Interview with Achille Mbembe." New Frame (2019).

Course Number
DES-3397

Hours/Location
Mon 9:00 AM - 12:00 PM

Spring 2021

Seminar/Workshop

4 Credits

↗ Website

Instructor

Charlotte Malterre-Barthes

Department

Department of Urban Planning and Design

What Donna Haraway calls "the appropriation of nature as resource for the productions of culture" and the translation of the Earth's resources into the built environment are mirrored in today's neo-colonial modes of extraction capitalism.

We Need a Global Moratorium on New Construction!

@Charlotte Malterre-Barthes.
Moratorium on New Construction

NON-EXTRACTIVE ARCHITECTURE WITHIN THE NOTION OF REPAIR

HOW DO WE DEAL WITH THE EXISTING ?

TOWARDS A POST-EXTRACTIVE ARCHITECTURE

ARCHITECTURE IS NO LONGER A PRACTICE FOR BUILDING .
ITS A PRACTICE FOR REPAIR / REUSE / MINIMIZATION / DISMANTLEMENT.

1.3 Hypothesis | Research Question

Following the research on non-extractive architecture **I position myself and my thesis within this topic by questioning the long-term impact of extractive practices on our environment and society.** What happens to all these materials and resources that we extract, after our industry decides that they are no longer “good” within the built environment. Or to put it in other words what happens to buildings at the “end” of their life cycle is that they, and all the materials and components that they are composed from turn into waste.

Where does waste go and how it is treated? This is a question that sits at the core of this master thesis and is explored within the second chapter that is named GEOGRAPHIES OF WASTE.

This question is explored within the context of Luxembourg, where the numbers of Waste generated by construction and demolition practices are quite significant.

1.4 Methodology

Several methodologies were used within the different stages of the thesis starting from reading patent literature on the subject of Construction and Demolition waste and positioning the topic in context by using Luxembourg as a case study.

This was followed by **gathering DATA** from, and **conducting conversations with the relevant stakeholders in Luxembourg.** These were mainly representatives from **LIST (Luxembourg Institute of Science and Technology)** and the Environmental Administration, that is part of the Ministry of Environment, Climate and Sustainable Development.

A fundamental part of the research was the **processing, filtering and visualizing the DATA** from two different datasets, including information related to all the waste produced in Luxembourg within a time frame of 4 years (2016-2019). As part of this process I collaborated with Federico Bigi, a colleague and PhD student from the MobiLab research group at the University of Luxembourg, on **generating a code** that helped me link the two datasets together and understand better the ratios, as well as the inflows and outflows of waste generated by Construction and Demolition practices in the context of Luxembourg. Alongside the DATA analysis, a **geospatial analysis** was performed in order to explore the infrastructures (the landfills) that accommodate that waste, realizing the way they function, their capacities, morphology and evolution through time.

A critical aspect of the research was the **multidisciplinary approach to practice,** since most of the information and knowledge gained came from disciplines outside architecture.

The outcome of this research materializes in **a set of strategies** that are a call for action towards a post-extractive architectural practice. Practice that aims to prevent the waste generated by construction and demolition processes, while realizing the value of material resources and applying principles of reuse and repair rather than demolish and building new.

Part II : Post Extractive Practices. Mapping Geographies of Waste.

How can we define post-extractive practices related to architecture and construction industries ?

Our built environment is operated by architecture and construction industries. **The notion of post-extractive architecture deals with the materials or resources that have already been extracted and materialized in our built environment.**

Materials and buildings **do not have an infinite life-cycle.**

Buildings are assemblies of components, made of different materials, and different materials have different life cycles. Some buildings last more than others because of reasons related to their life cycle, maintenance, use, economic or historic value, etc.

Architecture is a practice that relates to both construction and demolition processes.

Within the context of this research, post-extraction relates to the amount of waste produced by construction and demolition practices.

2.1 DATA Analysis. Construction and Demolition Waste within the context of Luxembourg.

Key Information Extracted from the DATA :

>**What sectors generate the most Waste within the context of Luxembourg ?**
>**For how much % of the total Waste generated is the Construction industry responsible ?**
>**Metrics : Construction and Demolition (C&D)Waste inflows and outflows : generated, imported and exported**
>**Where does waste go and how is it treated ?**

The following pages illustrate the means through which the DATA was processed in order to be made more comprehensive and easier to filter. **The "images" - spreadsheets filled up with exhaustive DATA, were fundamental part of the process and present it in its truest form.**

About the process itself ...

The initial idea was to **combine the two datasets in order to create a direct link between generated and treated waste, in order to get accurate values in terms of metrics.** After doing this exercise and consulting with specialists we realized that **a precise calculation of inflows and outflows of waste generated specifically by Construction and Demolition practices is not possible because of the system by which waste is distributed and traced.** The "total" values in the end are estimated in the best way possible but are not 100% accurate.

The issue, as discussed with representatives from the ministry, is that **waste streams from different origins are often collected together and transported to a sorting facility. In the sorting facility those waste streams are sorted, mixed and regrouped in new waste fractions which are then exported together for final treatment.**

A discarded vehicle may be displayed as such in waste treatment data, but the materials it was composed of like metal, glass, textiles etc. will appear separately in the waste treatment data together will materials sorted from other waste streams. It is for these reasons that waste statistics are split in waste generation and waste treatment at a European and national level.

Dataset 1 : Generated WASTE

LIB	NACE_Rev_
ing and sawing other than those mentioned in 01 04 07	SECTION G — TRADE;
	SECTION E — WATER
	SECTION N — ADMIN
	SECTION O — PUBLIC
g packaging)	Private persons / hou
g packaging)	SECTION A — AGRICU
g packaging)	SECTION E — WATER
re (including soiled straw), effluents, collected separately and treated off-site	SECTION A — AGRICU
re (including soiled straw), effluents, collected separately and treated off-site	SECTION F — CONST
re (including soiled straw), effluents, collected separately and treated off-site	SECTION G — TRADE;
re (including soiled straw), effluents, collected separately and treated off-site	SECTION Q — HUMA
re (including soiled straw), effluents, collected separately and treated off-site	SECTION R — ARTS,
ntaining hazardous substances	SECTION K — FINAN
her than those mentioned in 02 01 08	Private persons / hou
her than those mentioned in 02 01 08	SECTION D — GENER
her than those mentioned in 02 01 08	SECTION E — WATER
her than those mentioned in 02 01 08	SECTION G — TRADE;
her than those mentioned in 02 01 08	SECTION H — TRANS
her than those mentioned in 02 01 08	SECTION M — SPECIA
her than those mentioned in 02 01 08	SECTION O — PUBLIC
her than those mentioned in 02 01 08	SECTION Q — HUMA
	Private persons / hou
	SECTION H — TRANS
	SECTION G — TRADE;
	SECTION I — ACCOM
	SECTION L — REAL E
	SECTION P — EDUCA
r consumption or processing	SECTION C — MANU
r consumption or processing	SECTION K — FINAN
luent treatment	Private persons / hou
luent treatment	SECTION A — AGRICU
luent treatment	SECTION C — MANU
luent treatment	SECTION D — GENER
luent treatment	SECTION E — WATER
luent treatment	SECTION G — TRADE;
luent treatment	SECTION H — TRANS
luent treatment	SECTION I — ACCOM
luent treatment	SECTION K — FINAN
luent treatment	SECTION L — REAL E
luent treatment	SECTION O — PUBLIC
luent treatment	SECTION P — EDUCA
luent treatment	SECTION Q — HUMA
luent treatment	SECTION R — ARTS,
luent treatment	SECTION S — OTHER
leaning, peeling, centrifugation and separation	SECTION E — WATER
r consumption or processing	Private persons / hou

TRT	LB_TRT
R05	Recycling or recovery of other inorganic materials
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R10	Spreading on the ground for the benefit of agriculture or ecology
D10	Incineration on land
R04	Recycling or recovery of metals or metal compounds
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R13	Storage of materials with a view to submitting them to one of the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)
D09	Physico-chemical treatment not specified elsewhere in this list, resulting in compounds or mixtures which are eliminated by one of the processes numbered D1 to D12 (e.g. evaporation, d
D09	Physico-chemical treatment not specified elsewhere in this list, resulting in compounds or mixtures which are eliminated by one of the processes numbered D1 to D12 (e.g. evaporation, d
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R01	Use as fuel (other than direct incineration) or other means of producing energy
R01	Use as fuel (other than direct incineration) or other means of producing energy
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R13	Storage of materials with a view to submitting them to one of the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)
R13	Storage of materials with a view to submitting them to one of the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
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R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R01	Use as fuel (other than direct incineration) or other means of producing energy
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R01	Use as fuel (other than direct incineration) or other means of producing energy
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R01	Use as fuel (other than direct incineration) or other means of producing energy
R03	Recycling or recovery of organic substances that are not used as solvents (including composting operations and other biological transformations)
R02	Recovery or regeneration of solvents
R05	Recycling or recovery of other inorganic materials
R12	Exchange of waste with a view to subjecting it to any of the operations numbered R1 to R11
R05	Recycling or recovery of other inorganic materials
D01	Deposit on or in the ground (e.g. landfill, etc.)
R12	Exchange of waste with a view to subjecting it to any of the operations numbered R1 to R11
R04	Recycling or recovery of metals or metal compounds
R04	Recycling or recovery of metals or metal compounds
R01	Use as fuel (other than direct incineration) or other means of producing energy

Dataset 2 : Treated WASTE

CODE : Dataset 1 + Dataset 2

```
pandas as pd

low = pd.read_excel('C://Users//federico.bigi//Desktop//Simo//Luxembou
DATA Translated.xlsx',' GENERATE')

ping by year and extracting entries

uped_inflow = df_inflow.groupby('year')
ing inside the groupby
i want to create a dictionary in which for each year i count the numbe
ific item collected and the overall
tity of the item inflow
_df = pd.DataFrame(columns=['year','type','quantity (kgs)','IN/OUT'])
me, df_x in df_grouped_inflow:
try_dict = []
first i want the list of items collected in the year x
st_wastes = df_x[' LIB'].unique()
then for each item i want to count the entries (?) and the kgs - actu
he kgs
r wastes in list_wastes:
  entry_wastes = [name,wastes]
    # here I'm computing the qty of kgs produced by a specific code
  waste_kgs = round(df_x[df_x[' LIB'] == wastes][' Qt(kg)'].sum(),1)
  # now add the entry into the final dictionary
  entry_wastes.append(waste_kgs)
  entry_wastes.append('IN')
  # append to the df
  series = pd.Series(entry_wastes, index = inflow_df.columns)
  inflow_df = inflow_df.append(series, ignore_index=True)
this is good for inflow, now let's go to outflow
cally is the same exact thing
 = pd.read_excel('C://Users//federico.bigi//Desktop//Simo//Luxembourg
ranslated.xlsx', ' TREAT')
_lu = df_out[df_out[' COUNTRY'] ==' READ']
uped_outflow = df_out_lu.groupby('year')
ow_df_treatment = pd.DataFrame(columns=['year','type','quantity
,'treatment'])
w_df = pd.DataFrame(columns=['year','type','quantity (kgs)','IN/OUT'])
me, df_y in df_grouped_outflow:
try_dict = []
```

```
om operator import index
port pandas as pd
om sqlalchemy import column



inflow = pd.read_excel('C://Users//federico.bigi//Desktop//Simo//Luxembourg
te DATA Translated.xlsx',' GENERATE')
outflow = pd.read_excel('C://Users//federico.bigi//Desktop//Simo//Luxembour
te DATA Translated.xlsx',' TREAT')
rouping by year and extracting entries
inflow_2019 = df_inflow[df_inflow['year'] ==
9][df_inflow['NACE_Rev_2_sections'] == ' SECTION F — CONSTRUCTION']
outflow_2019 = df_outflow[df_outflow['year'] == 2019]
k now i have the lists of code of each DEC2
es_2019_inflow = df_inflow_2019['DEC2'].tolist()
ow let's filter the outflow based on this
outflow_2019_construction =
outflow_2019[df_outflow_2019['DEC2'].isin(codes_2019_inflow)]
ow i have the outflows for construction only
output_construction = pd.DataFrame()
output_construction =
merge(df_inflow_2019,df_outflow_2019_construction,on='DEC2',how='right')
ow i have the df, let's start creating the proportions
grouped = df_output_construction.groupby('DEC2')
final = pd.DataFrame()
 name,df_dec2 in df_grouped:
 # now for each value compute the proportion of the quantity of material ba
the overall
 df_dec2['prop'] =
nd(df_dec2['SumDEQtte_kg']/df_dec2['SumDEQtte_kg'].sum(),3)
 df_dec2['construction_waste_kg_treated'] =
nd(df_dec2['Qt(kg)']*df_dec2['prop'],2)
 df_final = df_final.append(df_dec2)
 # here I get the file with the distribution of waste by kg
final.to_excel('construction_waste_distribution_2019.xlsx')
rouping by country
contry_kg_treated = pd.DataFrame(columns=['Country','Qty (kg)'])
contry_grouping = df_final.groupby('COUNTRY')
 name,df_contry in df_contry_grouping:
 dict_contry = {'Country':name,'Qty
)':df_contry['construction_waste_kg_treated'].sum()}
 df_contry_kg_treated =
contry_kg_treated.append(dict_contry,ignore_index=True)
```

Qt(kg)	TRT	LB_TRT	SumDEQtte_kg	COUNTR
9420	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	8289590	LU
9420	R10	SpLUing on the ground for the benefit DE agriculture or ecology	150819	LU
7	D10	Incineration on land	24758	BE
14603	D09	Physico-chemical treatment not specified elsewhere in this list, resulting in compounds or mixtures which are eliminated by one DE the processes numbered D1 to D12 (e.g. evaporation, drying, calcination, etc.)	913807	LU
14603	D09	Physico-chemical treatment not specified elsewhere in this list, resulting in compounds or mixtures which are eliminated by one DE the processes numbered D1 to D12 (e.g. evaporation, drying, calcination, etc.)	70380	DE
48280	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	634220	BE
48280	R12	Exchange DE waste with a view to subjecting it to any DE the operations numbered R1 to R11	50420	BE
48280	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	41740	FR
48280	R01	Use as fuel (other than direct incineration) or other means DE producing energy	10260	FR
58760	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	737940	FR
58760	R01	Use as fuel (other than direct incineration) or other means DE producing energy	600939	FR
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	12952225	LU
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	2631059	FR
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	2261911	DE
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	1335284	BE
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	843787	CZ
15205	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	515500	BE
15205	R01	Use as fuel (other than direct incineration) or other means DE producing energy	311300	LU
15205	R03	Recycling or recovery DE organic substances that are not used as solvents (including composting operations and other biological transformations)	131787	IT
15205	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	73740	DE
15205	R01	Use as fuel (other than direct incineration) or other means DE producing energy	1820	DE
15205	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	6155	FR
160066	D10	Incineration on land	527140	BE
160066	D15	Storage prior to one DE the operations numbered D1 to D12	226673	DE
160066	R01	Use as fuel (other than direct incineration) or other means DE producing energy	177547	BE
160066	R12	Exchange DE waste with a view to subjecting it to any DE the operations numbered R1 to R11	97040	DE
160066	D10	Incineration on land	56360	DE
160066	D15	Storage prior to one DE the operations numbered D1 to D12	34500	LU
160066	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	20154	LU
160066	R01	Use as fuel (other than direct incineration) or other means DE producing energy	15140	DE
160066	R04	Recycling or recovery DE metals or metal compounds	3760	DE
160066	R04	Recycling or recovery DE metals or metal compounds	890	NL
1666	R04	Recycling or recovery DE metals or metal compounds	30	PL
657	R05	Recycling or recovery DE other inorganic materials	29337	FR
657	D10	Incineration on land	12960	BE
657	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	5	LU
9248	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	46459	DE
9248	R12	Exchange DE waste with a view to subjecting it to any DE the operations numbered R1 to R11	11820	DE
9248	D15	Storage prior to one DE the operations numbered D1 to D12	760	DE
2	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	200	DE
363000	R12	Exchange DE waste with a view to subjecting it to any DE the operations numbered R1 to R11	6203240	FR
363000	R05	Recycling or recovery DE other inorganic materials	2657040	BE
363000	R04	Recycling or recovery DE metals or metal compounds	774300	DE
363000	D05	Specially engineered landfill (e.g. placement in separate sealed cells, covered, and isolated from each other and from the environment, etc.)	24000	DE
1904770	R05	Recycling or recovery DE other inorganic materials	217547640	LU
1904770	R05	Recycling or recovery DE other inorganic materials	92772008	LL
1904770	D01	Deposit on or in the ground (e.g. landfill, etc.)	6055740	LU
28060	R05	Recycling or recovery DE other inorganic materials	22734940	FR
28060	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	9437440	DE
28060	R05	Recycling or recovery DE other inorganic materials	23250	DE
1065740	D01	Deposit on or in the ground (e.g. landfill, etc.)	1149160	DE
2105	D15	Storage prior to one DE the operations numbered D1 to D12	159319	DE
2913	D09	Physico-chemical treatment not specified elsewhere in this list, resulting in compounds or mixtures which are eliminated by one DE the processes numbered D1 to D12 (e.g. evaporation, drying, calcination, etc.)	187180	DE
2913	D15	Storage prior to one DE the operations numbered D1 to D12	6373	DE
2913	D15	Storage prior to one DE the operations numbered D1 to D12	1197	LU
700	R04	Recycling or recovery DE metals or metal compounds	41911180	LU
700	R13	Storage DE materials with a view to submitting them to one DE the operations numbered R1 to R12 (excluding temporary storage, before collection, on the production site)	1136620	IT
700	R04	Recycling or recovery DE metals or metal compounds	813820	FR
700	R04	Recycling or recovery DE metals or metal compounds	183160	NL

Dataset 1 + Dataset 2

By analysing the DATA we can argue that waste generated by Construction and Demolition practices counts for the majority of overall waste produced within the territory of Luxembourg. **(82%)** Within the framework of 4 years for which we have DATA, we can observe that the amount of waste generated by construction and demolition does not change much, it remains more or less stable, with slight increase.

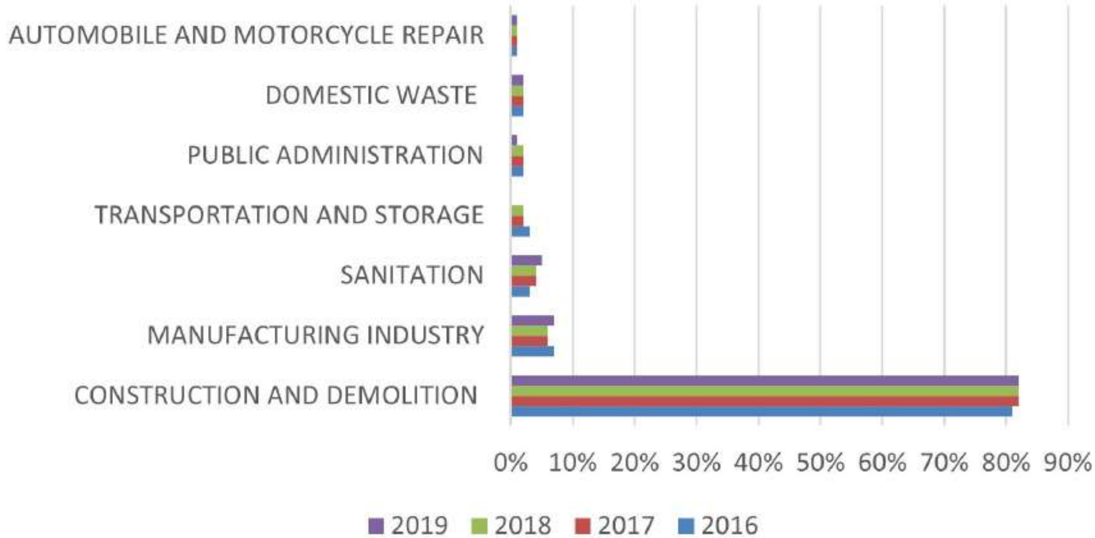


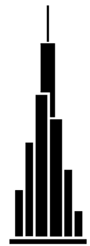
Fig. 5 Graph
Waste generated by Sector and by year

To convert these percentages into numbers : In the year of 2019 Construction and Demolition Waste, generated within the territory of Luxembourg = **8 billion kg.** (8,051,770,099).

In order to make this number more tangible I compared it to the weight of 3 iconic buildings...

World Trade Center
Weight : 500 000 t.

8 000 000 000kg :
500 000t =
16 ×
World Trade Centers of Waste per year.



Burj Khalifa
Weight : 2.2 million t.
8 000 000 000kg :
2 200 000t =
3.6 ×
Burj Khalifas of Waste per year

Pyramid of Giza
Weight : 5. 75 million t.
8 000 000 000kg :
5 750 000t =
1.3 × Pyramids of Giza of Waste per year

Mapping inflows and outflows of Waste generated by Construction and Demolition Practices within the context of Luxembourg.

C&D Waste : exported / imported / generated (fig.6)

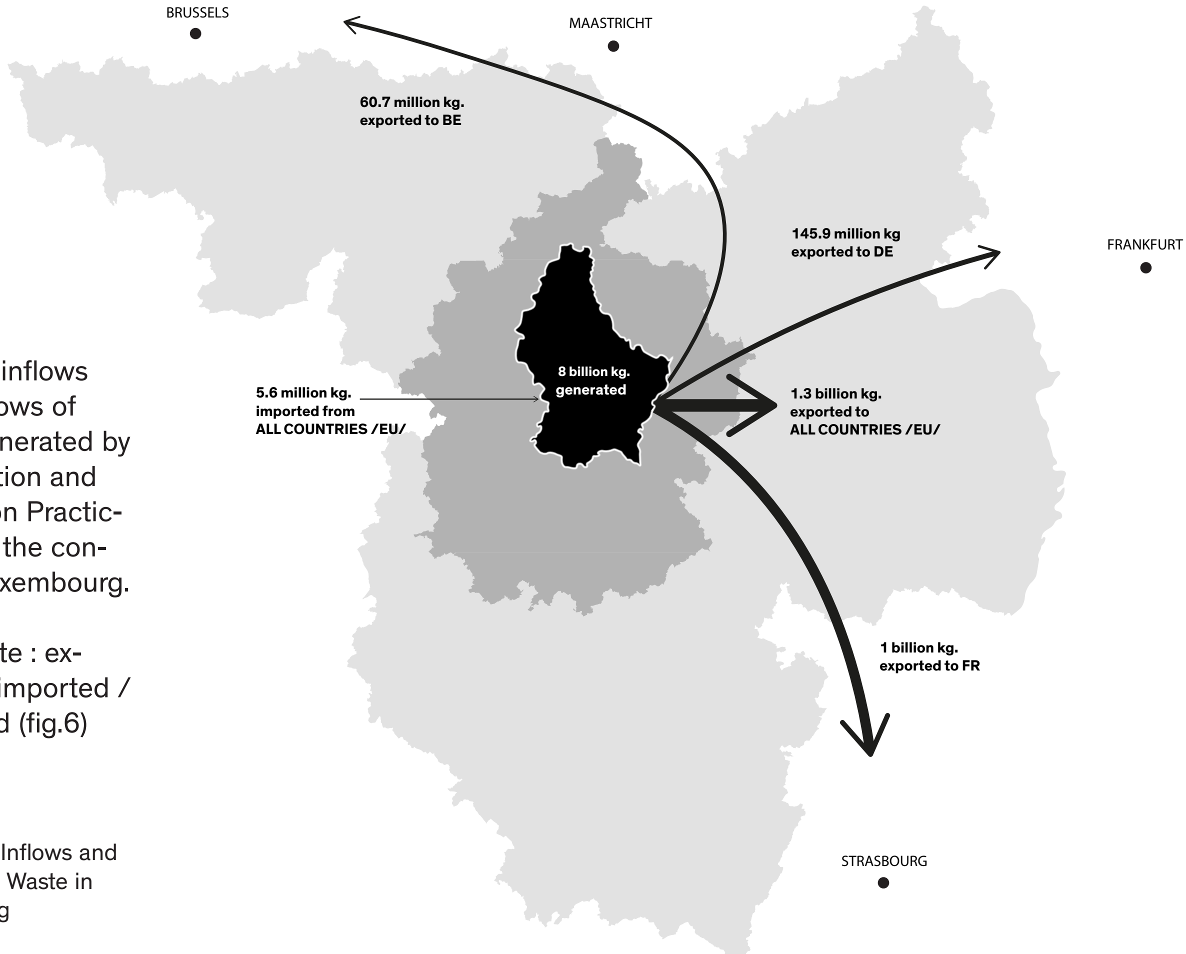


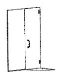
Fig. 6 Map. Inflows and Outflows of Waste in Luxembourg

2.2

WHICH MATERIALS, FROM CONSTRUCTION AND DEMOLITION PRACTICES, ARE RESPONSIBLE FOR GENERATING THE MOST WASTE ?

A CATALOGUE...

FINES AND DUST
1 million kg.
<1%



GLASS

1.1 million kg.

<1%

ALUMINUM

1.1 million kg.
<1%

COPPER , BRONZE , BRASS

1.3 million kg.

<1%

BIODEGRADABLE WASTE
1.4 million kg.
<1%

PLASTIC MATERIALS

1.8 million kg.
<1%

SLAG WASTE FROM BLAST FURNACES AND STEELWORKS

1.9 million kg.

<1%

BUILDING MATERIALS CONTAINING ASBESTOS

2.9 million kg.

<1%

CABLES

2.5 million kg.
<1%

PAPER / CARDBOARD PACKAGING

2 million kg.
<1%

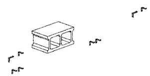
GYPSUM-BASED MATERIALS

5.1 million kg.

<1%

WOOD CONTAINING HAZARDOUS SUBSTANCES

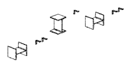
13.9 million kg.
<1%



MIXED MUNICIPAL WASTE

19. 6 million kg.

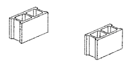
<1%



IRON AND STEEL

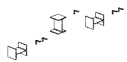
29. 4 million kg.

<1%



CONCRETE

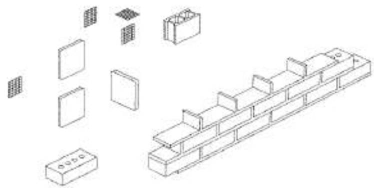
31.4 million kg.
<1%



IRON AND STEEL

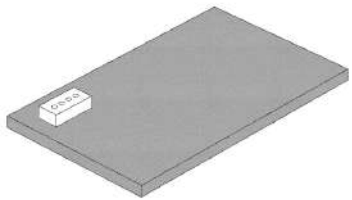
29. 4 million kg.

<1%



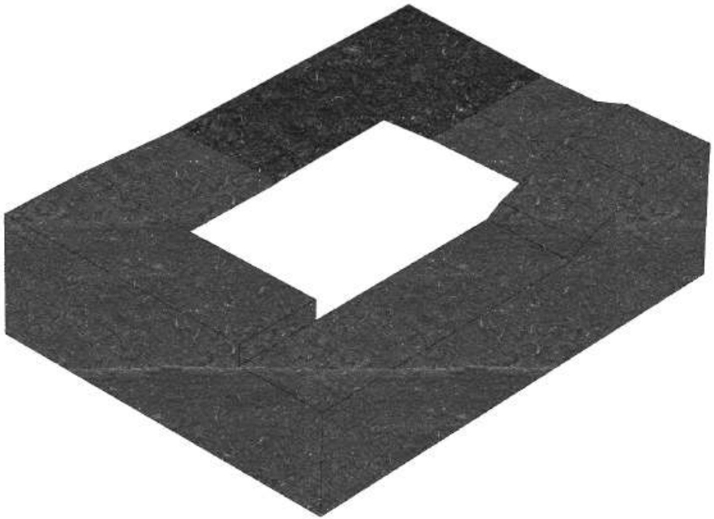
MIXTURES OF CONCRETE, BRICKS, TILES AND CERAMICS

237.1 million kg.
3%

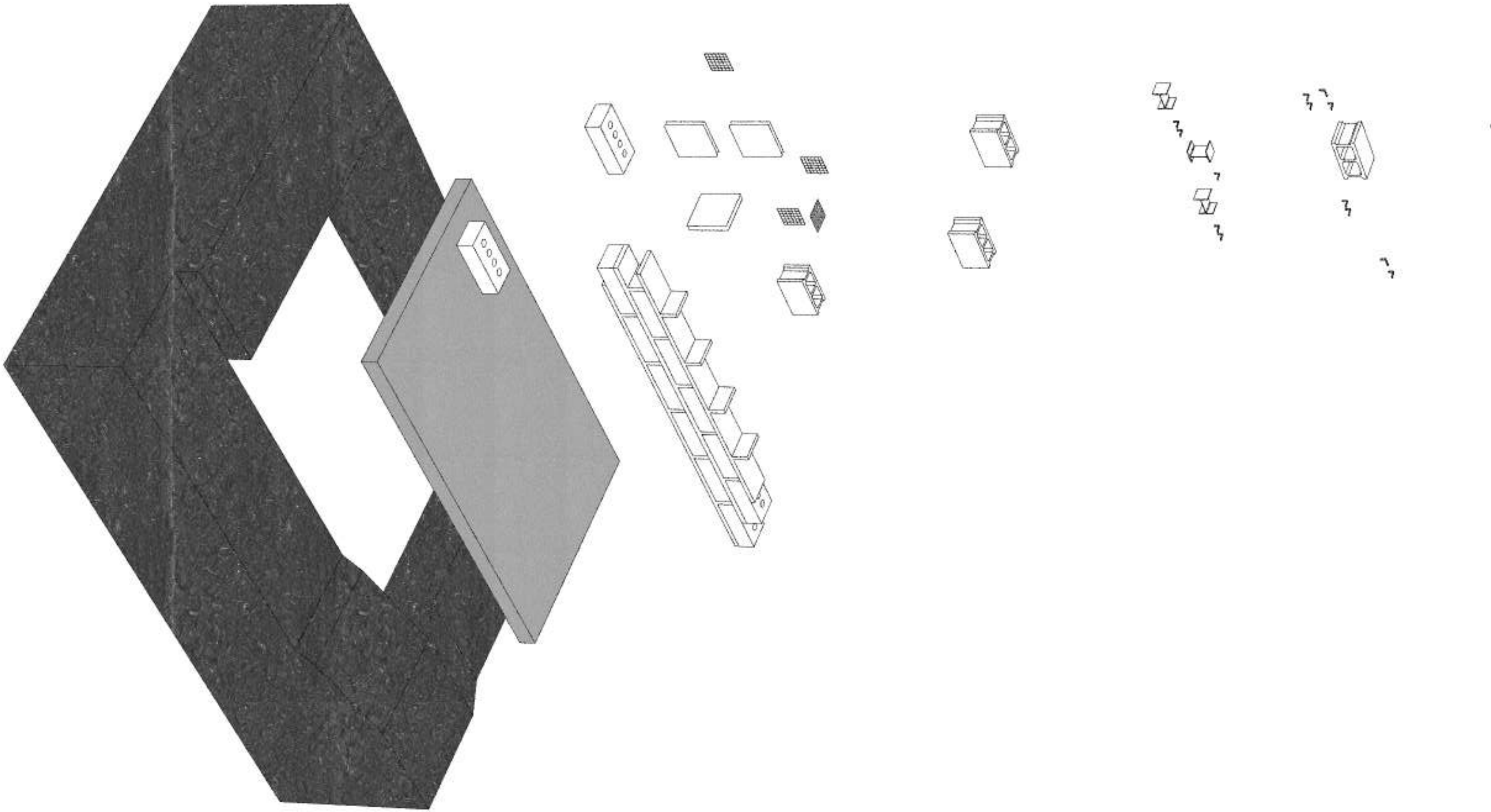


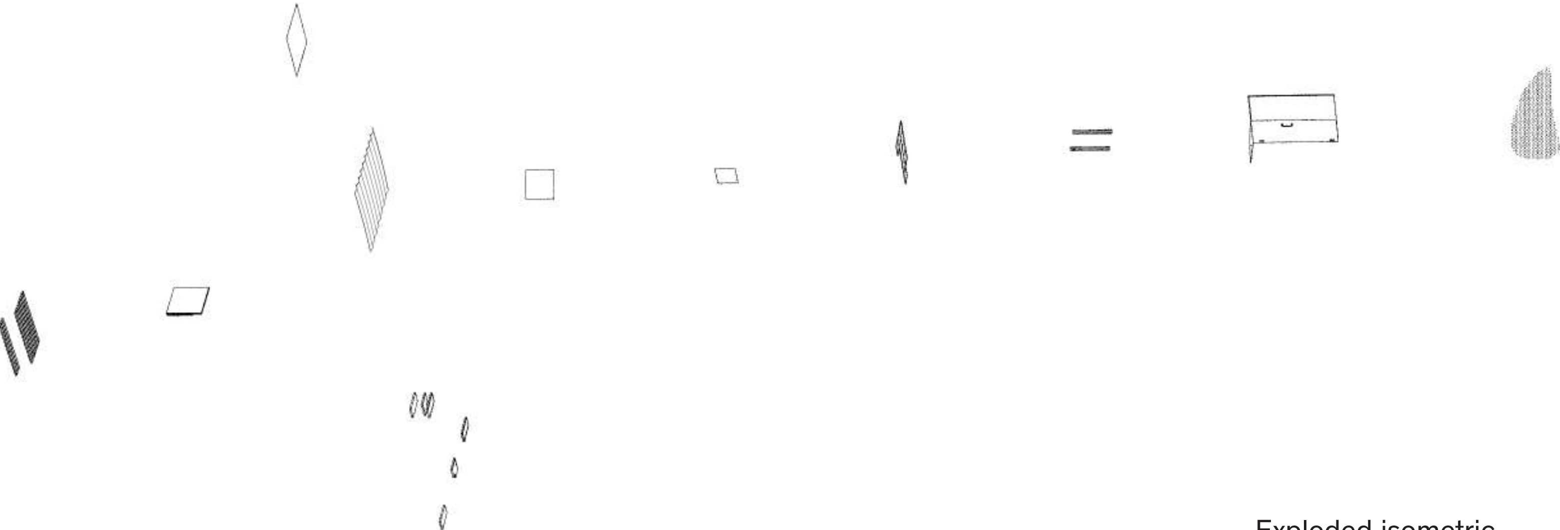
BITUMONOUS MIXTURES

285.3 million kg.
4%



EXCAVATED
EARTH AND STONES
7.4 billion kg.
91%





Exploded isometric drawing of the materials that generate the most C&D waste within the context of Luxembourg (fig.7)

Fig. 7 Drawing. Materials that generate the most C&D waste in Luxembourg

Excavated earth : The biggest source of waste you've never heard of ...

After processing the DATA in order to understand which are the materials that generate the most waste within the context of Luxembourg, I made an experiment and asked people from different disciplines including ones that work in academia and architecture practices : **"What do they think is the material that generates the most waste "** ? Almost all the answer which I received, which was also my speculation before analysing the DATA, was **"concrete". This is why it was surprising to realize that 91% of the waste generated from Construction and Demolition practices in 2019, was excavated earth, where around 80% of this excavated material is uncontaminated soil. "The overproduction of building rubble and excavation material is mostly due to the construction of multi-layered underground garages. The disposal of these materials is reaching its limits and is now often deposited in landfills beyond the border"** (University of Luxembourg et. al, 2021).

Only part of the excavated earth waste "(about 40%) is recovered and reused in areas excavated for the purpose of reclamation or safety of slopes, or for engineering purposes in landscaping. However, more than half of these soils is still landfilled. " (Bianchi and Merger, 2021).

A consultation study on C&D waste management in Luxembourg was published in 2015 by Bio by Deloitte, which stated that : **"Currently, the Ministry of Environment prepares documentation on how to improve management of excavated soils. As of the date of the consultation (16 April 2015) the documents were not signed by the Minister and thus no more details could be communicated by the Ministry. No other ministerial or legislative work has been reported. "** (Bio by Deloitte, 2015).

We can argue that within all circular economy and waste management strategy reports that have been published within the context of Luxembourg in the past years (After the Deloitte study) , the issue of excavated soils and the need of improving their management is made explicit. However, no clear strategy other than reusing the material as backfilling, is being proposed.

2.3 How is Waste Treated ?

In order to understand how the materials that generate the most waste is treated, I have worked with the DATA provided by the ministry, along with consulting with specialists and relevant case studies. In short, the Luxembourgish law on waste management distinguishes between two general categories of waste treatments, namely “Elimination” and “Valorisation” (reuse, recovery of waste). Within these two categories several different waste treatment operations take place. (fig 4.)

Even though **Landfilling** has the lowest priority within the waste management system, it still represents a significant treatment option within Luxembourg, counting for **38%** of the waste treated. **Recycling and Recovery** of waste is divided into several different categories depending on the materials that are being treated. The **recycling or recovery of metals** counts for **23%** of the waste treated, followed by the **recycling and recovery of other inorganic materials** with **22%,** and the **recycling and recovery of organic substances** with **3%.**

Last but not least, **backfilling** counts for **13 %** of the waste treated. **Backfilling** means a recovery operation where waste is used in excavated areas (such as underground mines, gravel pits) for the purpose of slope reclamation or safety or for engineering purposes in landscaping. (Bianchi and Merger,2021). Other less significant figures of **1%** include the **storage of waste material,** for future reuse or **using waste to produce fuel.**

Regarding i**nert Construction and Demolition (C&D) waste to be treated (the major portion are excavated soils),** those wastes are either **valorised by using them as backfill or eliminated by landfilling in one of the regional landfills for inert waste. It is prohibited by law to export inert waste for elimination.**

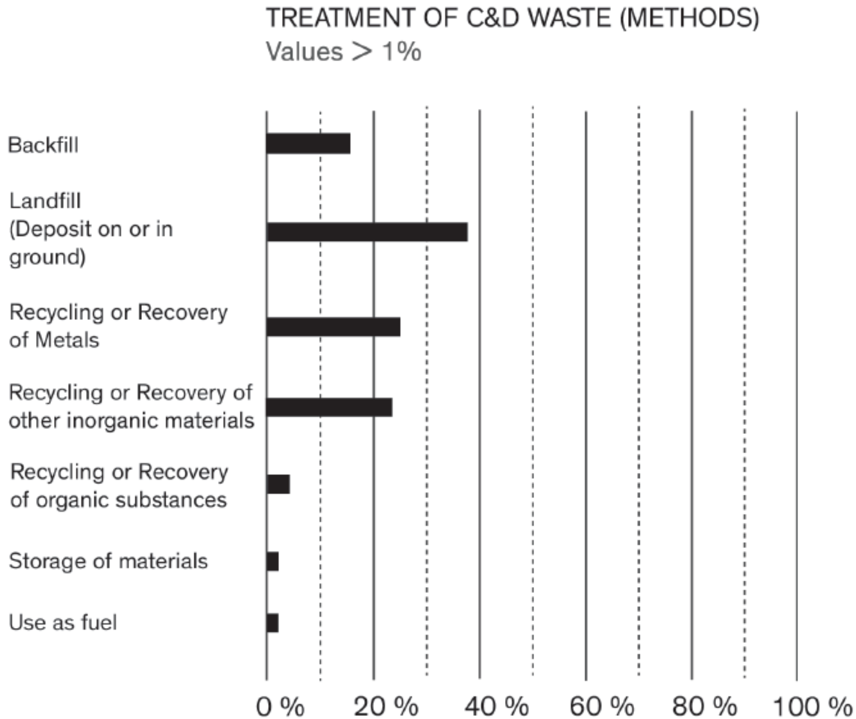


fig 8. Graph. Waste treatment methods

Other C&D waste (other than inert) are directed to different treatment operations: These wastes either are **valorised on national level or transferred to appropriate waste treatment facilities for vaporisation, mainly in the neighbouring countries. (**France, Germany, Belgium). **Non-inert C&D waste that cannot be eliminated on national level are mostly transferred across the border, for landfilling in appropriate waste disposal facilities.**

The country to which the wastes are exported depends on the type of waste to be treated (non-hazardous), the political, social and regulatory framework, and whether enough disposal capacity is available. If the acceptance quotas of some facilities are reached, longer distances have to be covered.

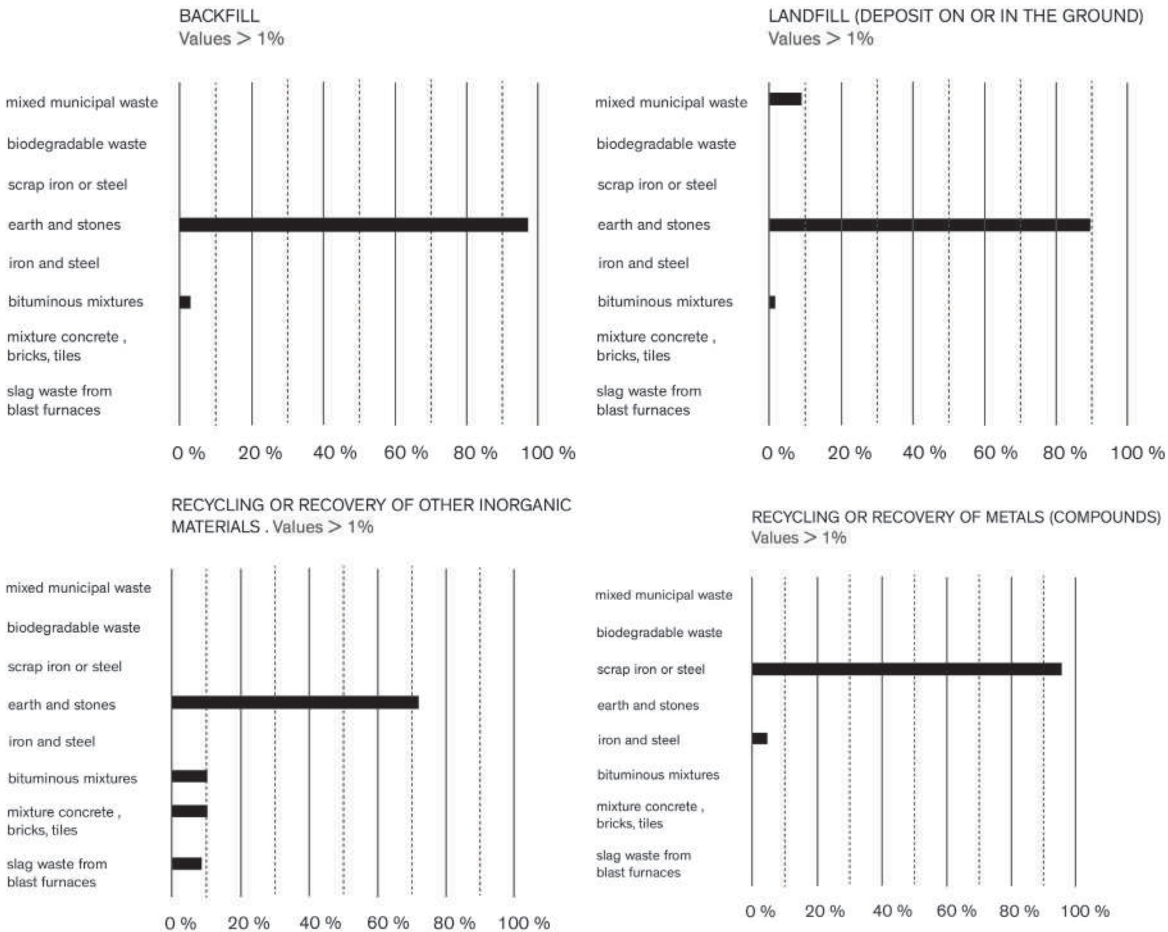


fig 9. Graphs. Waste treatment methods. Materials treated.

LANDFILLS .

THE INFRASTRUCTURES THAT ACCOMMODATE AND SUPPORT WASTE ELIMINATION PROCESSES

2.4 Anatomy and Metabolism of Landfills .

Key part of the analysis was exploring the infrastructures that accommodate the waste – the landfills. Everyone has an idea of how these might look like: massive infrastructures and pieces of land, with big mountain-like piles of material that is covered in soil.
If we look closely at the structure of a landfill and the processes that take place there, we can argue that they are actually much more complex than they look. Landfills are excavated pieces of land that perform as "well-engineered and managed facilities for the disposal of solid waste. They are located, designed, operated and monitored to ensure compliance with government regulations". (EPA,2022). They are carefully designed to protect the environment from contaminants, which may be present in the waste stream. The following diagram is a cross- section of a typical landfill structure, made by waste management company: Dulverton Waste Management (Dulverton Waste Management, n.d).

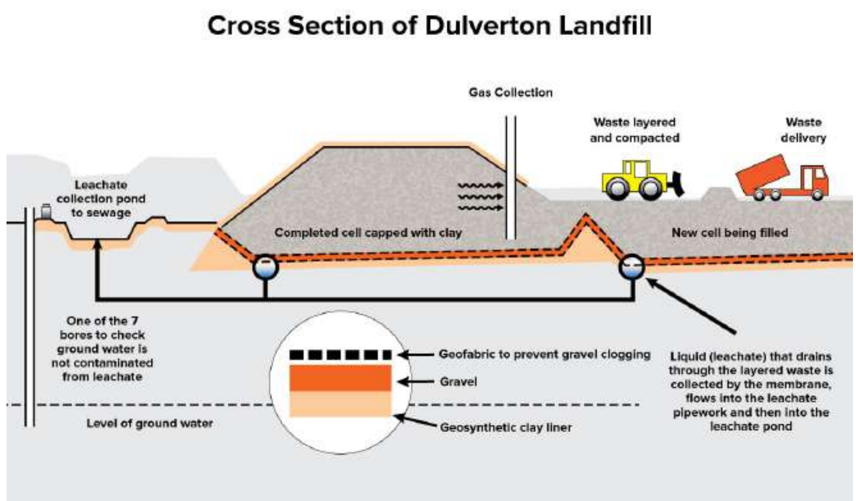


Fig. 10 Cross Section of a Landfill. Diagram by @Dulverton Waste Management

The landfill is constructed as a series of cells. Landfills usually have leachate collection and treatment system. Leachate is the liquid formed when waste breaks down in the landfill and water filters through that waste. This liquid is highly toxic and can pollute land, ground water and water ways. (Unisan, 2022)

The site of each cell is levelled with a slight incline to ensure all liquid drains in the same direction. Cells are precision-engineered to encourage any moisture coming from the waste to drain into a specially constructed leachate pond. Waste from municipal and other sources goes into the working area of the cell and is spread evenly to about 300mm before being compacted. As presented on the graph, the landfill cells include a geo-synthetic clay lining and have a manufactured hydraulic barrier of natural sodium bentonite and geotextiles to safely contain and direct moisture. After waste in a cell is compacted, it is covered with a layer of inert material such as soil, sand or crushed glass to minimize smell and the risk of rodents. The waste cell is built up layer by layer until it reaches its maximum height, then it is capped with a layer of clay to prevent rain from entering the waste hill and topped with soil before being revegetated. (Dulverton Waste Management, n.d) .

There are different types of landfills depending on the type of waste produced. In our case we are talking about construction and demolition waste (C&D Waste). A C&D landfill receives construction and demolition debris, which typically consists of roadwork material, excavated material, demolition waste, construction/renovation waste, and site clearance waste. C&D landfills do not receive hazardous waste or industrial solid waste, unless those landfills meet certain standards and have the permission. (EPA,2022). C&D waste landfills are considered less harmful since the materials being disposed are not likely to cause production of leachate of environmental concern.

...

However, construction and demolition waste can still cause a significant impact on the environment and human health. Growing landfills emit methane, which pollutes the air and causes the greenhouse effect. Dumping hazardous materials like paints, varnishes and other chemicals into landfills may cause dangerous substances to penetrate into the earth. This can affect groundwater and result in runoff, which can pollute waterways, destroy ecosystems and contaminate freshwater supplies. Demolition processes also can pollute the environment and harm human health. When buildings are destroyed, wind can carry loose dust and debris, leaving it to settle in the area or even miles away. Depending on what this dust is made of, it could have an adverse effect on public health. (EPA, 2022)

Fig. 11 Mapping Landfills in context to other Relevant Waste treatment facilities

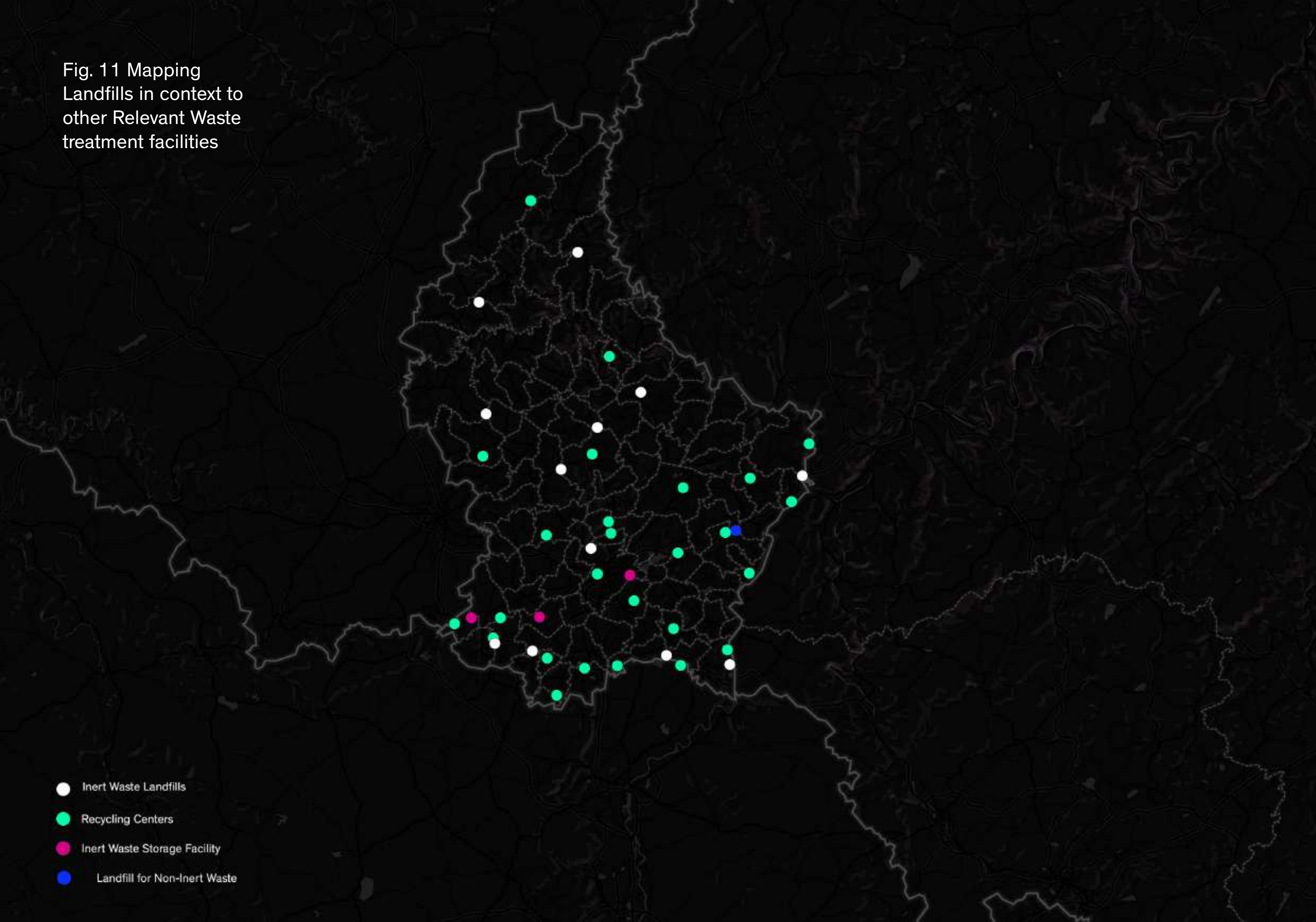
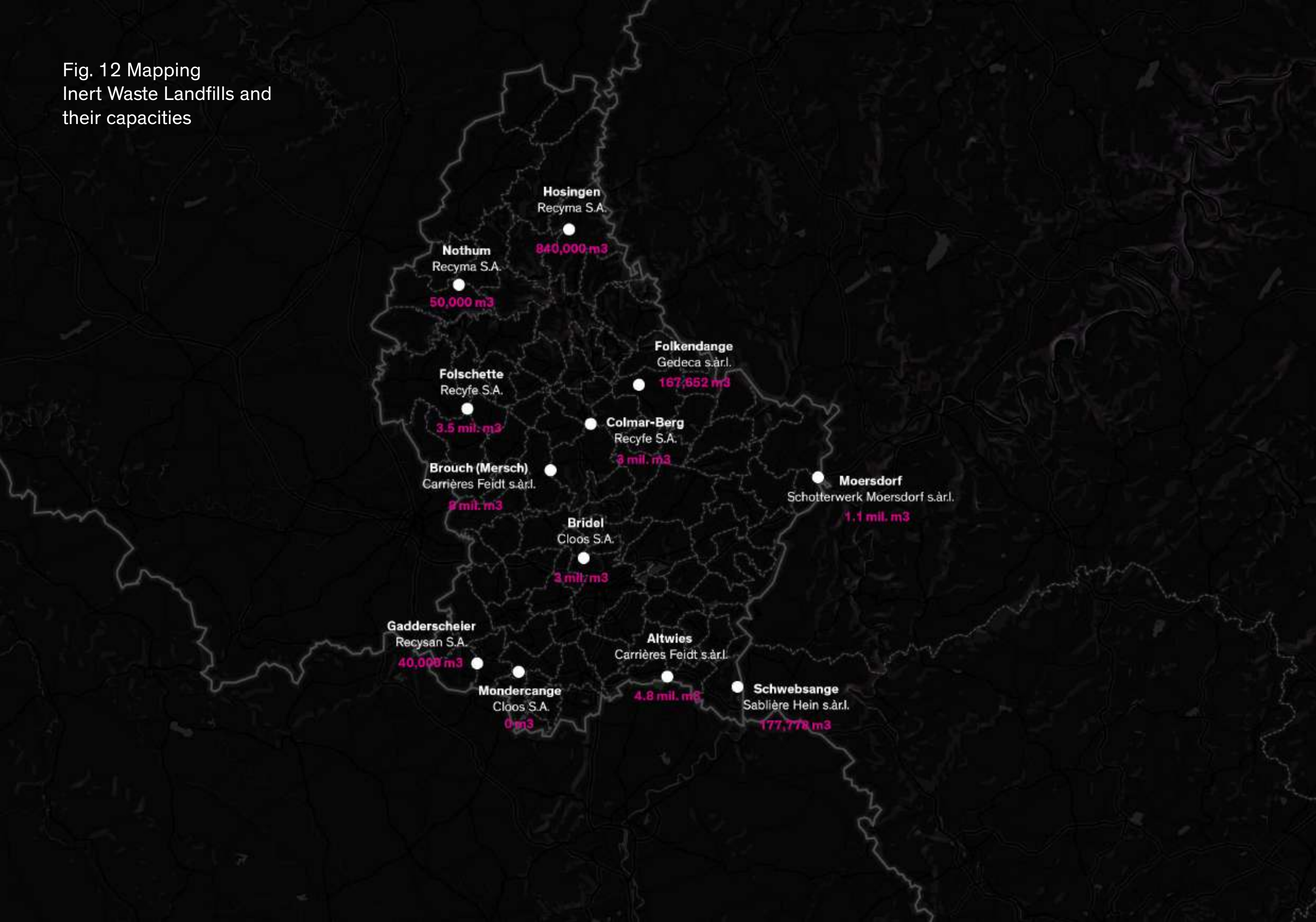


Fig. 12 Mapping
Inert Waste Landfills and
their capacities



2.5

MORPHOLOGY AND EVOLUTION OF THE LANDFILL WITHIN THE CONTEXT OF LUXEMBOURG


Altwies
2015
2007
View : 1.5 km radius
Capacity : 4.8 mil. m3
/2019/


Bridel
2015
2004
View : 1.5 km radius
Capacity : 3 mil. m3
/2019/


Brouch (Mersch)
2007
2014
View : 1.5 km radius
Capacity : 8 mil. m3
/2019/


Colmar-Berg
2011
didnt exist
2014
View : 2 km radius
Capacity : 3 mil. m3
/2019/


Folkendange
View : 1. 5 km radius
Capacity : 167,652
m3 /2019/


Folschette
View : 2 .15 km radius
Capacity : 3.5 mil. m3
/2019/


Gadderscheier
View : 1.80 km radius
Capacity : 40,000 m3
/2019/


Hosingen
View : 1.5 km radius
Capacity : 840,000
m3 /2019/


Moersdorf
View : 2.5 km radius
Capacity : 1.1 mil. m3
/2019/


Mondercange
The site was shut down in 2014 due to radioactivity
View : 1.5 km radius Capacity : 0 m3
/2019/


Nothum
View : 1.5 km radius
Capacity : 50,000 m3
/2019/


Schwebsange
View : 1.5 km radius
Capacity : 177,778
m3 /2019/

2.6 Diagnosis / Conclusion

> If we keep generating and landfilling waste with the same pace , **the landfill capacity of Luxembourg will be filled up within the next 15 to 20 years**

>**Are we willing to sacrifice more land to extend Landfill capacity, in times when land is too valuable; population in Luxembourg is growing and there is a shortage on housing ?**

> **The answer is no**, we cannot sacrifice more land...

> The **system of tracing and managing waste within the context of Luxembourg, and Europe in general, is not sufficient and needs serious improvement.**

>**Immediate action** is required to minimize and prevent the production of more waste, as well as **strategies to process and make use of all the waste that has already been generated by Construction and Demolition Practices.**

>A **new approach to architecture and construction practice is needed** : one that is not based on mentality of building more and new, but on **principles of minimization, dismantlement, repair and reuse.**

CALL FOR ACTION.
STRATEGIES TOWARDS POST-EXTRACTIVE ARCHITECTURAL PRACTICE

Part III : Call for Action. Strategies towards a Post-Extractive Architectural Practice

The outcome of this research materializes in a set of strategies that are a **CALL FOR ACTION.** A call for action because in-between thinking/reflecting on what were all the mistakes we did in the past practices (and discourses in architecture and construction), and strategizing how we can do things in the future, perhaps with better technologies, better materials and more advances skills, there are gaps of acting in the present and **REPAIRING** our immediate contexts, working with the existing and working through/with the damage that has already been done, post extraction.

The strategies relate to each other. They are interconnected and organized in a chronologically. There are 4 types of strategies, organized into 4 phases : Immediate strategies (that require immediate re(action)); Bridging strategies (tackling issues of the immediate context, allowing for a new/ different form of practice to take place in the near future) ; permanent strategies (calling for permanent approach to practice); and last but not least, prevention strategies (again calling for a permanent approach to practice, but their main aim is to slow down and even prevent the generation of further waste).

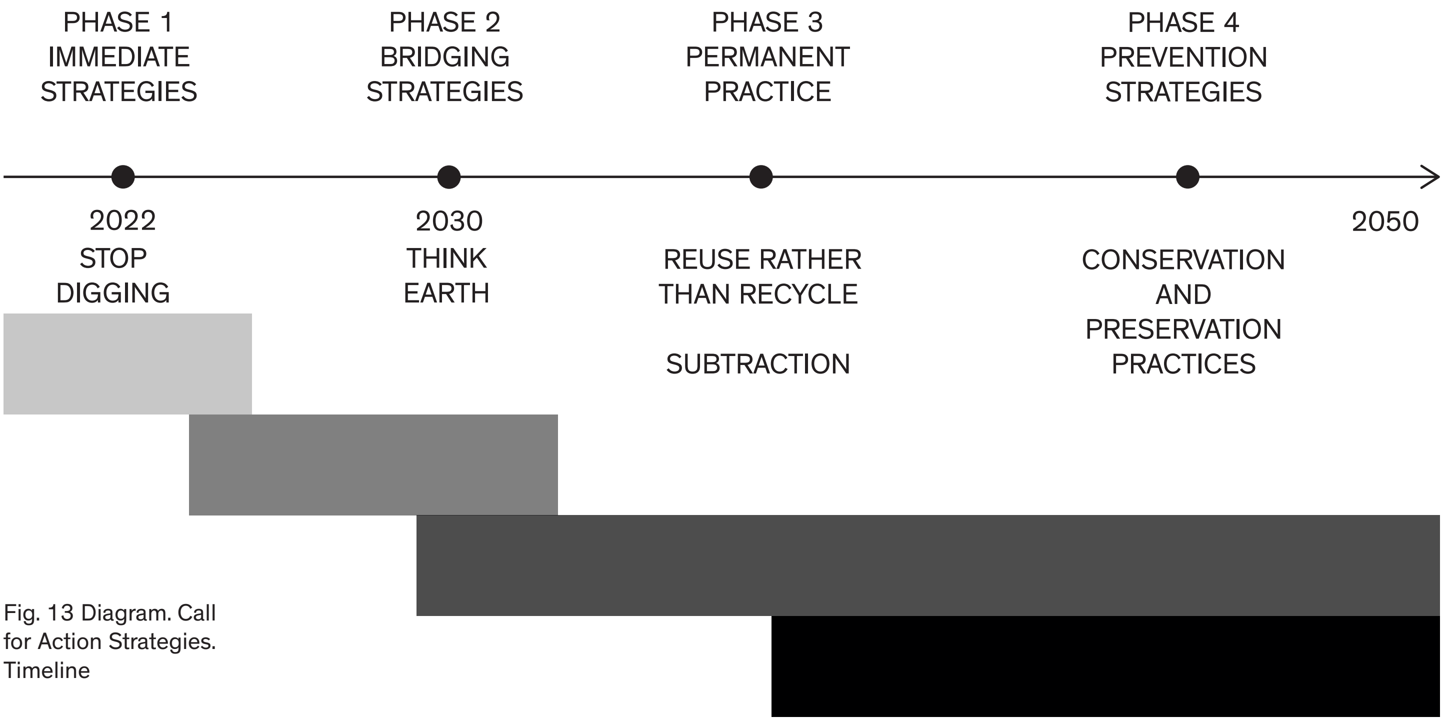


Fig. 13 Diagram. Call for Action Strategies. Timeline


STOP DIGGING
@Pierre Matge
Photograph ; Hamilius, Luxembourg

3.1 Stop Digging

The first strategy proposed as part of this Call for Action is classified as an immediate strategy since it's a response to an issue that requires immediate reaction – STOP DIGGING! Excavated soil of the currently biggest source of waste, in terms of volume, across Europe. "Yet, 80% of those soils are not contaminated and could be safely re-utilized elsewhere if a proper traceability system was put in place " (Simon, 2021)

State of the Art Analysis

>Even though most countries have certain regulations, mostly related to safety, for building underground, there is no actual law which says how deep into the soil can you dig?

>By looking at existing practices, on the larger scale, we find that no country has taken the initiative to STOP excavation of uncontaminated soil.

Mostly, what is being done is related to finding ways for the REUSE of excavated earth material as well as trying to improve the system of traceability of the waste, which presents a huge problem, also observed by working with the DATA from Luxembourg.

- Some case studies of successful reuse of excavated soils come from France, Norway, Portugal, Slovenia and Sweden, which are countries- members of ELGIP, a major European research organization for geotechnical research in Europe. (Hale et. Al, 2021).

-In reference to improving traceability of excavated soils, "in Belgium, all movements of excavated soils must be registered in a national database with a cost of 0.05 € per m3 of soil (Simon, 2021).

>On the architecture scale, Construction Start-Up companies, like "STOP DIGGING" from Sweden, are developing ground screw foundation systems for smaller scale projects, which are used as an alternative to conventional concrete foundations. Even though successful, this practice is still not upscaled within the architecture and building construction industries.

As a response to the existing state of the art practices, this strategy calls for urgent attention from policymakers, in order to adapt some strict regulations towards earth excavation practices, not only to prevent the generation of waste, protecting the environment and human health, but also to protect and realize the value of uncontaminated soil as a natural resource.

The physical environment of the earth includes the non-living components, namely the air, water and soil. ''Soil is the outermost part of the earth's crust on which we live, work and grow food crops. Soil provides all mineral nutrients, anchorage and water needed for the growth and development of plants and animals. Plants grow on the soil. All animals are directly or indirectly dependent on plants for food. Thus, plants and animals are both dependent on soil for nutrition. The man also uses soil for various other purposes, such as making bricks, pottery and porcelain." (Swamy, 2022)

Turning this valuable resource directly into waste, in order to accommodate huge infrastructures that sustain our way of living, is not sustainable and an unnecessary practice, that has to be prohibited.


THINK EARTH
@ThinkEarth ! „Earth and Resources “
Chair of Sustainable Construction
ETH Zurich

3.2 Think Earth. Processing and reusing excavated earth waste

The second strategy is classified as a bridging strategy. A bridging strategy is not promoted as a permanent form of practice, but rather a temporary action that needs to take place to respond to an issue that exists within the immediate context.

If we argue that following the STOP DIGGING strategy, no more waste from excavated earth (non-contaminated) will be generated, we still cannot ignore the amount of waste that has already been generated by previous excavation.

By looking at the existing STATE OF THE ART practices, THINK EARTH is suggesting the REUSE of that waste, without promoting the up-scaling of the activity. Furthermore, this action aims to stop the inflow of excavated earth waste towards landfill sites, in order to prevent them from expanding, freeing up the space and enabling them to be re-imagined as sites/infrastructures with a different function in the future.

State of the Art Analysis

There are several different approaches that could be implemented towards reusing the excavated earth material.

>The name of the strategy itself: THINK EARTH, comes from an existing research practice at the ETH Zurich, that realizes the potential of excavated earth as a building material.
Specifically, what the project is interested in is the ability of earth to regulate indoor climate. The practice is addressing the issue of dry air and humidity in new buildings. These are caused by high-density construction methods and controlled ventilation and heating systems. The response to this issue in practice is usually the use of sophisticated and complex building service technology. "However, using earth as plaster can regulate air humidity naturally and make for a significantly more comfortable indoor climate. Rather than viewing earth as a full and sufficient replacement for structural building materials such as concrete, we should see it more as an alternative for building services technology" (Habert and Cisar, 2017).

>Other examples, for successful reuse of excavated earth waste come from countries in Europe (France, Slovenia, Norway, Portugal and Sweden), that are members of ELGIP - a major European research organization for geotechnical research in Europe. Similarly, for all those countries, the excavated earth material goes through a process of evaluation where two things are determined: weather the material is classified as waste, and weather it is contaminated or not. Based on that the countries adapt different regulatory frameworks of how that material can be reused, or not. The case studies include reuse in road construction, landscaping, pavements, filling of cavities, and infrastructure projects.


SUBTRACTION
Architecture is not a practice about adding, its a practice about removing
@RotorDC
Reuse made Easy

3.3 Subtraction

The **third and fourth** strategies of the **CALL FOR ACTION** are classified as permanent strategies and are concerning the practice of architecture and construction itself. It is simply not enough to become aware of the value of material resources and to put forward some policies and regulations related to minimizing and managing waste. The ways in which we practice architecture and the way we perceive the notion of ''building" has to change. Architecture is a discipline related to" building", and building is considered an additive process. Yet, it is important to highlight that Architecture does not always mean Building.

Architecture doesn't mean building, it means adaptation and improvement, whose only justification must be to contribute to constructing an optimal environment and always bring the best work that is in many cases the one that is not built (Alejandro de la Sota cited in n'undo, 2011).

Subtraction is a strategy that perceives architecture not only as an act of addition but also an act of reduction. **''It is possible to build more and better by reducing, containing and well-reasoned declining.''** (n'undo , 2011).
If by adding elements we can change the shape, volume, construction and organization of space, we can also achieve the same by removing them.

''Subtraction is a heavy industry, a source of employment, a material resource, a global environmental protocol '' (Easterling, 2014).

State of the Art Analysis

>Looking at the State of the Art, we can argue that the discourse of Rotor, a Brussels based design practice can be related both to the strategies of **Subtraction** and **Reuse rather than Recycle.** The practice investigates the organisation of the material environment. Their work involves notions of **deconstruction , dismantling, reclamation of materials and their adaptive reuse .**

The strategy was mainly inspired by two books: Subtraction by Keller Easterling (2014) and the From subtraction manifesto by N'UNDO (2011) which states :

1. The purpose of Architecture is to improve people's lives and to increase the value of its surroundings by its very presence.
2. Given surplus production, overdevelopment and land deterioration, the following are proposals for actions to be taken: not constructing, reusing, minimizing and dismantling.
3. Architecture, urban planning and landscape architecture do not only imply building and producing, but also restoring, maintaining, clearing and reclaiming.
4. Every territory is a landscape, even the most ordinary and common. Territories must be appreciated and respected since they are fundamental to developing people's lives.
5. Any built configuration, whether urban or territorial must be thoughtful, argued, debated, and agreed upon according to social, environmental, urban economic, cultural and ethical criteria.
6. Reporting and criticizing actions that are harmful to the territory or to the city is necessary for promoting awareness, debate and re(action).
7. Architecture and the city are not consumer goods.
8. Much of the (non) architecture that pollutes land and cities is reversible, reducible, reusable, or disposable; these are the actions that should be developed by the discipline of architecture and territory.
9. The permanence and immutability of architecture and the impact of interventions are questionable at times when society's future stipulates flexibility and constant change.
10. Common space and the shared environment are given priority over individual space and private enjoyment.
11. Architecture cannot be used either as a tool to undermine human rights, or to replace education, civic values and common sense.

Manifesto n'UNDO 11.11.2011.

Manifesto n'UNDO 11.11.2011.

@Rotor DC :
reuse made easy

3.4 Reuse rather than Recycle

Reuse rather than recycle is another strategy for permanent practice, that is interconnected with Subtraction. They are interconnected in a sense that after an element is removed from a building its reuse is prioritized. ”Reuse rather than recycle” challenges the idea that recycling of materials is a sustainable practice, as suggested by multiple ”circular economy ” studies and strategies. Another concept that the strategy questions is related to the subject of waste management, especially within the context of Luxembourg, where ”reusing ” and ”recycling/ recovering” waste falls within the same category, while the two have to be distinguished and REUSE has to always be a choice before recycling. To differentiate between the two, we can define reuse as: ” the process of reusing the old product for the same, or different purpose without any processing, treatment, or changing its state.”, while recycling is :” the process of processing the original product to obtain raw materials that can be used to manufacture the same or different product”. (EarthReminder, 2022). The reason why recycling is not a sustainable practice is because it’s a highly energy intensive process.

Going back to the discourse of Nicholas Georgescu Roegen, where he explains economy as an extractive process through the second law of thermodynamics.

The laws of thermodynamics state that:
Law 1: Energy is always conserved
Law 2: Its quality to do anything useful tends to decrease in an isolated system/an isolated system is the universe/
When related to Economy, the second law of thermodynamics states that: Materials can be recycled, however they cannot be recycled a 100% because this will require too much energy
-Energy cannot be recycled at all
-All physical processes convert low-entropy energy and materials into high-entropy wastes
-The structure of any physical good/product degrades over time and energy inputs are needed to counteract this
-A decrease in entropy in one place, means a larger increase somewhere else

State of the Art Analysis

> As mentioned within the previous strategy, the work of the Brussels-based company Rotor is quite relevant to both Subtraction and Reuse rather than Recycle. In reference to the practice of Reuse, Rotor assists design teams and building commissioners in providing guidance for tasks such as: "identifying the reusable elements in an existing building; establishing reuse strategies; setting reuse targets and create evaluation tools; scouting suitable reclaimed elements; writing down bespoke specs for integrating reuse strategies; and design the projects so as to maximize the integration of reclaimed construction elements" (Rotor, 2022).

>The strategy can also be related to the concept of the "urban time" which understands the city as an accumulation of valuable materials and reusable elements.
The urban mine is by default heterogeneous and so far, unpredictable, consisting of a wide variety of different materials in small quantities at any given location. (Rotor, 2021).

>A relevant practice within the state of the art is the concept of the material bank. A relevant project on the European scale, is BAMB: Buildings as Material Banks. The project acts as a blueprint for key stakeholders and policymakers, and aims to create ways to increase the value of building materials. Dynamically and flexibly designed buildings can be incorporated into an economy – where materials in buildings sustain their value. That will lead to waste reduction and the use of fewer virgin resources. (BAMB, 2020).

> Another relevant project that is directly related to the context of Luxembourg, called FCRBE – Facilitating the circulation of reclaimed building elements in Northwest Europe, where the countries that are involved are: Luxembourg, France, Belgium, The Netherlands and The United Kingdom This project aims to increase by +50%, the amount of reclaimed building elements being circulated on its territory by 2032. (FCRBE, 2021).

LEARNING FROM CONSERVATION AND PRESERVATION PRACTICES

@ Preservation of a historic building, London (2017)

3.5 Learning from Conservation and Preservation Practices

The final strategy proposed is learning from Conservation and Preservation practices within the disciplines of Art and Architecture. This strategy, like the previous two, is to be considered as a permanent form of practice, however it is classified as a prevention strategy, since its aim is to maintain and repair buildings: their materials and components, and prevent their turn into waste, for as long as possible.

Conservation and Preservation are existing and well-established practices involved with buildings, objects, monuments and artefacts of historical value or/and cultural significance. The two terms are very similar to one another. According to the Venice Charter "Conservation is preservation, while restoration is an addition to preservation and should only be carried out for compelling reasons." (Venice Charter cited in Hart, 2016).

To differentiate the two terms, it is argued that " Preservation involves keeping an object from destruction and seeing to it that the object is not irredeemably altered or changed. In preservation, the final appearance is no longer the prime factor, but rather, retaining the maximum amount of building fabric. Preservation dictates that in order to retain the maximum amount of building fabric, repairs must be done with minimal or no changes to the original building fabric and in like materials, and if possible, using the same methods as first created. " (Bjorneberg, 2021)

In conservation " the absolute maximum amount of the original material, in as unaltered a condition as possible, is preserved. Any repairs or additions must not remove, alter or permanently bond/cross-link to any original material. All repairs or additions must be reversible and removable without affecting the condition of the original material now, and in the future." (Bjorneberg, 2021)

Conservation and Preservation Practices beyond the historic building typology suggests that we can and should apply the principles that these disciplines use towards all building typologies. Why can we not care for, conserve and preserve our built environment and our material resources in the same way that we care for and preserve our historic heritage

State of the Art Analysis

Some of the main principles of building conservation, that the contemporary architecture practice can really learn from are:
>Respect for age and character
>Apply Minimum intervention – only doing enough to execute a repair and no more.
> New work is subservient (inferior) to old – physically & aesthetically
> Honest repairs – letting the repair be seen and not attempting to hide or disguise – sometimes highlighting the repair.
>Repairs should not prevent later repairs from happening (when necessary)
(SPAB cited in Hart, 2016)

>One of the biggest, if not the biggest, authorities in the conservation and restoration of monuments and sites is ICOMOS (International Council on monuments and sites), that in 1964 adopted the Venice Charter. The Venice Charter is a document that presents a set of guidelines, providing an international framework for the conservation and restoration of historic buildings.
Respective to the practice of Conservation the Venice Charter states that. :
-Article 4: It is essential to the conservation of monuments that they be maintained on a permanent basis.
-Article 5.: The conservation of monuments is always facilitated by making use of them for some socially useful purpose. Such use is therefore desirable but it must not change the lay-out or decoration of the building. It is within these limits only those modifications demanded by a change of function should be envisaged and may be permitted.
Article 6: The conservation of a monument implies preserving a setting which is not out of scale. Wherever the traditional setting exists, it must be kept. No new construction, demolition or modification which would alter the relations of mass and colour must be allowed.

Art.7 : A monument is inseparable from the history to which it bears witness and from the setting in which it occurs. The moving of all or part of a monument cannot be allowed except where the safeguarding of that monument demands it or where it is justified by national or international interest of paramount importance.
Article 8.: Items of sculpture, painting or decoration which form an integral part of a monument may only be removed from it if this is the sole means of ensuring their preservation. (This can be relevant for the façade of a building.)

(ICOMOS, 2011)

“These old buildings do not belong to us only…they have belonged to our forefathers and they will belong to our descendants unless we play them false. They are not…our property, to do as we like with. We are only trustees for those that come after us.”

@ William Morris 1889

What if we change “old buildings” with “natural resources” ?

Part IV : Conclusion. What’s next ?

> **Non-Extractive Architecture** is a subject that raises a lot of important issues and questions related to the practice of architecture and building construction today : from **the way we use our resources** to **challenging our current economic system** and the **material and immaterial inequalities and externalities that it creates.** Having explored many relevant state of the art positions within the discourse, **my contribution comes with this master thesis, questioning the impact of post-extractive practices within architecture and construction, and the issue of WASTE.**
> One of the key issues addressed with this thesis is regarding **C&D WASTE,** which is a subject that is arguably overlooked and under-investigated within the discipline of Architecture.
When talking about **resource scarcity** it is of great importance to evaluate **how are we using our resources** and **where do they go when we no longer see them within our immediate context ?**
> The field of **Construction and Demolition (C&D) Waste Management** within the context of Luxembourg could benefit from **further investigation and contribution from the discipline of Architecture and Urban Design,** which is currently lacking.
>Strategies from the **CALL FOR ACTION are to be expanded further and applied into practice.**
>**Relevance of the research :** The topic **relates to many other fields of study, and concepts that are specifically relevant within the architectural discourse today. An example is the subject of “Degrowth” and the use of material resources,** on which I have been discussing and collaborating with my supervisor César Reyes Najera. As a result of this collaboration, **a paper will be published, linking together the topics of Degrowth and Non-Extractive Architecture.**

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