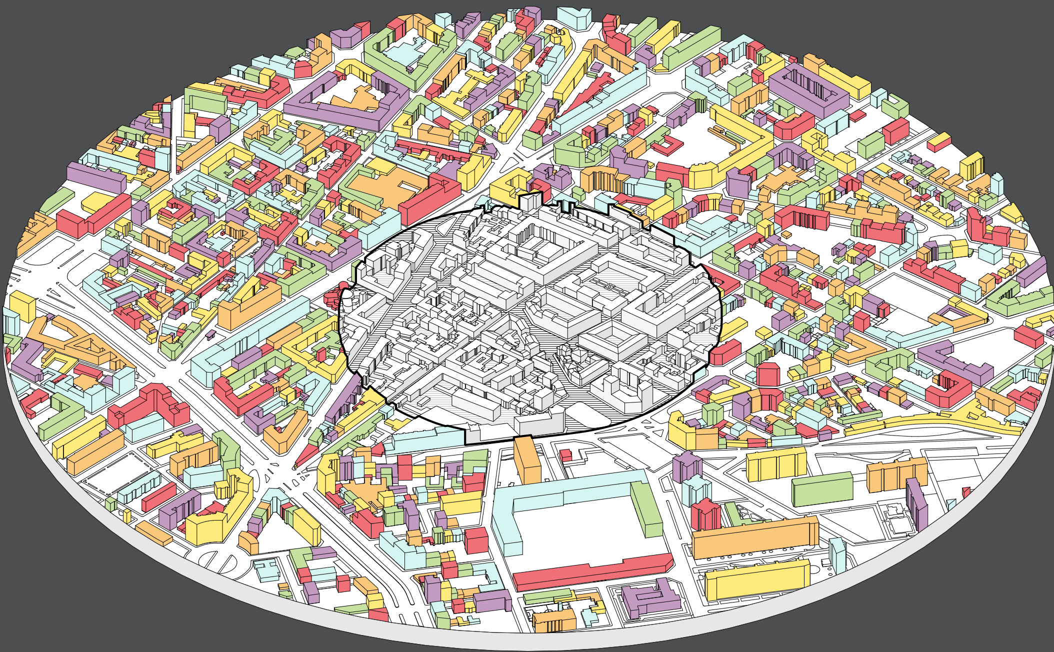


The Re-Urbanization of Waste

How to bring the waste cycle closer to users and improve its results

POLITECNICO
DI TORINO

Dipartimento
di Architettura e Design

POLITECNICO DI TORINO

MASTER IN ARCHITECTURE FOR SUSTAINABLE DESIGN

The Re-Urbanization of Waste

How to bring the waste cycle closer to users and improve its results

Session 2017/2018

CANDIDATE: Mattia Ghigo

SUPERVISOR: Matteo Robiglio

WHY WASTE?

Our current era is sleepwalking. Most of us, who live in Western societies, have practically everything our parents and grandparents have ever dreamed of except for one thing: sustainability.
We would need at least two planets if the world population were given the model of European consumption and of four other planets if everyone consumed as a typical American (1) (but fortunately we are not). We are simply living on this planet as if we had another one on which we can go. Something has to change and the best place to make that change is through waste, because we all produce waste - every day. Every time we produce waste, we are part of an unsustainable way of life on the planet, but with the right leadership we could all be part of an important first step towards sustainability.
We can no longer support "a disposable society" on a finite planet.

I started to approach the topic of waste when in my city, Turin, we began to discuss whether or not to build the waste-to-energy plant. The construction of these large plants brings with it many controversies related to their social, environmental and health impacts on the population. Those are mainly political discussions: on the one hand who says that burning waste is an obsolete technique and the result of combustion, exhaust fumes, are carcinogenic to the population surrounding the plant. For this faction, data on the production of harmful agents - which are transparent and public, easily accessible on a daily basis on the site of each waste-to-energy plant and are always below the limits permitted by law - are not true and in the case of bad maintenance of the plant these harmful agents could turn into an ecological bomb. On the other side of the political arena there are those who say that the high levels of consumption of the current society no longer allow burying waste in saturated landfills. The best solution is to burn them and the heat produced by combustion uses it to heat the houses with thermo heating. This movement affirms that filters to purify exhaust fumes always comply with the law, and since these rules are imposed at European level they can not harm the citizen.

All these discussions, in my opinion, are more influenced by politics than by scientific data.
To get a concrete idea on which of the two choices was correct I had to ask myself a few questions:

- *How many methods do we know to dispose of waste?*
- *Are there any concrete alternatives to waste-to-energy?*
- *What degree of consciousness does our society have on the subject of waste?*

To look for answers to these questions I had to refer to virtuous examples of waste treatment, the countries of northern Europe are some of these. I wanted to analyze these good examples firsthand by living for six months in Rotterdam, in the Netherlands.

I had no idea where the investigation of this fascinating world of Waste would take me.

"If space-junk is the human debris that litters the universe, junk-space is the residue mankind leaves on the planet."
Rem Koolhaas, Junkspace

AGENDA 2030

2.

2. Agenda 2030: the Sustainable Development Goals as a goal for a better Future

During the Sustainable Development summit held from 25 to 27 September 2015, the main international leaders presented the document "Transforming our world. The 2030 Agenda for Sustainable Development ". In this document, 17 objectives have been identified, namely the Sustainable Development Goals (SDGs), with which the international community has ratified the commitments to be respected by 2030, regarding the issue of sustainable development. (2)
The 2030 Agenda recognizes the close link between human well-being and the health of natural systems and the presence of common challenges that all countries are called to face.
In doing so, it touches upon different, interconnected and fundamental areas to ensure the well-being of humanity and the planet: from the fight against hunger to the elimination of inequalities, from the protection of natural resources to the affirmation of sustainable production and consumption patterns. (3)

The SDGs have a universal character - they address both developing countries and advanced countries - and are based on integration between the three dimensions of sustainable development (environmental, social and economic), as a prerequisite for eradicating poverty in all its forms.

The Agenda identifies the global forum in the High Level political forum to monitor, evaluate and guide the implementation of the SDGs. To support this activity and ensure comparability of assessments, the United Nations Statistical Commission has set up the Inter Agency Expert Group on SDGs (IAEG-SDGs), with the task of defining a set of indicators for monitoring the implementation of the Agenda 2030 globally. Each year, States can present the status of implementation of the 17 SDGs in their country, through the elaboration of Voluntary National Reports - Voluntary National Reviews.
By signing it up, Italy has committed itself to declining and calibrating the objectives of the Agenda 2030 within its own economic, social and environmental planning. He presented the first report at the High Level Political Forum in July 2017. (4)

Sustainable development Goals as a starting point for Circular and Green Economy practices

In the next discussion, the focus is on the analysis of three objectives present within the SDGs, which served as a theoretical starting point for the motivations of the project proposal, that is the case study of the present work.

2.1 Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Energy is central to nearly every major challenge and opportunity the world faces today. Be it for jobs, security, climate change, food production or increasing incomes, access to energy for all is essential.

Sustainable energy is opportunity – it transforms lives, economies and the planet. UN Secretary-General Ban Ki-moon was the initiator of the "Renewable Energy for All" initiative to ensure universal access to modern energy services, improve energy efficiency and increase the use of renewable resources.

Facts and figures:

- One in five people still lacks access to modern electricity.
- 3 billion people rely on wood, coal, charcoal or animal waste for cooking and heating.
- Energy is the dominant contributor to climate change, accounting for around 60 per cent of total global greenhouse gas emissions.
- Reducing the carbon intensity of energy is a key objective in long-term climate goals.

Main Goals:

- By 2030, ensure universal access to affordable, reliable and modern energy services.
- By 2030, increase substantially the share of renewable energy in the global energy mix.
- By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology. (4)

2.2 Goal 11: Make cities inclusive, safe, resilient and sustainable

Cities are hubs for ideas, commerce, culture, science, productivity, social development and much more. At their best, cities have enabled people to advance socially and economically.
However, many challenges exist to maintaining cities in a way that continues to create jobs and prosperity while not straining land and resources. Common urban challenges include congestion, lack of funds to provide basic services, a shortage of adequate housing and declining infrastructure.
The challenges cities face can be overcome in ways that allow them to continue to thrive and grow, while improving resource use and reducing pollution and poverty. The future we want includes cities of opportunities for all, with access to basic services, energy, housing, transportation and more.

Facts and Figures:
-Half of humanity – 3.5 billion people – lives in cities today.
-By 2030, almost 60 per cent of the world's population will live in urban areas.
-95 per cent of urban expansion in the next decades will take place in developing world.
-828 million people live in slums today and the number keeps rising.
-The world's cities occupy just 3 per cent of the Earth's land, but account for 60-80 per cent of energy consumption and 75 per cent of carbon emissions.
-Rapid urbanization is exerting pressure on fresh water supplies, sewage, the living environment, and public health.
-But the high density of cities can bring efficiency gains and technological innovation while reducing resource and energy consumption.

Main Goals:

-By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.

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

-By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.

-By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities. (4)

3.

"It is time to move beyond the worn out make-use-dispose models in our sector. We have the ambition,capabilities and mind-set to decouple economic growth from resources consumption."

Carol Lemmens

Director and Global Lead Management Consulting

ARUP

2.3 Goal 12: Ensure sustainable consumption and production patterns

Sustainable consumption and production is about promoting resource and energy efficiency, sustainable infrastructure, and providing access to basic services, green and decent jobs and a better quality of life for all. Its implementation helps to achieve overall development plans, reduce future economic, environmental and social costs, strengthen economic competitiveness and reduce poverty. Sustainable consumption and production aims at "doing more and better with less," increasing net welfare gains from economic activities by reducing resource use, degradation and pollution along the whole lifecycle, while increasing quality of life. It involves different stakeholders, including business, consumers, policy makers, researchers, scientists, retailers, media, and development cooperation agencies, among others. It also requires a systemic approach and cooperation among actors operating in the supply chain, from producer to final consumer. It involves engaging consumers through awareness-raising and education on sustainable consumption and lifestyles, providing consumers with adequate information through standards and labels and engaging in sustainable public procurement, among others.

Facts and Figures:

-Each year, an estimated one third of all food produced – equivalent to 1.3 billion tonnes worth around $1 trillion – ends up rotting in the bins of consumers and retailers, or spoiling due to poor transportation and harvesting practices.
-If people worldwide switched to energy efficient lightbulbs the world would save US$120 billion annually.

-Should the global population reach 9.6 billion by 2050, the equivalent of almost three planets could be required to provide the natural resources needed to sustain current lifestyles.

Water

-Less than 3 per cent of the world's water is fresh (drinkable), of which 2.5 per cent is frozen in the Antarctica, Arctic and glaciers. Humanity must therefore rely on 0.5 per cent for all of man's ecosystem's and fresh water needs.
-Man is polluting water faster than nature can recycle and purify water in rivers and lakes.
-More than 1 billion people still do not have access to fresh water.
-Excessive use of water contributes to the global water stress.
-Water is free from nature but the infrastructure needed to deliver it is expensive.

Energy

-Despite technological advances that have promoted energy efficiency gains, energy use in OECD countries will continue to grow another 35 per cent by 2020. Commercial and residential energy use is the second most rapidly growing area of global energy use after transport.
-In 2002 the motor vehicle stock in OECD countries was 550 million vehicles (75 per cent of which were personal cars). A 32 per cent increase in vehicle ownership is expected by 2020. At the same time, motor vehicle kilometres are projected to increase by 40 per cent and global air travel is projected to triple in the same period.
-Households consume 29 per cent of global energy and consequently contribute to 21 per cent of resultant CO_2 emissions.
-One-fifth of the world's final energy consumption in 2013 was from renewables.

Food

-While substantial environmental impacts from food occur in the production phase (agriculture, food processing), households influence these impacts through their dietary choices and habits. This consequently affects the environment through food-related energy consumption and waste generation.
-1.3 billion tonnes of food are wasted every year while almost 1 billion people go undernourished and another 1 billion hungry.
-Overconsumption of food is detrimental to our health and the environment.
-2 billion people globally are overweight or obese.
-Land degradation, declining soil fertility, unsustainable water use, overfishing and marine environment degradation are all lessening the ability of the natural resource base to supply food.
-The food sector accounts for around 30 per cent of the world's total energy consumption and accounts for around 22 per cent of total Greenhouse Gas emissions.

Main Goals:

-By 2030, achieve the sustainable management and efficient use of natural resources
-By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses
-By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment
-By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse
-Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle. (4)

FROM LINEAR ECONOMY TO CIRCULAR ECONOMY

3.1 Criticality of the Current Economic Model

Starting from the industrial revolution we tried to impose a linear society on a planet that works by cycles. Nature recycles everything, we do not. In four steps we transform virgin matter into waste.
We start with the extraction of raw materials, which are often shipped around the world, then we continue with manufacturing, consumption and eventually waste. The more a society is "evolved" and the faster this transformation takes place. Every step in this linear chain causes enormous impacts on the environment. The extraction of raw materials requires large amounts of energy and in turn produces huge quantities of solid waste, air and water pollution and gives the ecosystem a huge amount of CO2 and other gases which in turn cause global warming. Many of these impacts are repeated again with the manufacture of products. Then the transport between one phase and the other involves a further use of energy and a further production of carbon dioxide and therefore still greater global warming. [1]
It should also be noted that all the resources made available by science and technology are applied to the production of goods - destined to become waste - ie the progress of physics, chemistry, biology and information sciences. While, when it comes to disposing of this waste, the four elements of pre-Socratic physics are still used: earth, water, fire and air. In fact, waste is buried (in landfills), burned (in incinerators), is released into the air (in the form of gaseous emissions) or is "discharged" into watercourses.
It is good to consider that, over time, the world population has had an exponential increase which, according to the latest surveys, has doubled in the period from the 60s to today, passing to the current 7 billion and, following the most optimistic forecasts, will increase by about a third by 2050 reaching to reach 9.6 billion people. It is easy to image that, with such an increase in the population, there is a directly proportional increase in the demand for services and primary goods, which will reach levels never seen before. This phenomenon of uncontrolled growth leads to the greater reduction of the so-called "scarce resources" or simply limited ones, those resources which, as per definition, have a low ratio between availability and requirements and with this increase they will become further rare.

Leaving aside the first critical issue concerning the growth of the world population, it is good to consider the impact that the extraction of raw materials has on the environment that surrounds us that, does nothing but worsen the landscape conditions, endangering the existence of entire ecosystems, starting from the flora and coming to affect the fauna. A further problem created by the current economic model is the pollution that occurs following the uncontrolled extraction of raw materials and along the whole production chain for the transformation, in finished products, of the same.
A data that supports the theory of waste of raw materials is the one proposed by a study of the European Thematic Center on Consumption and Sustainable Production which affirm that about 50% of extracted raw materials becomes directly waste in the extraction phase.
Another substantial problem is that of the uneven distribution of resources; in fact some material resources important for the technological innovation, such as rare earth elements (i.e. a group of 17 chemical elements used for example for the manufacture of smartphones, turbines, etc.), are present, for the most part, in a limited number of countries from which Europe depends. In fact, the European Union imports 90% of these materials directly from China, which is the largest producer of 14 of the 18 raw materials that are identified by the European Commission as "critical", because of their lack and increase their use in technology.
In terms of volumes of raw materials used by the world production system in 2001, about 65 billion tons of raw materials were used and, according to some studies, their consumption is destined to increase up to 82 billion tons in 2020.
In the last years, giant steps have been taken to improve resource efficiency and find new forms of energy. But their subsequent disposal was not contemplated. Production systems based on the recurrent use of non-renewable resources (i.e. those resources whose natural reconstitution in nature results in greater times than human consumption) do nothing but cause significant losses in the value of virgin raw materials, with consequent negative effects on its eventual re-use.
Recently, many companies have begun to perceive the risk that the linear system has adopted up to now, even in economic terms, considering the fluctuations in the prices of scarce resources and the respec-

"The Circular Economy forces companies to redesign in depth their business models, from the relationship with customers to the suppliers' networks, thus creating opportunities for disrupting many industrial sectors"

Davide Chiaroni
Ellen MacArthur Foundation
Politecnico di Milano

tive production malfunctions, due to their supplying. In fact, more and more companies find themselves in the situation of having to cope with the rising and less predictable prices of resources, in one hand, and with the increase in the level of competition, on the other.
The beginning of the new millennium marks the point where the prices of natural resources are beginning to rise, thus confirming the definitive change in real prices of the previous decade, which have been stable for several decades. It is therefore appropriate to consider that, if containment measures are not adopted, the costs of extraction increase in step with the increase in population growth.
After all the considerations made on emerging issues, compared to the linear economic system, it is easy to assume a future in which the waste material resources and end-of-life products are re-used, recycled or recovered in another way and fall again to be part of the production cycle in other ways or for different uses, trying, as far as possible, to reduce waste and aiming to obtain a life cycle of "almost zero" waste products.

3.2 Advertising and Consumerism

Consumption - the real driving force behind this whole linear process - is stimulated by advertising, especially through the number one of today's hobbies: watching television. Excessive advertising produces excessive consumption. In the United States, every seven minutes tell us that we need to buy something. They tell us that we are hungry, thirsty, too fat, too sick, sexually frustrated and that we need a new car! At the time a high school student leaves high school in the United States, he has seen more than 350,000 television ads. [2]
From an early age our children have been programmed for a lifestyle based on excessive consumption.
I produce Waste, therefore I am ... (Cogito Ergo Sum) This is a new Cartesianism from garbage collectors, in which I confirm myself only by separating myself from what seems to anticipate my natural mortality, distancing itself from putrescence [...] If I am a producer of waste it means that I am not waste myself. [3]
The senseless dilapidation of forests, the extinction of animal species overwhelmed by smog and opaque oceans like oil, the "right" wars to

grab the last precious metal mines and the last fuel wells, the drastic reduction of biodiversity, the insane waste of the beauty of a nature that should at least make us think of its destination different from the systematic rape perpetrated against it. Everything that awaits us around the corner, as the possible interruption of the party, that is celebrated between the everlasting thrill of shopping.
But these items do not even die when we throw the remains in the trash can, even if we know much less about what happens to this product - or what's left of it - after we've consumed it. For us, the problem is to remove it from home. But then?
Then, if the separate collection does not intervene - and in Italy it is still too little - it is collected, compressed together with thousands of other former former products, transported to a transfer site, downloaded and reloaded on another truck that transports it. to a landfill. Here it is again downloaded and reloaded on another vehicle, taken to the burial site and buried. Or he is thrown into the pit of an incinerator; his spirit rises in heaven while his vital breath will feed an electric discharge; and what remains of his body will receive a special burial.
With China, India, Brazil and the European countries, with huge populations trying to reach western consumption, the demand for finite resources and global climate change threaten to become worse than anything we have seen so far. It is time for us in the West to propose a better example. Where is it best to start if not from an unsustainable daily activity involving almost all human beings - the production of waste? A sustainable society must be a Zero Waste company.

THE BIOLOOP

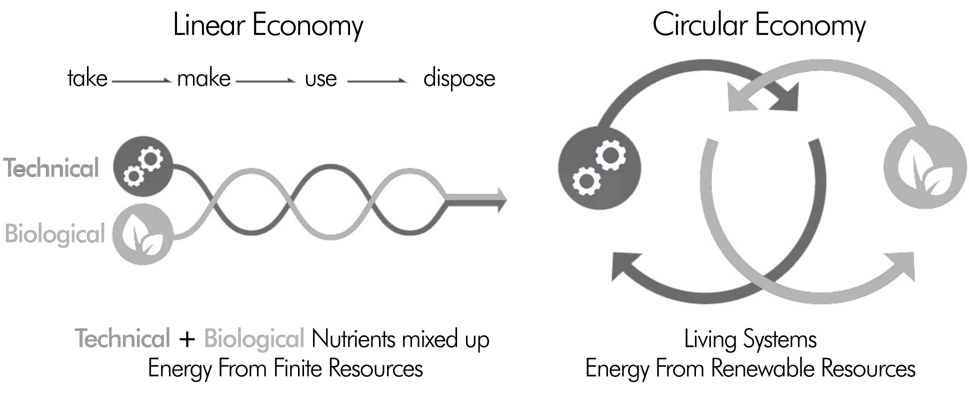
Nature becomes an endless source of feedstock for the built environment

3.3 What is Green Economy?

The principles of Circular Economy would provide the rationale for a shift form a linear - disposal model - towards a circular value chain where natural waste is the main resource. In this context new business models could be identified and developed to enable alternative use of organic waste streams as opposed to the current value chain. This approach could also help supporting local and rural economies with benefits for both existing and new stakeholders. [4]
Fundamental elements that contribute to implementing this type of economy with low environmental impact are technology and scientific knowledge. A point of extreme importance on which the green economy is based is constituted by alternative energies from renewable resources such as solar energy, wind energy, geothermal energy, hydropower and biomass. The green economy differs from sustainable development, because does not intend to make only environmentally friendly productions: this type of economy also has the objective of producing business, of carrying out a very broad turnover, capable of invoicing and promoting profits. In Italy the sectors of the green economy that are the most successful are those of energy and waste recovery. The green economy considers the environment as an investment and a sustainable and supportive economy. With this type of economy, we try to reduce energy consumption and to undertake important strategies aimed at reducing pollution, not neglecting the possibility of achieving energy efficiency. The green economy can be practiced both by private individuals and by public institutions. In any case, we must bear in mind that the main purpose of the green economy is to ensure good working conditions for all. This is its sense of being a supportive economy, since it aims at respecting the environment through respect for people.
The green economy is implemented through the action of banks and organizations that decide to work with this kind of economy. Banks and organizations pay attention to ensure that their investments are used to affirm environmental sustainability.

This explains the particular interest of green projects, for the implementation of which, the banks make available to specific loans, which have the aim of encouraging ideas to support the environment. There are also bank loans for renewable energy in the green economy. We can also become part of the environmentally friendly economy, using a bank that seeks to carry out actions aimed at environmental protection and environmental awareness. (5)

7.



3.4 Main ideas of the Circular Model

The circular economy model has its roots in concepts dating back to the 1970s, including the Club of Rome's 'Limits to Growth' theory, Braungart and McDonough's 'cradle to cradle' concept, Stahel's 'performance economy', and Lyle's 'regenerative design' model, to name a few.
The approach has gained attention recently thanks to the Ellen MacArthur Foundation, a charity dedicated to promoting the global transition to the circular economy.
When we talk about the Circular Economy, we refer to industrial systems that are of reparative or regenerative type, allowing to replace the concept of end of life of the product with that of restoration. They also are focused on the use of renewable energy, on the elimination of the use of toxic substances that hinder the re-use of the raw materials in question and also aim to cancel the production of waste, through the review of the basic phases of design that is approached under a greener perspective, hence the term "Eco-Design".
With the latter we mean a new interpretation of the product phases design, whose main objective is to reduce the environmental impact of the entire life cycle of the product, starting from the review of production processes for which attempts are made to reduce emissions and the production of waste materials along the supply chain, arriving to the study of materials used for the production of finished products, trying to increase their durability as much as possible and facilitating their recycling possibility in the phase of end of life of the product.

The Circular Economy is based on some simple solutions.
First of all, there is the idea of redesigning the waste, which must no longer be considered a waste in itself, since the products must be rethought to provide for a cycle of dismantling and subsequent reuse of its components. These new product cycles and the cycles of components after the dismantling of the product at the end of life, are precisely to define the essence of the circular economy. These components according to the type of reuse or recycling become part of the same production cycle in the first case or of other cycles associated in the other.

Secondly, circularity introduces a rigid differentiation between the consumable and durable components of a product.
Nowadays the substantial difference with regard to the consumables used in the circular economy, is given by their particular composition which results purely on the basis of "biological" or composed of nutrients, which must underline their biodegradability; they are certainly less toxic and, in most cases, constitute an advantage because they can be safely reintroduced, directly in the biosphere or in cascade for further consecutive uses, without causing pollution in the surrounding environment. Talking about durable materials, such as computer processors, it should be noted that they are not made of biodegradable materials because they are composed of materials such as metals and plastics, which are unsuitable for being re-introduced directly into the biosphere. These components because of their critical disposal, must be designed from the beginning for easy re-use.

Thirdly, emphasis is placed on the energy needed to set in motion a generic production cycle; for consistency with the idea proposed by the circular economy, it must have an environmental impact that is as low as possible, aiming to reduce as much as possible the emissions of CO_2 in the atmosphere. This is possible through the use of renewable energies such as photovoltaic and wind power. The use of these technologies provides the additional advantage of not being dependent on material resources that are polluting and non-renewable in themselves, such as fossil oil and methane.

Below are the principles on which the circular economy is based:

Waste design:

It is easy to hypothesise the lack of waste of a product made by a biological material if they are designed with the aim of adapting to a biological or technical material cycle, providing for a disassembly and a recomposition.
The biological substances are not toxic, so they can simply be composted.
While the technical substances are polymers, alloys and other man-made materials can be used with a minimum of energy and with losses

in the quality of the products (as opposed to the usual recycling practice which provides a loss of quality of the raw material in most cases).

Building resilience through diversity:
Features such as modularity, versatility and adaptability are invaluable and must be privileged in an ever-changing world.
Obviously, different systems with many connections are more resistant to negative events than systems that are built with the only objective of maximizing efficiency and exposing the system itself to greater fragility.

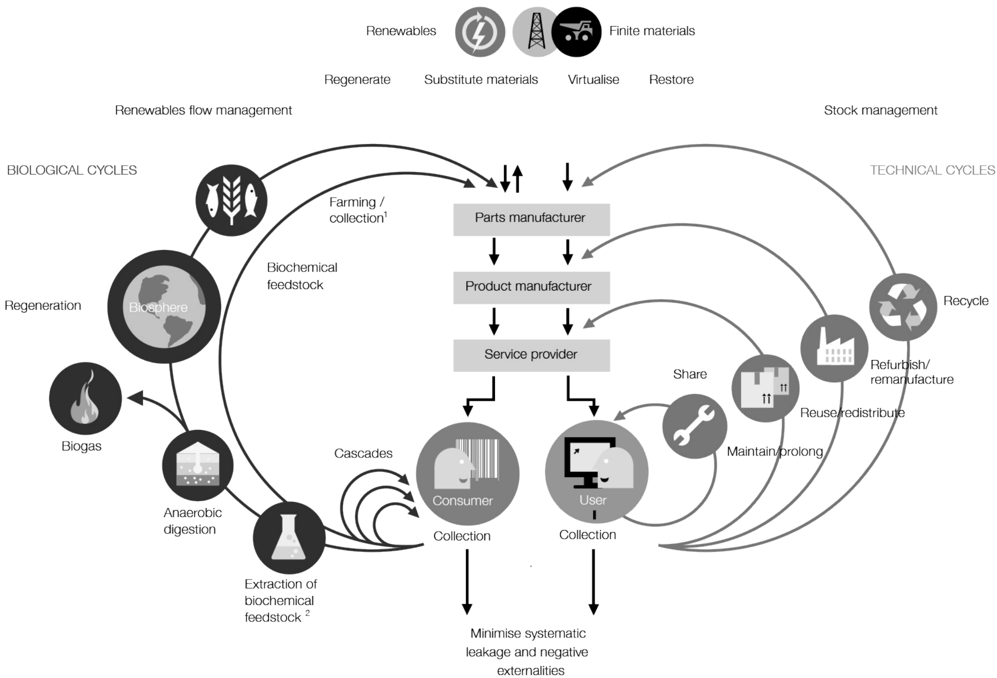
Energy from renewed sources:
It is important to consider that these systems, with a view to reducing the environmental impact, should be based on the use of renewable sources for their energy needs.

Holistic System view:
It becomes crucial, in a system, the ability to understand how the parts within it interact and influence each other and how they fit into the system, influencing it from the inside.
The elements are considered according to the relationship with their infrastructures, with the environment and with the social contexts in which they are located.
As opposed to a machine, which can be considered as a limited and deterministic type system, the circular system is characterized by a non-linearity condition, typical of feedback-rich system. In such systems, the answers are inaccurate and have never been so positive. The analysis of the system emphasizes that the conditions are regenerative rather than focusing on one's attention on one or more parts in the short term.

Waste as a new raw material:
Considering the organic components, the main idea is to reintroduce the organic waste products and materials into the biosphere, through non-toxic regeneration cycles.
While, as regards the technical components, it is possible to improve the quality and their durability, making possible an upcycling of the

product.
The impulse of the change in the composition of consumables, from the technical to the organic, and the use of these in cascade, through different applications, before they are dismantled to extract raw materials and that their organic components are re-introduced into the biosphere, it completes the fundamental principles behind a revitalizing circular economy.

8.




NAFAG
GHANA

WASTE?
DOES NOT EXIST!

"He looked at all that soaring garbage and knew for the first time what his job was all about. Not engineering or transportation or source reduction. He dealt in human behavior, people's habits and impulses, their uncontrollable needs and innocent wishes, maybe their passions, certainly their excesses and indulgences but their kindness too, their generosity, and the question was how to keep this mass metabolism from overwhelming us.
The landfill showed him smack-on how the waste stream ended, where all the appetites and hankerings, the sodden secondthoughts came runneling out, thethings you wanted ardently and then did not."

Don DeLillo, Underworld pag. 191. 1997

4.1 What is Waste?

The definition of waste is trivial: *"Waste is any substance or object that the holder discards or intends or is obliged to discard"*, according to the Waste Directive, issued by the European Parliament in 2008, in Article 3, and implemented by the Italian Government in 2010.

Take any object, a piece of paper, for example: if I write on it is a piece of paper, but as soon as I decide I do not need it anymore and throw it away, here is my paper sheet immediately becomes a waste in accordance with the law. Becoming waste is not a trivial matter, because from that moment an important series of consequences begins. First of all, the piece of paper is virtually labeled with a 6-digit code, to be precise 20 01 01, which uniquely identifies it as "Paper and cardboard subject to separate collection" and determines its subsequent fate. It is a virtual label that allows us to correctly catalog that piece of paper in counts and statistics that tell us something about how we handle waste.
The code assigned to the sheet to be thrown is, together with other hundreds of codes, in chapter 20 of the European Waste Catalogue (EWC). It is a very long list of codes, a list that tries to understand all the different types of waste that our society can produce. Not only urban ones that actually occupy a small part of the catalog, but also and above all industrial, commercial, agricultural ones and so on.

01 00 00	Waste resulting from exploration, mining, quarrying, and physical and chemical treatment of minerals
02 00 00	Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing.
03 00 00	Waster from wood processing and the production of panels and furniture, pulp, paper and cardboard.
20 00 00	Municipal Wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions.

[5]

Once a refusal obtains its qualification and its code, it is subject to a series of constraints that condition its collection, treatment, recovery and disposal.
The purpose of these restrictions is to prevent manipulation of the waste from causing damage to human health and the environment. [6]

4.2 Garbology: Waste in History

Let's take a small step backwards, they never sprouted it at school, but Archeology is largely the art of reconstructing the culture, technique and daily life of a vanished people, digging through its Waste.

Seen in this light, there is already, or is in the process of being, an Archeology of contemporary society, which in the United States, where this discipline is more developed, also has the name of Garbology, which can be defined as the science of Garbage.
The meticulous analysis of what we throw every day in the waste bag or - on a larger scale - the analysis of what has been accumulating over the years in the overlapping layers of which a landfill is composed. A landfill is like the cemetery where we bury the bodies of goods, as we bury those of men in the cemetery.
In fact, they tell us more about our daily consumption, but also about our way of life, of spending time and the relationships that exist between the members of a family unit, or the different way of life of the rich and the poor. More than the most expensive marketing study can reveal, the most accurate sociological inquiry or thousands and thousands of surveys. [7]
Waste does not lie.

Let’s make a waste timeline:

Prehistory

The waste of prehistoric man consisted mainly of the bones of animals hunted and eaten, which were found in large quantities. Other finds are the remains of weapons and tools.

Ancient Rome

In the houses, except for the richer ones, there were no toilets and the poorest population threw from the windows all kinds of waste, consisting of food and excrement. The artisans, the street vendors, the shopkeepers and the animals that pulled the wagons also contributed to the dirtiness of the streets. To avoid epidemics, in addition to public sewers, public baths and baths were built. Out of town, landfills were set up where not only waste and debris were thrown away, but also dead animals and victims of games in the circus. The archaeological excavations have revealed that the accumulations of rubbish have formed real hills such as Montecitorio and Monte dei Cocci, consisting of broken amphorae.

Middle Ages

Around the year one thousand, the cities began to revive slowly but showed considerable hygienic deficiencies. The houses were deprived of toilets and waste and excrement were used as fertilizer for the gardens or thrown in the streets, despite the prohibitions. Animals, artisans and markets helped make roads even dirtier.
There was no cleaning service and the dirt caused epidemics, mostly spread by rats. The waste consisted of human and animal excrement and food remains, rather scarce because everything was used in the kitchen.

Renaissance

They sought to remedy the lack of hygiene and it was decided that the owners had to clean the stretch of road in front of their house or their shop and sellers the area of the market used. The streets however continued to be frequented by animals that roamed freely and dirty. The waste was excrement and remains of food.

End of 1700 - early 1800s: Industrial Revolution

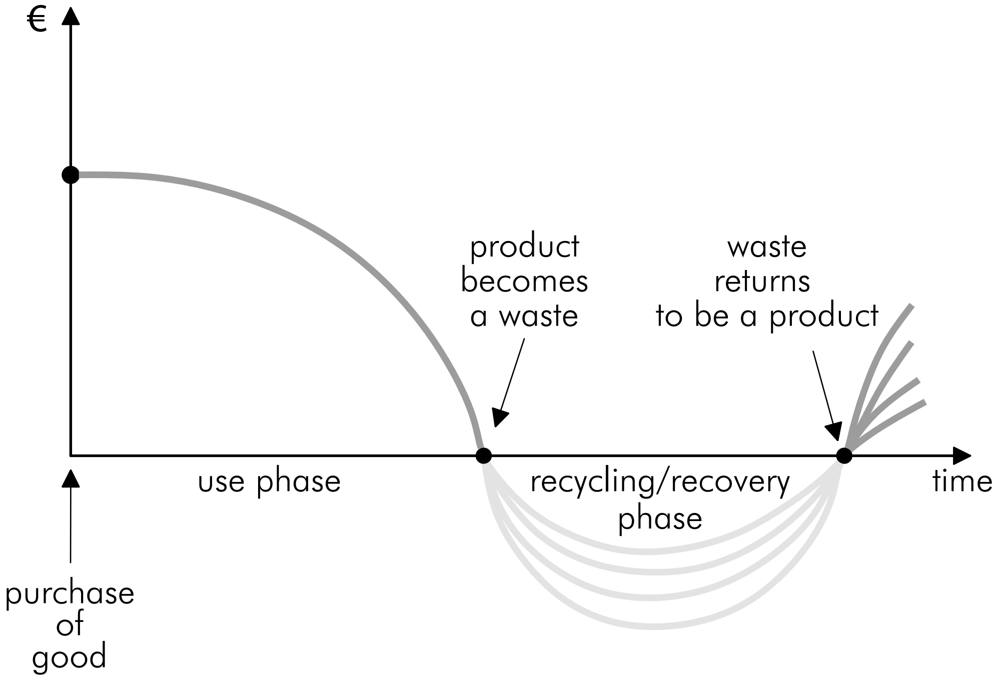
During this period the system of production of goods changed, thanks to innovations and technological inventions. There was a need to solve the problem of waste produced not only by population growth but also by industries. The most abundant wastes are food leftovers, but the industrial waste increases a lot.

Modern city

Wastes increase rapidly, but they are not just organic, as plastic objects are made and sold, and synthetic fibers for fabrics are spread. In addition, the wood-burning or coal-burning stoves, in the 1960s, disappeared and even the combustible materials can not be incinerated, but end up in the trash.
Currently, with the habit of throw-away and the increase in packaging, the quantity of non-biodegradable waste has grown in a worrying manner, creating problems of disposal and pollution. The situation has led to considering the need for recovery, recycling and separate collection. (6)

4.3 What is the cost of Waste?

Let's go back to the moment when my decision changed the destiny of the piece of paper (page 42). From that moment the economic value that I attribute to the new rejection is zero, since I am willing to pay for someone to get rid of me. Technically we talk about "negative market value". It is the opposite of what happens with any good you buy: you give me the item and I give you money in return. But on closer inspection, the leaflet, which is no longer worth anything to me, has instead a potential value for someone who is able to recycle it, to produce, for example, other paper. However, this someone, who is a paper mill, does very little of my miserable piece of paper; because only if it is in



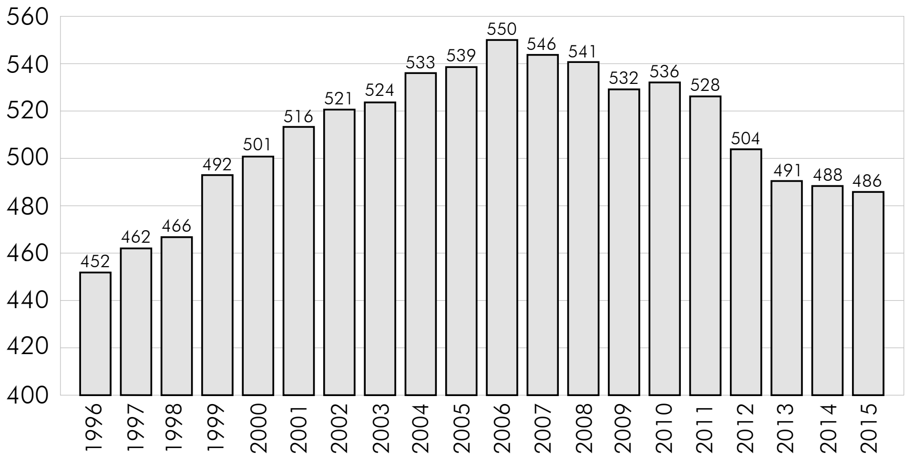
Each product has a value that changes over time. It comes down to zero when it becomes a waste. So it acquires a negative market value, from here it can return positively if it is put back on the market after recycling and recovery.

possession of large quantities of paper can break down and make sustainable the cost of collecting the many leaflets scattered around the world. In any case, this collection is still supported by the contributions that each of us pays every time he buys a product contained in a package. Here is a crucial aspect of waste collection: it is very important to design and manage systems able to group small quantities of waste scattered throughout the territory and transfer them to facilities able to treat and recycle them. In a sense it is as if the piece of paper, at the time it was thrown, acquired a negative market value, had hit the bottom and from there could only come up, returning first to a null value and then hopefully worth more and more. It will be the recycling that will make the sheet (or rather, the cellulose fibers of which it is composed) again attractive to the market. This line of reasoning is quite smooth until we are talking about materials that are clearly identified and easy to separate, just like paper. But even with paper, it is enough that the sheet ends up in the undifferentiated container, mixing with other materials, that bringing the market value back into the positive field becomes a more difficult task, because recovery and recycling are more expensive and not always convenient. [6]

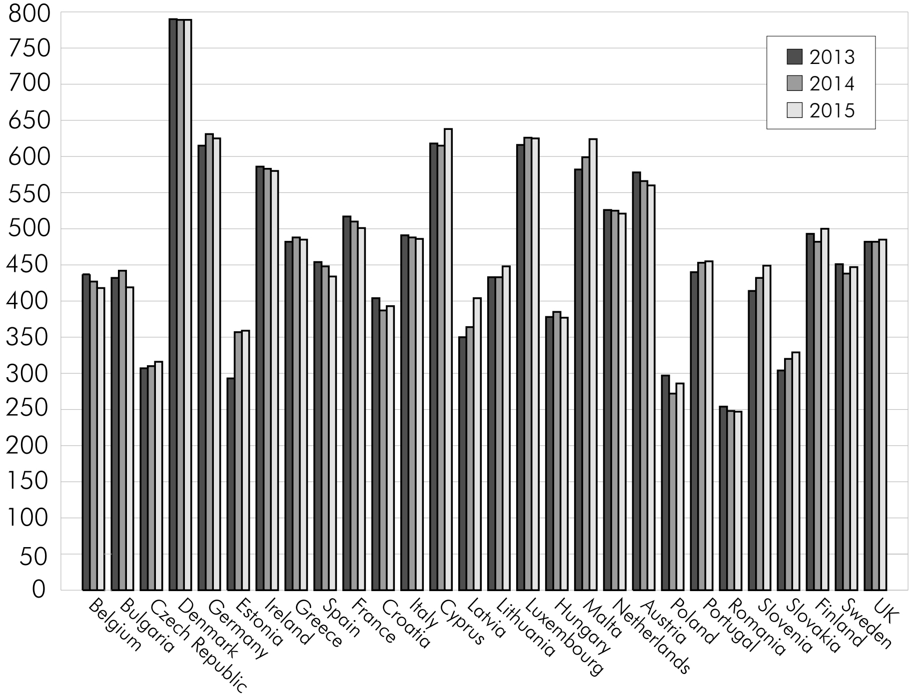
4.4 How much Waste we produce?

We can estimate that on a normal day I, or you who are reading, alone we produce about 1.5 kg of waste on average. For the accuracy of urban waste, a category of waste that in reality does not only include what is generated inside homes, but also the waste produced in other activities, however, attributable to the daily life of people: from cleaning the streets to the maintenance of the green public, up to the small commercial activities of the neighborhood. Even cemetery waste, like withered flowers, falls into this category.
From the data of the Waste Report published every year by the *Istituto Superiore per la Protezione e Ricerca Ambientale (ISPRA)*, the amount of daily per capita urban waste generated in Italy reached a peak of 1.5 kg in 2006, a sharp increase compared to previous decades: in 1979, for example, each Italian produced less than half, 0.68 kg per day.

This disparity is due not only to the increase in consumption, but also to changes in society and the types of consumption, such as the growth of "disposable" products, the shortening of the life cycle of many products and a increasingly massive packaging.
To not forget, the increased spread of single portions, where the percentage incidence of packaging on overall weight is inevitably higher.
From 2006 in Italy the production of waste began to decrease, first timidly, then more decisively.
There is no need to be very happy, because of this decrease is certainly linked in large part to the consumer crisis. However, it is likely that recent prevention policies have contributed to this trend at least a little.
In total, around 30 million tonnes of urban waste were produced in Italy in 2012, a small part of the total waste generated. In fact, this number is quadrupled if we include the so-called special waste, that are: those deriving from agricultural, industrial, artisanal, health waste, construction and demolition (building waste) and those coming from service operations, such as water purification or vehicles that can no longer be used.
These wastes are evidently not produced by me or you, but by the society to which we belong. If we include them in the count made earlier every day, we will produce a total of almost 7 kg of Waste! [6]



The trend of per capita production of urban waste in Italy in recent years, in kg per inhabitant (graph adapted from the 2017 Waste Report, ISPRA).

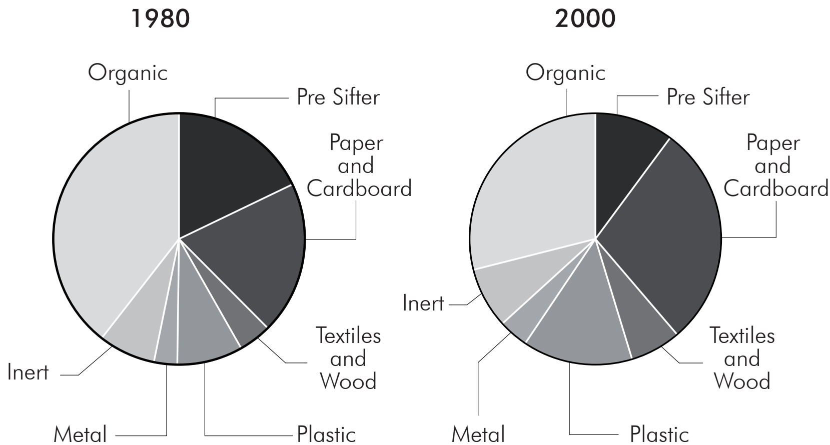


The trend of per capita production of urban waste in Europe in recent years, in kg per inhabitant (graph adapted from the 2017 Waste Report, ISPRA).

Let's go back to the question we asked ourselves earlier: where do waste end up once we have selected them, more or less well, and have been picked up by trucks?
Where they end up depends mainly on the way we separate them and collect them. Even today in Italy less than half of urban waste is collected in different ways (in 2012 the national average value was 40% of total production).
The organic fraction, the so-called wet, and the cellulosic material (paper and cardboard) are the main ingredients; glass follows, then plastic, iron, aluminum and other minor fractions. Everything else remains mixed together, to build the undifferentiated waste, a heterogeneous mixture of the same materials just listed, as well as many others.
To orientate between the different fractions of waste and to know

the various components that end up in the undifferentiated bin, we must study how the goods are composed and identify the quantity of glass, metals, aluminum, batteries and batteries, of wood, of cardboard, present among these wastes. In technical terms we talk about commodity analysis, a discipline that classifies products in a certain number of distinct classes (at least eighteen), and that today applies not only to residual waste but also, for example, to plastic or paper collected for differentiate, because not all types of plastic and paper are the same.

Commodity Waste Composition in Italy



Well, where does our waste go?
In the past they only ended up in landfills, ie they were accumulated on the ground. Today the system has become much more complex than in the past, and is punctuated by a series of precise steps. First of all there is the recycling of the materials collected for differentiated, then the biological treatments are done for the wet fraction; the mechanical ones for the extraction of additional recyclable materials; and often the energy recovery of the indifferentiation through the waste-to-energy plants. The landfill is an option that only occurs at the end of this

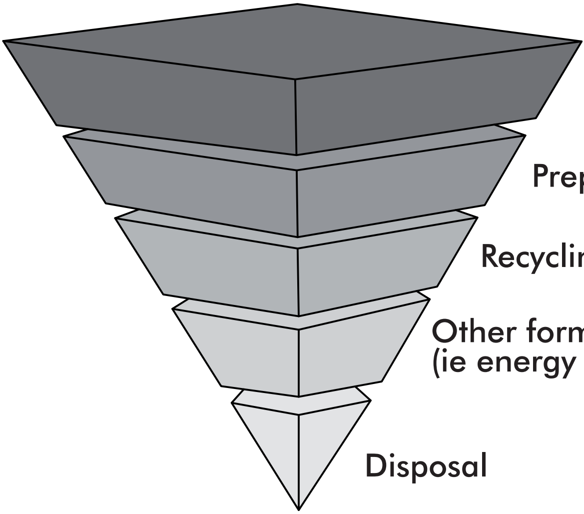
cycle, which should be used only for the non-recyclable and non-combustible residue, according to the indications of the European Union. The landfill in fact generates impacts on the environment, both at the local level - we think about the smells and the degradation of the territory - and global. The latter are mainly due to methane emissions from the degradation of the organic waste fraction. Furthermore, the use of landfill is a waste of resources that could be re-used. Yet still in 2012 in Italy 42% of municipal waste ended up in landfills, against 23% recycled, 17% that fed the waste-to-energy plants, and the remaining portion distributed mainly between composting and biological mechanical treatment. And with this we come to another ideological dilemma about waste: is it a problem or an opportunity? In an ideal world waste should not be produced, because it is the waste of our activities. But waiting (and hope) to reach this goal, we just have to try to get the best out of them, considering them as a source of raw materials to be reused and reused in production processes, trying to move more and more towards a circular society, a recycle society. [6]

4.5.1 The Hierarchy of Waste Management

Once you understand how to classify waste, you need to organize for its management in compliance with the laws in force. Waste management, in particular, is governed by European Directives which must be incorporated into the body of the laws of each Member State. The most recent Directive, which we have already mentioned, is n. 98 of 2008, identified as the "Waste Framework Directive". It is a strategic text that defines the general principles, fixes the definitions and establishes the priorities and objectives to be achieved. But the central element of the Directive is the so-called "waste management hierarchy", ie the priorities among the available treatment and recovery options, often represented as an inverted pyramid. "The best waste is what is not produced", says an old saying.
And so the European Directive has put the prevention on the top of the hierarchy: reduce the weight of waste produced and in the meantime also their danger, must be the first goal of the good waste management, as indeed the first thought of every citizen and whose goods it produces. These measures are taken before a substance, material or

product becomes waste in order to reduce:
a) the quantity of waste, including through products or the extension of their life cycle.
b) the negative impacts of waste produced on the environment and human health.
c) the content of hazardous substances in materials and products.

After prevention, there is preparation for re-use. The control, clean-



ing, disassembly and repair operations through which the products or components of products that have now become waste are prepared in such a way that they can be re-used without any other pre-treatment. If I return the glass bottle of milk to those who sold it to me, I'm starting a re-use preparation procedure: someone will take care of cleaning and sterilizing the bottle for later use, without the glass being melted and converted into some other object.
Further down we find the recycling, that is the recovery of the materials: the waste returns to be a product, but in shape and for a use that could also be different from the original ones: the aluminum can become a bicycle or a heater, the iron it can be turned into a rod for reinforced concrete reinforcement, the plastic bottle of water is the raw material of a pile sweater. At this level are also the biological treat-

ments such as composting for organic waste but not the recovery of energy nor the reprocessing to obtain materials to be used as fuels or in filling operations.
We almost got to the bottom. After recycling we meet the recovery of enegia, ie the possibility of obtaining electricity or heat from waste. This happens in the process of conversion that can be carried out in dedicated plants, for example the waste-to-energy plants, which we will discuss later, or existing industrial plants, where the energy obtained allows replacing in part the one generated by traditional fuels.
The last level is the disposal of those waste from which it is no longer possible to obtain anything useful, in controlled landfills or through low efficiency incineration.
This hierarchy of priorities is a good idea, but the approach is rather rigid, with categorical constraints that are badly adapted to the complex waste management. For example, not all plastics present in the waste are easily recyclable, particularly if they are very heterogeneous, dirty or of poor quality. In short: the criterion must be the search for the "best overall environmental result" and therefore the hierarchy must be applied with common sense.
To achieve this, very complex evaluation procedures are needed, such as life cycle assessment (LCA).

4.5.2 LCA (Life Cycle Assessment)

The Life Cycle Assessment, or Life Cycle Assessment, is one of the main references for many of the methods for assessing the environmental compatibility of products. In general, the term Life Cycle Assessment, or LCA, is a process of objective quantification of energy consumption, of materials used and releases in the environment and a procedure for assessing the impacts on the ecosystem attributable to the consumption of resources and Polluting emissions. Through a life cycle analysis it is therefore possible to arrive at an evaluation of the energy-environmental performance during one or more phases of the existence cycle of a product, a component or a technical element.

The term LCA - Life Cycle Analysis - was officially born in 1990 during the SETAC Congress (Society of Environmental Toxicology and Chem-

istry). From this moment on the aspects related to energy analysis and pollution problems environmental issues have converged into a unitary methodological approach.The considerable interest developed around the LCA methodology, thanks to the growing number of studies conducted in the 90s, has recently led to its recognition in terms of international standardization through the definition of a series of ISO standards (1998) recently updated in the UNI EN ISO 14040: 2006 and 14044: 2006 and its renaming in Life Cycle Assessment.
These rules characterize LCA in four main moments:

1) Goal Definition and Scoping, which defines the purposes of analysis and evaluation, the functional unit and the system boundaries;

2) Inventory Analysis, in which the sequential processes that characterize a production system are reconstructed, identifying the respective quantities of energy and of necessary raw materials, in order to reproduce a theoretical model able to represent the functioning of the real system;

3) Life Cycle Impact Assessment, in which the data relating to releases in the environment and to the consumption of resources are processed. The processing process means that information is classified, characterized and standardized in relation to the contribution it can make to the formation of potential environmental effects.
The analysis of the impacts implies, therefore, the transition from an objective analysis, conducted during the inventory phase, to a judgment of environmental compatibility, based on cognitive elements that are updated over time and subject to systematics.
variations;

4) Life Cycle Interpretation, in which the energy and environmental performance of the system in question is evaluated; at this stage it is also possible to compare different supply scenarios for raw materials, energy sources, possible recoveries of secondary raw materials, etc. [8]

4.5.3 European Ecolabel

The Ecolabel, introduced with the EEC Regulation n.880 / 92 and revised in the "New Ecolabel "CE 1980/2000, is the European brand that rewards the ecological quality of a product or a service.
This is a label that contains information that certifies compliance with a series of ecological criteria, related to the entire life cycle of a product, established at Community level by a committee that works on the mandate of the European Commission: the CUEME - Committee of the European Union for the Ecological Trademark. The European Commission also performs the task of the body responsible for issuing the same trademark. The validity of the trademark is three years.
The ecological criteria established for the issue of the brand are more stringent than those set by the European Directives in the environmental field, so it is a label that attests the excellence of a product. Every 3-5 years the criteria are subjected to a review process and, if the need arises, made even more restrictive, so as to continue to reward excellence and encourage continuous improvement of the environmental quality of the products.
The products bearing the Ecolabel label are marked with a flower (a daisy) whose petals consist of twelve stars. The flower of the Ecolabel is now well known to most European consumers, particularly in Italy some major supermarket chains have introduced, for over a decade, products such as paper towels, detergents, light bulbs, etc.
Like other brands that are part of the ISO 14020 series of standards, this is a voluntary mark that a manufacturer or a service provider can request obtain prior verification of the criteria established in the EU.
For a company, the Ecolabel is an investment in terms of visibility on the market, allowing you to make use of a brand that is a symbol of

excellence in the field environmental.
For a consumer, the brand is synonymous with quality assurance ecological certificate attested by the EU.
Membership in the ISO 14020 series of standards implies that the main methodological reference for the verification of environmental criteria is an LCA, and it is no coincidence that performance testing is based on the well-known approach: “from cradle to grave”.
For a product, or for a group of products, the following are expected to occur environmental aspects:

- air quality;
- water quality;
- soil protection;
- waste reduction;
- energy saving;
- management of natural resources;
- prevention of global warming;
- ozone layer protection;
- safety and environmental risk;
- noise pollution;
- biodiversity.

1 PETE	**Polyethylene Terephthalate:** Polyester fibers, soft drink bottles
2 HDPE	**High-Density Polyethylene:** Plastic bottles, plastic bags, trash cans, oil cans, imitation wood
3 PVC	**Polyvinyl Chloride:** Window frames, bottles for chemicals, flooring, plumbing pipes
4 LDPE	**Low-Density Polyethylene:** Plastic bags, buckets, soap dispenser bottles, milk bottles, plastic tubes
5 PP	**Polypropylene:** Bumpers, car interior trim, industrial fibers, carry-out beverage cups
6 PS	**Polystyrene:** Toys, flower pots, carry-out food containers, Styrofoam
7 OTHER	**All other plastics:** Polycarbonate (PC), polyamide (PA), styrene acrylonitrile (SAN), acrylic plastics/polyacrylonitrile (PAN),

4.5.4 Recycling Codes

Recycling codes are used to identify the material from which an item is made, to facilitate easier recycling or other reprocessing (table above). Having a recycling code, the chasing arrows logo or a resin code on an item is not an automatic indicator that a material is recyclable but rather an explanation of what the item is. Such symbols have been defined for batteries, biomatter/organic material, glass, metals, paper, and plastics. Various countries have adopted different codes. In the United States there are fewer, as ABS is grouped in with others in group 7. Other countries have a more granular recycling code system. For example, China’s polymer identification system has seven different classifications of plastic, five different symbols for post-consumer paths, and 140 identification codes. [9]

Everything is poison, and nothing exists without poison. Only the dose makes the poison not effect.
Paracelsus, a Swiss alchemist from 1500

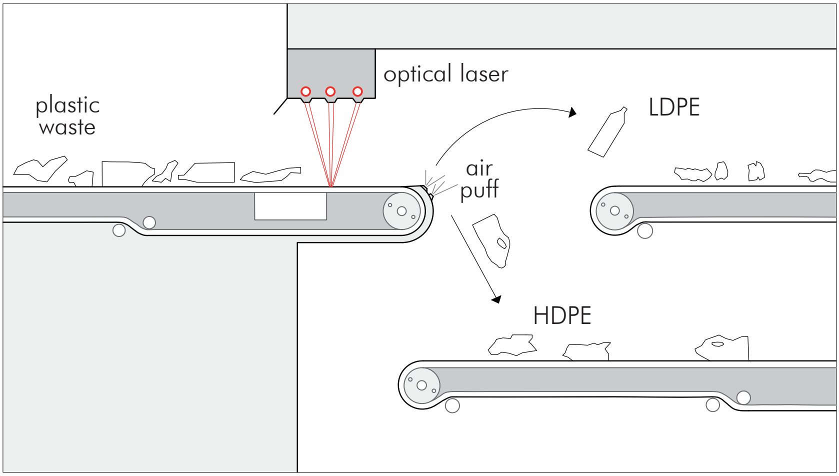
URBAN WASTE

5.1.1 Plastic

The word plastic derives from the Greek *plastikos* meaning “capable of being shaped or molded” and, in turn, from *plastos* meaning “molded”. (7)
In Italy in 2016 the differentiated collection of plastics stood at almost 1.2 million tons (+ 4.8% compared to 2015), the per capita quantity collected is 20.4 Kg / inhabitant / year2016 and represents 6.8% of the total recycled. [10]
Plastic is undoubtedly the type of material that has the most diverse and versatile characteristics, and must be taken into account in the separation and recycling procedures. We consider the plastics a single category because they all derive from oil and have a repeating unit structure called monomers, which are joined by chemical bonds to form long chains called polymers. It is then the chemical nature of each monomer, and of the polymer it forms, to dictate the characteristics of the different types of plastic.

Once the recycling plant has been reached, the plastic is inserted in a special system that provides for the tearing of any collection bags. The first selection of the mechanical type plastic takes place in a rotating screen that separates the various plastic families according to their size.

Following this first mechanical separation which is carried out by the rotating screen (a sort of huge centrifuge), further separation takes place by optical readers that separate the plastic, in this case the separation does not take place with a rotary movement (centrifugal) but with puffs of air.
Specifically, plastic flows on a roller until it meets an optical sensor that recognizes the color and composition of the polymer (using the International Resin Identification Coding System, often abbreviated as the RIC, (see the table above on page 60) a puff of air will be released next to the object that will be catapulted into another roller in order to continue the recycling in another way.



how plastic waste selection works

In addition to the mechanical divisions, there are also manual divisions where plastic passes on a conveyor belt and the workers remove any plastic materials not suitable for recycling as plastic toys mistakenly disposed of in the separate collection of the plastic.
The human labor goes to correct any errors of the machines, for example those made by the optical reader about the color pigments of the bottles, only in this way you can have a quality control to obtain a selection of plastic suitable for recycling.

Only after the plastic will be conveyed into a press that will give various bales of plastic material: PET (mainly given by bottles) in three different colors, ie colored, blued and transparent, high density polyethylene (mainly given by detergent drums and various bottles) and low density polyethylene (mainly given by envelopes, shoppers and other industrial stretch).

Then it goes to the shredding stage that produces the crushing coarse material, leading the same to assume homogeneous even if irregular size. The loading system is generally made up of a prehensile

spider or a conveyor belt. Following the crushing, the material undergoes a considerable reduction of the initial volume; this is particularly evident when dealing with hollow bodies, both closed and open, in which the reduction in the volume ratio is very high (generally more than 1: 5).
For the processability of the treated material it is important to guarantee a certain homogeneity of the product size.

The product obtained after shredding is washed in case it is necessary to separate those parts that could be harmful to the subsequent transformation phase. Based on the characteristics of the recycled polymer and the sector of origin, different washing systems have been developed. The most widespread system is that which involves the passage of the shredded material into a tank in which a stream of water is maintained. The material coming from the previous grinding step is conveyed into the washing tank and is drawn by the stream of water towards the tank outlet. On the bottom are collected materials that have a higher density of water such as for example sand, metal parts or other polymers. It is clear that this washing system is valid for polymers with a density lower than 1 g / cc, mainly polyolefins.
For other polymers, the washing usually takes place by passing the material on a conveyor belt and on which water is sprayed, as it is or additived, in order to facilitate the washing of the material. To guarantee the correct cleaning of the material in some plants, a second washing tank is placed.

The product coming from the washing operation is conveyed into a mill that has the purpose of further reducing the size of the material.
This operation is usually performed for rigid (printed) products. For soft artifacts such as film and leaves, the grinding occurs after the operation of drying. It is important that the product from the washing does not contain metal parts or other material that may compromise effectiveness of the mill.
The ground, after being subjected to a possible washing, is fed to a screw or centrifuged press system to be separated from all the free water. The further drying of the ground is carried out in a stream of hot air or flue gas, by means of vertical or centrifugal dryers to reach a small

water residue in the order of 2-3% compatible with the subsequent processing by means of an extruder with degassing. The dried material is sent to the storage silos. The silos used are generally supplied with stirrers that have the purpose of homogenizing the product.

Granulation is the final part of the plant during which the granule is obtained, which will be used for subsequent applications. The material coming from the storage silos is fed into an extruder equipped with a perforated plate with holes of the final diameter of 2-4 mm. The molten polymer leaving the supply chain can be cut away from a cross cutter, after cooling "spaghetti" (extruded wires) in a water tank (cold cut) or from a system of rotating knives in contact with the die itself, in a nebulized water environment (hot cut).

At the end of processing there is always a part of non-recoverable plastic material, the so-called waste. The waste is given by material mistakenly inserted in the collection of plastic or plastic material that has not been unpacked. The waste will be the basis for energy recovery (waste-to-energy plant).

As I was able to see for myself during the visit to the waste treatment center in Montello (BG), at the end of the treatment cycle, together with the non-recyclable plastic, there are all the bottles (often derived from soap containers) composed of two types of polymers. We could call them multi-material. I refer to the bottles made of transparent polymer, often of low quality, which for advertising reasons are wound externally by a further film composed of a polymer different from that of the container.These objects are discarded because when they pass under the optical reader, the laser is confused by the double material and is only able to recognize the type of polymer of the external film and not that of the container.
A good citizen behavior would be to always fill the used bottles by going to buy the loose soap, in order to reduce the plastic waste, if that were not possible before throwing away the bottle would be good action to divide the two types of polymers so be able to separate and recycle them correctly.

5.1.2 Plastic Pollution

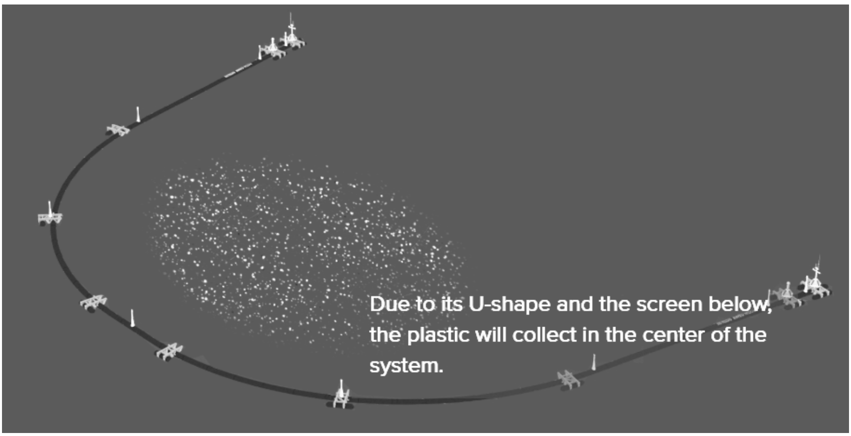
The problem of plastic in the seas around the world, and particularly in the Pacific Ocean is increasingly pressing. In the Pacific, between California and Hawaii, a frightening amount of plastic has accumulated in a relatively circumscribed area, the Great Pacific Garbage Patch. It is a gyre of marine debris in the central North Pacific Ocean between 1985 and 1988. It is located roughly between 135 ° W to 155 ° W and 35 ° N to 42 ° N. The collection of plastic extends over an indeterminate area of widely varying range.
The patch is characterized by exceptionally high relative pelagic concentrations of plastic, chemical sludge, and other debris that have been trapped by the currents of the North Pacific Gyre. Despite the common public image of floating rubbish, its low density (4 particles per cubic meter) prevent detection by satellite imagery, or even by casual boaters or divers in the area. It consists of an increase in suspended, often microscopic, particles in the upper water column.
The analysis of the samples revealed that 75% of the material derives from debris with a diameter greater than 5 cm from containers, bottles, lids, cables, fishing nets and packaging tapes. A study conducted by Ocean Cleanup also allowed to trace the year of origin of part of the waste: in a sampling of 50 pieces, for example, there were one from 1977, seven from the eighties, 14 from the nineties, 24 of two thousand and one of the last decade.
Another part of the problem is the microplastics, that is the minute plastic particles, deadly for the fauna (because the fish feed on it) and now a common ingredient in the whole food chain. They are 8% of the total mass of plastic dispersed at sea, but as many as 94% of the 1,800 billion pieces that float on the oceans. (8)

8 Million tonnes of plastic enter the ocean every year. By 2050, the ocean could contain more plastic than fish

World Economic Forum
and
Ellen McArthur Foundation

5.1.3 The OceanCleanup

The Ocean Cleanup is a foundation that develops technologies to extract plastic pollution from the oceans and prevent more plastic debris from entering ocean waters. The organization was founded in 2013 by Boyan Slat (1994), a Dutch-born inventor-entrepreneur of Croatian origin who serves as its CEO, and has received over $31.5 million in donations since foundation. The Ocean Cleanup also raised over 2 million USD with the help of a crowdfunding campaign in 2014.The foundation's headquarters are in Delft, the Netherlands.
Since the gyres are so large, The Ocean Cleanup proposes a larger-scale, passive method of removing marine debris in the ocean gyres by means of 1–2-kilometre (0.62–1.24 mi) drifting floating systems, moving faster than the plastic due to the impact of wind and waves, and thus concentrates it. A solid screen underneath the floating pipe will catch and concentrate the debris not directly on the surface. The systems do not require an external energy source to concentrate the marine debris, as they utilize the currents that allow them to drift to locations in the ocean with the highest concentration of debris. These U-shaped systems will drift freely in the North Pacific gyre and concentrate plastic before it can be extracted by support vessels for transportation back to shore. The first system is set to be deployed by September 2018 and The Ocean Cleanup estimates to be able to clean up 50% of the debris in the Great Pacific Garbage Patch in five years' time as of full-scale deployment in 2020. (9)



5.1.4 Precious Plastic

Precious Plastic is a project trying to boost plastic recycling worldwide, trying to give people solutions to fight plastic pollution.
It is a global community of hundreds of people working towards a solution to plastic pollution. Knowledge, tools and techniques are shared online, for free.
Hundreds of people all over the world contribute to the project with their skills & knowledge, single or monthly donations.
Precious Plastic was started in 2013 by Dave Hakkens and is now at its third iteration (version) counting on dozens of people working on the project, remotely or on site (somewhere below sea level in the Netherlands). Dutch designer Dave Hakkens has updated his series of Precious Plastic machines, which anyone can build and use to make products by recycling the material. Blueprints for the new machines, which the designer described as "a solution to plastic pollution", are now available online for anyone to download and build. The devices are made using everyday materials and basic tools that Hakkens said are available all over the world. The set includes a plastic shredder, an extruder, an injection moulder and a rotation moulder, which can each ne used to turn waste plastic into new products. Hakkens first showed prototype versions at the Design Academy Eindhoven graduation show in 2013, and has spent the last two years refining the designs. (10)

5.1.5 Bioplastic

Bioplastics are plastics derived from renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips, food waste, etc. Bioplastic can be made from agricultural by-products and also from used plastic bottles and other containers using microorganisms. Common plastics, such as fossil-fuel plastics (also called petrobased polymers) are derived from petroleum or natural gas. Production of such plastics tends to require more fossil fuels and to produce more greenhouse gases than the production of biobased polymers (bioplastics). Not all bioplastics are biodegradable nor biodegrade more readily than commodity fossil-fuel derived plastics. Bioplastics are usually derived from sugar derivatives, including starch, cellulose, lactic

acid. As of 2014, bioplastics represented approximately 0.2% of the global polymer market (300 million tons). [11] The advantages of this type of biodegradable plastic (according to the European standard EN 13432) are easily understandable, capable of disintegrating in ninety days in composting plants against the metals of years required by traditional plastics.
Materials are called compostable because they also decompose naturally, they are what remains of our lunches; the remains of pruning and dry leaves; but also paper handkerchiefs and napkins deriving from the cellulose of plants.
In composting plants, as we will see in the following chapters, green and wet are treated together in the presence of oxygen. The result is that for a limited period of time, in the order of a few months, the materials introduced into the plants are transformed into compost, a soil that lends itself to different agronomic uses. An identical process would be even if we left the same waste in the open air, as we do in the countryside, with the difference that the times would be much longer and the results would not always be so favorable.

But how do I recognize a bottle in bioplastic?
In Italy for every product the compostability must be guaranteed and demonstrated through the trademark issued by the Italian Composting Consortium (CIC). This consortium undergoes a trial treatment within one of its plants: the bottle is placed in a jute sack (in order to keep it separate from the rest of the material, but in any case in contact with the air), it remains in the composting plant for about three months, at the end of which it degrades. Only then does the consortium issue the brand that guarantees its biodegradability. So when you find in your hands a product on which this brand is present, do not hesitate to throw it in the organic bin!

5.2.1 Glass

Glass is a material obtained by solidifying a liquid that is not accompanied by crystallization. The glasses are amorphous solids, so they do not have an ordered crystalline network, but a disordered and rigid structure composed of covalently linked atoms; such disordered lattice allows the presence of interstices in which impurities, often desired, given by metals can be present.
Moreover, the above glasses could be obtained from any liquid, through a rapid cooling that does not give the crystalline structures the time to form. In practice, they can solidify in glass form only materials that have a very slow crystallization rate, such as silicon oxide, germanium dioxide, boric anhydride, phosphoric anhydride, arsenic anhydride.
In 2016 in Italy the separate collection of glass stands at almost 1.9 million tons,
with a growth of 6% compared to 2015, the amount per capita collected is 30.6 Kg / inhabitant / year2016 and represents 15.6% of the total recycled. [16]
If you happen to travel to Germany or Switzerland, you may have noticed that the glass bells are of different colors, these invite the citizens to separate the glass precisely for the color: green, white and brown.
It will seem an exaggeration, but we must know that from the mixed glass scrap you can only get the green recycled glass - that of the water or beer bottles, so to speak. Since glass is a material that is recovered very well, provided that a good sorting is made, the Swiss and German choice is the undoubtedly the most effective way to recycle this material, even if it is a little more inconvenient for the citizens. In the very near future, it will still be possible, as in Japan, to separate the various types of glass with automatic selection systems equipped with optical sensors that distinguish colors. Plants that, as we have already seen, are used with plastics to separate the different polymers.
To avoid damage to the plants and guarantee the quality of recycling, after the glass is collected, it is subjected to different sorting, both manual and automatic, to remove the foreign materials.
<u>The most common mistake of citizens is to dispose of ceramics as if they were glass. Ceramics is a “poison” for glassworks as it does not</u>

melt (it is made of water, clay and sand); and so, when the residues remain in the melted and recycled glass, this must be discarded.
In the glass sorting plant, the metal parts are removed by magnets, any paper and plastic waste with suction systems, and non-ferrous parts such as aluminum with current-driven machinery.
The glass cleaned of the impurities to which it was mixed after the separate collection is called "oven ready": that is, it can be directly introduced into the glassworks ovens where it will be mixed with the natural raw materials (silica, calcium carbonate, soda and other additives) . In the ovens, very high temperatures are reached, up to 1500 ° C, and the presence of glass scrap allows to lower these temperatures a little and to save fossil fuel. The fusion then follows various processes designed to shape the glass and prepare it for its final use.
And if instead of throwing the glass containers we bring them back to the seller in order to reuse them as they are, without transformations?
Let's take an example, this evening I go out with my friends and I go to a pub. I order a beer in a glass bottle, time to have a chat with friends and beer ends. Half an hour after opening it. And now what happens? The bartender takes it back and throws it in the separate collection (hopefully). The bottle is part of the cycle described above and then finished in an oven which will consume a huge amount of fossil fuel (and relative CO2 production) in order to be able to recycle it.

5.2.2 Reverse Logistic

All this waste of energy only for my ephemeral pleasure lasting half an hour? No!
Here comes the Reverse Logistic, which means ensuring that the residues or packaging of products sold to the end consumer, at the end of their cycle of use, return to the manufacturer, following the same path that they have traveled in (from the producer to consumer); or an organized road, to this parallel.

The problem of insufficient surfaces in the units of the distribution system exists independently of their commitment in the management of return logistics. The problem can also be dealt with outside the areas strictly for sale, with the creation of well-kept neighborhood consorti-

um stores, for the collection and management of returnable vacuums and abandoned products. These same deposits could be used as distribution points for items sold through e-commerce or online shopping, given that home delivery clashes today not only with the obstacle of congestion, but also with the difficulty of finding the home recipients during normal working hours.
Internal courtyard: 1) Empty storage to make 2) Differentiated Bins 3) Distribution points e-commerce. [7]

But in practical terms, how does the Bottle Deposit work?
I buy a glass bottle at the supermarket, on which I will pay an additional deposit with respect to the base price (around 10 cents). Once the use is finished, I bring the glass bottle back to the seller who will be forced by law to give me the bail money back. Regardless of whether I bought the glass bottle from him or not. At this point the bottles will be taken by the supplier who will pay the price of the deposit to the merchant. The bottles will be checked, washed, sanitized and returned to the production cycle without being processed. The void to make has a multitude of benefits, including the social one, in countries where the empty space has been law for many years (without going too far, in Germany it is mandatory from the 80s) to report to the seller the empty bottle has become a real job for the homeless. This translates into a profit for them, a saving in road cleaning costs and a reduction in pollution due to recycling.
The idea of a returnable void has been defined in many respects better than the one-time gap, for economic, political, ecological and social issues (as we have said before): according to studies conducted by the Federal Office for the Environment of Germany to make are significantly less polluting than disposables; the amount of waste is reduced by 96% for glass and 80% for plastic. The 20-fold reuse of a glass bottle also results in energy savings of 76.91%. [12]
On the other hand, the vacuum to lose entails greater consumption of raw materials and energy, and greater pollution.
According to these studies, a 1991 German ordinance provides that at least 72% of the containers produced by the companies are empty to return. In Denmark, for drinks, the vacuum to make in glass bottles is mandatory. In Norway, returnable vacuum is used for glass and PET

plastic bottles, as well as cans. But in practical terms, how does the glass vacuum work?
I buy a glass bottle at the supermarket, on which I will pay an additional deposit with respect to the base price (around 10 cents). Once the use is finished, I bring the glass bottle back to the seller who will be forced by law to give me the bail money back. Regardless of whether I bought the glass bottle from him or not. At this point the bottles will be taken by the supplier who will pay the price of the deposit to the merchant. The bottles will be checked, washed, sanitized and returned to the production cycle without being processed. The void to make has a multitude of benefits, including the social one, in countries where the empty space has been law for many years (without going too far, in Germany it is mandatory from the 80s) to report to the seller the empty bottle has become a real job for the homeless. This translates into a profit for them, a saving in road cleaning costs and a reduction in pollution due to recycling.
The idea of a returnable void has been defined in many respects better than the one-time gap, for economic, political, ecological and social issues (as we have said before): according to studies conducted by the Federal Office for the Environment of Germany to make are significantly less polluting than disposables; the amount of waste is reduced by 96% for glass and 80% for plastic. The 20-fold reuse of a glass bottle also results in energy savings of 76.91%. On the other hand, the vacuum to lose entails greater consumption of raw materials and energy, and greater pollution.
According to these studies, a 1991 German ordinance provides that at least 72% of the containers produced by the companies are empty to return. In Denmark, for drinks, the vacuum to make in glass bottles is mandatory. In Norway, returnable vacuum is used for glass and PET plastic bottles, as well as cans.

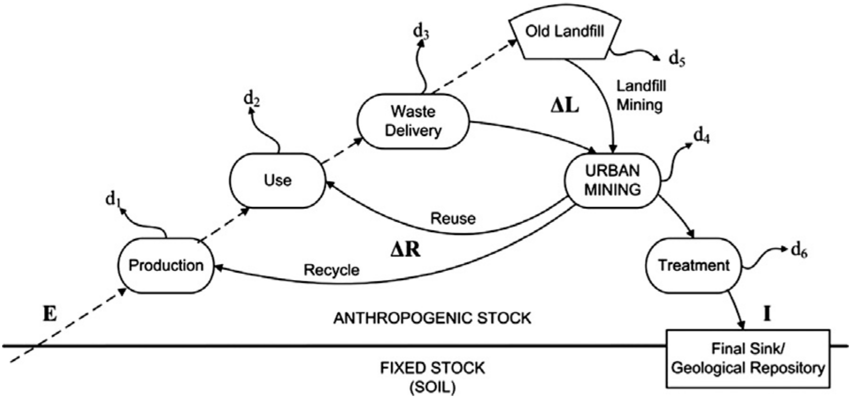
5.3.1 Aluminium

As mentioned previously, some municipalities allow glass and aluminum to be placed in the same bins. These two materials once arrived at the selection plant will be separated in order to make it take two separate roads for recycling. Think of a can Coca Cola. That can, like the many similar ones that accumulate in urban waste, is made of aluminum. But aluminum is also found in tuna cans, in sheets to store food and in glass bottle stoppers. In Italy 40% of the circulating aluminum is recycled and our country is the third largest in the world for recycling this metal [6]. It is not by chance that in Italy we do not have deposits of bauxite, the mineral from which, through the extraction of the oxide, alumina, elementary aluminum is obtained. The first step on the way of recycling an aluminum can is therefore its separation from other materials, thanks to a particular machine called "induced current separator". In fact, aluminum is not attracted to a simple magnet, as happens with iron, but it must be magnetized at the moment. Once separated, the can is brought into the foundry along with all other aluminum objects. Here it is subjected to pretreatments to remove foreign substances, such as paint, labels or any food residues. Then the aluminum waste is melted at 800 ° C and the molten aluminum is then cast into ingots; at this point it is identical to that obtained from the minerals in primary production. Recycled aluminum is mainly used in the transport sector (many car components, from pistons to rims, are in aluminum) or in construction (for doors, windows, radiators), or to create frames for new bicycles. The most critical point of the aluminum recycling process is the high temperatures required for the fuction, which can cause harmful emissions. To avoid this problem, the recycling plants must be equipped with suitable smoke separation systems. Even if this aspect is taken into account, the impact of the recycling process on the environment and on health is lower than that caused by the extraction of the first natural amteries: only energy savings exceed 90%, not to mention the pollution caused from the extraction activities and the transport of minerals from very distant localities, which is avoided by obtaining aluminum for recycling. We have the mine at home, and it's right in our waste! This approach is called Urban Mining.

5.3.2 The Urban Mining Concept

The transition from a linear to a circular approach has characterised waste management strategies over recent decades. The traditional linear approach is based on the extraction of raw materials, production, use, wasting and landfilling. In other words, there are no options for the raw materials except to be used and then discarded. However, with the constantly expanding populations, there is a shortage of raw materials to continue to support this linear path. The circular approach primarily arises from this increasing need for raw materials. Attention is currently moving from the limited and fixed stocks of raw materials to the increasing anthropogenic stocks of materials. This creates the base for the development of the Urban Mining concept (Stallone, 2011). Urban Mining activities are undertaken in this context, comprising actions and technologies designed for the recovery of materials and energy from products of the urban catabolism. Therefore, Urban Mining provides a systematic management of anthropogenic resources stocks and waste (products and buildings), in the view of long term environmental protection, resource conservation, and economic benefits. An illustrative example is given by Waste from Electrical and Electronic Equipment (WEEE). Due to their short economic life, the amount of this waste stream is on a continual increase. Given that gold concentration in electric and electronic scraps could be considerably higher than the amount of gold in gold mines, recovery of gold from WEEE may potentially result in a more ecologically compatible mining activity. However, these concepts are not limited to WEEE as they can be applied to several of the traditional fractions of MSW, which are usually considered in source segregation programmes (plastics, paper, cardboard, glass containers, cans, putrescibles, etc.). These and other waste materials can be considered as Urban Mining resources. Among these we may include: End of life vehicles, scraped tires, construction and demolition waste, combustion residues, food waste, road sweeping waste, water treatment sludges, exhausted oils, old landfilled waste, residues from food industries, incineration slags, as well as other industrial wastes. These materials can alternatively be used for obtaining different kind of products, such as secondary raw materials, building materials, fuel and biofuel, composites and soil fertilisers. [18]

5.4 Paper



The recycled paper is not all the same: the cellulose fibers that compose it, in fact, at each recycling round degrade by about 20-25%, becoming shorter and thus reducing mechanical performance. Thus the possible lives of each fiber are at most five or six. The recycled paper is therefore mainly intended for uses for which the quality of the material is not fundamental, such as packaging. Most corrugated cardboard and cartons to produce boxes, boxes and packaging of products are made of recycled paper. But also for the paper, a selection phase is necessary before entering the paper mill. In fact, who has not happened to throw a magazine or an advertisement without removing the plastic that surrounds it, or remove the gadget contained inside? An example of extraneous elements that disturb recycling are the staples that hold magazines together and can not be "digested" by the paper mill. To overcome problems such as this, in the paper mills are involved in purged processes before starting the production of a new sheet of recycled paper.

5.5.1 Biodegradable Waste

Biodegradable waste includes any organic matter in waste which can be broken down into carbon dioxide, water, methane or simple organic molecules by micro-organisms and other living things using composting, aerobic digestion, anaerobic digestion or similar processes. In waste management, it also includes some inorganic materials which can be decomposed by bacteria. Such materials include gypsum and its products such as plasterboard and other simple organic sulfates which can decompose to yield hydrogen sulphide in anaerobic landfill conditions (11).
Biodegradable waste can be found in municipal solid waste (sometimes called biodegradable municipal waste, or BMW) as green waste, food waste, paper waste, and biodegradable plastics. Other biodegradable wastes include human waste, manure, sewage, sewage sludge and slaughterhouse waste. In many parts of the developed world, biodegradable waste is separated from the rest of the waste stream, either by separate kerb-side collection or by waste sorting after collection. At the point of collection such waste is often referred to as green waste. Removing such waste from the rest of the waste stream substantially reduces waste volumes for disposal and also allows biodegradable waste to be composted.
How can organic waste be disposed of?
Following the hierarchy of waste described above, we begin to discuss the simplest method for dealing with this refusal.

7.5.2 Guerrilla Kitchen

It all started in Amsterdam with the initiative of two friends, who today run a mobile kitchen in a second-hand van that can feed even two hundred people at a time. But the beginning of the story has more distant origins and leads us to the other side of the world, where the girls met Andrew George, who was also involved in the fight against waste and founder of the Free Feed Street Kitchen voluntary service, that since 2013 recovers food waste still intact at the exit of the kitchens of restaurants and distributes them on the street, free of charge.

So when they returned to the Netherlands, the girls also began to rummage through the cans of a populous city like the Dutch capital. The research took into consideration above all the food left unused in the foodstuffs of supermarkets, including still perfectly intact milk, coffee, fruit, vegetables. And at the beginning of 2015, the awareness that good food every day wastes a lot of it has led to the creation of an impromptu and itinerant supermarket, sighted several times out of school by the students of Amsterdam. The products in "assortment"? All food recovered from waste, often donated by the same conventional supermarkets. And all for free.(11)

5.5.3 Composting

In the presence of oxygen, or in aerobic conditions, organic waste decays. This method provides for the aeration and intensive turning of the material. With this method the microorganisms are different from those that operate in the absence of oxygen (as we will see in the next paragraph) and are called "aerobic", as they degrade the organic substance using oxygen. In this case the biodegradable carbon is completely transformed into carbon dioxide (CO_2) and the process is called composting. It takes place in special facilities, lasts about three months, stabilizes the material and transforms it into soil, called "compost".
The main problem of composting plants is linked to gaseous emissions into the atmosphere. The air that is blown into the waste to ensure that there is sufficient oxygen is in fact charged with many organic substances, which in addition to having an unpleasant smell, as you can imagine, are partly toxic. These include ammonia (NH_3) and hydrogen sulphide (H_2S). So, before the air coming from a composting plant is released into the atmosphere, it is absolutely necessary to purify it: for this purpose "Biofilters" are frequently used. Compost can be used in agriculture as an "organic soil improver", a material that brings organic carbon to the soil - <u>not to be confused with fertilizers, which instead provide plants with nutrients such as nitrogen and phosphorus.</u> The organic soil improver can play a significant role, given that intensive cultivation, the excessive use of synthetic chemicals in the fields and erosion deplete the soil of organic carbon content, with the

risk of desertification phenomena which is necessary to counter. The compost can be used directly by the farmers who spread it directly on the fields, or in the preparation of the soils for fluorescent use. Now that we know what happens to organic waste collected by differentiation, it is easy to understand how important it is to collect it in bags that are also biodegradable. In fact, only if the bag is biodegradable, even better if in paper, the decomposition process can also include the bag itself.

In San Francisco, organic kitchen waste and other sources are sent to a large composting plant located about 100 km from the city. The place is surrounded by farmland and local farmers use compost to produce fruit, vegetables and wine, which are then sent back to San Francisco (13). Instead of exporting their mixed waste to landfills and incinerators, municipalities should work with farmers to produce together a compost with which everyone can live together and benefit from it. Furthermore, these structures must be located carefully for the odor problem, as we have explained before.

In many other cities where housing has more space, before building centralized composting plants, they have made the simple first step of encouraging the largest number of citizens to compost their kitchen and garden waste in backyard compost. Communities are sometimes helped by non-governmental organizations that prepare volunteers to become “masters in composting”. These show citizens how to start and how to solve the problems that are gradually highlighted. In Zurich, a Swiss city, which presents situations of dense housing construction, “community composting” has been encouraged. According to this project, a number of houses (from 3 to 200) has the task of following a simple composting system. This system does not occupy a large footprint and can be located in city parks or in the space between the tallest buildings. At present, the city boasts more than 1000 collective canisters, which in total treat about half of the domestic organic waste. *What can be another advantage of this type of treatment?* One of the most important things achieved are the “social ramifications”. This helps people to oppose the anonymity of living in a big city. People accumulate near the compost accumulation! [13]

5.5.4 Anaerobic Digestion

Among the possible treatments to be subjected to separate organic substances by differentiation, there are degradation mechanisms that can be exploited to obtain biogas, in a controlled manner within appropriate reactors. The process takes the name of "anaerobic digestion", is experiencing a phase of great popularity and takes place in the absence of oxygen. But let's look a little more in detail what happens in this process, and how the main products are obtained. Organic waste arriving from the separate collection, mostly kitchen waste, is placed in a suitable reactor, completely waterproofed, in which anaerobic conditions can be established. Bacteria start to rapidly degrade organic substances, producing high quality biogas, because it is obtained from a homogeneous starting material and uncontaminated by inorganic substances. In this way the so-called "digestate" is also stabilized, the residual solid material, that is a sort of soil quite similar to compost, which after further treatment can be reused in agriculture or in nursery gardening. From the purified biogas and then used to feed a specific engine from which it is possible to directly obtain electric or thermal energy. Today, however, there are even more interesting alternatives. If we can remove the carbon dioxide from the Biogas, we get some practically pure methane (CH4), in addition to the impurities. With the added value that, compared to traditional methane, this is of biogenic origin and therefore is a biomethane.

Biogenic: materials that originate in natural processes are biogenic and that have not become fossils such as oil or coal. Not all biogenic materials are biodegradable in a short time: wood, for example, decomposes even after centuries.

The combustion of biomethane liberates in the atmosphere a quantity of carbon dioxide substantially equal to that that the chlorophyll photosynthesis had subtracted from the atmosphere itself, when the organic substances collected in the waste had been originally synthesized. By virtue of this balance, the carbon dioxide released in the combustion of biomethane is not accounted for as greenhouse gases.

Biomethane can be exploited in two ways: it can be introduced into the natural gas distribution network, which in Italy is very widespread, and here it will be mixed with the fossil origin (in this way the methane distributed as a whole can become a bit more green"). Or it can be placed in the tanks of methane vehicles: in this case it can be considered a real biofuel. If then to use the biomethane fosser public transport or waste collection trucks, we would find ourselves in front of a real virtuous circle.

5.5.4 Waste Collection in Open Air Marketplace Areas

Separate collection in the markets is one of the aspects of waste management that is less visible to citizens but which affects the quantity and quality of waste collection throughout the city. Of course, those who live in areas adjacent to the markets know at first hand the system of collection, schedules and how it is organized, but for those who are only a customer this aspect escapes and getting lost in the frenzy of the market.

It is increasingly pressing and felt by the various stakeholders (public and private) the intention to make some changes to the methods of management and collection of waste produced within the “market system”, with the initial shared objective of reducing costs of cleaning services, waste collection and disposal.
It is known as anyone who individually pays for the “tax” for waste disposal; the Municipality of reference applies a tariff system normally calculated, for non-domestic users as in the case of the markets, calculated on: product category to which it belongs and area covered by the activity. As a rule, the Municipality has a subject delegated to the collection - disposal and to the tariff.

Separate collection in the markets is an aspect of waste management that is underestimated but which, for results and performance, represents one of the strengths of the city of Turin. In fact, the city among the many records can certainly boast that of the highest concentration of daily outdoor markets. In fact, today there are 32 local markets active that enliven an impressive volume of goods every day and, play power, produce a quantity of waste that in the first half of 2017 exceeded 5 thousand tons of waste, equal to 3.5% of all waste produced by the city.

But if the performance of the Turin markets for years, thanks to the bench-top system introduced in 2005 (except for that of Porta Palazzo), can be defined virtuous stands out the recovery of the largest market in Europe that 46% of separate waste collection in 2016 rose to 53% in just six months.

A chase of the increased attention dedicated to the collection of organic waste, thanks to the Porta Palazzo Organic Project launched at the end of November 2016 during the European Week for the Reduction of Waste in collaboration with the City, Novamont, Amiat and Fondazione Crt, has allowed to relaunch this collected from 9.7% in 2016 to 19.3% in the first half of this year. In fact, almost doubling the amount of organic waste intercepted. In fact, if in 2016 in Piazza della Repubblica 412 tons were collected in the first six months of this year, 384 were recorded. An even more interesting figure considering the general decline in organic waste production both in the markets and in the whole context citizen.

HOW
WE
COLLECT
WASTE?

It is convenient for manufacturers to report their disposal instructions on their products so you do not have to worry about making the right choice and you also learn how to behave when you are on similar unlabeled waste.
Each municipality can make different choices for the collection of the same type of waste, depending on the treatment and recovery systems available on the territory. Thus, even if manufacturers write generally correct information, these may be in contrast to the local waste separation rules.
Let's take an example: some municipalities give indications to collect the cartons of milk and fruit juices together with the plastic, while in other countries it is indicated to throw the milk carton with the paper.
Why this difference?
Containers such as milk are made of a layer of cardboard, one of aluminum and one of plastic film (commercially known as Tetra Pak, from the name of the Swedish company that produces them since 1951): paper is the structural element, aluminum works as a barrier and plastic waterproofs the paper; the set of the three materials guarantees the best conservation of liquids.
If we add to this mixture of elements a plastic plug (but made with a polymer different from the film), here is that recyclability becomes a bit more problematic, but still possible. In any case, whether the container is differentiated with paper or plastic, in the treatment plants it will then be separated from them to be recycled separately. Each municipality makes different agreements with those involved in the recovery of the various fractions of waste and on the basis of these agreements it then provides indications to citizens on how to behave.
The materials to be differentiated are at least ten: paper, plastic, glass, iron, aluminum, wood, wet, green, WEEE (Waste Electrical and Electronic Equipment), expired medicines. We must also add the undifferentiated waste, which is eleven.
But fortunately in our homes there are not eleven different containers! The first reason is that there would be no space. And then it would all be a go-ahead of trucks, and separate collection shifts to be stored for each type of waste.
The most reasonable solution is the so-called multi-material collection, which brings together different waste as long as it can be easily

separated later. Typical is the case of glass and cans, where in reality the materials to be separated are three: glass, steel and aluminum. How many of us are sure to always know how to distinguish an aluminum can from a steel one?
So the multi-material collection makes life easier for the citizen and for the companies that collect waste, which thus perform a single collection round and then easily separate the three types of materials with the use of simple mechanical machinery.
This is just one example of the possible types of multi-material collection: in some municipalities paper and plastic are collected together, or even glass, aluminum and ferrous materials. Some wastes, however, do not lend themselves to this type of collection, think of the organic waste: it would be impossible to separate the slurry of our organic waste at a later time and arrive at a product that can be used in agriculture after composting.

6.1 Road Collection

The collection of urban waste in the cities is often carried out through large containers positioned on the road. By differentiating the type of waste, different types of containers are also required.
A commonly used container is the bell whose shape is reminiscent of the classic bronze bell of church bell towers. It is usually intended for the collection of glass, cans or plastic (or a combination of these materials). Unlike the box, which must be turned over for emptying, the bell is emptied from the bottom, lifting it and opening the lower base with a mechanical control located next to the lifting hook.

The organic bins are often smaller in size because the frequency of emptying is greater to reduce the problem of odors.

Pay attention to some garbage, because you can not put in any of the bins on the road because they are dangerous (eg batteries, building waste ...) or potentially recyclable (clothes, toys ...).

Compared to the “door to door” collection, the large containers positioned on the road have the advantage of being very capacious and have lower running and emptying costs.
However, they have the disadvantage of being away from the user, there is less control over the conferment and are more exposed to vandalism. They also often become areas of abandonment of all kinds of waste.
In some cities, for reasons of space and aesthetics, underground bins have been installed, in which the waste is deposited through a trap at the road level.
This method has some advantages, including the possibility for the user to confer their waste at any time and lower collection costs, since the trucks have to take the waste only from the bins placed in certain places and not from every single dwelling, condominium or activity. However, it has the disadvantage of reducing the percentage of separate collection as well as the quality of the material collected in a differentiated way, since the correct conferment of waste is subordinated to the civic sense of citizens, since it is not possible to sanction erroneous contributions, as the road containers can be used by anyone and not nominative.

6.2 Automated Vacuum Collection

An automated vacuum waste collection system, also known as pneumatic refuse collection, or automated vacuum collection (AVAC), transports waste at high speed through underground pneumatic tubes to a collection station where it is compacted and sealed in containers. When the container is full, it is transported away and emptied. The system helps facilitate separation and recycling of waste.
The process begins with the deposit of trash into intake hatches, called portholes, which may be specialized for waste, recycling, or compost. Portholes are located in public areas and on private property where the owner has opted in. The waste is then pulled through an underground pipeline by air pressure difference created by large industrial fans, in response to porthole sensors that indicate when the trash needs to be emptied and help ensure that only one kind of waste material is travelling through the pipe at a time. The pipelines converge on a central

processing facility that uses automated software to direct the waste to the proper container, from there to be trucked to its final location, such as a landfill or composting plant.[14]

The system was born in Sweden in 1961, where it was installed for the first time at the Sollefteå hospital. The first residential system was installed in the new residential district of Ör-Hallonbergen in Sundbyberg, in 1965. The inventors of the system were four Swedish technicians: Torsten Karefelt, Olle Genberg, Sten Olsson and Olof H. Hallström. (14)

The Swedish system is based on the operation of the old pneumatic post, when the internet did not yet exist in the offices, this system was used to carry documents from one side to the other. In practice, the waste bags are first differentiated (separate the paper from the plastic and the rest of the generics) then thrown away by the citizens, in specific columns located along the roads that represent the access points to underground pipelines. Special sensors indicate when the containers are full, then a suction system starts that makes the waste travel 70 kilometers per hour, always conveying them underground to a sorting center. Here the scavengers wait for them and take them to the landfill or incinerator, or recycling center.
In the path there are special activated carbon filters to eliminate dust and bad odors from the air and then return it to the environment. Through computers, the staff check that everything works properly.
This system can be applied in any city, only columns are needed, in the number of 1 every 150-250 people, and the waste sorting point must be within 2 kilometers of the collection points. In theory, therefore, every district would have an area where the vehicles transporting the waste arrive to their final destination.

What are the benefits?
Reduction of traffic by road since everything is underground, less pollution, less problems of hitches in the street, no more bins from which comes out, especially in summer, bad smells and finally more space for parking.

What are the costs of this system?
The installation of this system costs 8.5 million euros and has urban limits: installing these pipes implies a large number of excavations that in historic cities this can lead to structural problems. (15)

6.3 Door-to-Door Collection

The door-to-door separate collection is a waste management technique that provides for the periodic collection at the domicile of the user of the urban waste produced by the same.

The various types of waste are generally collected (organic wet waste for composting, glass, steel, aluminum, paper and cardboard, plastic, dry non-recyclable) in different days and containers.
Non-differentiated urban waste is usually collected at different frequencies depending on the type. Typically the frequencies vary from once a month to two or three times a week depending on the collected waste fraction. At the same time as the door-to-door system is started, the large road bins are removed from the streets of the entire area, replaced with wheeled and smaller-sized equipment, to be positioned inside the courtyards or condominium appurtenances.

6.4 PAYT - Pay As You Throw

Pay as you throw (PAYT) (also called trash metering, unit pricing, variable rate pricing, or user-pay) is a usage-pricing model for disposing of municipal solid waste. Users are charged a rate based on how much waste they present for collection to the municipality or local authority.

A variety of models exist depending on the region and municipality. Waste is measured by weight or size while units are identified using different types of bags, tags, containers or even RFID. Services for waste diversion, like recycling and composting, are often provided free of charge where pay-as-you-throw systems are implemented.[15]

The instruments through which timely pricing is applied in Europe, USA and Australia are different and have undergone rapid evolution over

the last five years, mainly thanks to the development of technologies linked to traceability in general, which have lowered costs making it possible to application of individual tags even on disposable bags. The punctual pricing systems are divided into two application methods: the first is based on the identification of the user, the second is based on the identification of the containers associated with a single user or, subordinately, shared by a group of users .
Among the first we include the so-called volumetric systems with voluntary input and the transfer systems at presidential collection centers or fixed or mobile ecological islands where the users are identified by cards with transponders, magnetic badges or health card, etc. The most widespread models are those that fall within the second method, ie those that identify the user by reading a Tag posted on the container or bag.
This method is particularly suitable for door-to-door systems and further reinforces the element of user responsibility with the direct association between single contribution and the user from which the waste originates. (16)

6.5 Road Collection VS Door-to-Door

In 2012 some fully public companies - *Contarina (Consorzio Priula and TV3), Ponte Servizi srl (municipality of Ponte nelle Alpi), Bellunum srl (municipality of Belluno), Etra spa (Vicenza-Padua), Ecogest srl (Rovigo), ESA. com spa (Verona), Ambiente Servizi srl (Pordenone), Fiemme Servizi spa (Trento), San Donnino Multiservizi srl (Fidenza), ASIA (Trento), ASSA (Novara), Azienda Ambiente (Fiera di Primiero), Consorzio dei Comuni dei Navigli (Milan), Sive (Verona)* - which currently manage the separate collection service for almost three and a half million citizens have developed a comparison study, comparing their performance with the national averages of the same year. The results speak for themselves.
The study, coordinated by the inter-municipal consortium Priula di Treviso, has shown that virtuous public companies have a separate collection average of 73.5% compared to the national average of 31.7% largely below the minimum targets set by the guidelines EU. The citizens served by these companies characterized by door-to-door home collection services, which intrinsically involve a greater degree

of involvement and responsibility of users, have over time reduced their total production of waste up to 414Kg per inhabitant compared to 532 in the Italian media and, more than anything else, they differentiate almost everything. What remains and ends up in landfills is just under 92Kg per head per year, compared with 346 for the national average. [16]

Impressive numbers, but how much does such an accurate service cost?

Definitely less than in the rest of the country, where in some areas the collection is still steadily below 5%. The indicator used universally to give a comparison value to the costs of the service is the average inhabitant cost per year, calculated by dividing the total cost of the service by the number of inhabitants served. The average cost per inhabitant / year of virtuous public management is 107 euros compared to 175 for the Italian average, and each household pays an average of 162 euros a year bill instead of 240 euros which is the average of Italian bills. [16]

The more you differentiate and the less you pay. Unavailable future?

No, simply the application of a standard. The first structured experience of virtuous public realities began in 2000 by the Inter-communal Consortium of Priula, which initially involved a group of 14 municipalities of Treviso and then extended its model to 50 municipalities, for a total of approximately 500,000 inhabitants. A management model based on door-to-door home collection together with the application of the so-called PAYT. All the citizens have been delivered at home colored bins to separate the waste. Bins that, exposed full in front of the house the night before the day indicated in the special calendar, are not only emptied but also "read" automatically, as previously "microchipped" and associated with the family. The rate has left the insipid parameter of the square meters of the house (which provided for the payment of a fixed size according to the size of the house) to replace it with the number of emptying the undifferentiated waste: more different, less fill the bin, less pay!

Clear, no? Result: the undifferentiated waste drops from 320 kg per capita to 40, separate waste collection rises from 27% to 84%! And the costs? Families pay just over 160 euros a year against 240 of the national average, and the overall costs are 60% lower than the same national figure. [16]

"Respectable society does not produce excluded, but neither waste or dross."

Serge Latouche

WHERE IS THE WASTE TRANSPORTED?

7.1.1 Landfill

The first law that has dealt with the issue of waste disposal in Italy dates back to the beginning of the 80s. It is a Decree of the President of the Republic number 915 of 1982, which incorporates European Union Directives issued in the previous decade, and represents a milestone in environmental legislation. It is precisely the Decree 915 that introduced the concept of controlled landfill, in contrast to the unauthorized ones that were so widespread until 1982 and unfortunately they are still today in many parts of the world, even in Italy.
A controlled landfill is a large hole in the ground, which is first prepared by waterproofing the bottom and walls. Waterproofing is necessary to prevent water from coming into contact with waste and becoming contaminated, it can infiltrate the ground and pollute the ground and the strata. To this end, several layers of waterproofing materials must be prepared, both of natural and artificial origin (usually plastic sheeting). In the hole the waste is piled up following a precise procedure: first they are compacted by large and heavy machineries that pass over them several times, and then at the end of the day they are covered with a layer of inert and natural material (soil, stabilized organic fraction) . According to the ISPRA Waste Report, in 2011 the landfills for municipal waste in Italy were just under 200, a figure that was falling sharply compared to previous years. And they still welcomed about 13 million tons of waste. The black shirt belonged to Molise, with more than 400 kg of waste per inhabitant disposed of directly in landfills every year. The first of the class are Friuli Venezia Giulia and Lombardia, with less than 50 kg. Over 10% of illegal sites are unfortunately concentrated in Sicily. [6]

7.1.2 Biogas from Landfill

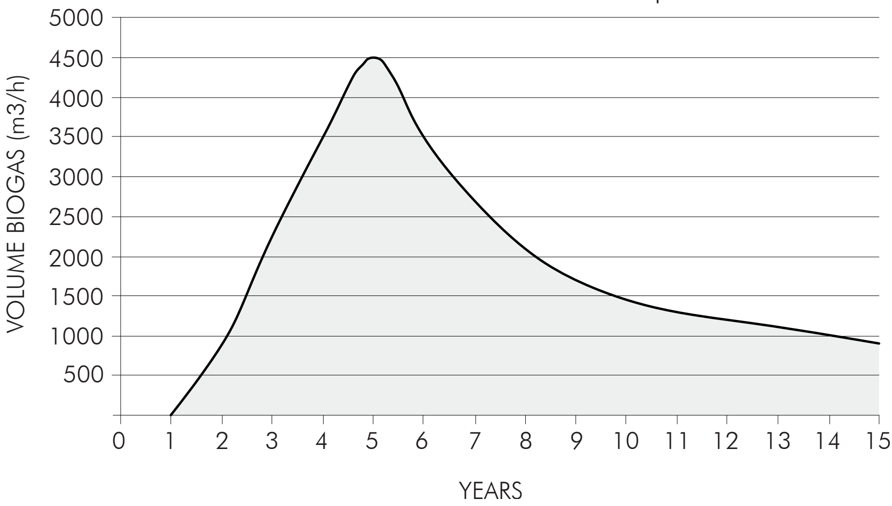
A landfill is not forever. When it is full and can not be expanded it must be closed. To do this, it must be covered on the surface, with a thick layer made of inert material, draining systems and waterproofing barriers, which isolate the waste from the external environment, similarly to what has been done on the bottom and on the walls. The project for the restoration and transformation of the landform in Madrid (image

below) brings together the basic actions: sealing the surface of the landfill, extracting the biogas accumulated within it for use in generating electricity, while transforming the surface of the landfill into a public park of enormous biological value. This is a new public educational and cultural facility, located in a strategic position for the development of the city. Valdemingomez landfill with an example of a proposed model of continuity between the forest and the surrounding area; a pseudo botanical garden with indigenous species seeking integration into the Regional Park of Sureste.
It was transformed into a free public area, along with woods and wetlands. Within it, one can observe the life of both nature and the city. This plan was to establish a small colonies that would be more complex, respond to local conditions, and this has occurred. (17)
The decomposition of solid waste in a controlled discharge often takes on aspects various and complex: mainly physical, chemical and biological processes, which act simultaneously with the degradation of the organic component of the waste.
The main mechanism of decomposition of waste in landfill is however the biological degradation, ie the transformation of matter by microorganisms, such as bacteria. The biological degradation takes place in various phases, the main of which are: the aerobic phase, the anaerobic phase (optional) and the anaerobic metanigen phase.

Aerobic degradation occurs immediately after the waste is deposited in the drain
controlled following the use of free oxygen by micro-organisms:
this is taken from the air incorporated in the landfill during the deposition of the
waste or penetrated after closing. Aerobic degradation is linked to the availability of oxygen (and is therefore normally of short duration, from a few hours to a few months) and to the type of waste. In the first phase the phenomenon is favored by the presence in the rejection of easily and rapidly degradable substances.
This phase is strongly exothermic (the heat produced can reach temperatures of 70 ° C) and is characterized by emissions of carbon dioxide, water and partially degraded organic substances.

Optional anaerobic decomposition occurs when oxygen availability is reduced to the point where an aerobic process is no longer possible. The organisms present, defined as optional, prefer free oxygen but, if it is absent, they can use "bound" oxygen. Characteristics of this phase are the production of carbon dioxide, a lower generation of thermal energy compared to the aerobic process and a notable production of partially degraded organic matter, most of which consists of organic acids.

The final stage of decomposition of municipal solid waste consists of anaerobic metanigenic decomposition. In this phase the organisms convert the organic matter, partially degraded by the optional aerobic organisms, in methane and carbon dioxide. The characteristics of this phase are always the production of thermal energy (in any case lower than the aerobic phase), the use of dissolved organic matter, the production of methane and carbon dioxide, as well as the increase in pH with values close to neutrality. Numerous studies have found that this phase usually takes place after a period varying between 3 and 9 months from the deposition of the waste. Once the methanogenic phase has started, the production of biogas normally occurs for several years (even over 40), according to a trend that shows the maximum production in the early years and a progressive asymptotic depletion until the complete degradation of the organic substance or until when there are environmental conditions suitable for the process.



Extracting the biogas that is formed is the first thing to do, for both environmental and economic reasons. From the point of view of environmental protection, in fact, it is necessary to prevent the biogas from being released into the atmosphere or spreading into the subsoil.
Biogas is one of the greenhouse gases responsible for global warm-

ing, so it is important to minimize its release into the atmosphere. If instead it spreads in the subsoil, perhaps exploiting a flaw of the waterproofing system of the bottom or walls, it can reach the surrounding houses, with serious consequences: the methane is a flammable gas and when it is at a concentration between 5 and 15% in volume can also burst due to a spark.
From an economic point of view, then, it would be wasteful not to exploit the energy contained in the biogas. Methane can in fact be burned to produce electricity to be distributed in the national network, as we said earlier for anaerobic digestion. At this point it seems clear that when designing a landfill it is necessary to provide a system of biogas extraction and extraction through a series of wells, just as if it were a natural gas field.

7.2.1 Waste-to-Energy Plant

Undifferentiated waste can be burned to produce energy. The energy potentially contained in waste is a chemical energy. In fact it is freed with combustion and can be measured through a defined quantity Lower Heating Value (LHV) (net calorific value (NCV) or lower calorific value (LCV)).
Typically, in normal combustion the combustion products are released at a higher temperature than the fuel reference temperature. Thus, a part of the theoretically available heat is 'dispersed' by the heating of the fumes and, above all, by the vaporization of the water produced by the combustion. Take into account that, for each degree of increase in the flue gas temperature, about 1 kJ / kg of fumes are required and that for each kg of steam in the fumes, about 2.5 MJ is required for latent heat of vaporization at 100 ° C .
What could be the best use of energy obtained from the combustion of undifferentiated waste?
The simplest thing is to transform it into a form of energy other than heat that can be easily exploited and transportable, like electricity.
How to proceed to burn in an environmentally friendly and cost-effective way that comes from undifferentiated waste containers?
There are different possibilities that differ from one another for the guiding philosophy: plants can be built specifically for this purpose

- for example Waste-to-Energy plants - or existing plant lines can be exploited and built for other reasons - for example cement works or thermoelectric power plants.
In the first case there will be a completely autonomous system that produces energy, while in the second one will replace a search quantity of traditional fuel (generally coal) in the cement plant or in the thermoelectric plant, with the waste.
In this case we speak of “co-combustion”, indicating the fact that the two fuels, coal and waste, burn together according to well-defined proportions. The differences between the two approaches do not stop here: with the first option (plant dedicated to disposal) the waste can be started up as it is, while in the second case it is essential to provide a preliminary treatment that makes it suitable for the specific industrial use.

7.2.2 How Waste-to-Energy Plant works?

The waste-to-energy plants are made up of three main elements: the oven, the boiler and the environmental control and waste management systems.
The oven is the section where the actual combustion takes place. This is the process in which the waste mixed with air reacts with oxygen, the gaseous molecule that allows and maintains the combustion itself. There are different types of ovens: the most common are those on the grid, followed by those with fluidized beds.
A grill oven is similar to a large metal staircase, where however the “steps” slowly move back and forth to allow the waste to move forward. The air is fed from the bottom, through the grid, thanks to numerous small holes. The waste takes 30 to 60 minutes to go down this staircase, during which it starts and then combustion is completed. What does not burn, for example a can accidentally left in the undifferentiated, is discharged at the bottom of the grid, and becomes a solid residue of the process, commonly called slag. The waste represents between 15 and 20% by weight of the waste treated, but they are also a mine of recoverable materials: iron, steel, aluminum, aggregates.
In the case of fluid bed furnaces, the combustion does not occur on a grid, but inside an empty vertical reactor, where a strong flow of air fed

from the bottom upwards keeps the waste in suspension, and causes it to burn while "float" in midair. To facilitate the process, the interior of the reactor is not empty: there is a certain amount of sand, which also remains suspended due to the combustion air.
Unlike systems with a grill oven, a system of this kind is not suitable for burning unsorted waste as it is: try to imagine a black garbage bag, suspended simply by blowing air from below. Obviously it would not be possible. It is therefore necessary to pre-treat waste and to transform it into something that the standards identify as Refuse-derived fuel (RDF). This is a particular type of material obtained by treating the waste indifferentiated with mechanical and biological procedures. The aim is to remove the non-combustible or otherwise problematic components for combustion, such as metals, glass, moisture, while maintaining and concentrating the combustible fractions such as paper, plastic and wood.
Regardless of the type of oven used, the combustion of waste in a waste-to-energy plant releases a high quantity of heat, which is transferred into the fumes. Here is the function of the second section of the system, the boiler, which serves to recover such heat from the fumes. As in traditional thermoelectric power plants, the fumes also follow a rather tortuous path, designed to maximize the contact with the pipes inside which flows a large amount of water. At those temperatures the water heats up and subsequently evaporates; the steam is further overheated up to very high temperatures and pressures (in the order of 400 ° C and 40 bar), and is therefore ready to be introduced into a turbine which, by rotating very quickly, produces electricity thanks to an alternator.

7.2.3 Energy from Waste

The energy produced by the turbine is first of all used by the plant for internal consumption, but there is still a large excess, which can be fed into the national transmission grid and distributed throughout the territory. In practice, a waste-to-energy plant produces energy that fits into the normal power lines of our cities and this saves a similar amount of electricity produced by other sources, for example coal or fuel oil plants.

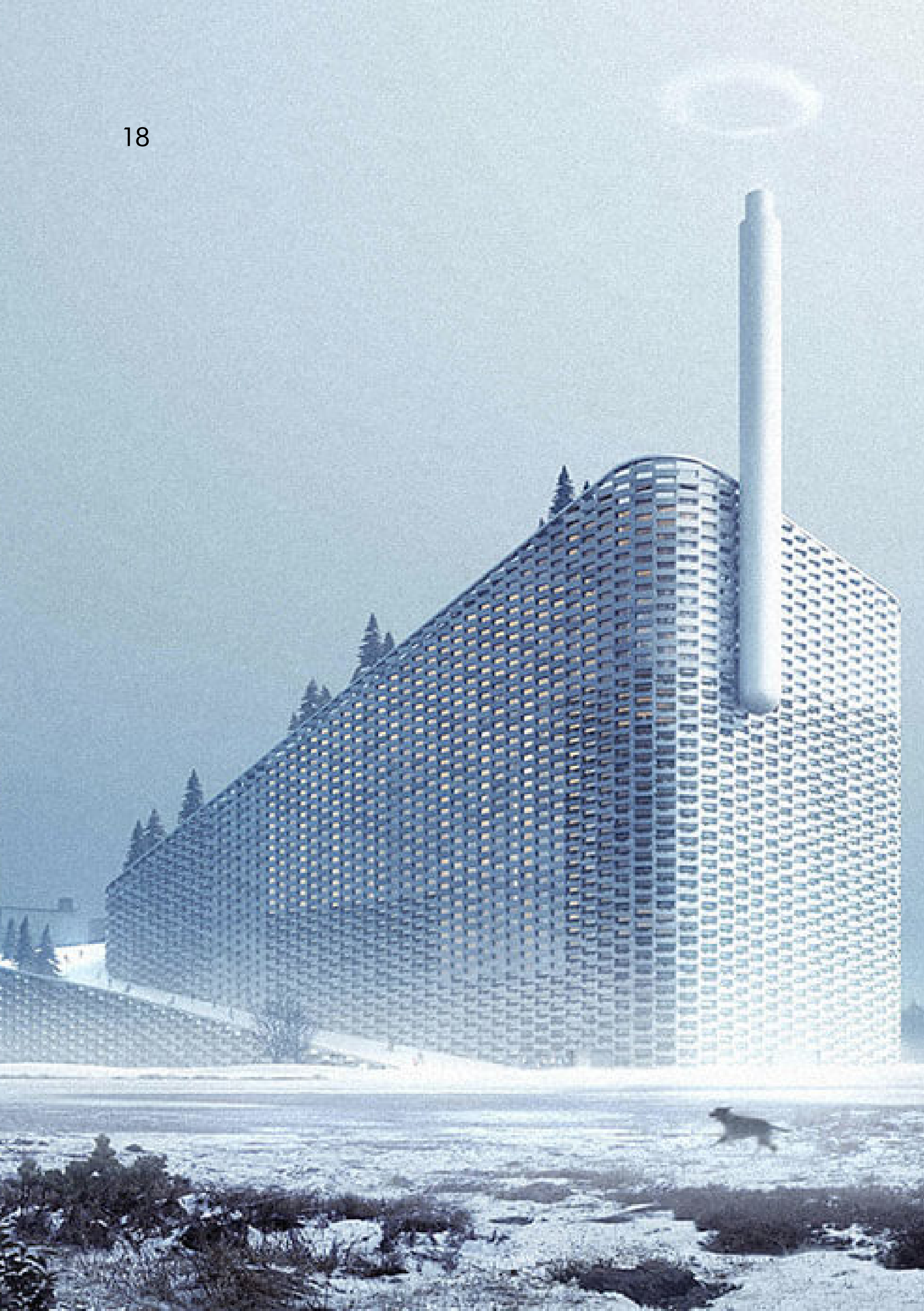
In addition to electricity, or alternatively, it is possible to directly use the heat of combustion without it passing through the turbine. In fact, it is possible to decide to disperse the steam produced by the boiler directly to the city, through a network of pipes, to provide heating to homes. In this case, he speaks of “district heating”.
With district heating, a service is provided directly to the citizens who produce the waste from which the heat is obtained, and the energy is exploited in a better way. The transformation of heat into electricity is in fact a decidedly less efficient process due to the laws of thermodynamics. The heat, however, is not used continuously throughout the year: it is much needed in winter, for the heating of the houses, while in summer it is only necessary for the hot water in the shower.
As for electricity, it is rather constant: in winter it consumes more to keep the lights on in the houses and on the streets, while in the summer the air conditioners. It is better then to find a solution of compromise, elastic, which provides for the possibility of appropriately modulating the production of electricity and heat, based on what is needed most. The solution exists and is called “cogeneration” (electricity + heat): according to the need of the moment, the chemical energy obtained from waste can be converted into different percentages in electricity or heat.

7.2.4 Smoke from the Waste-to-Energy plant

Finally, the waste-to-energy plant includes a fundamental element, the smoke purification system. In fact there are numerous pollutants that are generated by the combustion process: some more "traditional", derived from the combustion process as such, others typically associated with the type of waste burned. For this reason, the purification involves a complex system of filters and reactors that allows to break down the polluting substances below the limits set by Italian and EU laws. Only after these treatments the fumes, now cold and purified, are released into the atmosphere through tall chimneys even more than 100 meters (see image above). In the fumes emitted by the waste-to-energy plant in operation in 2013 in Turin we find on average 10 mg / m3 of carbon monoxide against the 50 granted by the standard, 5 mg / m3 of sulfur oxide and 70 mg / m3 of nitrogen oxides against 50 and the 200 respectively granted. Almost all systems make these values available on their website, so anyone can verify that they work properly.

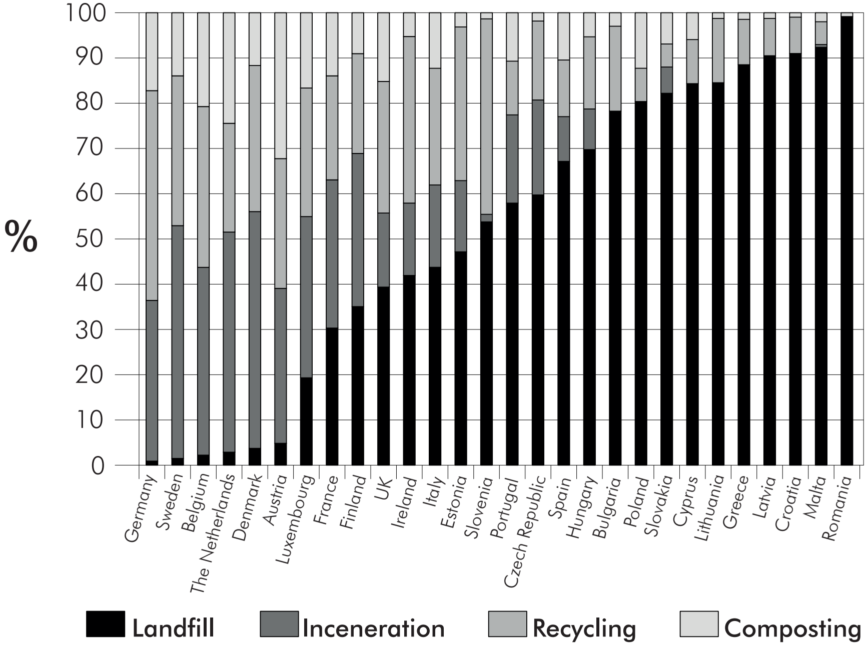
7.3 Waste Around the World

Unlike the poorer world, the industrialized world has at its disposal the two main alternatives that we have examined before for the disposal of undifferentiated waste: the controlled landfill or the waste-to-energy plant. The availability of space has always been a factor in determining waste management strategies. Countries such as the United States, Canada or Australia, which have a very large territory with a low population density, have historically been content to carry out large landfills, without worrying about investing in the recovery of materials or energy. On the other hand, small or densely populated nations such as Japan and Switzerland have chosen to treat non-recyclable waste in thermal processes such as incineration or gasification, in order to drastically reduce the volume of materials to be disposed of in landfills. In fact, as we have seen, the waste-to-energy process reduces the volume of residual material by about 90%.



Copenhagen has three waste-to-energy plants, which provide almost half the heat needed for homes across the city. At the moment the construction of a fourth innovative plant is underway which will include even a ski slope inside (see image on the side). The energy needed for the operation of the ski lift and for cooling will be produced directly by the combustion of waste.

If we observe the world statistics on urban waste management, we deduce that to reduce the amount of waste disposed of in landfills it is necessary to intervene on three fronts: the first and most important starts from the source, a conscious and targeted design for a reuse of the product so as to avoid that once it has been used, it immediately becomes waste (eliminating disposable products and limiting packaging). Avoid planned obsolescence by designing objects that can be updated and improved over time according to the needs of the user. The second point is the recovery of matter (recycling and composting) and recovery of energy (waste-to-energy and co-combustion). The way waste management reflects the level of civilization of a population. In this sense, Japan and Switzerland are undoubtedly the spearhead.



The breakdown as a percentage of the methods of treatment of municipal waste, including landfill, incineration, recycling and composting, in the European Union in 2012 (table adapted from ISPRA elaborations on Eurostat data).

CIRCULAR AMSTERDAM

The pillar of sustainable politics in the city of Amsterdam is the creation of a circular economy. The result of the study "City Circle Scan" is the report "Circular Amsterdam": a vision and guidelines for the city and the metropolitan area that provide information to the municipality regarding the potential steps towards greater circularity. The bases of these guidelines are linked to numerous initiatives that are already active in the area. The City Circle Scan approach, used to draft the report, consists of four phases:

1) The main material and energy flows, as well as the levels of employment in the economic sectors of the region, were analyzed, laying the foundations for the next phase.

2) In phase 2, a complete analysis of the value chains that connect several sectors within the city of Amsterdam was conducted. Through macroeconomic statistics, the study determined which of these chains can achieve a greater positive impact from the introduction of a circular perspective. The results were discussed during a round table together with representatives of the municipality and local stakeholders, with the consequent decision to carry out a detailed analysis of the **construction chain** and the **organic waste flow chain**.

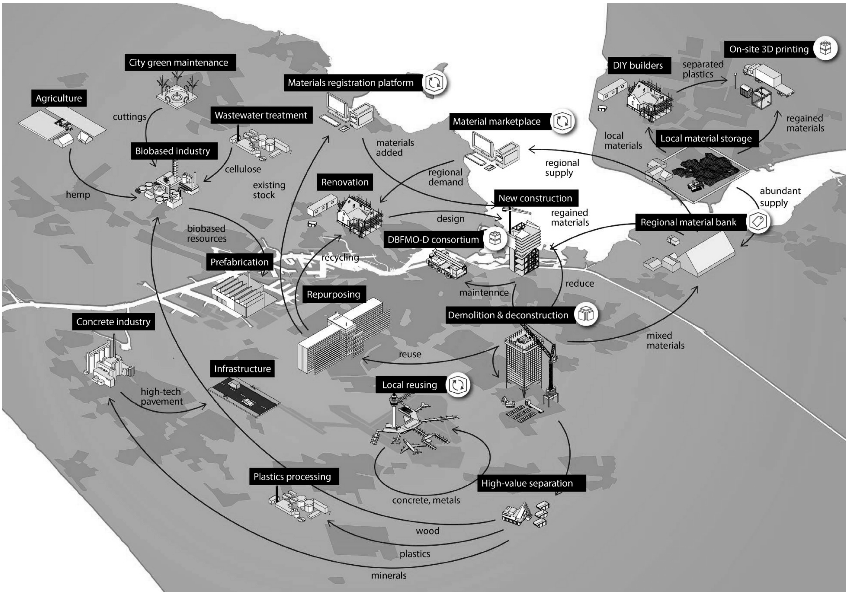
3) Phase 3 analyzes the two chains just mentioned in an ideal circular future. These future analyzes provide a vision of how chains (and their interactions with other supply chains) can be set up in order to be more effective.

4) In phase 4, an action program and a roadmap were drawn up to initiate relevant circular projects and potential obstacles were identified. The results of the study show that Amsterdam has the potential to significantly reduce greenhouse gas emissions and the consumption of raw materials, while at the same time achieving economic growth and increasing job opportunities.
The economic activity of the metropolitan region of Amsterdam amounts to 106 billion euros a year, of which 47 billion are represented by the city of Amsterdam alone (2013) (CBS, 2015).
The following sections summarize the future vision and the roadmap

that have been developed for both chains and the impact that the implementation of these would have on the economy and on the use of materials.

8.1 Construction Chain

19



By organizing the construction chain in a circular way and at the same time satisfying the growth ambition of realizing 70 thousand new homes by 2040, the municipality can achieve a productivity increase of 3% equal to 85 million euro a year. This economic growth is largely achieved by the constancy of the value of the materials due to their reuse and improvement of efficiency. Productivity growth translates into more job opportunities: with due time, around 700 additional jobs can be created. 75 thousand people are currently employed in the building sector in Amsterdam. For the most part, additional jobs would be for medium-low staff.

The improvement due to the reuse of materials saves 500 thousand tons of material, which is significant when compared with the current

annual import of about 1.5 million tons of materials. It is estimated that the emissions of greenhouse gases may decrease by half a million tonnes of CO_2 a year, equal to 2.5% of the current annual CO_2 emissions of the city of Amsterdam.
The aforementioned impacts are based on three strategies that improve the circularity of the construction sector:

1) **Smart Design**: engage in the intelligent design of buildings to make them more suitable for their re-use or the reuse of the materials it is made of.

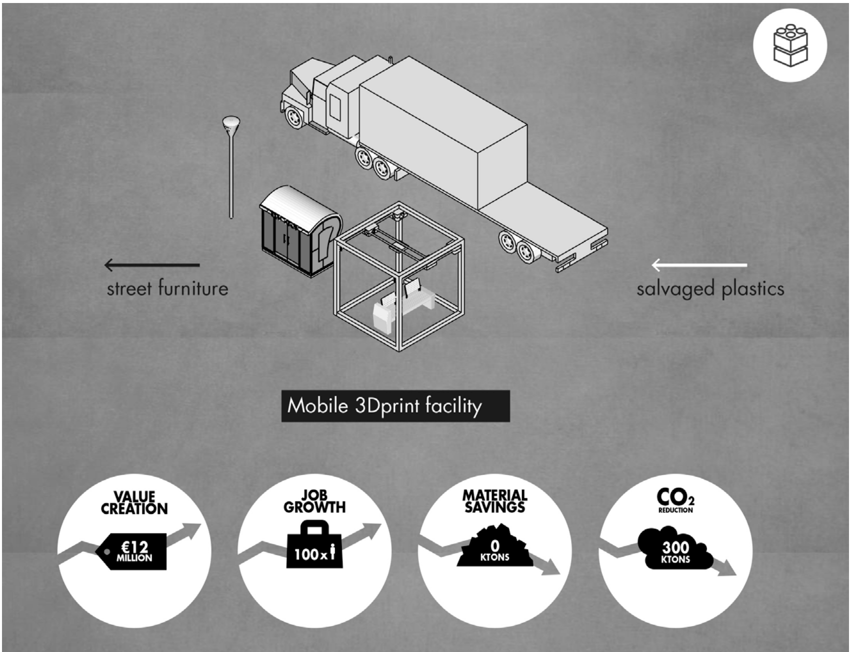
2) **Disassembly and separation**: efficient dismantling and separation of waste streams.

3) **Marketplace of building resources**: exchange of raw materials among market operators.

8.1.1 Smart Design

8.

20



Visual display of smart design: Recovered bio-plastics are used by a 3D printer to produce new products such as street furniture. In addition, mobile stations enable on-site production. The effects of circular strategies on the environment and the economy have been calculated for the construction of 70 thousand new homes in Amsterdam. It is expected to take five to seven years to achieve circular design within the construction industry. The impact will also manifest itself after a similar time-frame. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

Intelligent building design is important in the transition to a regional-based circular construction chain (EMF, 2015a). People move more frequently, so work areas should be designed to adapt and meet changing work patterns such as dynamic work and flexible working hours. Furthermore, it has been found that companies tend to move to another building rather than renew the current one. These factors lead to a growing demand for flexible and customizable areas that meet the changing needs of tenants and landlords. To illustrate the concept, we will focus on four categories of intelligent design, namely modular and flexible design, 3D printing, bio-based materials and experimental construction areas.

Modular and flexible design: One of the aspects of intelligent design is

a modular and flexible approach, whereby buildings can be upgraded to the needs of new users without sacrificing current safety guidelines (Schoenborn, 2012). These projects make the real estate sector more functional and more durable, thus guaranteeing more revenue during the period of use. Examples of integral modular projects are Solid in Amsterdam from the Het Oostent housing association, TempoHousing student housing in Keetwonen in Amsterdam and Park 20 | 20 of Delta Development Group in Hoofddorp. Flexibly designed homes are often more attractive to users because they can adapt to ever-changing lifestyles. Companies also prefer flexible offices because they do not need to move when their business situation changes.
Start-ups and other fast-growing companies, in particular, can benefit from these offices. Leasing or buying flexible office space can even lead to cost savings (Cushman & Wakefield, 2013).

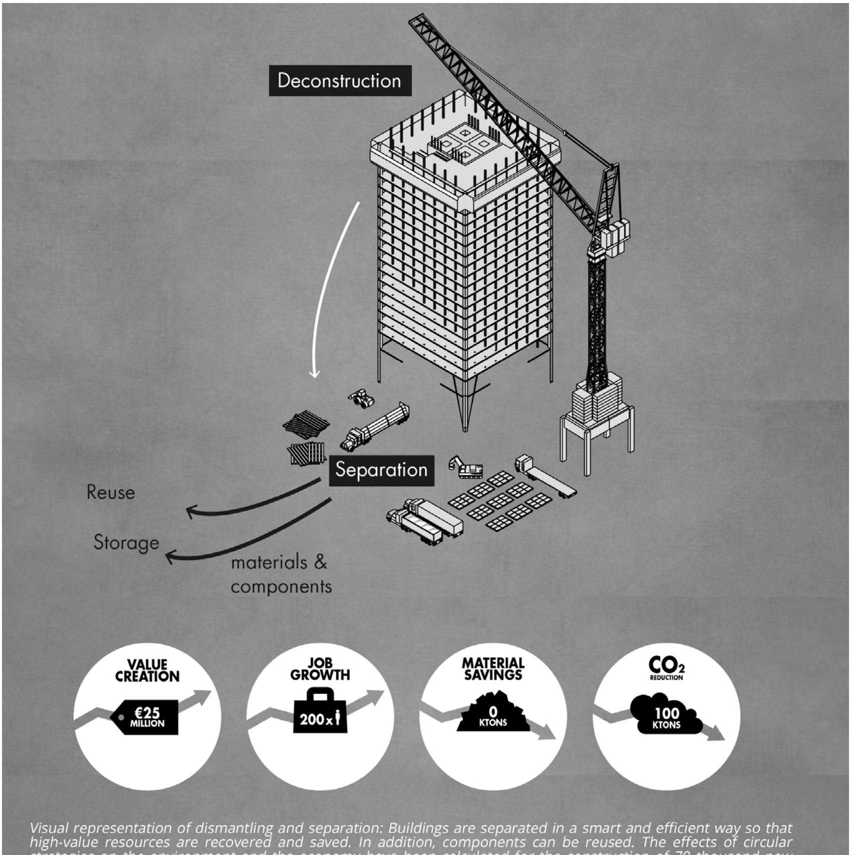
3D Printing: New technologies, such as 3D printing, can play a pioneering role in reducing costs and using materials (EMF, 2015b). These technologies lead to less waste and offer the possibility of new materials (for example biologically based). The Amsterdam architects' studio, SO Architects, has started, in collaboration with Hager and Henkel, the "3D Printing Canal House" project to investigate the possibilities of 3D printing for the construction industry.
The research project examines different building materials, such as recycled building materials and stone waste (SO, 2015).

Bio based materials: New sustainable building materials of biological origin can contribute to the design of smarter buildings. More than 3 million tons of biomass and residual organic flows are released from agricultural activities in the metropolitan area of Amsterdam, from which it is possible to produce significant quantities of bio-composite materials. This, at least, would be sufficient to provide the materials necessary for the planned building expansion of 70 thousand homes (CBS, 2014). The municipality of Almere has already started projects concerning organic waste, which are used to generate bio-composites for the construction sector.
The 60,000 m2 of buildings planned for Floriade 2022 can be constructed as widely as possible through the use of biomaterials.

Experimental construction areas: Laws and regulations can be flexible to allow the development of modular buildings based on green building (Acceleratio, 2015). By changing building codes, developers get more space to experiment and more freedom to put their smart designs into practice. The success of Park 20 | 20 is partly due to the municipality of Haarlemmermeer, which created flexible rules for the area where innovative building projects could be tested. These free zones offer a great opportunity for start-ups working on innovative concepts, contributing to the vision of Amsterdam as a start-up center.

8.1.2 Dismantling and separation

21 9.



Visual representation of dismantling and separation: Buildings are separated in a smart and efficient way so that high-value resources are recovered and saved. In addition, components can be reused. The effects of circular strategies on the environment and the economy have been calculated for the construction of 70 thousand new homes in Amsterdam. It is expected to take five to seven years to achieve circular dismantling within the construction industry. Four indicators have been used to determine impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emission.

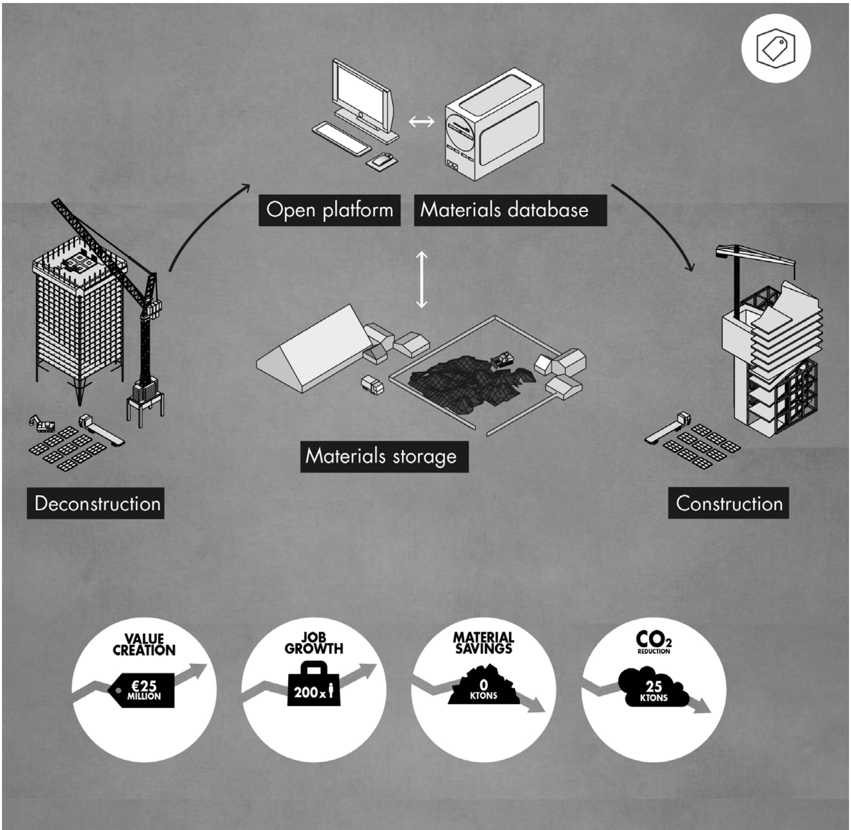
The dismantling of existing buildings more efficiently by separating their waste streams, materials and components from old buildings is one of the cornerstones of the circular economy in the building sector. An important phase in the life cycle of a building is its end of life (Acceleratio, 2015). Nowadays maintenance is a clause included in real estate development contracts; however, these almost never include end-of-life costs. Therefore, destruction now seems to be the cheapest option at a cost of only € 20 / € 30 per square meter (Circle Economy, 2015). By managing the demolition of buildings smarter, high-quality materials can be separated to prevent them from being contaminated by other resources. To achieve this, it is necessary to consider already in the planning stage how the buildings will be dismantled. Efficient separation of waste streams can facilitate the recycling and re-use of these materials. These components and materials can then be sold to offset demolition costs. In Amsterdam, there are already companies specializing in dismantling and demolition methods.

8.1.3 Marketplace and Resource Bank

Each building can be seen as a source full of precious materials. A building could be seen as a modern interpretation of traditional mines. However, after the dismantling, separation and recycling of materials from a building a gap is created between the supply and demand of these resources. Moreover, it is often not clear what materials are present in existing or abandoned buildings but above all of what quality they are. There is a need for a complete online market and a logistic support system that facilitates the exchange of materials derived from demolition waste. Furthermore, it is necessary to identify a place where these materials can be stored temporarily, a so-called "resource bank".

Online Marketplace: through an online market, the supply and demand for building materials for local projects can find a meeting point. In addition to information on the type of construction, you can access documents, passports and information on the quality and quantity of materials in the bank. This offers opportunities for trading and the exchange of building materials between builders and demolishers and encourages the re-use and recycling of high value.

22



Visual representation of market place and commodity bank: Raw materials are traded between disassembly of old buildings and new construction by means of a physical repository and online marketplace. The effects of circular strategies on the environment and the economy have been calculated for the construction of 70 thousand new homes in Amsterdam. It is expected to take five to seven years to achieve a marketplace and resource bank within the construction industry. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

Logistics for collection: An online market alone is not enough, it is necessary to collect and transport the demolished materials taking into consideration their variety and their volume. Therefore, there is a need for an advanced collection system and for intelligent logistics, in order to facilitate the exchange of materials. Because many developing locations are located near waterways, the port of Amsterdam may be the central point in that logistics system. Shipping companies could play an important role in transport. Many logistics companies such as DHL and PostNL are available to offer the reverse logistics of material flows. In reverse logistics, the empty truck after delivering its products would be used for waste recovery.

Commodity Bank: Currently, there are difficulties in the temporary storage of construction waste, mainly because this requires space and, therefore, investment. Free pitches around Amsterdam, such as in the port of Westpoort, Zaanstad and Almere, are ideal places for temporary storage of construction waste before they are exchanged via the online market. Designers and architects can view a catalog of materials and see if they can find new applications.

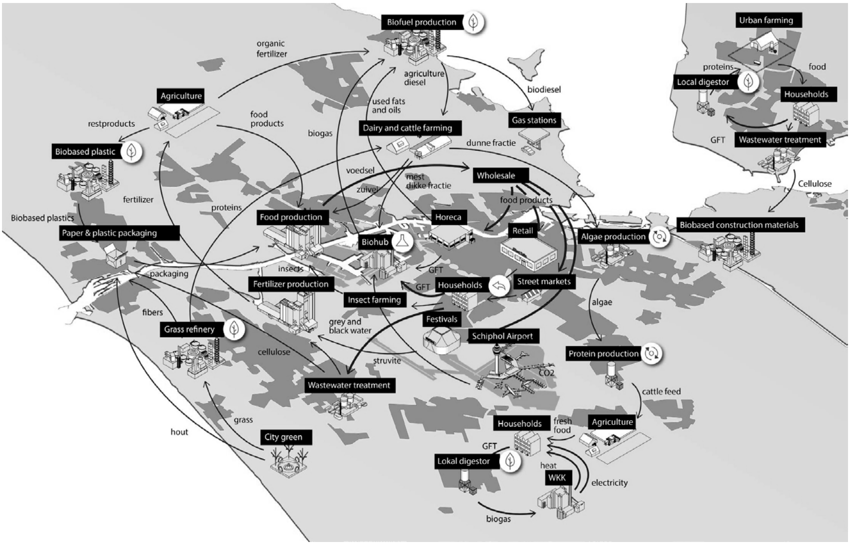
4.2 Organic Residual Streams Chain

The process of treatment of residual organic flows for the city of Amsterdam can, in a period of five to seven years, lead to an added value of 150 million euros per year. This future circular scenario is based on a series of measures taken, including the separation of organic waste sources in all 430 thousand families in Amsterdam. Separate waste collection allows to direct the flow of organic waste to new uses, such as the production of animal feed proteins, biogas and elements for the chemical sector, including the production of bioplastics.

In the long term, it is estimated that this scenario will create an additional 1,200 jobs in Amsterdam, to be added to the current 10,000 jobs in the agricultural and food processing sectors. The creation of some of these jobs will result from the necessary adjustments to the waste infrastructure, including the installation of underground containers, collection services for separate waste streams and the more complex processing of data derived from waste streams.
In addition to the direct effects on employment in the agri-food industry, there are possibilities for indirect increases in the number of jobs in sectors such as engineering and logistics.
The savings of materials that can be achieved add up to about 900 thousand tons annually, a significant amount compared to the current annual production of 3.9 million tons of biomass for the entire

metropolitan region. Savings mainly consist of materials that can be replaced by flows generated by waste treatment. For example, the production of high quality organic waste protein can replace imports of proteins such as soybeans for animal feed and the production of bioplastics could replace fossil-based plastic production. All this would result in a reduction of greenhouse gas emissions in the order of 600 thousand tons of CO_2, about 3% of the annual CO_2 emissions of the city of Amsterdam.
The above impacts are based on four strategies that can allow recycling with the highest value of residual organic flows:

23



1) **A bio-refinery**: a central hub for the exploitation of organic waste streams from domestic and industrial waste.

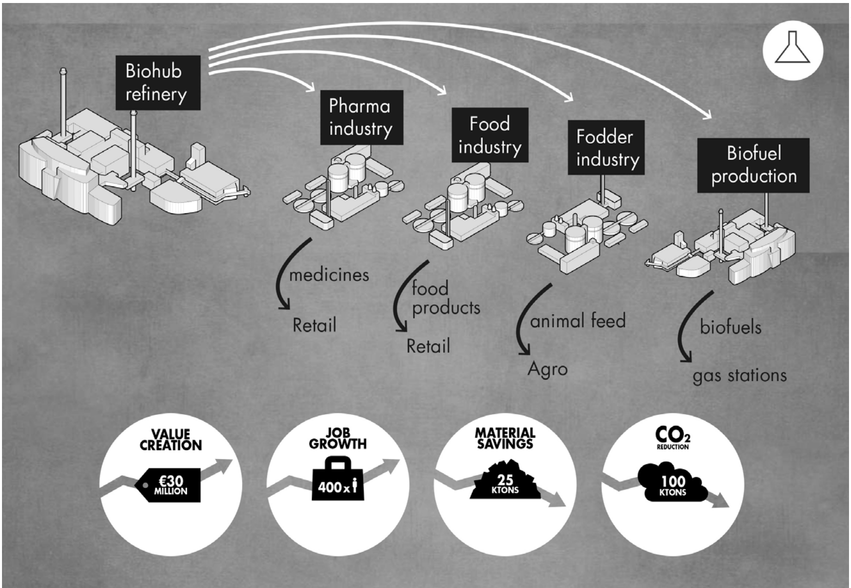
2) **Waste separation and return logistics**.

3) **Monitoring of organic flows:** in order to distribute them in the most intelligent way possible.

4) **Recovery of organic nutrients**.

8.2.1 Central Bio-Refinery HUB

24



Visual display of bio-refinery: Organic residual streams are processed and used as raw material in, for instance, medication, food producers, feed and biofuel. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take five to seven years to achieve a circular arrangement of the processing of organic residual streams coming from all 430,000 Amsterdam households in the long term. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

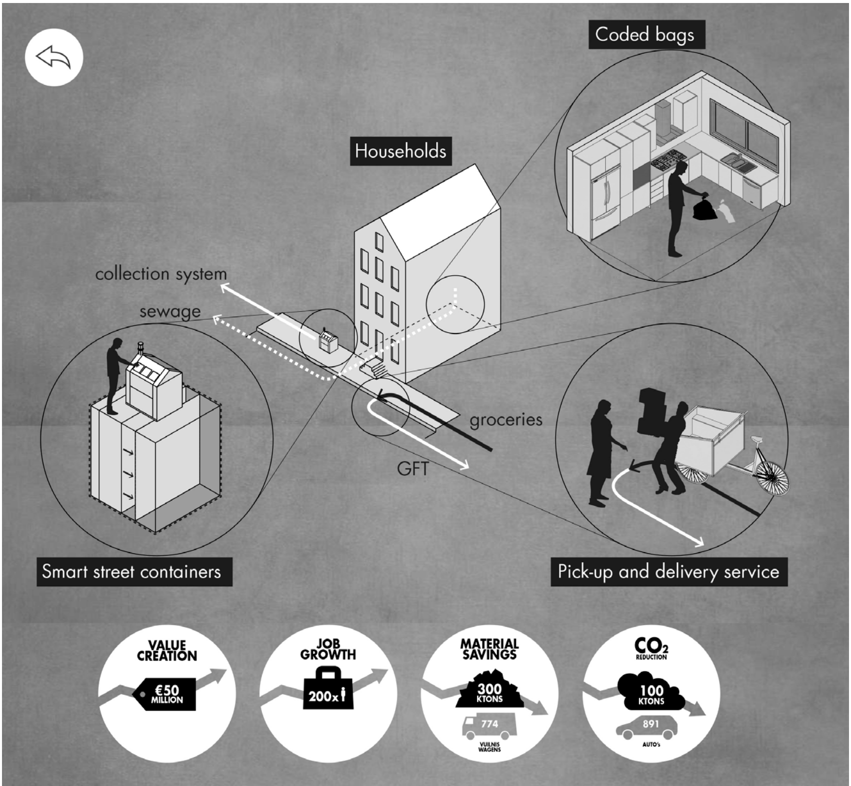
To achieve a hub for the treatment of organic waste and the reuse of residual organic flows, a certain scale is required, an achievable goal for the city of Amsterdam (Green Raw Materials, 2014). This hub will be able to produce a variety of bio-products such as biomaterials, constituents for the chemical industry, food, feed, biodiesel, biogas, lubricants, paints and biologically based oils, fertilizers, algae and bio-aromas.
To allow optimal management of residual organic flows, it is necessary to link existing initiatives so that the resulting volume is larger. In the city of Amsterdam, organic flows (including edible fats, animal fats and supermarket waste) are processed to produce almost 300 million liters of biodiesel, 25 million cubic meters of biogas through anaerobic digestion (city of Amsterdam, 2015) and 5000 tons of fertilizer.
Similar activities, such as an anaerobic digester plant, are planned for

Schiphol airport. This structure, which in the future will be responsible for 6% of the energy supply of
Schiphol (Croes, 2015), will use grass clippings in the surroundings and organic residues generated in the region.

4.2.2 Waste Separation and Return Logistic

Good waste separation and intelligent return logistics are important for

25



Visual display of waste separation and return logistics: Organic residual streams are processed and used as raw material in, for instance, medication, food producers, feed and biofuel. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take five to seven years to achieve a circular arrangement of the processing of organic residual streams coming from all 430,000 Amsterdam households in the long term. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

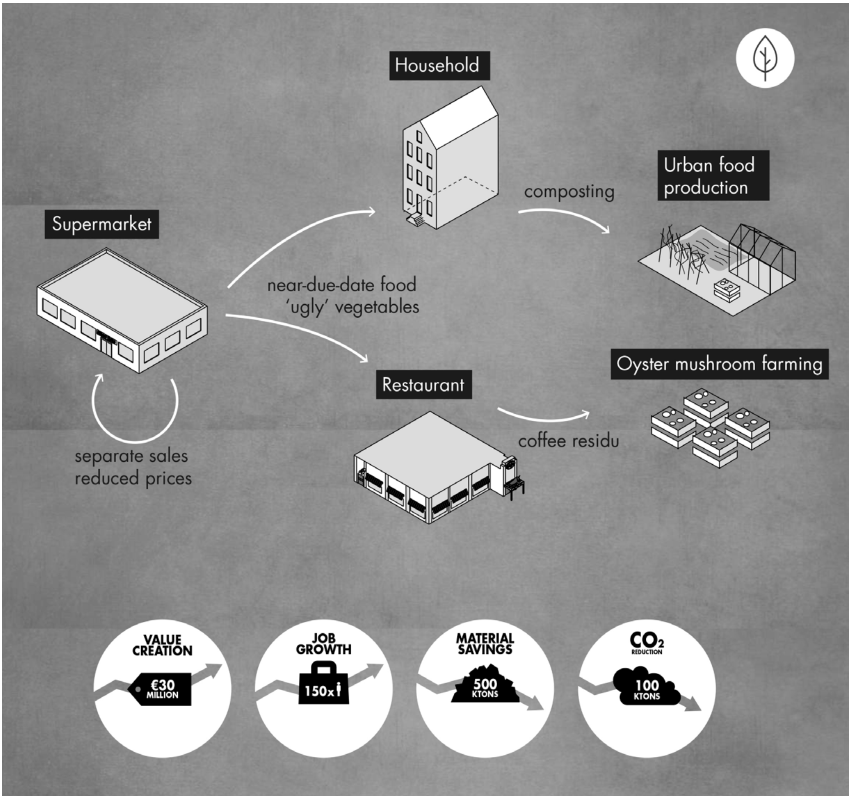
the optimal exploitation of residual organic flows (Consonni, 2015). From this point of view, the separation rate of waste in Amsterdam is far below the Dutch average (CBS, 2015c) and in particular, organ-

ic waste is rarely separated at source. Finding effective solutions for the separation of household waste in densely populated urban areas requires a complex technological approach, particularly for existing buildings.
Underground containers can be equipped with intelligent sensors for measuring waste streams. This allows a much better processing of waste streams, more information on their composition and improved logistics. Where it is not possible to install containers for underground waste, separate waste collection can be achieved through alternative systems, such as the use of specific bags for the separation of different waste materials.

8.2.3 Cascading of Organic Flows

Although there are a variety of options for recovering and reusing organic waste for other purposes, 97% of domestic organic waste in Amsterdam is burned for energy recovery and only 3% is re-used or recycled for other purposes (Circle Economy , 2014). Incineration currently provides a valuable source of heat and energy, but several new technologies and business models can now be applied to these waste streams to create more valuable ones (Bio-based Economy, 2015). The recovery of food in the metropolitan area of Amsterdam and a new concept of catering are aimed at preserving edible food waste from warehouses and shops. There are also bottom-up community initiatives, such as Guerilla Kitchen and companies like Kromkommer that recover edible but deformed or damaged food, no longer suitable for retail, and use them to make soups and other food products, giving them a second life. Companies like Exter can extract additives for the food industry; an example is the extraction from vegetable proteins of bio-aromas and reactive flavors as a substitute for chemical flavorings. Wastewater and organic waste produced by the municipality of Amsterdam, industries and agricultural companies can be treated on a large scale for algae growth projects (Loftus, 2013). GRO Holland, for example, uses coffee grounds discarded from bars and restaurants and uses them for mushroom cultivation, which are then immediately sold or used as food ingredients.

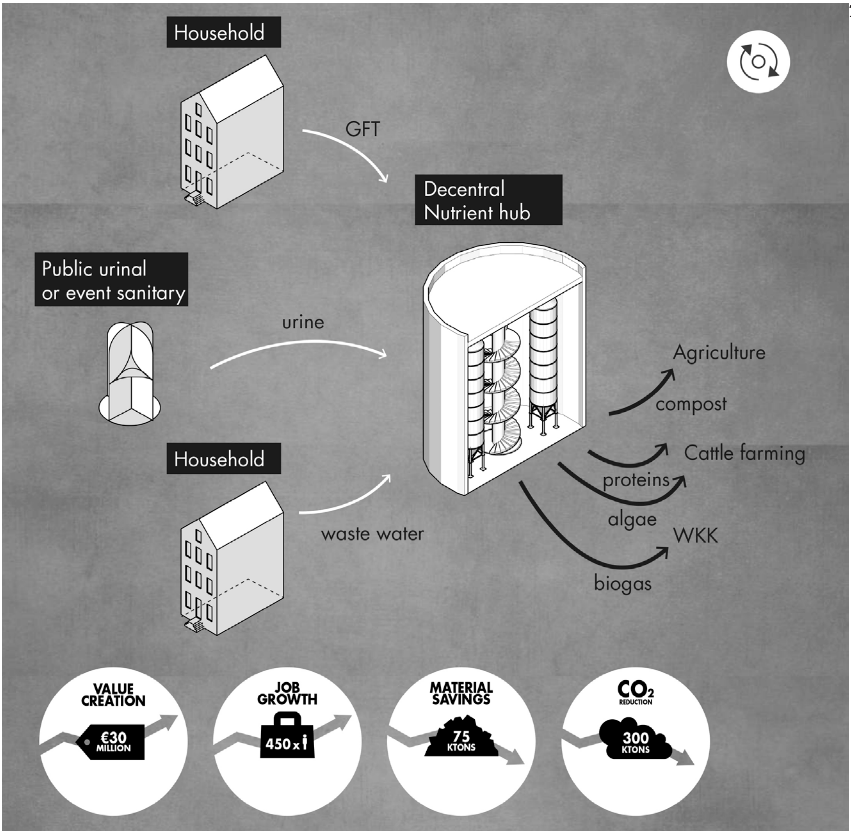
26



Visual display of cascading: Organic residual streams that cannot be directly reused can be cascaded to high-value applications. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take five to seven years to achieve a circular arrangement of the processing of organic residual streams coming from all 430,000 Amsterdam households in the long term. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

8.2.4 Recovering Nutrients

27



Visual display of recovery of nutrients: Organic residual streams are processed through decentralised, local processes to recover nutrients. The effects of circular strategies on the environment and the economy are calculated for the organic residual streams in Amsterdam. It is assumed that it will take five to seven years to achieve a circular arrangement of the processing of organic residual streams coming from all 430,000 Amsterdam households in the long term. Four indicators have been used in determining impact: (1) net added value in millions of euro, (2) net job growth in FTE, (3) material savings calculated by value retention in domestic material consumption and (4) reduction in CO_2-emissions.

Through the analysis of the whole food chain - from field to table - only 5% of the nutrients placed in the soil are effectively used to provide us with nutritional input (Circle Economy, 2014). The remaining 95% of the nutrients are lost somewhere in the production cycle. For example: the crops absorb only 30 to 50% of the fertilizer applied to them and of these percentages almost 25% is exploited for the growth of inedible parts, which in the current economic model are disposed of as waste. The sewage drainage system is a valuable resource for nutrient recovery; the average per capita production is 500 liters of urine and faeces in a year. Because the human body does not absorb all the nutrients from the food we consume, this is a waste of nutrients. An important opportunity to improve the nutrient cycle in Amsterdam lies in the application of decentralized local processes in order to recover these nutrients.

The municipality could be interested in finding local actors able to recover nutrients from the food system through anaerobic digestion and develop techniques to convert urine into precious nutrients such as nitrogen and phosphate. A disadvantage of these techniques is that they are often not financially profitable (AEB, 2015). [6]

"The City of Amsterdam is convinced that the circular economy carries enormous economical and ecological potential for the city and the region. Especially when focusing on the value chains of construction and biomass in the built environment. We see the need for new paradigms in the governance for the circular economy. Gaining insights through `Learning by doing' is key to new governance in companies, governments and society"

Esther Agricola
Director Urban planning and Sustainability
City of Amsterdam

CIRCULAR BARRIERA

9.1 Road VS Door-To-Door collection in Turin

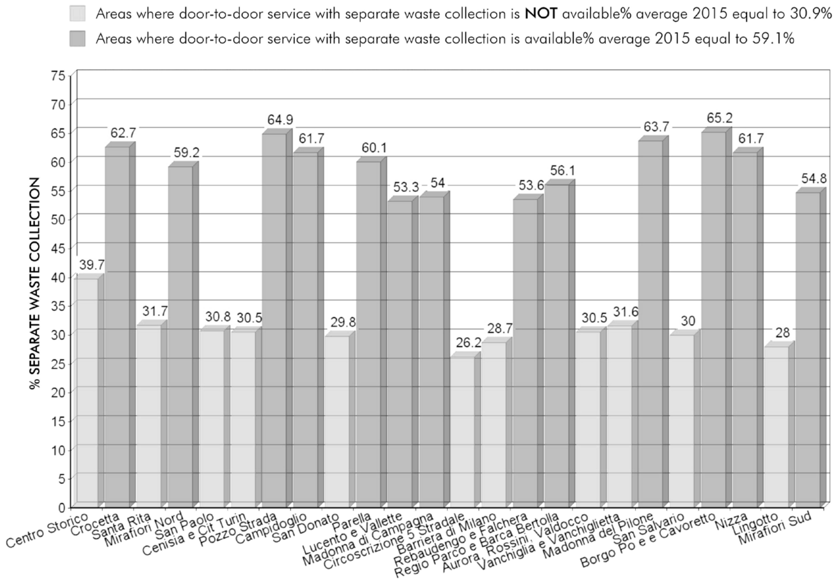
Separate waste collection is active throughout the city in two different ways: separate road collection and differentiated waste collection, better known as “door to door”. The collection includes four separate commodity fractions: paper and cardboard, plastic packaging, glass and cans, organic waste. The waste conveyed in the different containers must be clean, ie free of waste, in order to increase the quality of the separate collection. For this reason, it is necessary to roughly rinse the packaging, and avoid giving dirty material. The differentiated collections are carried out with the use of dedicated containers of different volumes, having different colors depending on the recyclable material to which they are intended.

Differentiated road collection: it is realized through the use of large containers positioned on the road and gathered in ecostations located throughout the city. Users have the obligation to collect separately the different types of waste (paper and cardboard, plastic packaging, glass and cans, organic waste) and use the road bins for the correct conferment of each fraction.

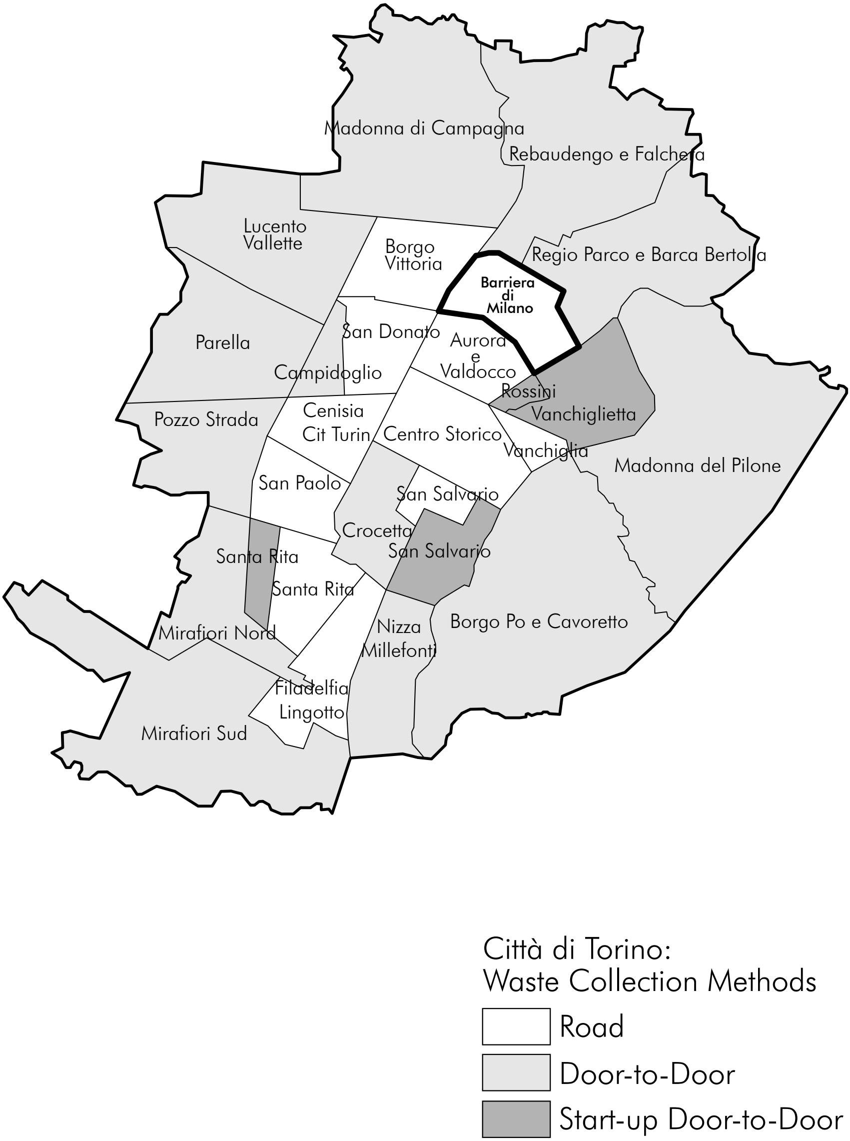
Door-to-door collection: Home waste collection, better known as door-to-door, is a type of collection that Amiat and the City of Turin have adopted since 2003. It is regulated by specific city ordinances and is currently active on about half of the Turin area; the large road bins are replaced with wheeled equipment and smaller, to be positioned inside the courtyards or condominium appurtenances. The exposure of the bins on public land takes place according to a specific calendar provided by Amiat and by users.

Starting from the autumn of 2018, integrated home collection was also activated in the Lingotto - Filadelfia district, in the area between Corso Sebastopoli, Corso Unione Sovietica and Corso Traiano.
The new method of collection will involve about 37 thousand residents, bringing Turin to a total of over 500 thousand citizens served by the home collection system.

Separate waste collection in the districts of Turin



As can be seen from the graph, door-to-door waste collection has a greater effectiveness at the expense of road collection. This is due to the fact that the citizen feels more involved in the waste disposal cycle, which he is in fact one of the main players. On the other hand, as far as road collection is concerned, at the moment in which the waste is thrown away, the citizen feels enthralled as the dumpster is positioned on the street without any control and supervision. Therefore the districts of Turin that have not yet been reached by door-to-door separate collection have weaknesses. They are mainly suburban neighborhoods where it is more difficult to educate the citizen on how to make a virtuous separate collection, this is also due to a lower cultural level than the central areas of the city. If we want to intervene concretely with urban regeneration actions to improve the waste cycle and the quality of separate waste collection, we need to start from the neighborhoods with these deficiencies.
Barriera di Milano is one of these, an area that in the post-industrial era remained isolated on the edge of the city but which in recent years is subject to redevelopment.


Madonna di Campagna
Rebaudengo e Falchera
Lucento
Vallette
Borgo
Vittoria
Regio Parco e Barca Bertolla
Barriera
di
Milano
Parella
San Donato
Aurora
e
Valdocco
Campidoglio
Rossini
Vanchiglietta
Pozzo Strada
Cenisia
Cit Turin
Centro Storico
Vanchiglia
Madonna del Pilone
San Paolo
San Salvario
Crocetta
San Salvario
Santa Rita
Santa Rita
Nizza
Millefonti
Borgo Po e Cavoretto
Mirafiori Nord
Filadelfia
Lingotto
Mirafiori Sud
Città di Torino:
Waste Collection Methods
Road
Door-to-Door
Start-up Door-to-Door

9.2.1 District of Barriera di Milano

Barriera di Milano, often called simply Barriera, is an ancient district of Turin belonging to the District 6, located about 4 km north of the city center. It arose as a proletarian and worker village. An ancient conglomeration of scattered houses and shops in Turin, Barriera was officially founded only in 1853, with the first city boundary.
Erected with the aim of guaranteeing customs control over incoming goods, it separated the countryside from the northern access, which continued to the bridge over the River Dora (Aurora district). The district takes its name from one of the gates that allowed entry into the city: these gates, called barriers, assured the payment of the duty, and among all the most famous barrier to the north was that of Piazza Crispi, along the then Royal road of Italy (today Corso Vercelli), and called - in fact - of Milan, since it gave to the famous Lombard capital.
This district is of particular industrial and economic interest since the early sixties, in contrast with the Mirafiori Sud district, of the south area of Turin and headquarters of the Fiat. The first important industrial plants, however, were already established at the end of the 19th century, with Fiat Grandi Motori (the historic GM brand, 1905) and various textile industries, including the Piacenza Brothers in Via Bologna and the CEAT tire industry, in Via Leoncavallo, opened in 1939 and whose production ceased in 1979, with final closure in 1982.
Barriera di Milano is also home to the tertiary and market sectors, still developing today. There are in fact four important local markets open all week, precisely in Via Porpora, Piazza Crispi (albeit greatly reduced over time), Piazza Foroni and Corso Taranto.
The Barrier of Milan today has lost much of its strategic and industrial importance and many areas are waiting for a functional reconversion and a restructuring of the buildings.
The district reflects the majority of suburban neighborhoods of the big cities and is today very cosmopolitan, given the residence of many different cultures and peoples, this fact also linked to the proximity to Porta Palazzo and Borgo Dora.

9.2.2 Urban Regeneration in Barriera di Milano

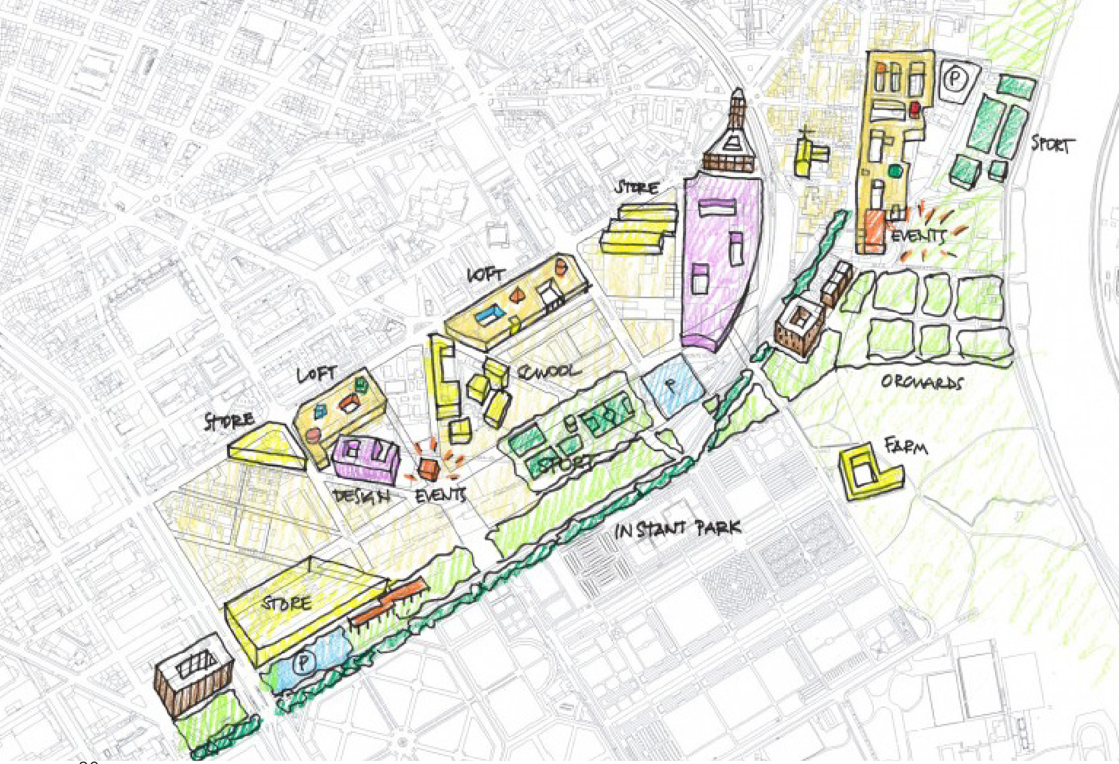
The whole area is affected by the project of the City of Turin called "Variante 200" which should redesign the urban planning, road and transport in the near future, connecting the area to the station of Turin Rebaudengo Fossata.
The areas involved in the transformation are three: the Spina 4 (the last large area still to be transformed of Turin's Spina Centrale, which greatly advanced with the work of the Olympics and which was prefigured by the master plan of Gregotti and Cagnardi in 1995) ; the former Scalo Vanchiglia and the Corso Sempione railway trench, which will be occupied by the subway line two.
The "Alberata", that is the space of the trincerone, will instead see on the surface, above the future metro line 2, the construction of a green boulevard, which will rebuild two districts today separated from the railway and will have a vocation that looks to wellness and health , public and private, also considering that in this area the San Giovanni Bosco hospital is already present.
The road to the transformation indicated by the designers is that of the bottom-up, the city that is built from the bottom (contrary to the top-down, the model used until yesterday, which starts from a predefined design to drop it from above), which it is capable of accommodating the future and where a series of trigger areas of transformation, with even temporary uses, are able to attract investors, to then leave space for development according to what the market will require.

Urban Barriera is an urban development program aimed at triggering a process of overall improvement of the Barriera area of Milan, the historic district of the northern area of the city of Turin. Funded by the City of Turin, the Piedmont Region and the European Community, the program has worked on the physical, economic and social level and intervenes on the territory, fostering collaboration and proactive interaction between all actors and beneficiaries of redevelopment (Public Sectors) Administration, territory realities, associations, institutions, citizens, entrepreneurs, etc.).

Aerial Photo from 1968

29

Aerial Photo from 1968



30

Urban Barriera officially started in the first quarter of 2011 and ended December 31, 2015. The program, composed of 34 interventions, was the outcome of a process, which lasted almost two years, which saw the involvement of the technical sectors of the City , called to provide their own planning contribution, and of the territory, which through the activity of the District 6 presented its requests. The interventions have been identified to address the main problems, defining a fully fundable program able to act strategically on well-defined redevelopment objectives. Urban Barrier of Milan acted on the physical-environmental level, on the economic-employment, on the socio-cultural and through a strong action of communication and social support.

9.3 Piazza Foroni

The first seat of this market was the current largo Giulio Cesare. From 1925, when the Turin-Milan motorway was inaugurated and Corso Giulio Cesare became the main thoroughfare connecting the outskirts and the city center, Piazza Foroni became the neighborhood market square. The strong point of the market is the offer for the whole year of food products and first fruits at very competitive prices but also typical foods of the Apulian and Mediterranean tradition.

This regional identity is underlined, at the center of the market, by the presence of the aedicule with the painting depicting the Madonna di Ripalta brought by a family of Cerignola in 1945. Even today the tradition is kept alive and, on the third Sunday of the month of June, the original families of Cerignola together with the inhabitants of Barriera di Milano are in the square to celebrate.

The houses are uneven at the right point and almost every balcony has the clothes hanging out. These are very clear signs, this is the theater of the world. The square is an invention, they are two streets that form a widening in the shape of an hourglass, a metaphor of the passage of time. In a city that has always been orthogonal, such a crossroad could only happen in the countryside, in fact, the neighborhood exists only since the nineteenth century, when they made the cinemas of Turin and the houses have taken the place of the fields. The market was born then.

The peddlers are almost all from Puglia, in spite of those who speak of Barriera di Milano as a multi-ethnic market. It is certainly for the manpower but not for the stalls, especially the food. Fruit, vegetables, meat, cheese and spices. Here we speak Italian, especially of the south.

In the postwar years Barriera was a landing for those who rose from the south. Before that, those who came from Cuneo, the poorest Piedmontese, made the workers at Fiat Grandi Motori or at the Fratelli Piacenza or at the Ceat of Virginio Bruni Tedeschi. Two generations later, for the children of those factories, the world has changed. The market has grown over the years, has expanded branching beyond the boundaries of the same Piazza Foroni: via Monterosa, via Santhià and via Candia have been swallowed to become one of the stalls.

9.4 Separate collection and cleaning in the Turin markets

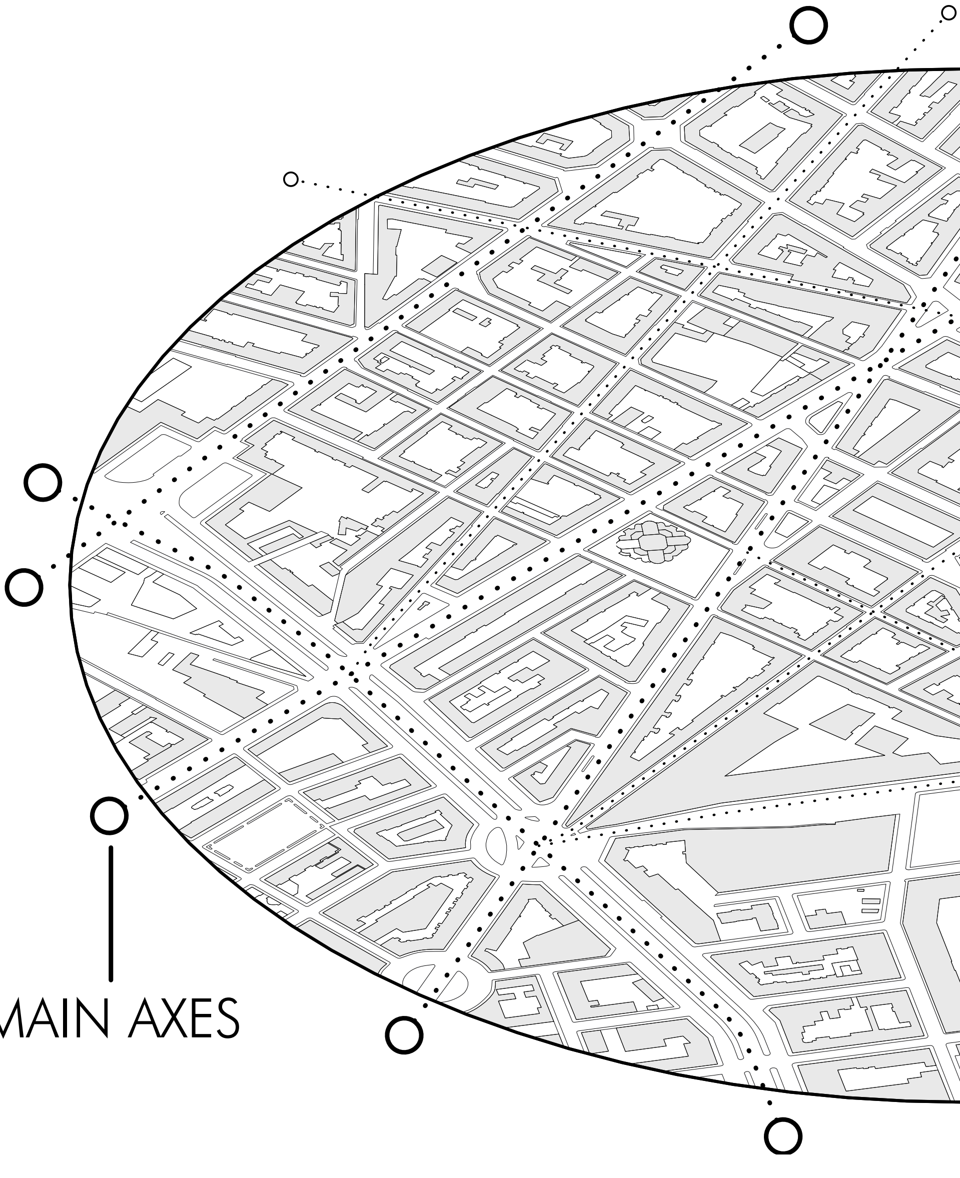
For several years the bench-top collection reaches all the local markets of Turin, with the exception of Porta Palazzo. The counter bench collection is an active service since the end of 2003 with the aim of increasing the percentage of separate waste collection and making cleaning activities at the end of the market slimmer and faster.
In the local markets where the bench-based collection takes place, every morning the ecological operators deliver the bins for the separate collection of the organic fraction to the vendors and collect manually small light and medium-sized paper and plastic packaging; inside the square there is also a dedicated and manned area in which to store large packaging (wooden and polypropylene boxes, cardboard ...). The various fractions thus obtained and already widely separated are finally collected by the compactors and subsequently sent to enhancement plants.
The service makes it possible to recycle 90% of the waste produced and, at the end of the market, allows Amiat to clean the sales area in less time and with better results.

Each local market of the city of Turin mainly produces organic waste and packaging waste, large or small. The prevailing materials are the wood of the boxes, the cardboard, the plastic. Overall, over a year, over 5,000 tons of differentiated collection of packaging coming from local markets: of these, at least half are wood waste. In fact, in the last three years, that is since 2008, the collection amounted to 2,500 tons of wood waste coming from the markets (specifically, 3,054 tons of wood collected in 2008, 2,582 in 2009 and 2,438 tons in 2010 - but for the latter data from the Christmas market are missing). These results are obtained without the use of road bins (all eliminated, in the market areas, to encourage separate collection and avoid malpractice) and thanks to the 130 operators of external companies that cover the 41 markets and which are activated en masse at end of the market day. In fact, Amiat has contracted the service for logistical needs, and remains the coordinating contact for operations.

9.5.1 Circular economy: further element of regeneration for Barriera di Milano

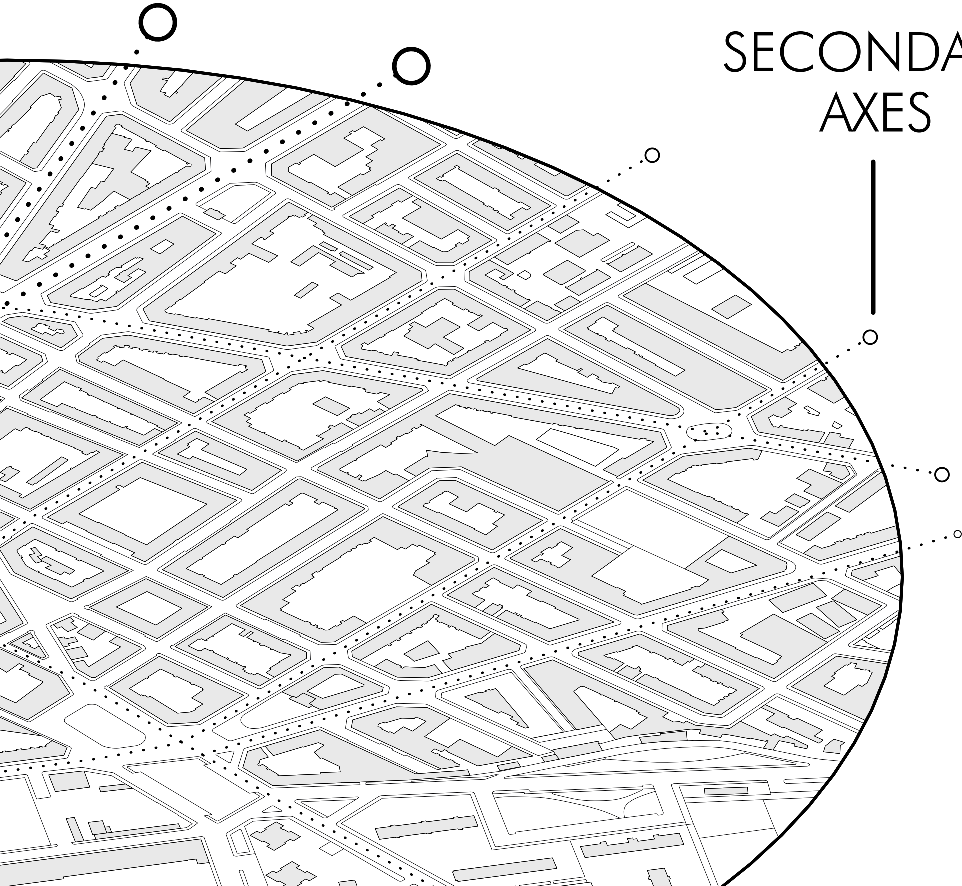
The concept of circular economy responds to the desire for sustainable growth, in the context of the growing pressure to which production and consumption subject global resources and the environment. So far the economy has worked with a "production-consumption-disposal" model, a linear model where every product is inexorably destined to come to "end of life". Precious materials are used to produce food, build houses and infrastructure, manufacture consumer goods or supply energy. When they have been fully exploited or no longer needed, these products are disposed of as waste. Increasing population and increasing wealth, however, push demand for (scarce) resources more than ever before and lead to environmental degradation. The prices of metals and minerals, of fossil fuels, of food for humans and animals have risen, as well as clean water and fertile land. Nearly 15 tonnes of materials are used each year in the European Union, while every EU citizen generates an average of over 4.5 tonnes of waste per year, almost half of which is disposed of in landfills. Linear economy, which relies solely on the exploitation of resources, is no longer a viable option. The transition to a circular economy shifts the focus on reusing, adjusting, renovating and recycling existing materials and products. What was normally considered "waste" can be transformed into a resource.

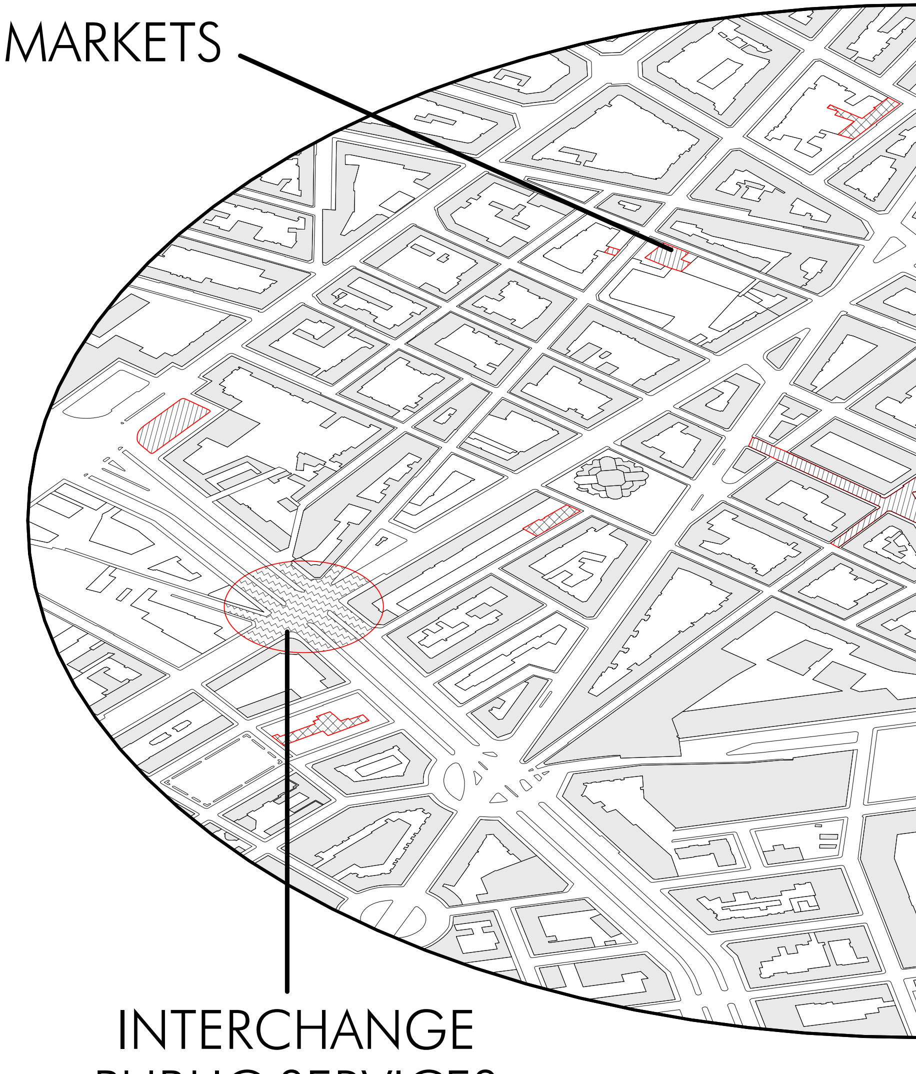
How can a virtuous circular economy be started within the Foroni market? Waste is the starting point. As described in the previous pages, the city markets are large producers of municipal waste: in particular organic waste - in the case of Piazza Foroni it is the most significant being a market with mainly fruit and vegetable and dairy counters and plastic waste due to packaging and crates for transport. So we need to intercept these two flows by limiting their movements and reusing them within the urban perimeter. Nowadays waste carries daily long journeys, on average 35km, this is due to the fact that for regulations in Italy waste treatment centers are positioned outside the city perimeter. In other countries of the world this does not happen, particularly in northern Europe - known to all for the foresight and virtuosity in the disposal of waste - it does not happen.

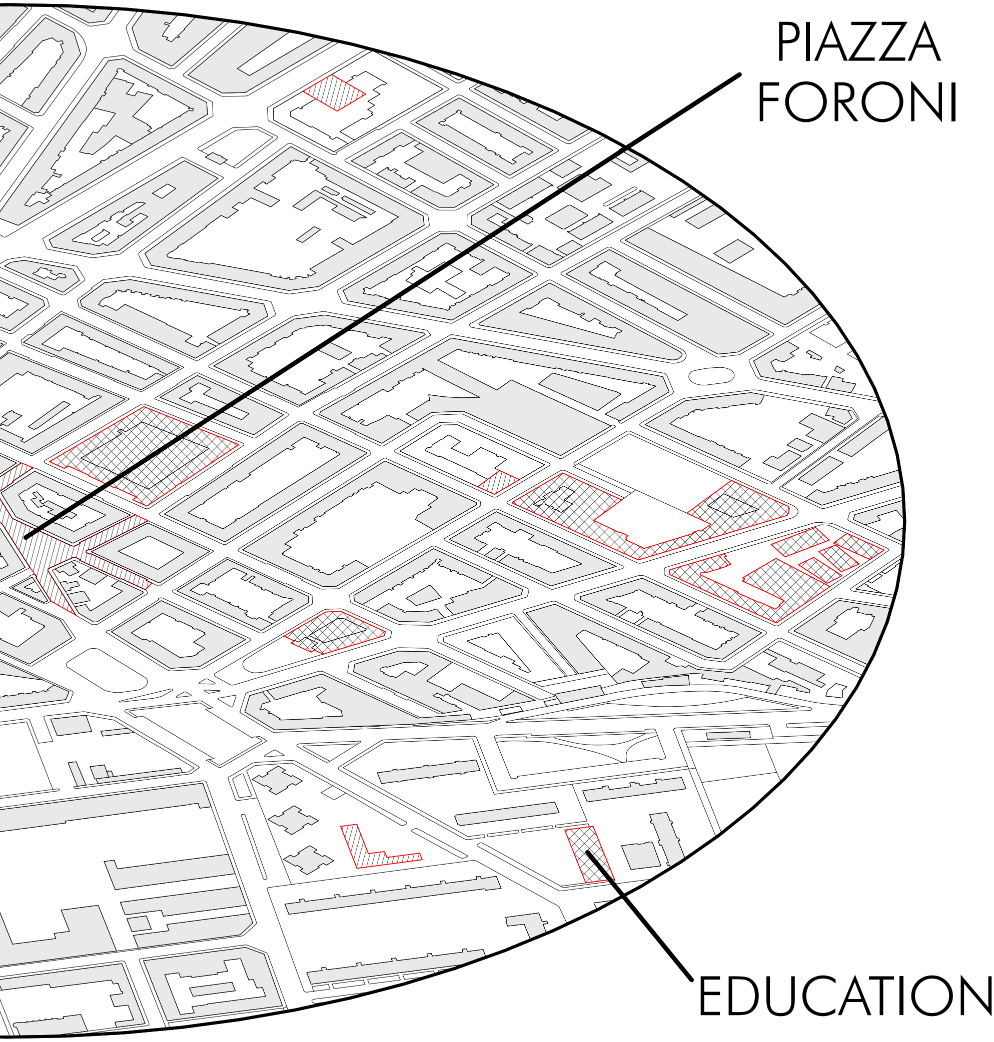


MAIN AXES

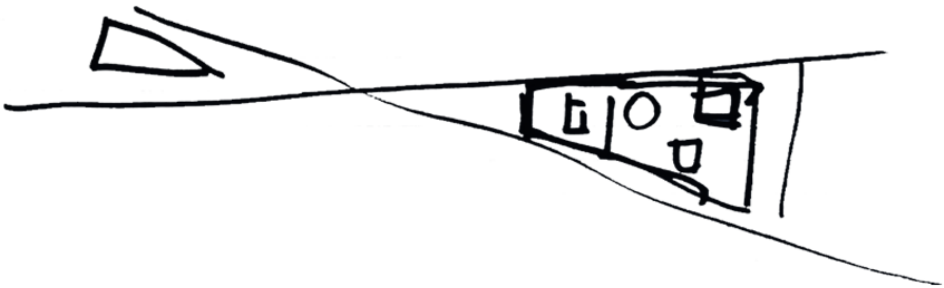
SECONDARY AXES

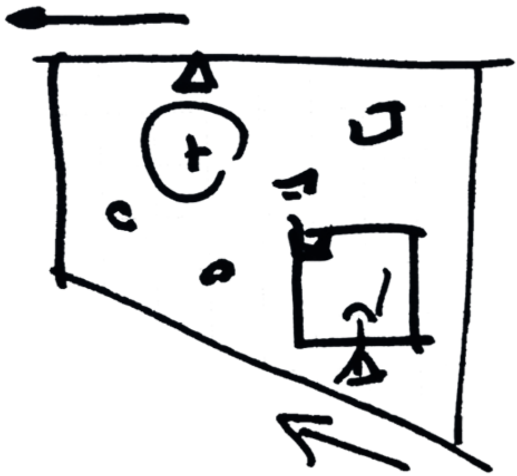


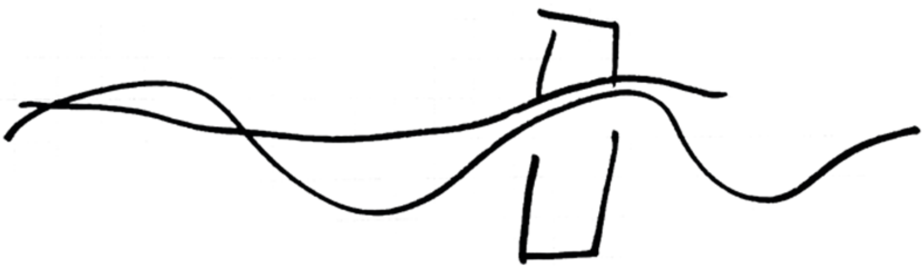

MARKETS
INTERCHANGE
PUBLIC SERVICES

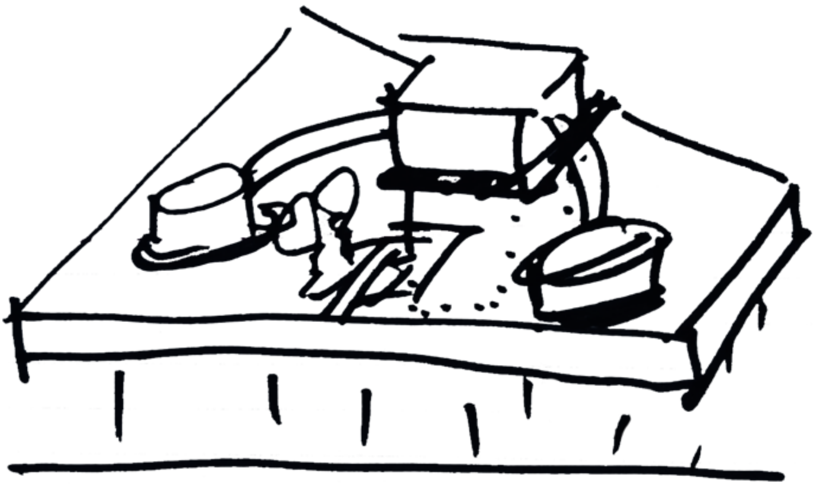

PIAZZA
FORONI
EDUCATION

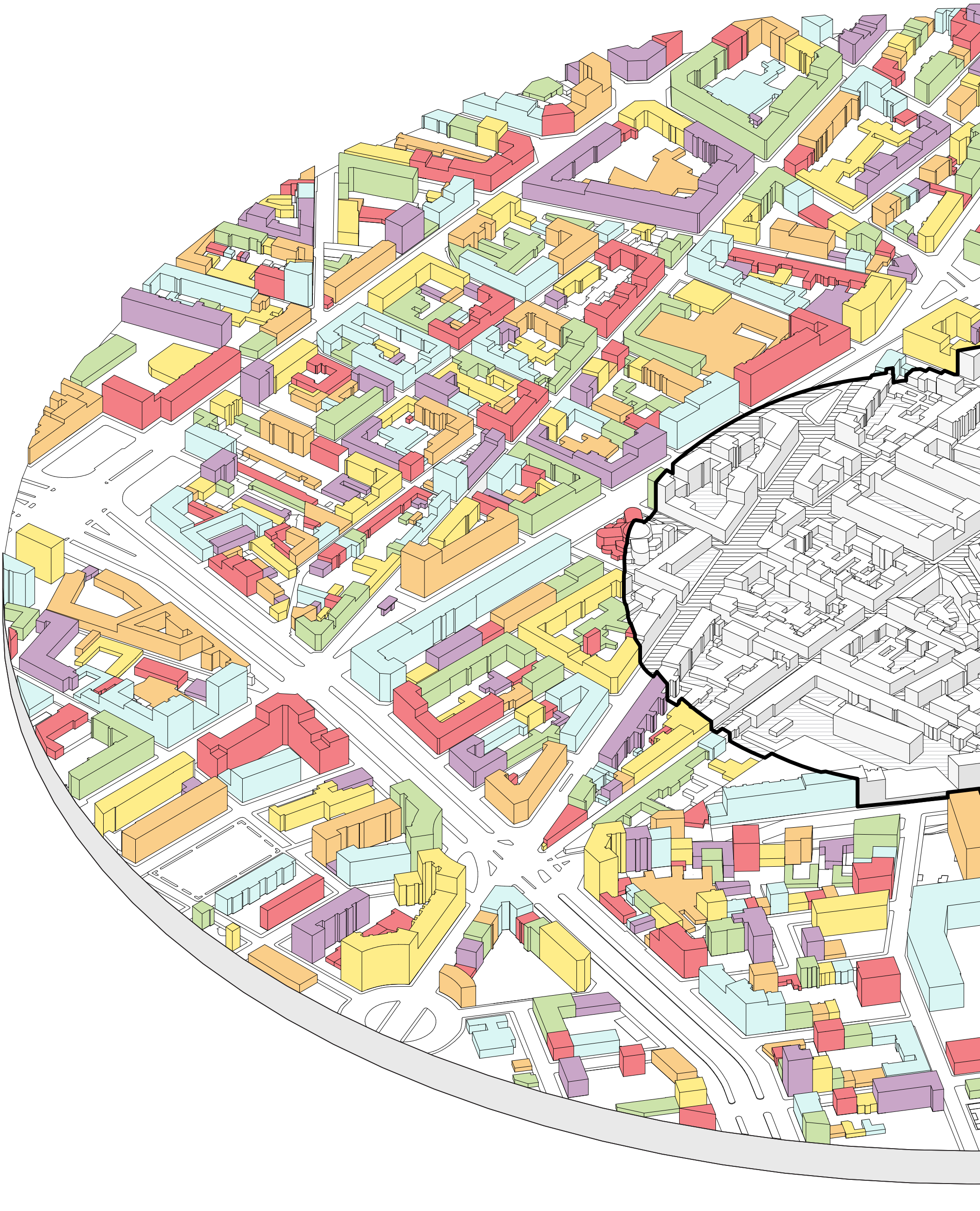

GREEN
AREAS

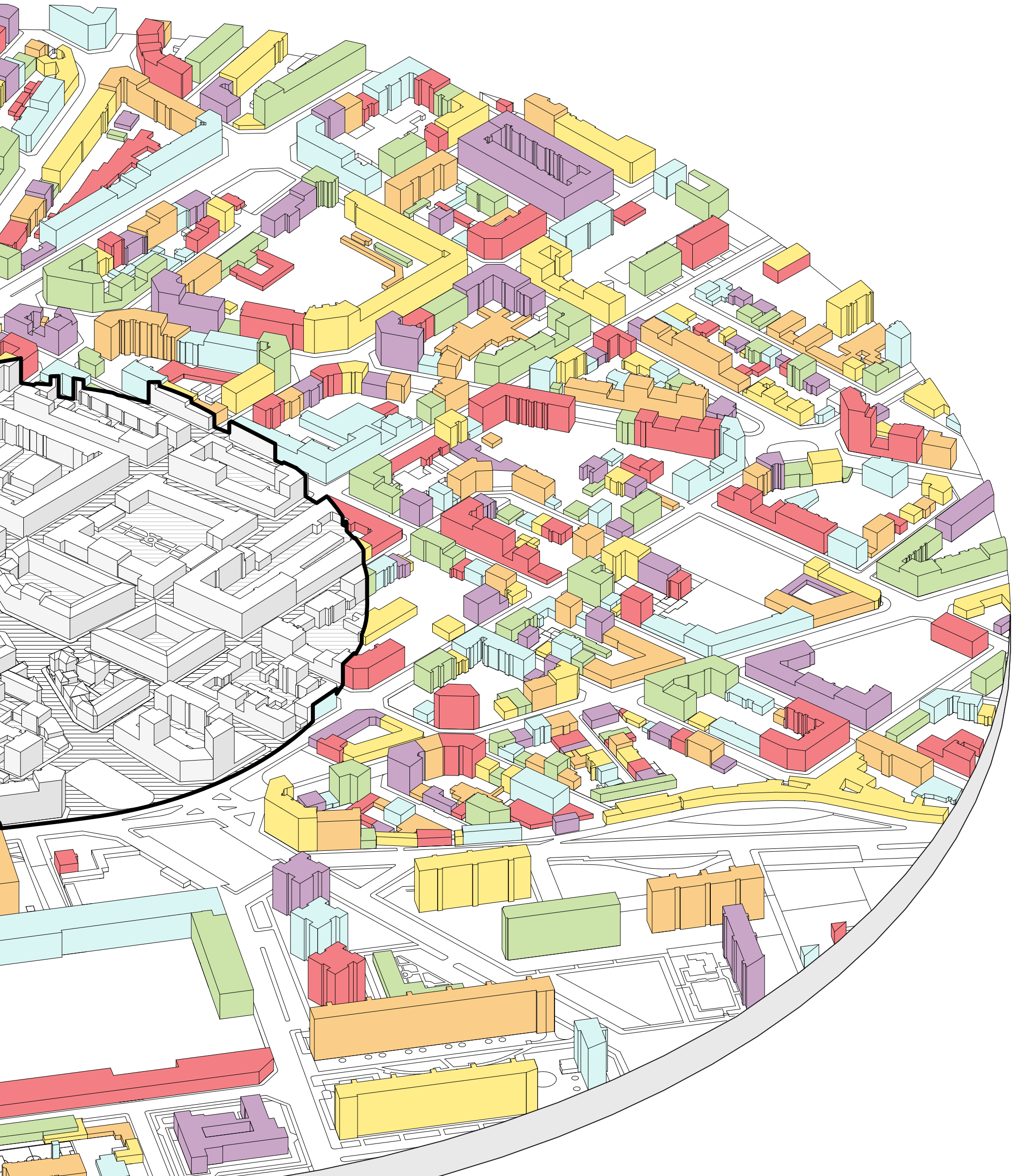


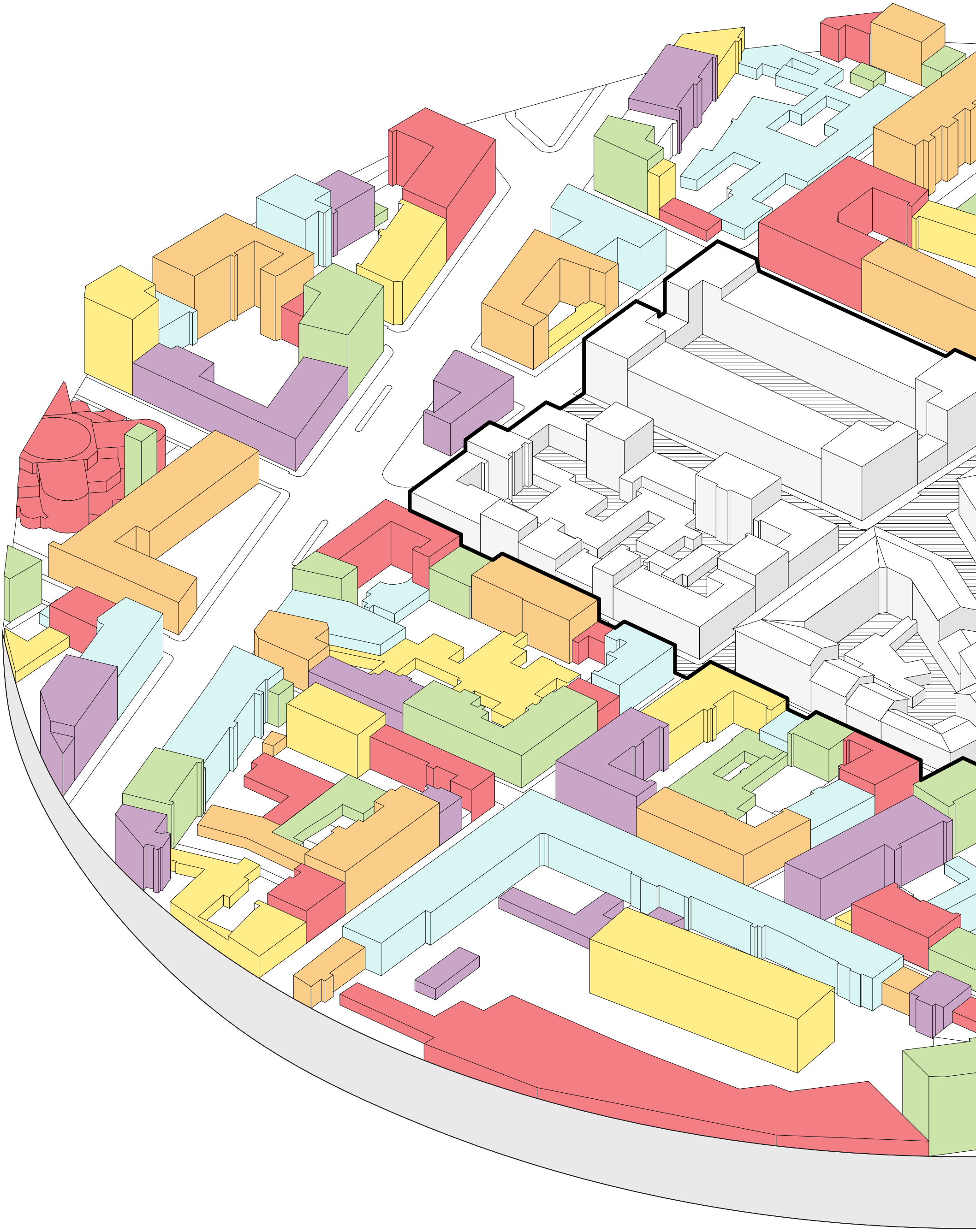


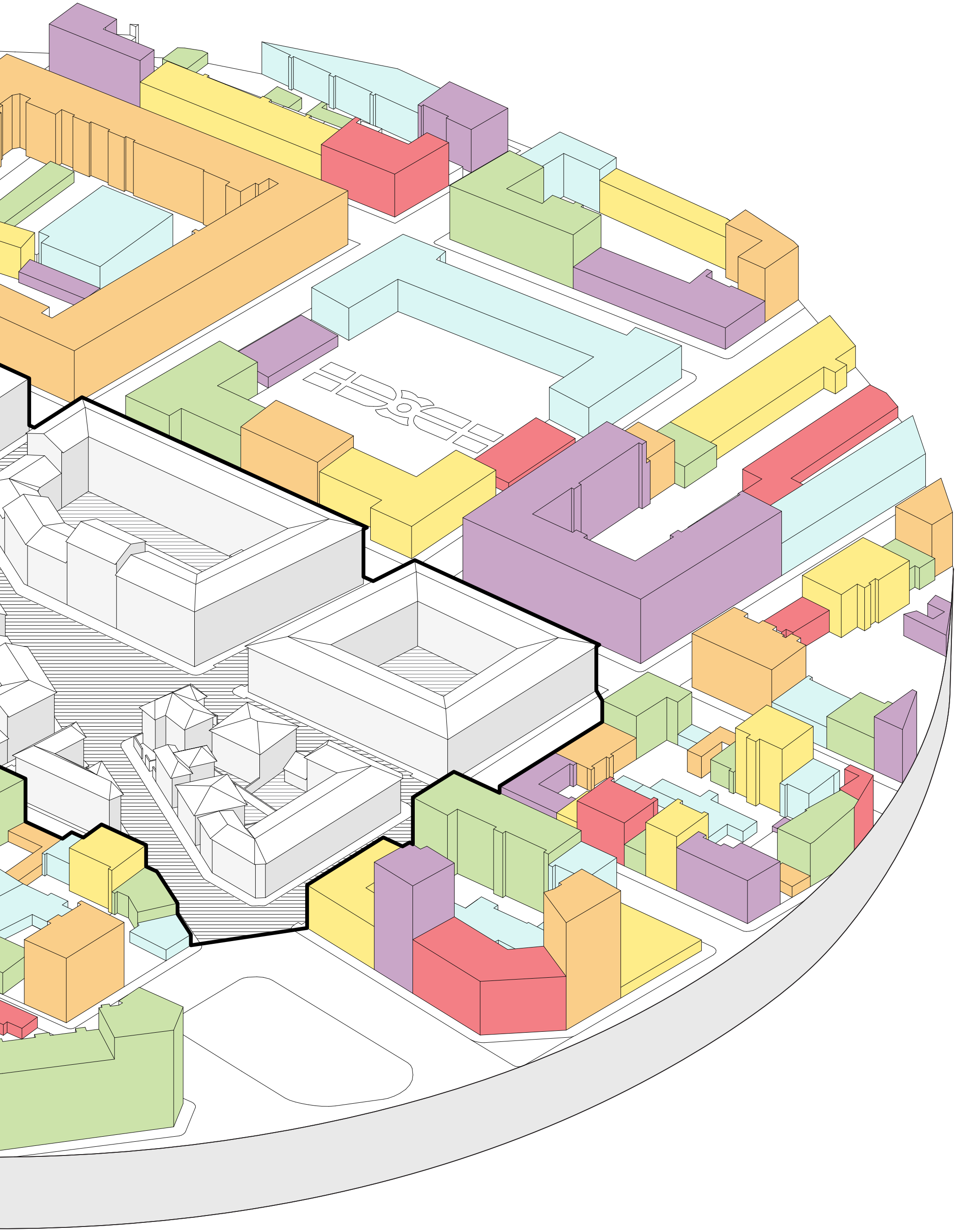


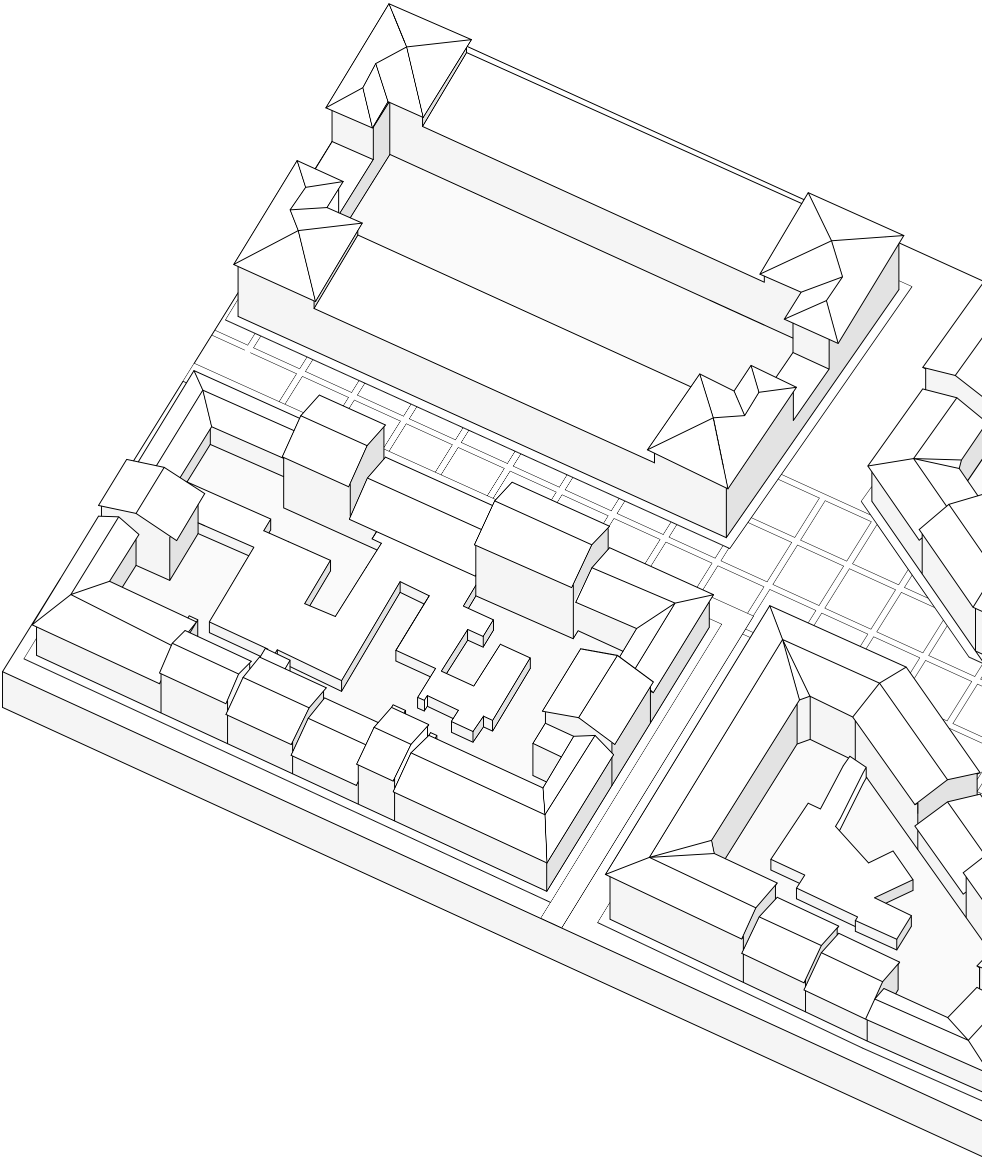




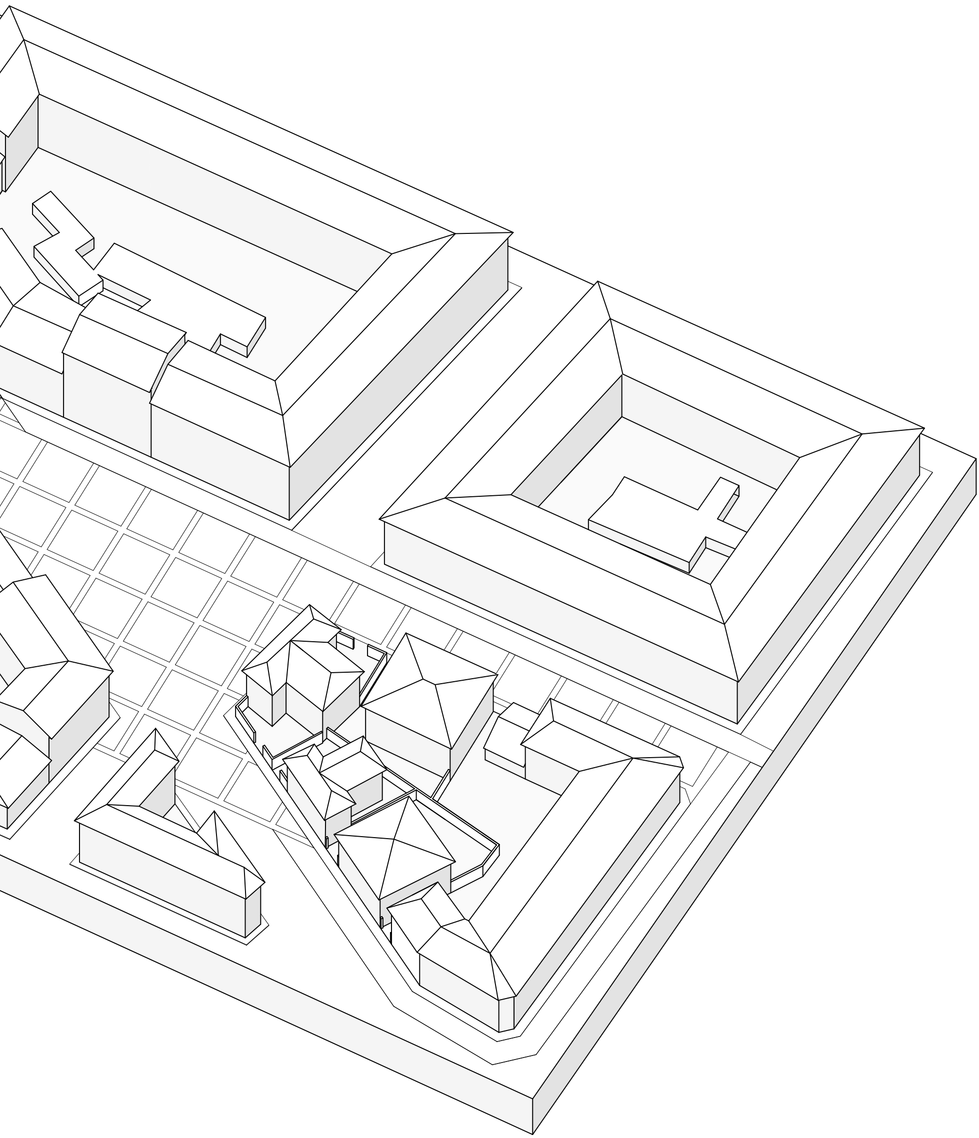


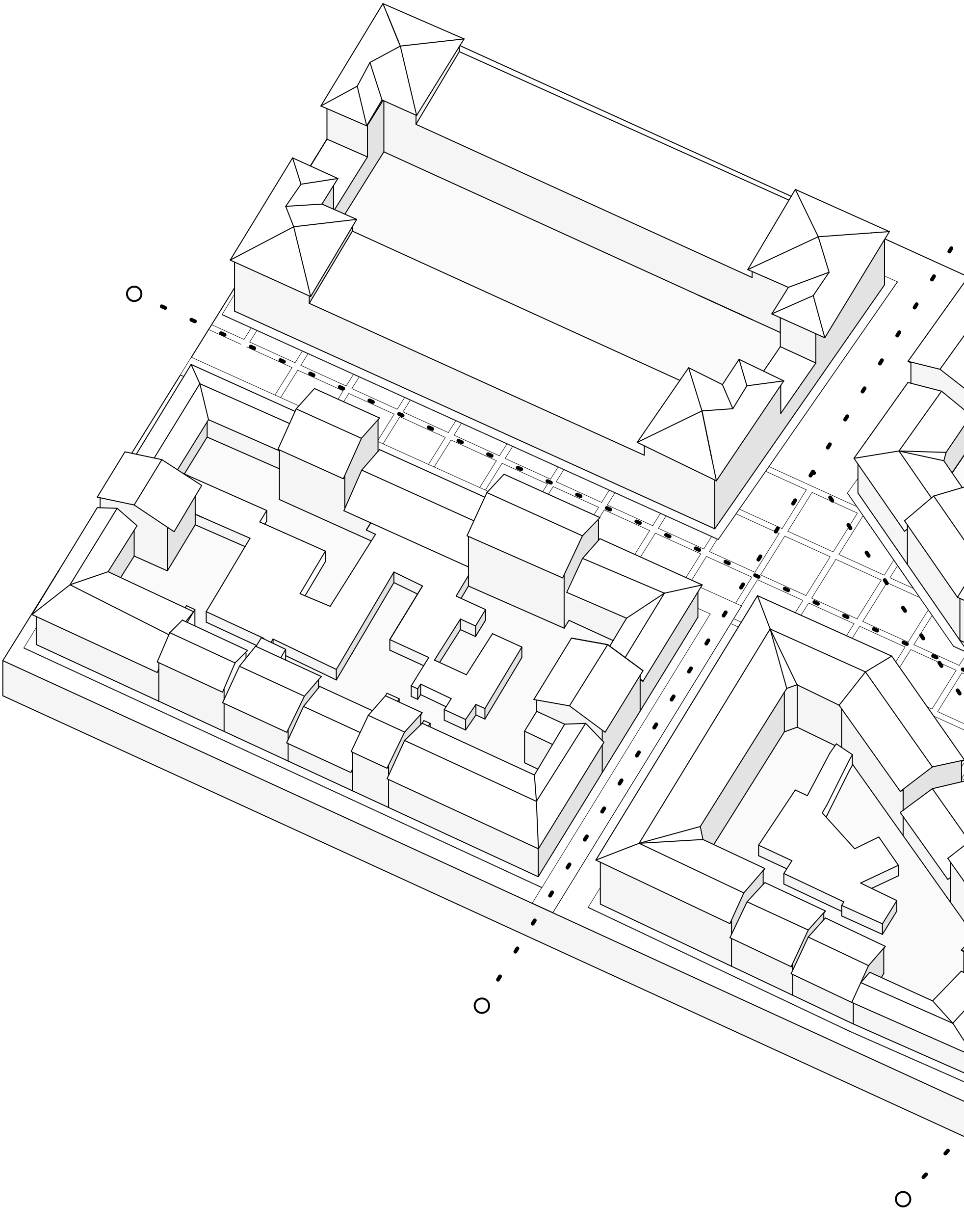




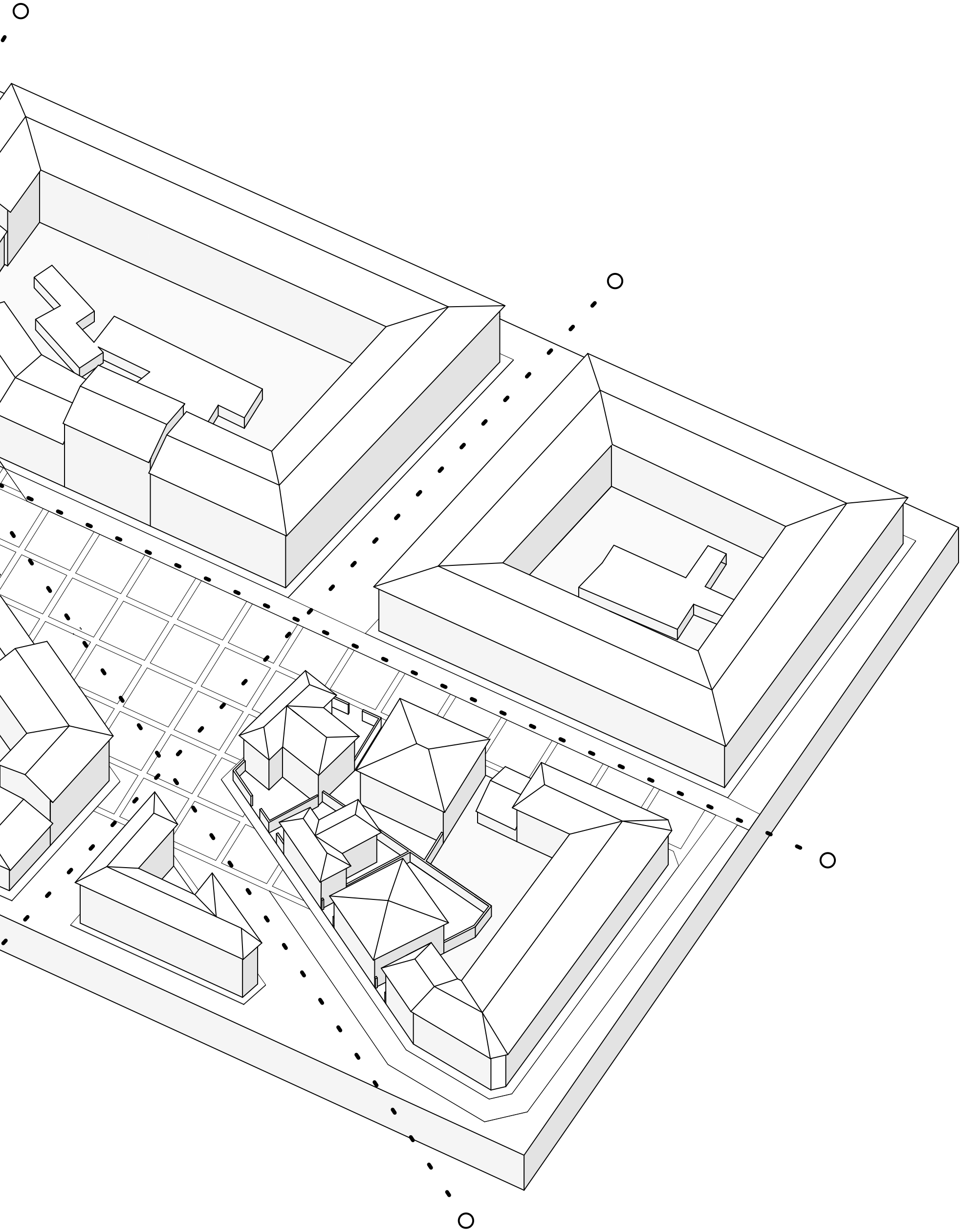


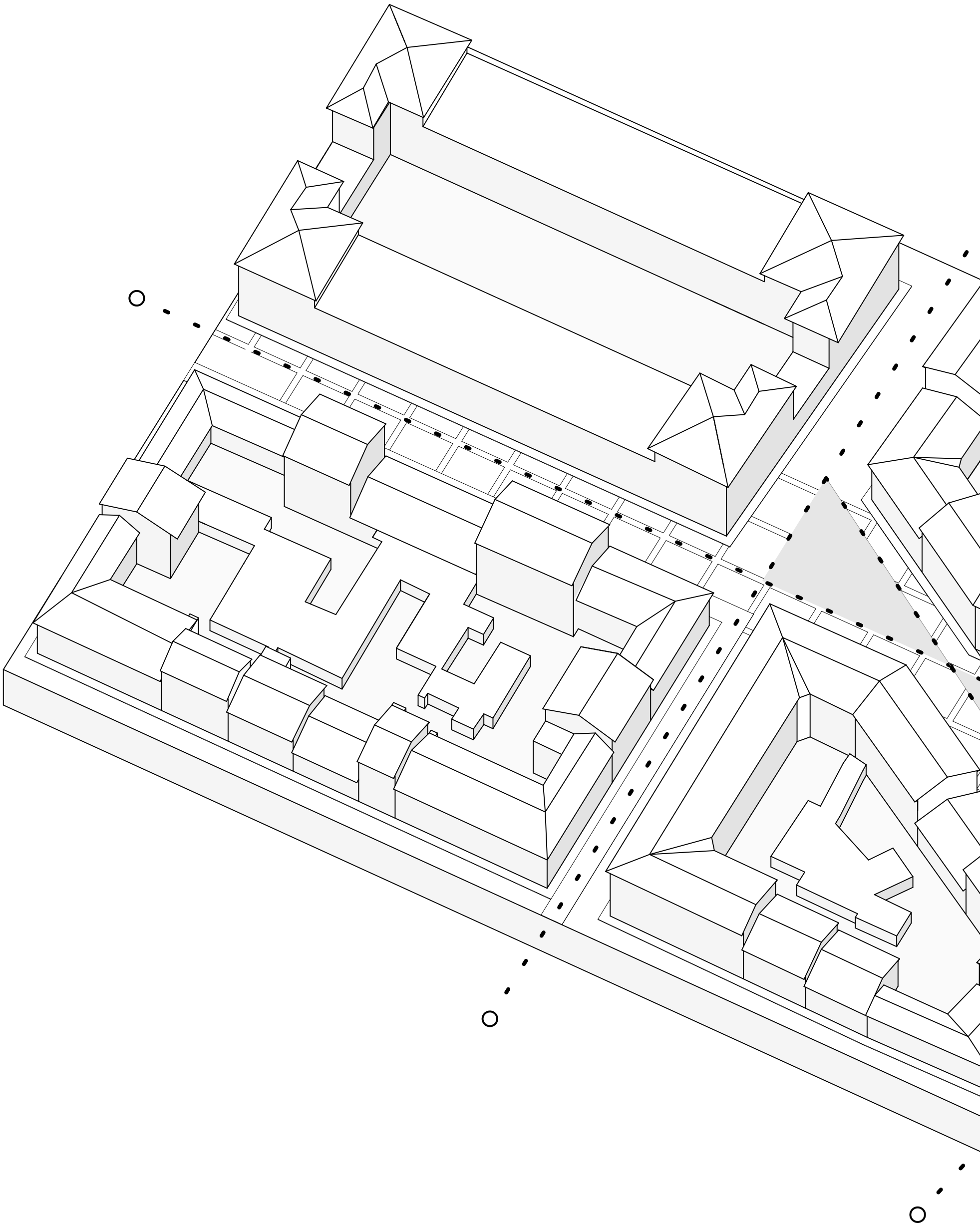
CONCEPT



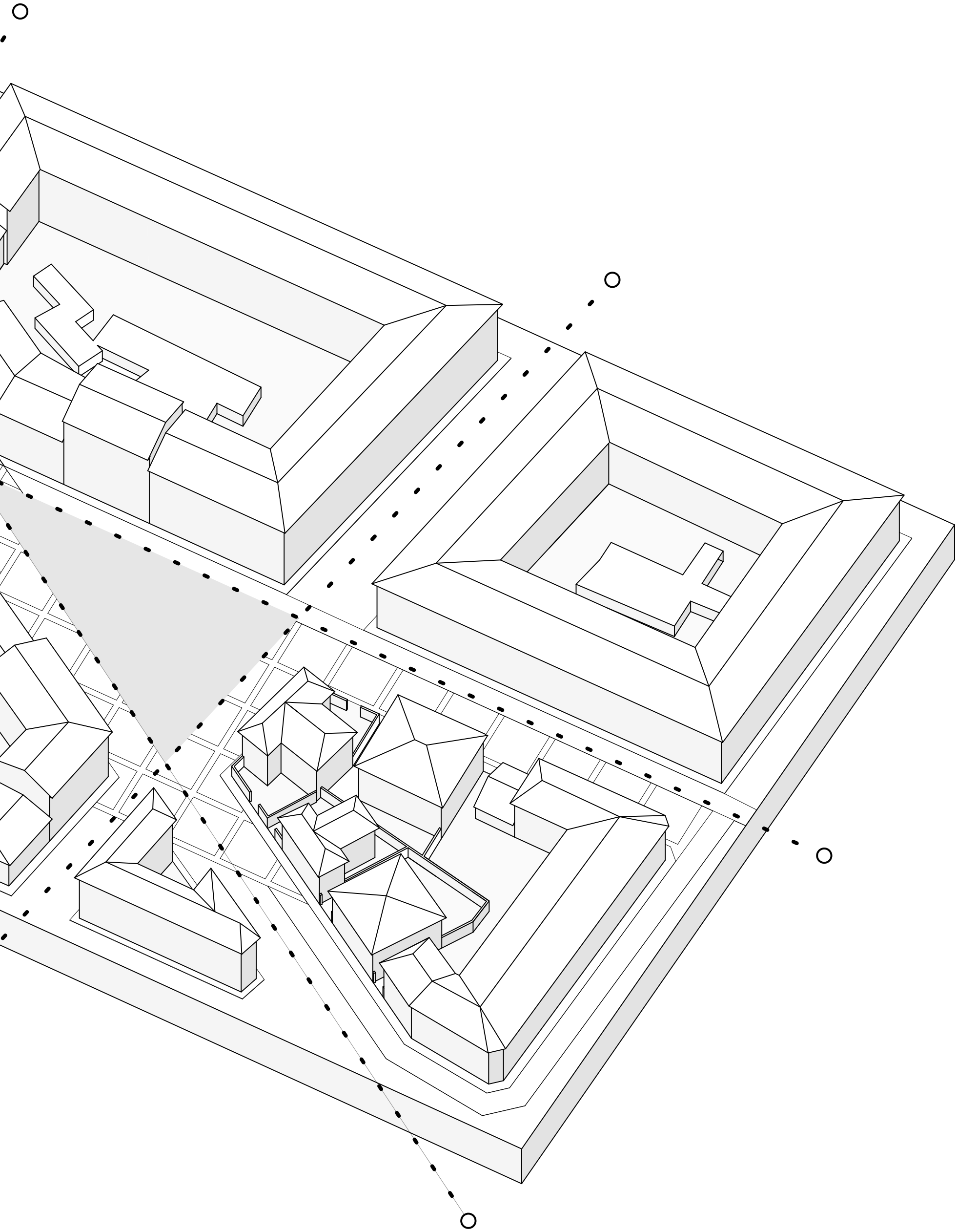


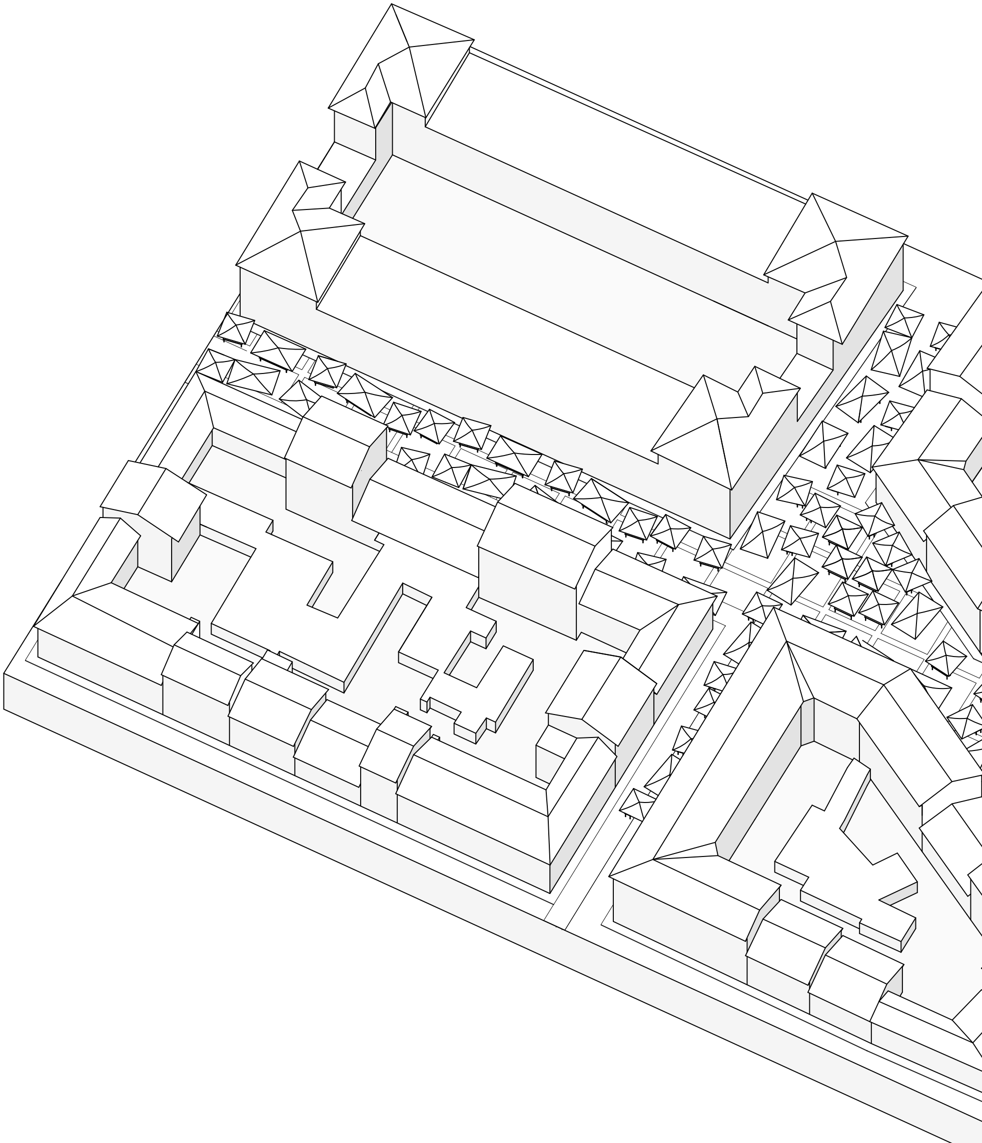
MAIN AXES



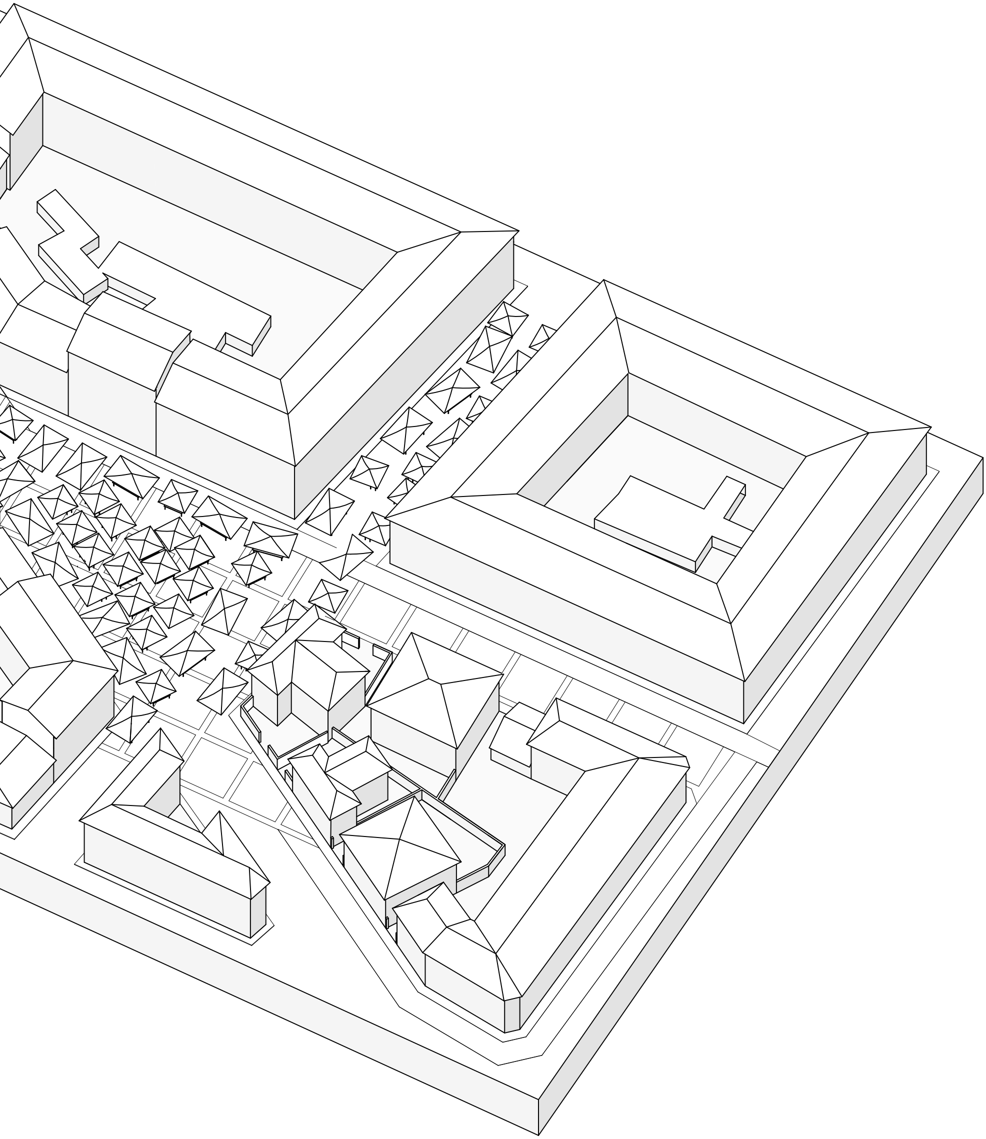


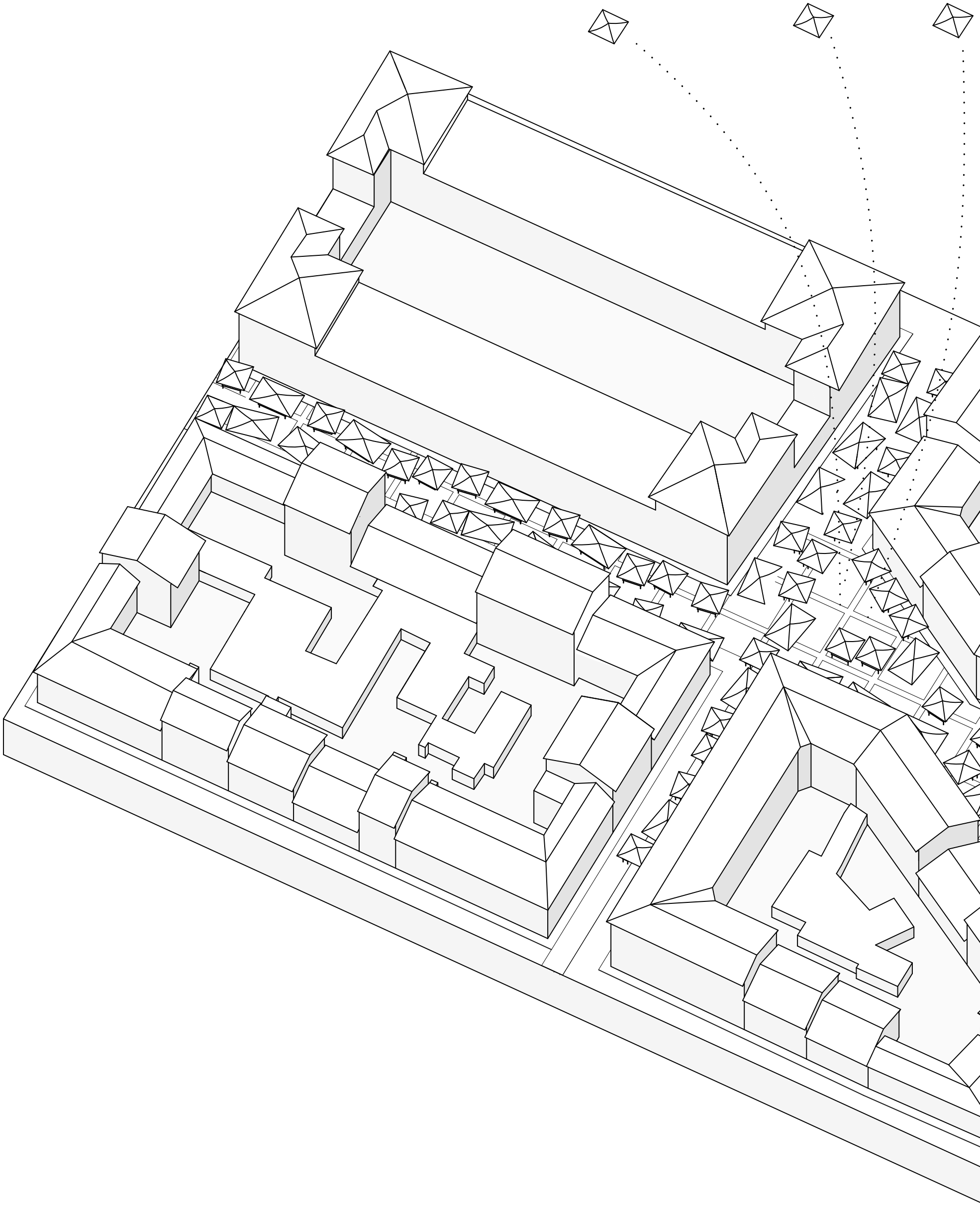
AXIS INTERSECTION



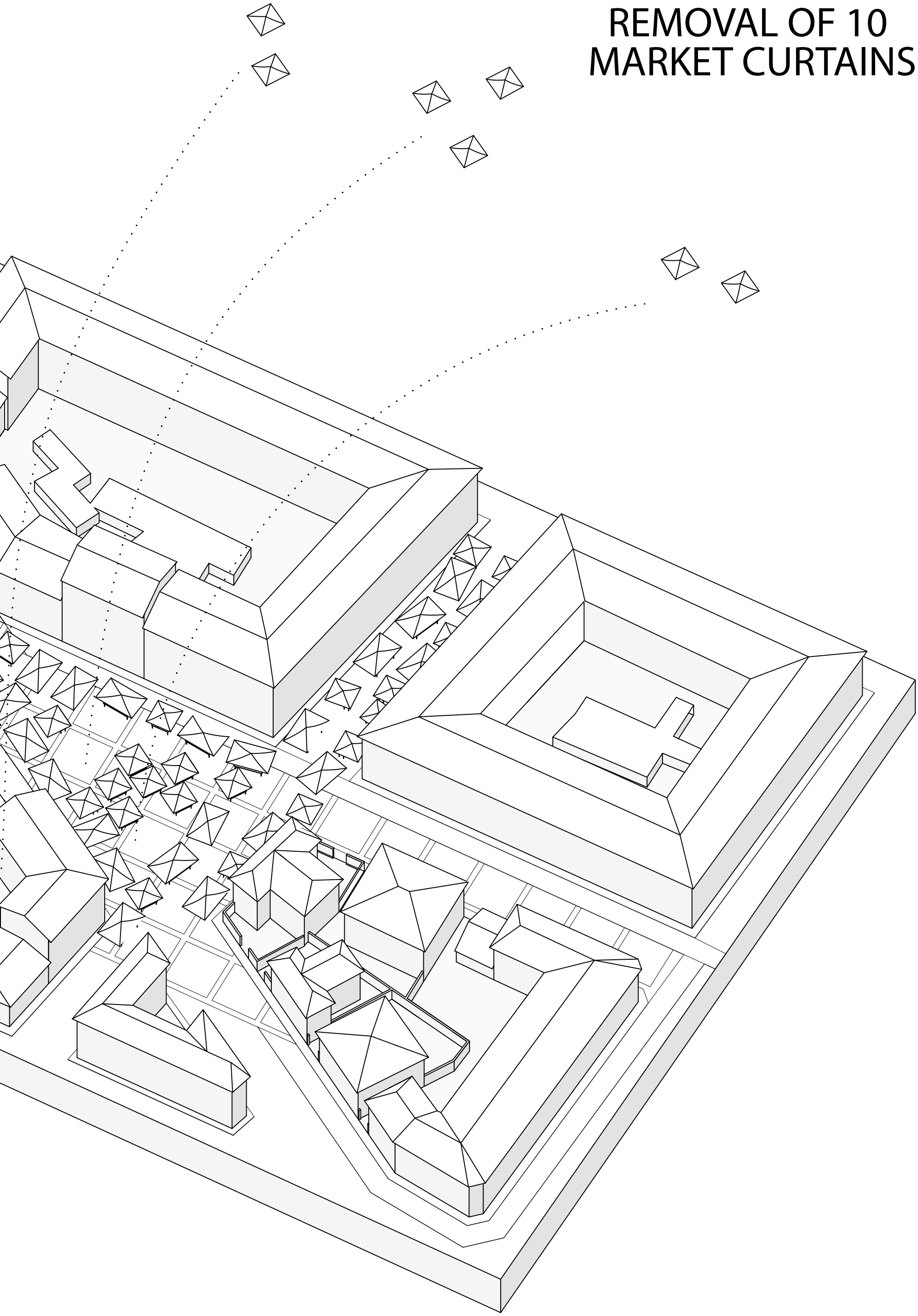


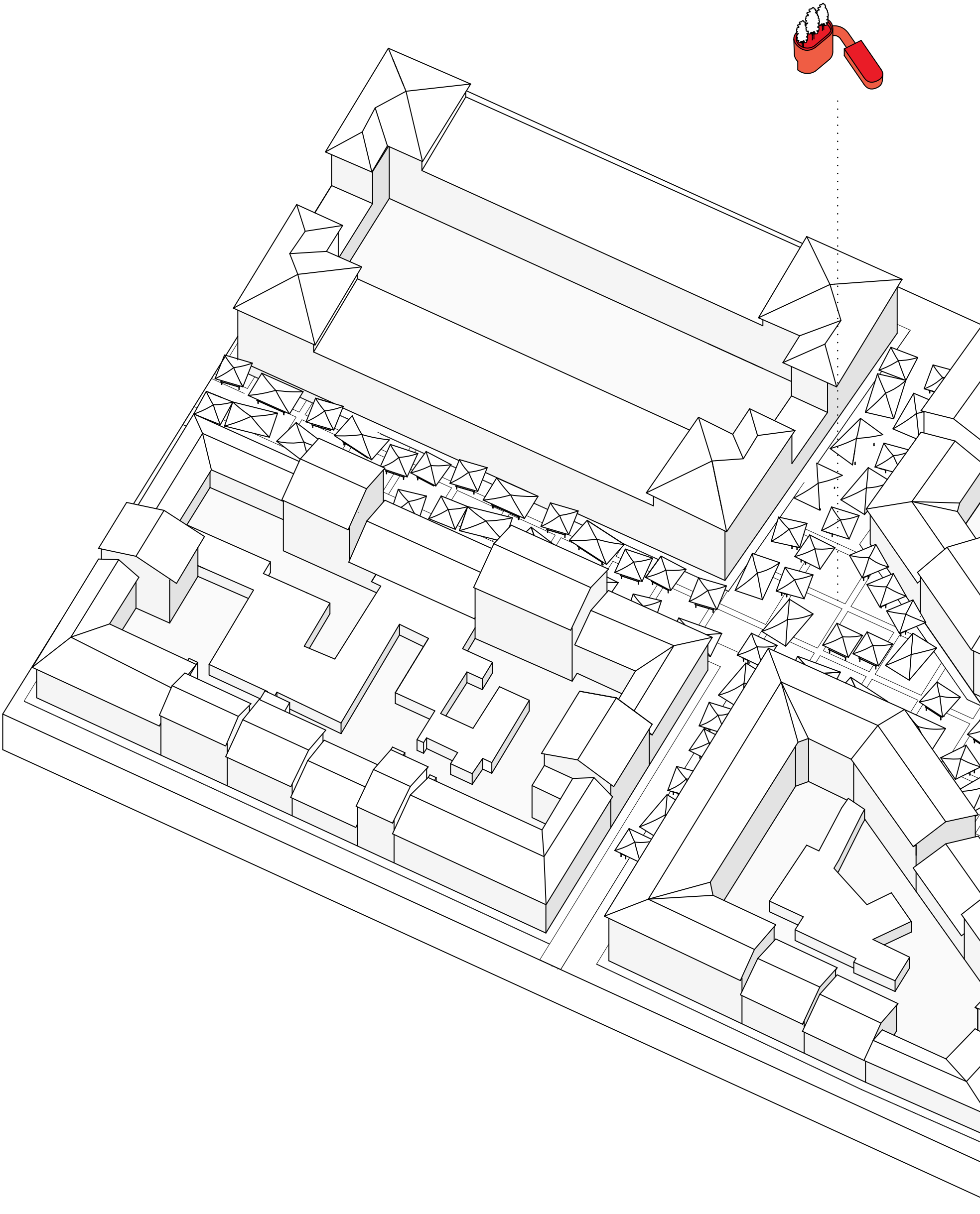
MARKET CURTAINS



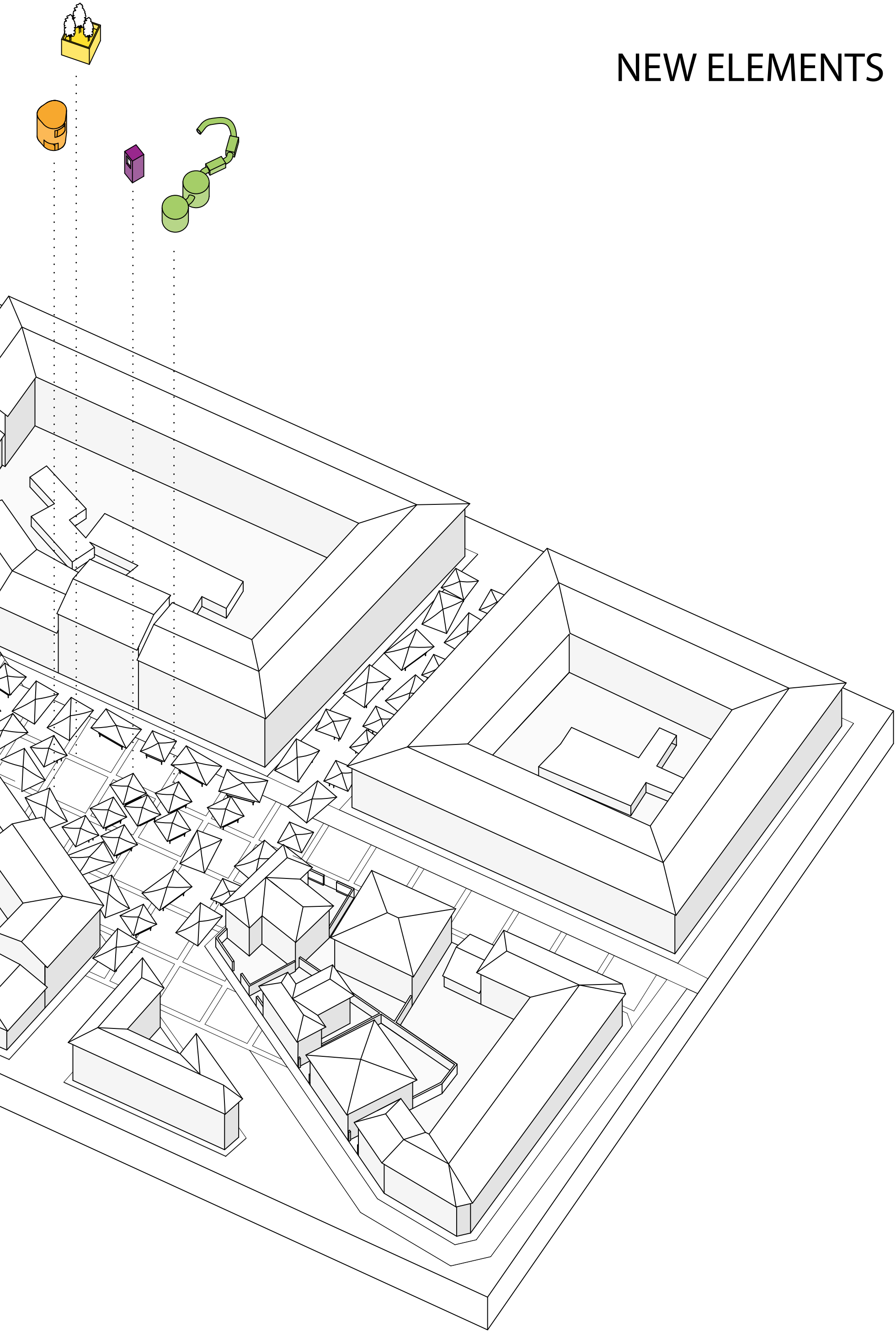


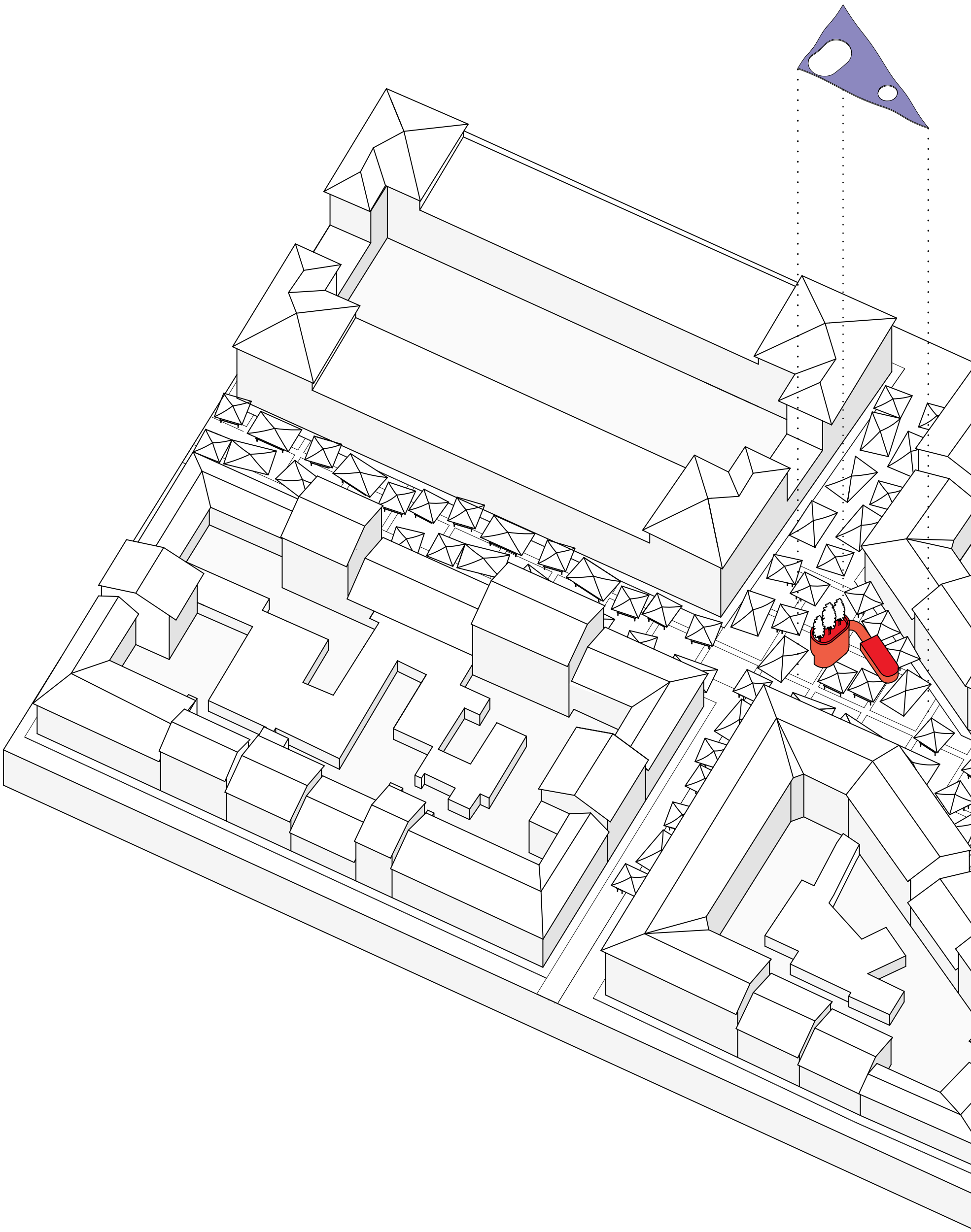
REMOVAL OF 10 MARKET CURTAINS



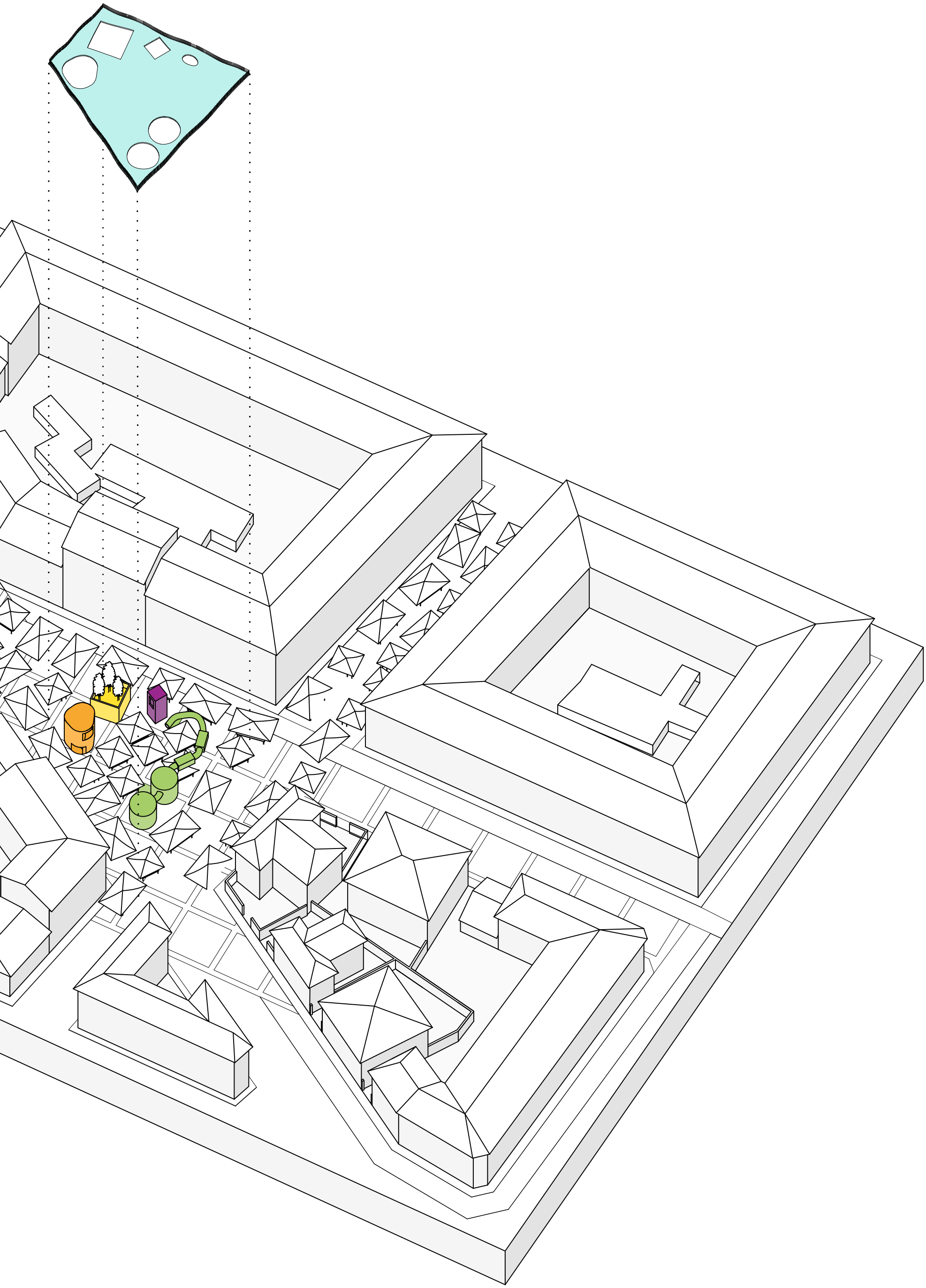


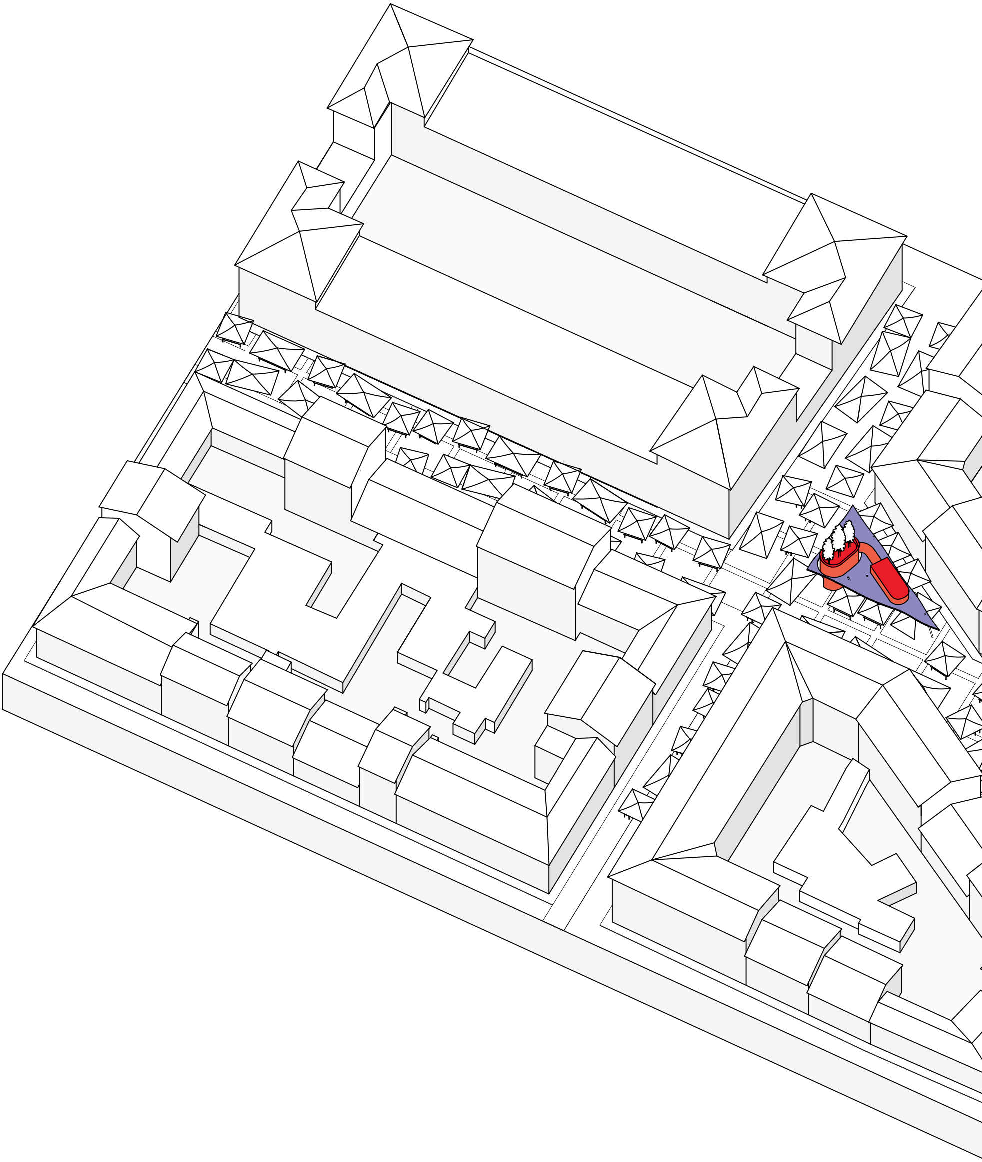
NEW ELEMENTS



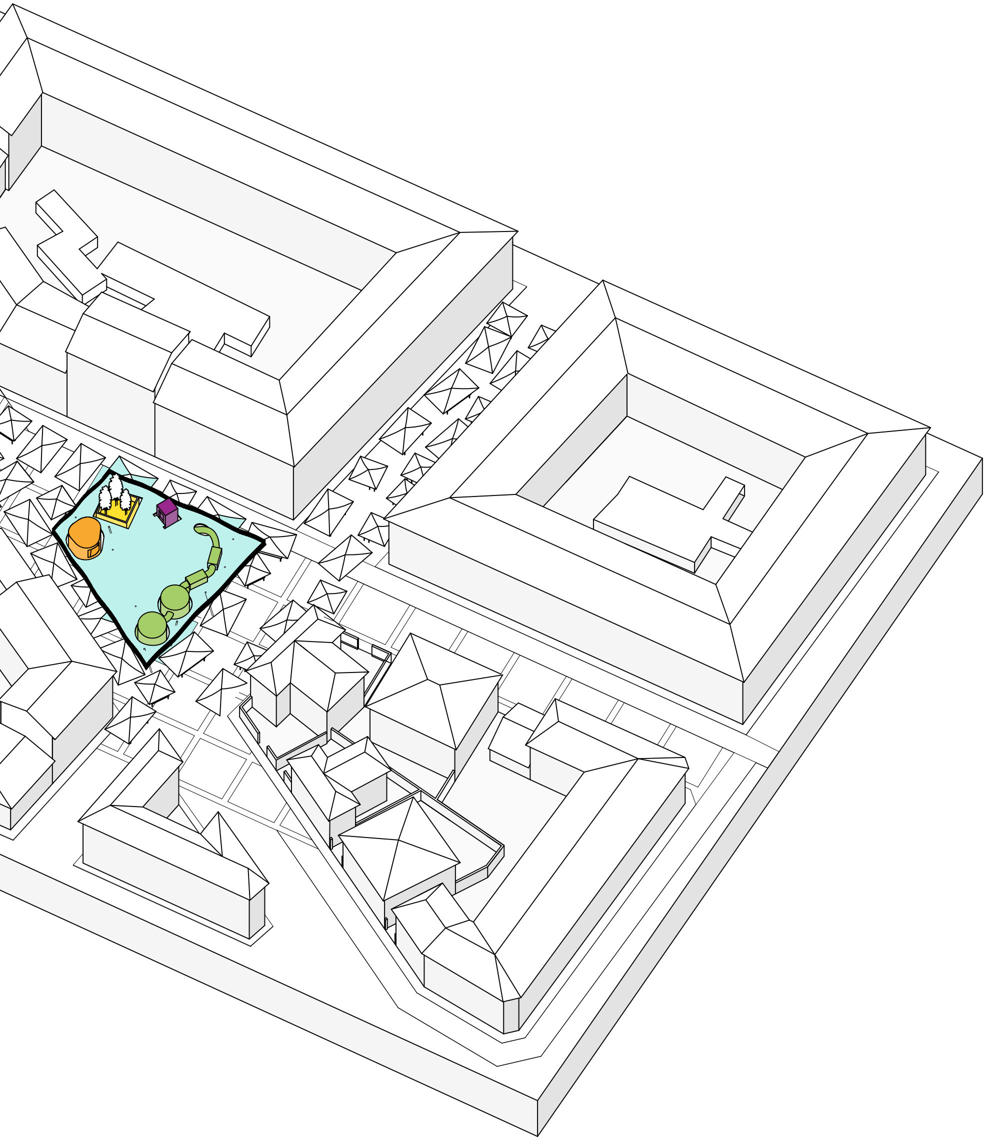


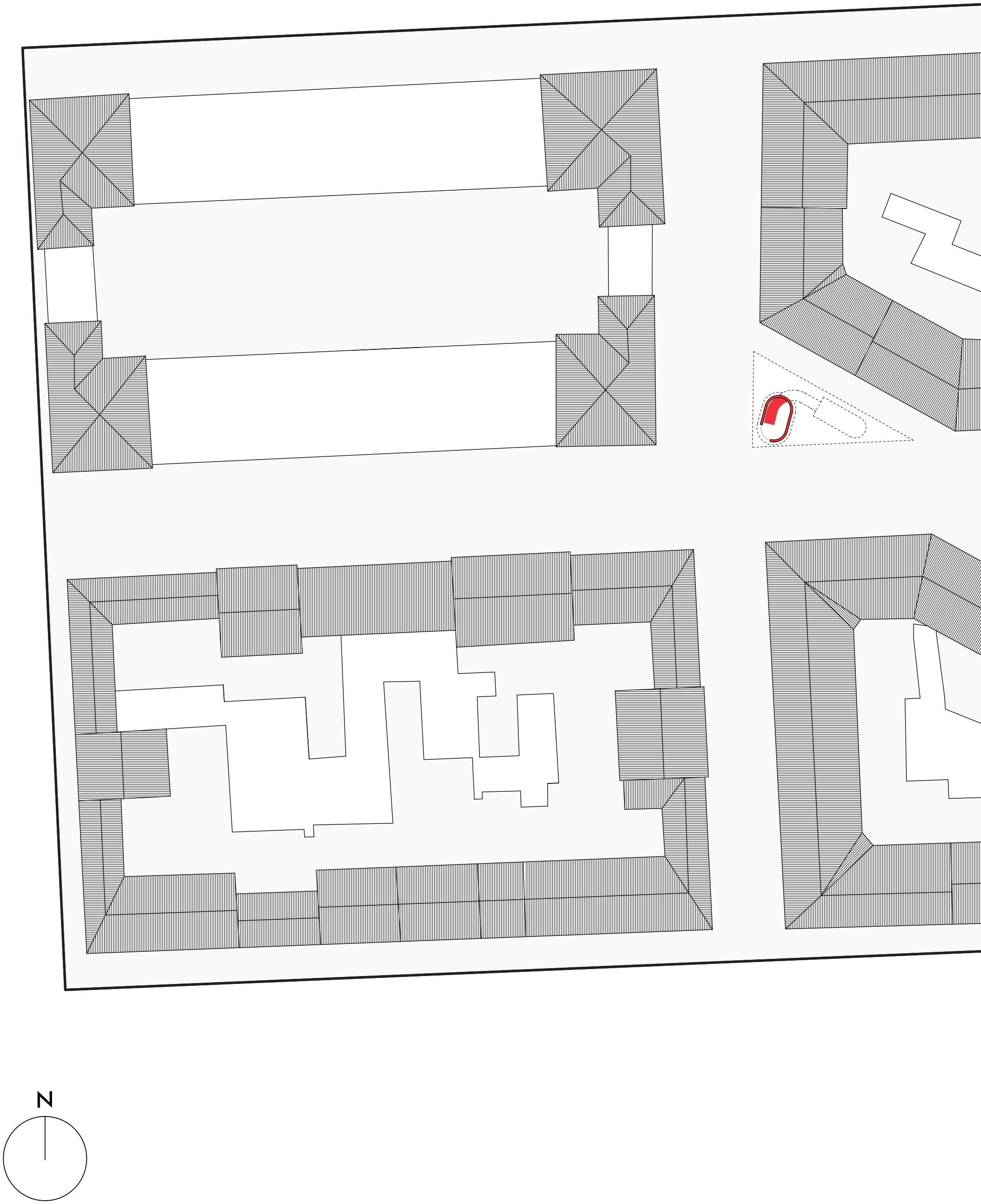
NEW ROOF COVERINGS





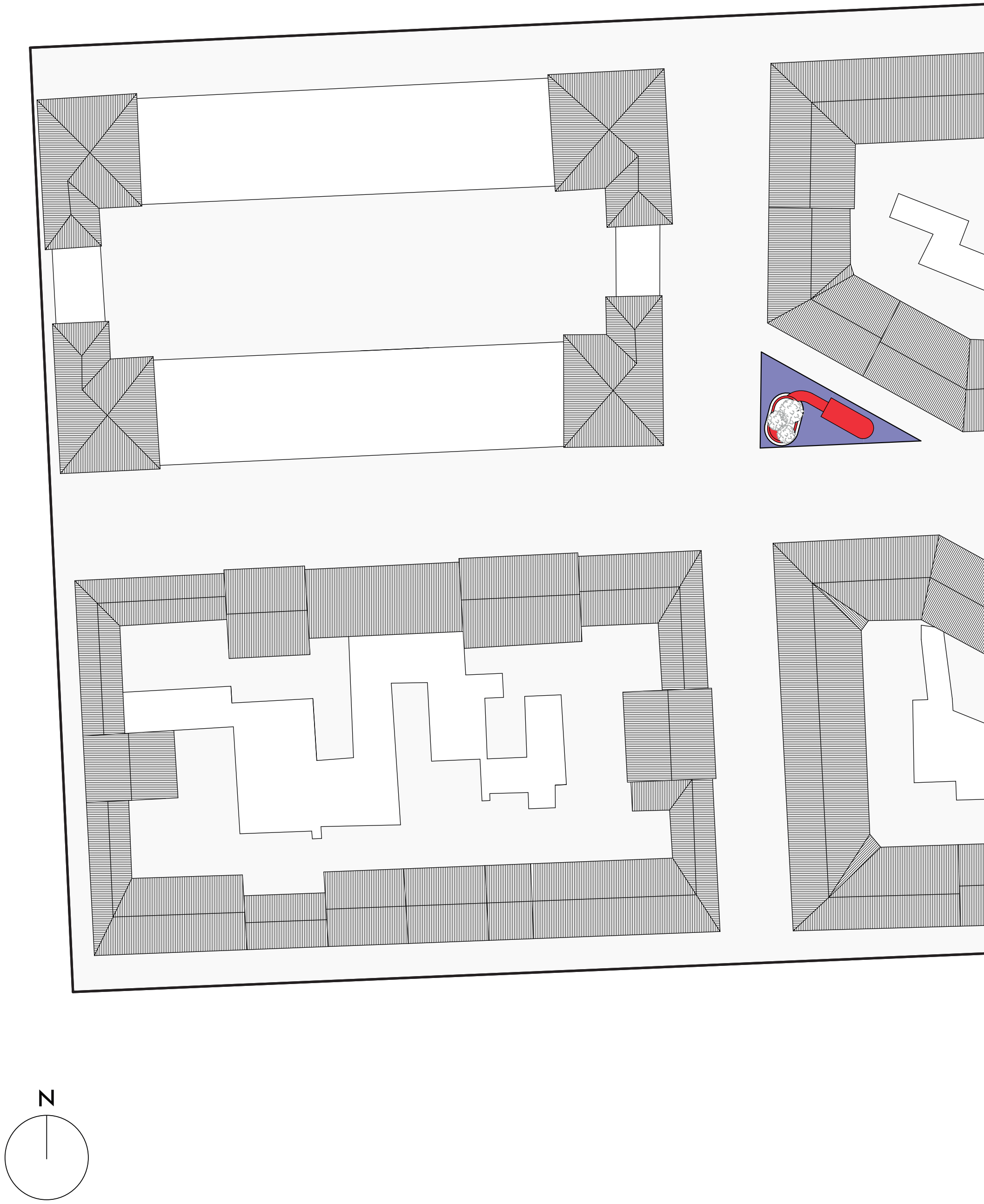
NEW PIAZZA FORONI

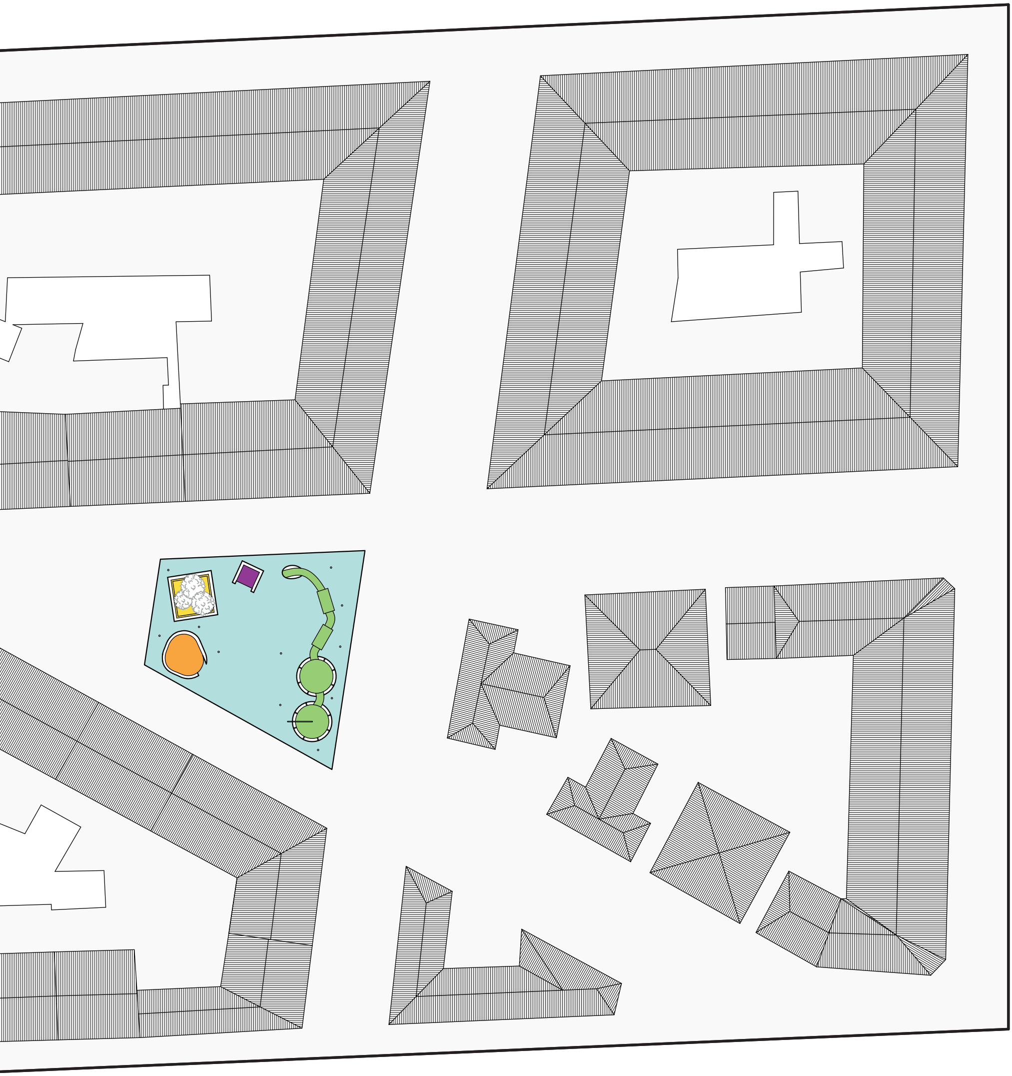


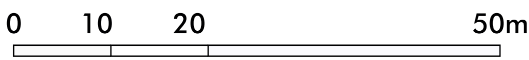


N


0
10
20
50m


N




0
10
20
50m

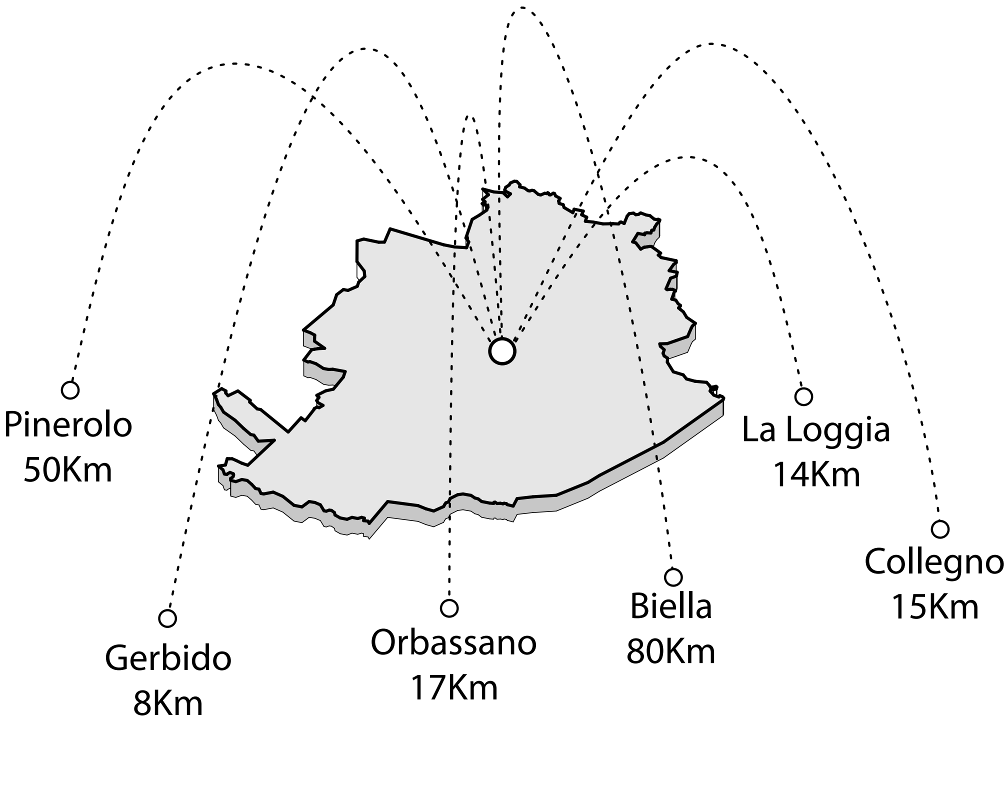
9.5.2 Why limit waste streams within the city?

As can be seen by comparing the types of waste collection, the road and door to door, when the citizen finds himself having to live in close contact with the waste that produces tends to deal with it more conscientiously. As it should be. The method we are used to is: I go home with the organic trash bag, I find the bin closest to me and I throw it according to the type, and then? Where does that bag go? Only a few know in which treatment center will end after the special vehicle will have extracted from the urban bin. In the case of Turin, that bag of organic waste will end up in the ACEA treatment center in Pinerolo (52km away) where there is a large-scale anaerobic digester able to dispose of a good percentage of the city's staff. And if instead of having a single large center, located a kilometer away, we had many but small? District-wide anaerobic digester, sized according to needs and utilities. In that case, the citizen could see firsthand what happens to his refusal, how it is transformed and reused, because as one of the cornerstones of the circular economy teaches us: waste is not a waste but a resource.
And in the case of plastic waste? The treatment of plastic waste - as I was able to see in person, during the research phase, in the center of Montello Spa (BG) - is a process that requires a multitude of special machines, large spaces and produces odorous odors. Completely dealing with plastic waste within the city would be a utopia. This does not mean that there are no methods in which one can act. Think of plastic waste: most of the objects we throw are all kinds of packaging, we still live in the obsolete world of disposable waste. These packings have a characteristic, little mass and a lot of volume. This results in bins full of air and little plastic: trucks carrying plastic waste travel long distances carrying air. If these wastes were compressed directly on site, in the case of the Foroni market in the square, with special machinery capable of reducing the volume by 80%? This would result in a reduction of 80% of plastic waste movements with a reduction in CO_2 produced by vehicles and a saving in economic terms for the company in charge (and this would result in savings for the citizen, since in most cases company is public) due to reduced fuel supplies.

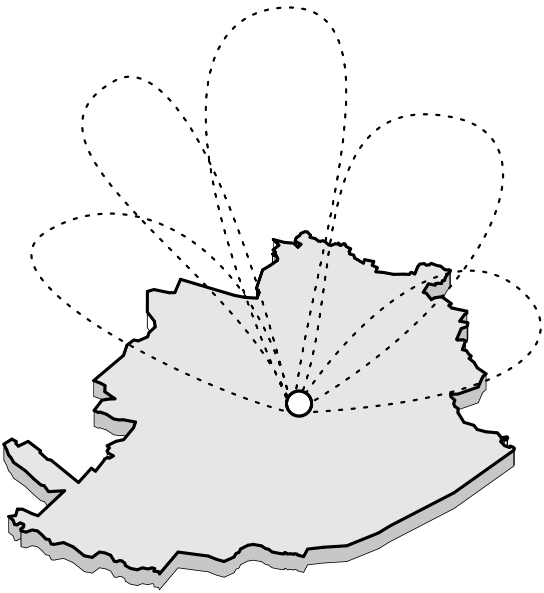
9.5.3 How can the circular economy be started?

The economy is a circle that starts from the bottom.
Making a transition from the current linear capitalist to the circular economy can be difficult, particularly in peripheral areas where there is a lower cultural level. Waste treatment is a method to start the circular economy starting from the public, an action that starts from the top down, starting with the institutions.
To start the circle in the private sector - from citizens to citizens - requires the presence of an intermediary actor able to act as an intermediary between those who want to get rid of a gap that can still be used by those who would like to reuse the gap.
Who has a box of pears bruised as he can get in touch with a producer of jams? And vice versa, how can a jams producer know who owns the damaged pears he wants to get rid of?
This task is entrusted with the *"Marketplace of the circular economy"*, an office located inside Piazza Foroni and in an online manner on all online platforms, able to put in communication and act as guarantor for circular transactions.

TURIN WASTE FLOWS LINEAR ECONOMY



TURIN WASTE FLOWS CIRCULAR ECONOMY



9.6 Circular Barriera

The urban regeneration intervention is aimed at transforming Piazza Foroni into a virtuous center for the treatment of urban waste. Currently the market branches on all the streets tangent to the square. Analyzing the main axes that are inserted within the area, in order to reduce the impact of the intervention to a minimum, it is necessary to act in the two zones of intersection, one in the east and the other in the west. The intervention is intended as an insertion of new blocks, and the removal of the least possible number of areas dedicated to the tents for the market, each block corresponding to a function and each of which is protected by a new coverage able to incorporate the existing market . Coverage as an added value of the market.

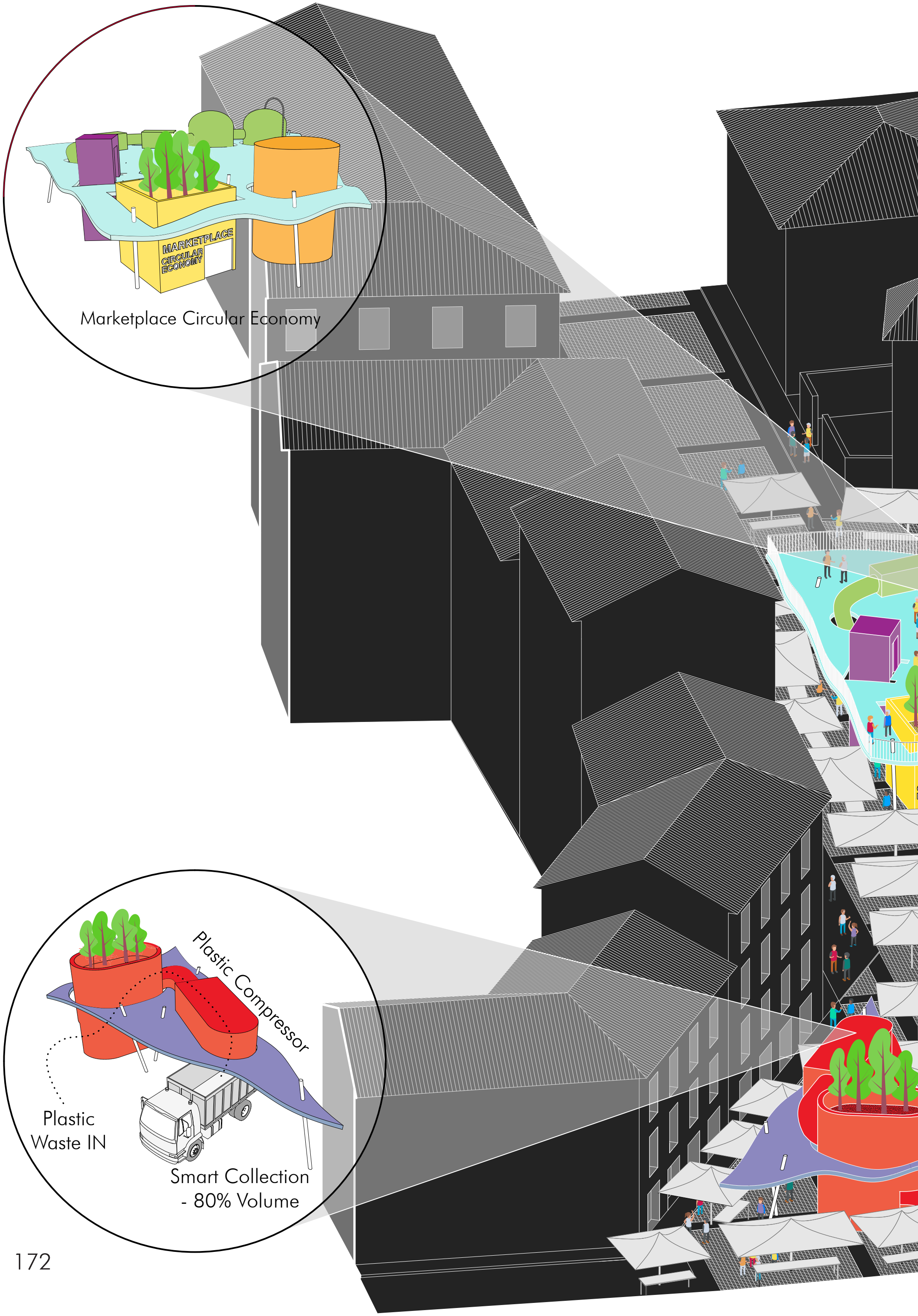
9.7.1 Piazza Foroni West: Urban Anaerobic Digester

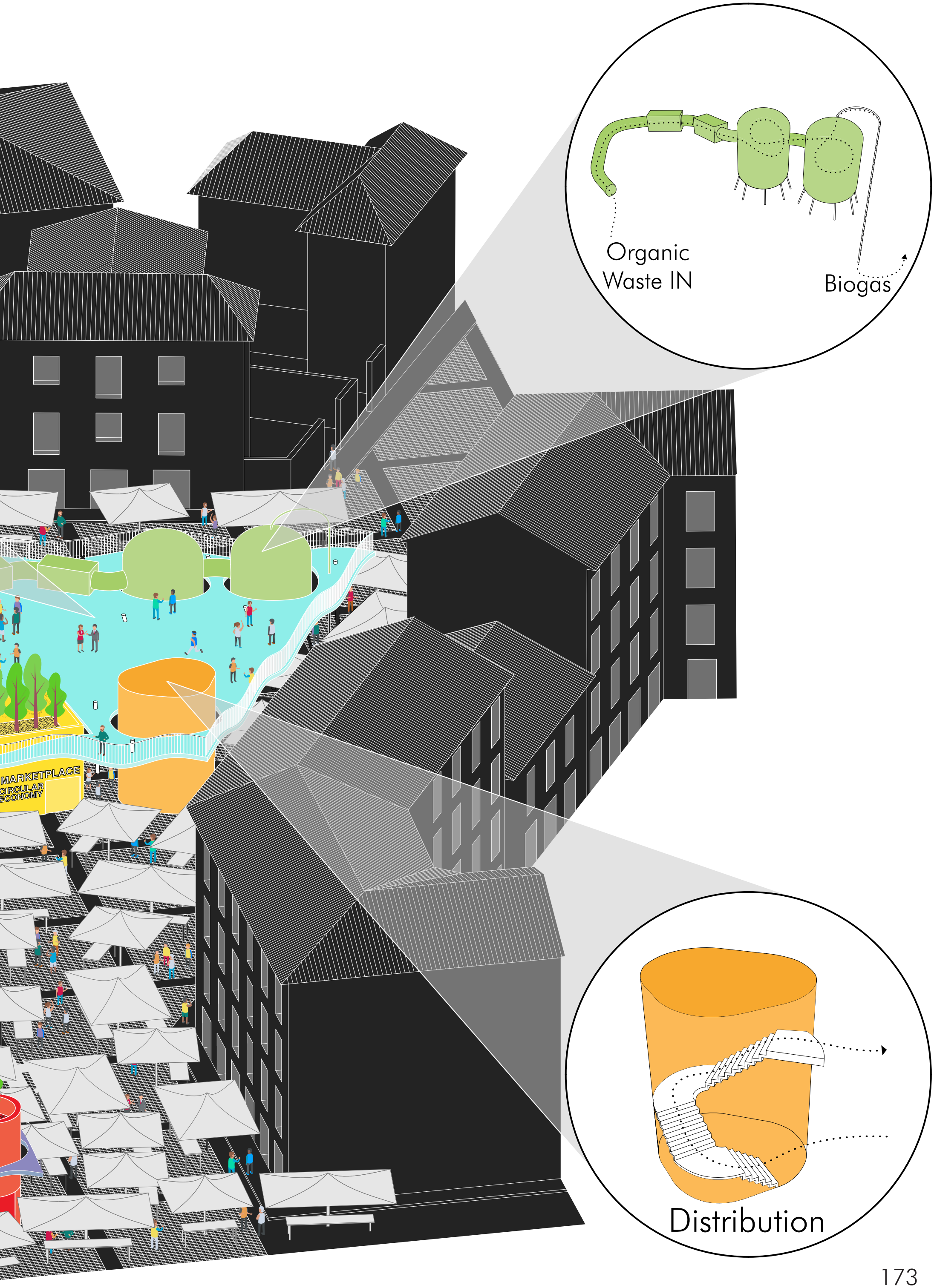
The intervention that concerns the western area of Piazza Foroni is the insertion of a series of blocks with different functions, each function is characterized by a different color in order to facilitate the recognition by the citizens, each of which is protected by a walkable coverage able to incorporate areas that are still dedicated to the market.
The main element of this intervention is an urban-scale anaerobic digester for the treatment of organic waste from the market area. As described in the previous chapters, the anaerobic process - pronounced by the word itself - occurs in the absence of oxygen, and for this reason does not produce odors. Five elements are necessary to carry out the process: the first of which is the draft tube where the market workers can give the waste, this tube composed of a conveyor roller moves the waste to the top floor, on the roof, where the whole process will take place.
The first two components positioned on the cover are the sacks and the sifting machine, the first machinery takes care of breaking and separating the bags used to confer the organic - as told in the first chapters, the best method to throw organic waste is to do it all The inside of the biodegradable bags, once conferred, become one with the compost without the need to carry out the bag-breaking phase which

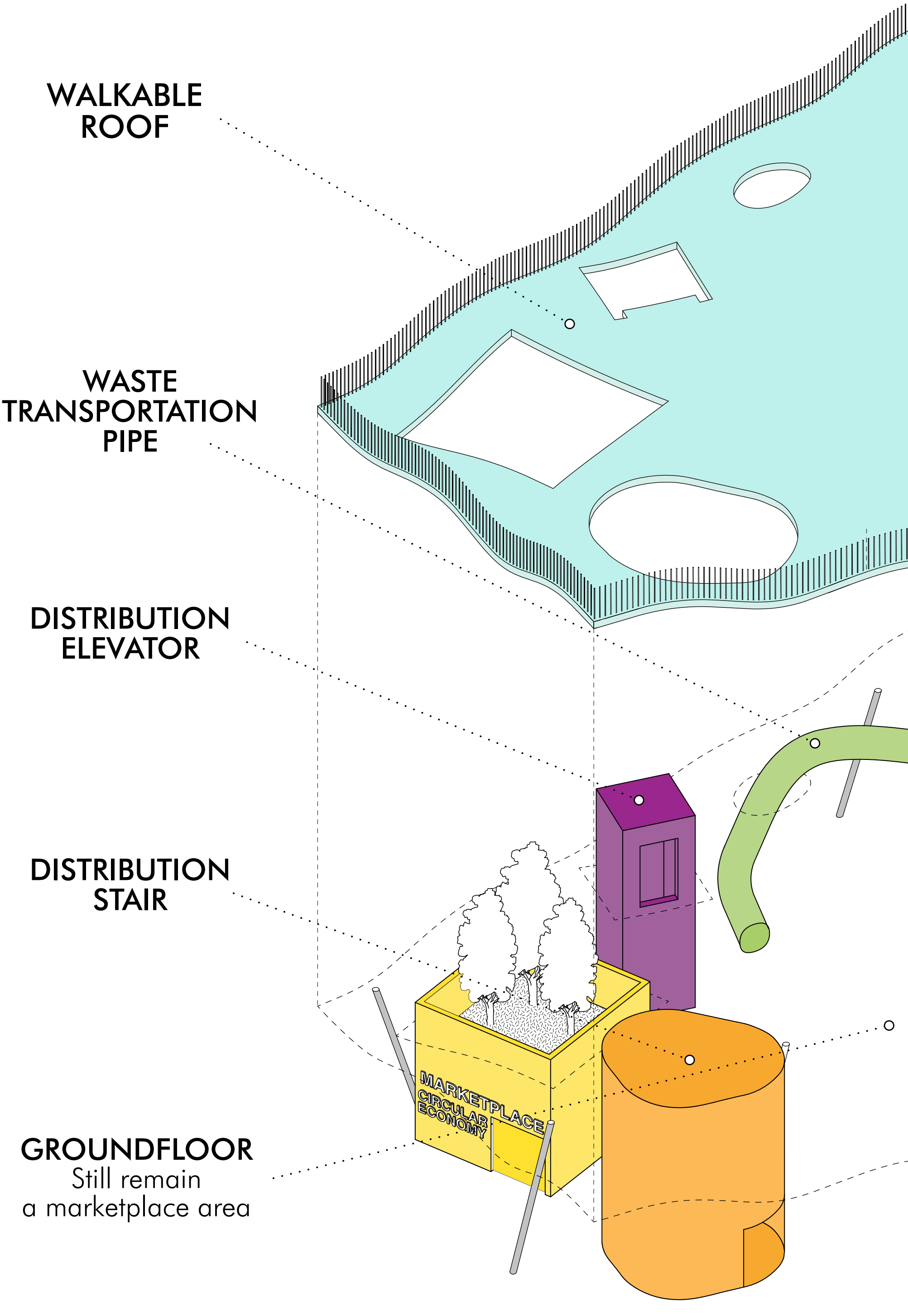
is obligatory when a polymeric bag is present which is dangerous for the successive phases of digestion.
The second machine is the screening machine, this element is used to separate the material dimensionally by passing it through a screen. The two successive phases take place inside two silos, the first silos is used for the storage of the material: it is a closed tank to prevent the escape of odors, here it is stored waiting for space in the next phase of digestion. Once these four steps have been overcome, the organic material is ready to be inserted into anaerobic digestion silos where, by means of mesophilic bacteria, it will be decomposed. The result of the decomposition is the production of biogas, which will be channeled into a tube.

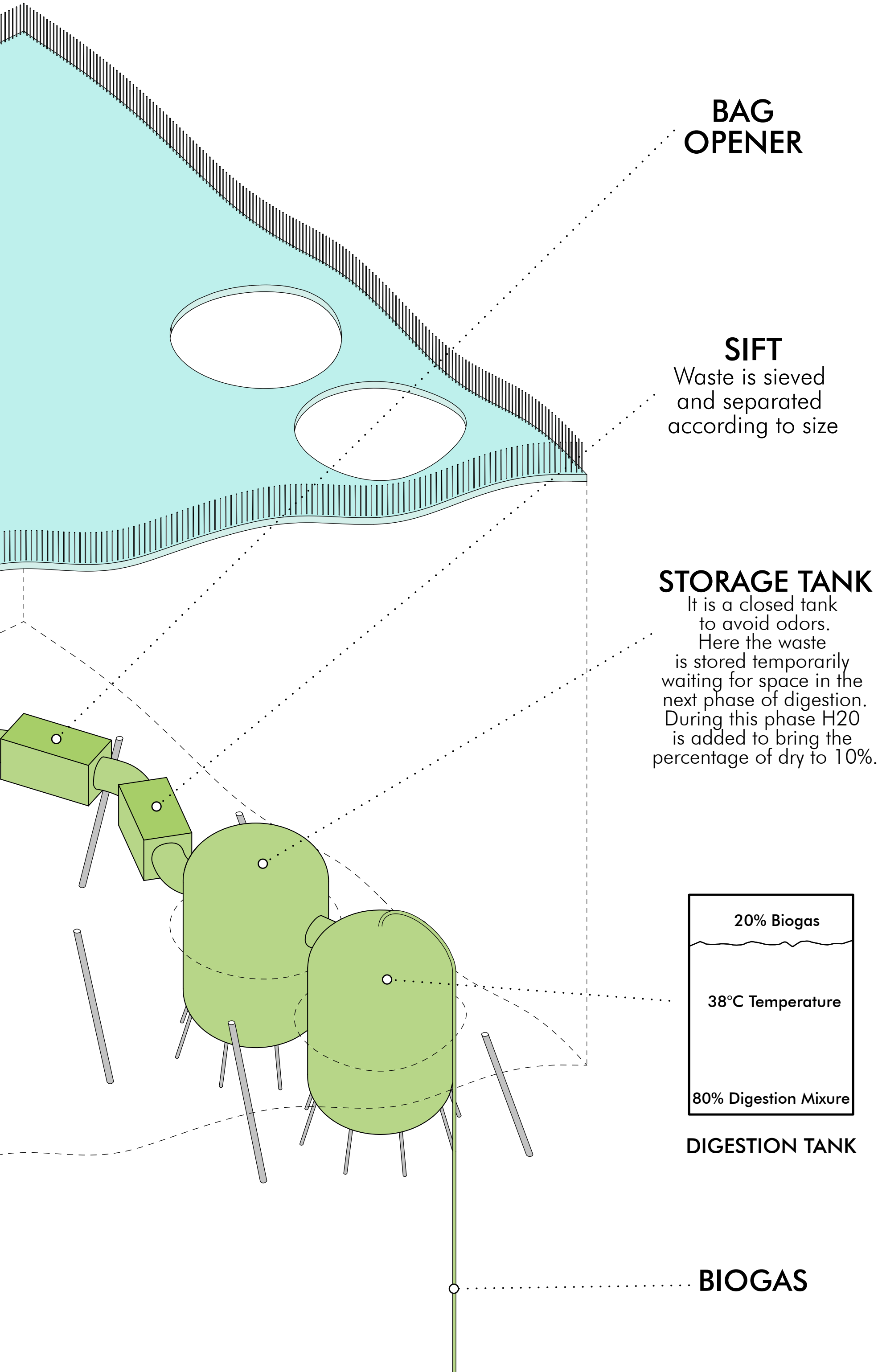
The second element, no less important, inserted in the west of Piazza Foroni is the marketplace for the circular economy, it is an office located in the middle of the square that acts as a link between the two actors: who wants to get rid of a gap but it is not able to reuse it and those of that waste could make a new product. The other two blocks are distributive elements, one is the elevator shaft and the other the stairwell which are used to access the upper floor which can be walked on.

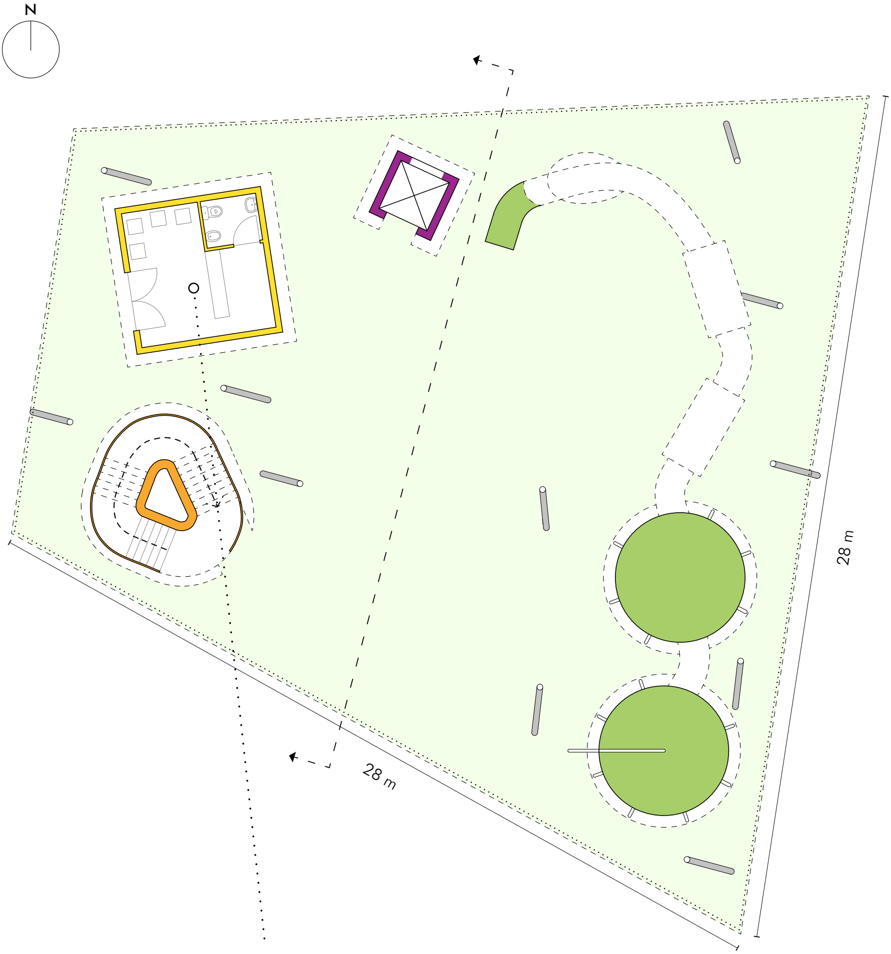
Why should I go upstairs?
From the roof the citizen can see firsthand what are the stages of treatment of the waste, this is useful to sensitize and educate. The cover fits perfectly into the area under the intersection of the road axes born in the concept phase. Its wavy profile wants to refer to a veil moved by the wind, the same veils that make up the curtains of the stalls of the underlying market. The arrangement of the elements makes it possible to cohabit the market with the new functions: when the market is active the stalls will easily fit under the cover, which will protect them in bad weather, when the market is not active the coverage can be used to neighborhood activities, a place able to create community and sociality in order to revive the Barriera di Milano.


MARKETPLACE
CIRCULAR
ECONOMY
Marketplace Circular Economy
Plastic Compressor
Plastic
Waste IN
Smart Collection
- 80% Volume

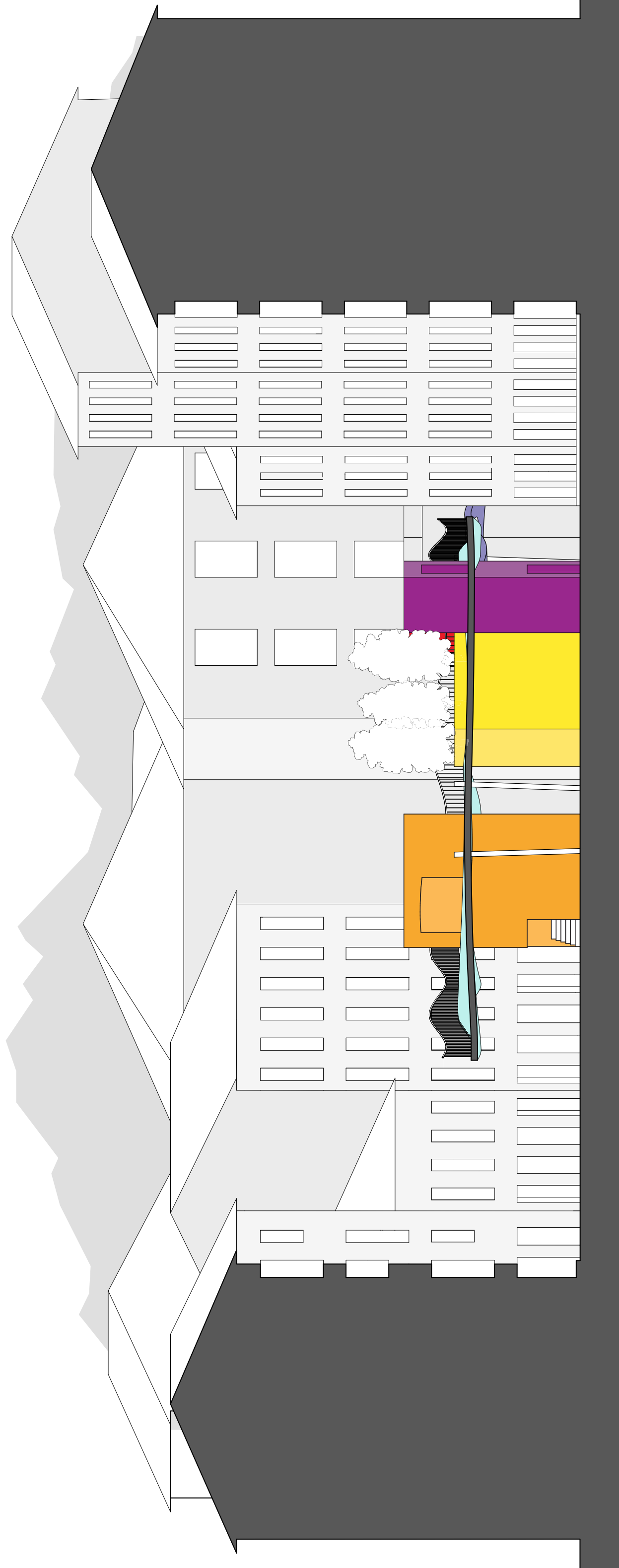

Organic
Waste IN
Biogas
MARKETPLACE
CIRCULAR
ECONOMY
Distribution


WALKABLE
ROOF
WASTE
TRANSPORTATION
PIPE
DISTRIBUTION
ELEVATOR
DISTRIBUTION
STAIR
GROUNDFLOOR
Still remain
a marketplace area
MARKETPLACE
CIRCULAR
ECONOMY


BAG OPENER
SIFT
Waste is sieved and separated according to size
STORAGE TANK
It is a closed tank to avoid odors. Here the waste is stored temporarily waiting for space in the next phase of digestion. During this phase H20 is added to bring the percentage of dry to 10%.
20% Biogas
38°C Temperature
80% Digestion Mixure
DIGESTION TANK
BIOGAS



It is a place that aims at the rebirth of Barriera di Milano.
An area of social aggregation and a reference point for the neighborhood.
Circular economy starts from the bottom:
this marketplace is the meeting place for those who want
to draw value from their waste and those who want to buy them.



9.7.2 Sizing of the anaerobic digestion tank

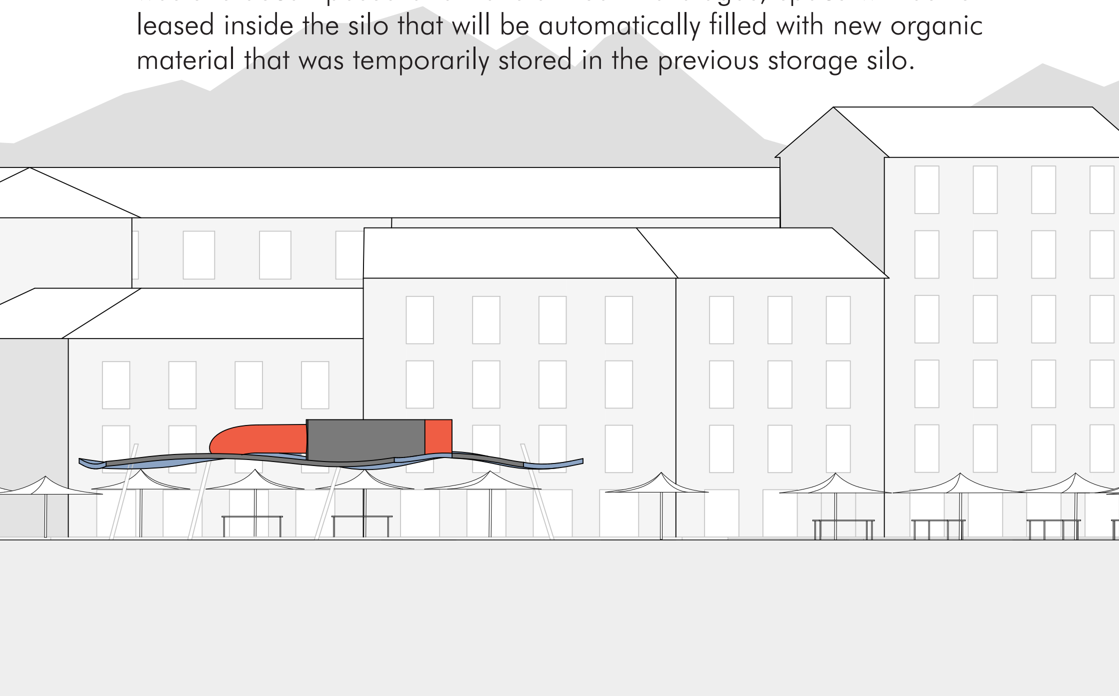
NEW SQUARE

MARKETPLACE

The first step for sizing is to understand daily how much organic waste is produced by the market area. The municipality of Turin on this topic, annually conducts statistical research in order to define the price of the waste tax.

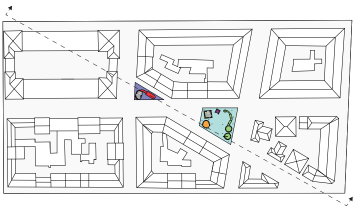
The Piazza Foroni market area produces 3721Kg of organic waste every day. The process of anaerobic digestion takes place at a mesophilic temperature of 38 degrees, a perfect temperature to keep alive those bacteria that deal with the decomposition of waste.

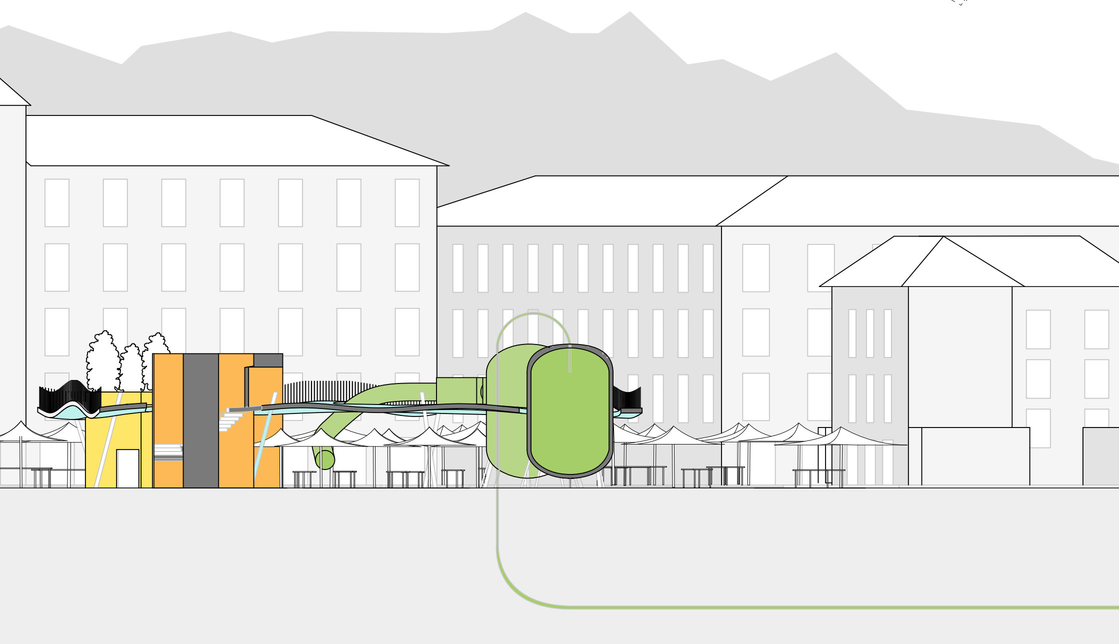
This is a process that once activated will be continuous: every time the waste is decomposed and transformed into biogas, space will be released inside the silo that will be automatically filled with new organic material that was temporarily stored in the previous storage silo.



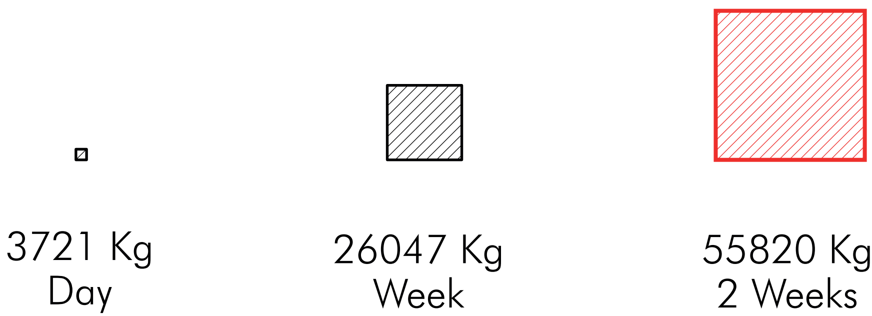
This process lasts 15 days, so to understand the volume of the silos it is necessary to calculate the production of organic waste in this time span: (3721x15 = 55820kg) to which we must add a 20% volume necessary for the temporary storage of the biogas .
Considering the specific weight of the wet organic waste (ie freshly thrown) equal to that of water (1m3 = 1000kg) and imposing a maximum radius due to the constraints of the area, the resulting element will be the height of the silo.
At this point all that remains is to calculate how much biogas they produce these wastes and how much thermal energy can be transformed into biogas. To do this we must rely on equivalence: the result is that with the waste produced by the market in Piazza Foroni every two weeks it is possible to obtain 19118 kwh of thermal energy.

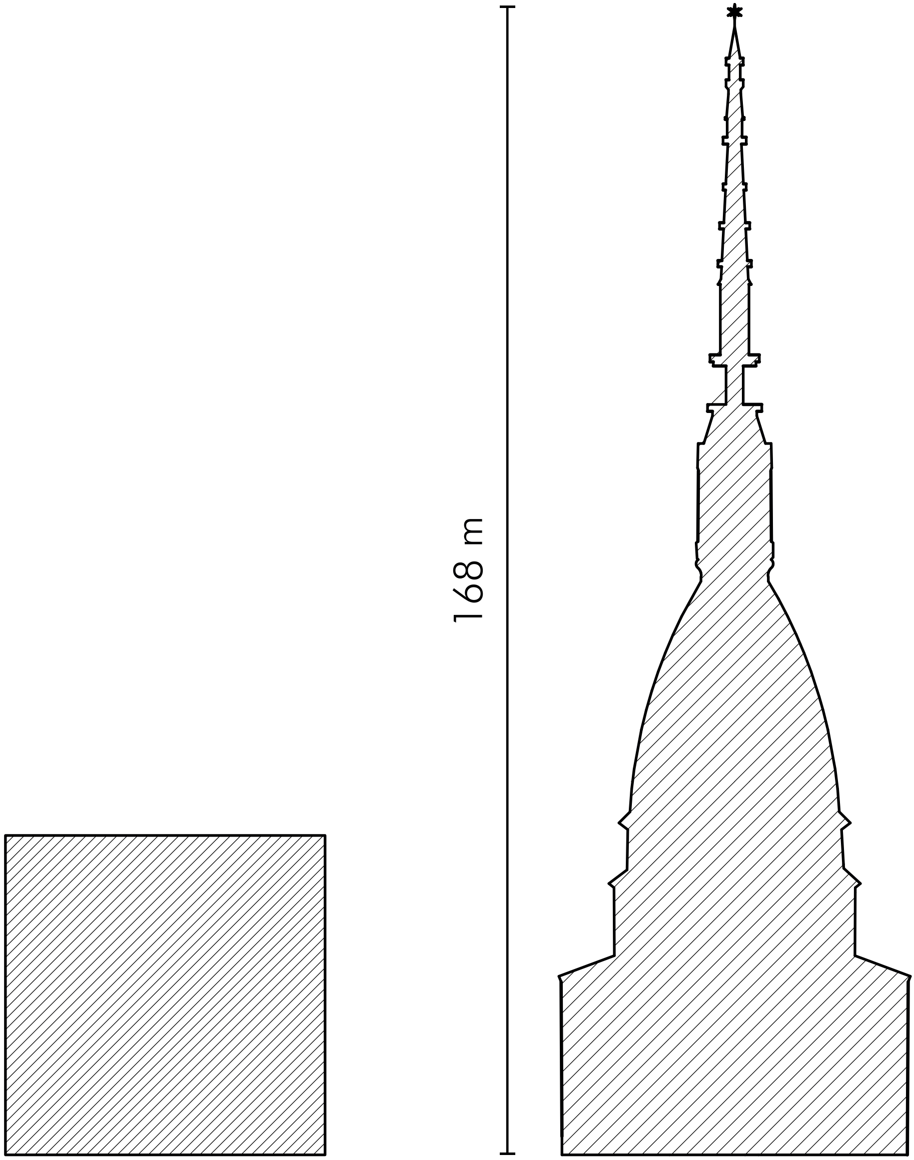
How do I use this thermal energy?
A percentage (9%) will be used to maintain the anaerobic silo at a temperature of 38 degrees, the remaining 91% is used to feed the school boiler adjacent to the square.





Proportions of Waste Consumption of Piazza Foroni Market (18)





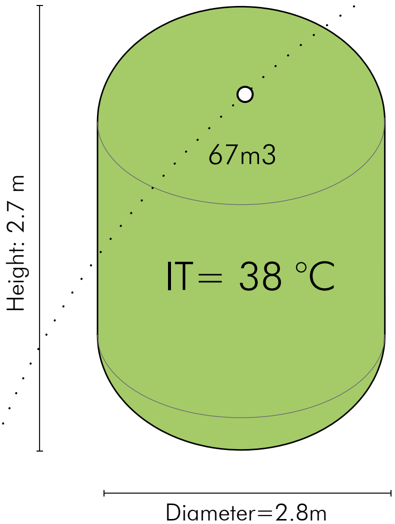
111630 Kg
Month

Mole
Antonelliana

BIO

Wet Organic Waste Density = Water [17]

ρ = (1mc=1000kg)



ET= 15 °C

Daily Cost for Waste

Annual Savings on the disposal

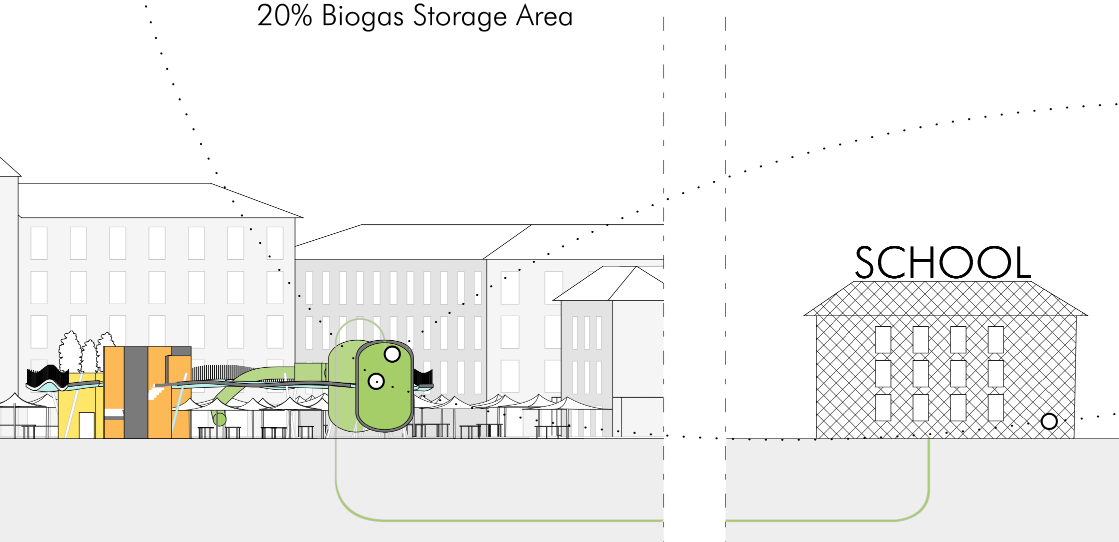
Wet Digestion Period: 15 DAYS [17]

=

55820 kg Waste (18)

+

20% Biogas Storage Area



GAS

1000 Kg Wet Organic Waste = 137 m3 Biogas [17]
15 Days = 7647 m3 Biogas

1 m3 Biogas = 2.5 Kwh Thermal Energy [17]
15 Days = 19118 Kwh Thermal Energy

How much Thermal Energy do I need to heat the silos?

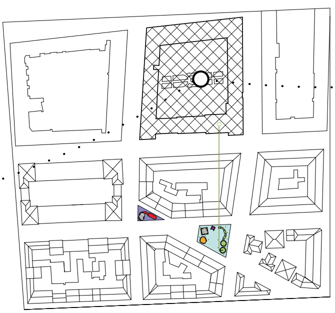
Disposal = 1287€ (18)

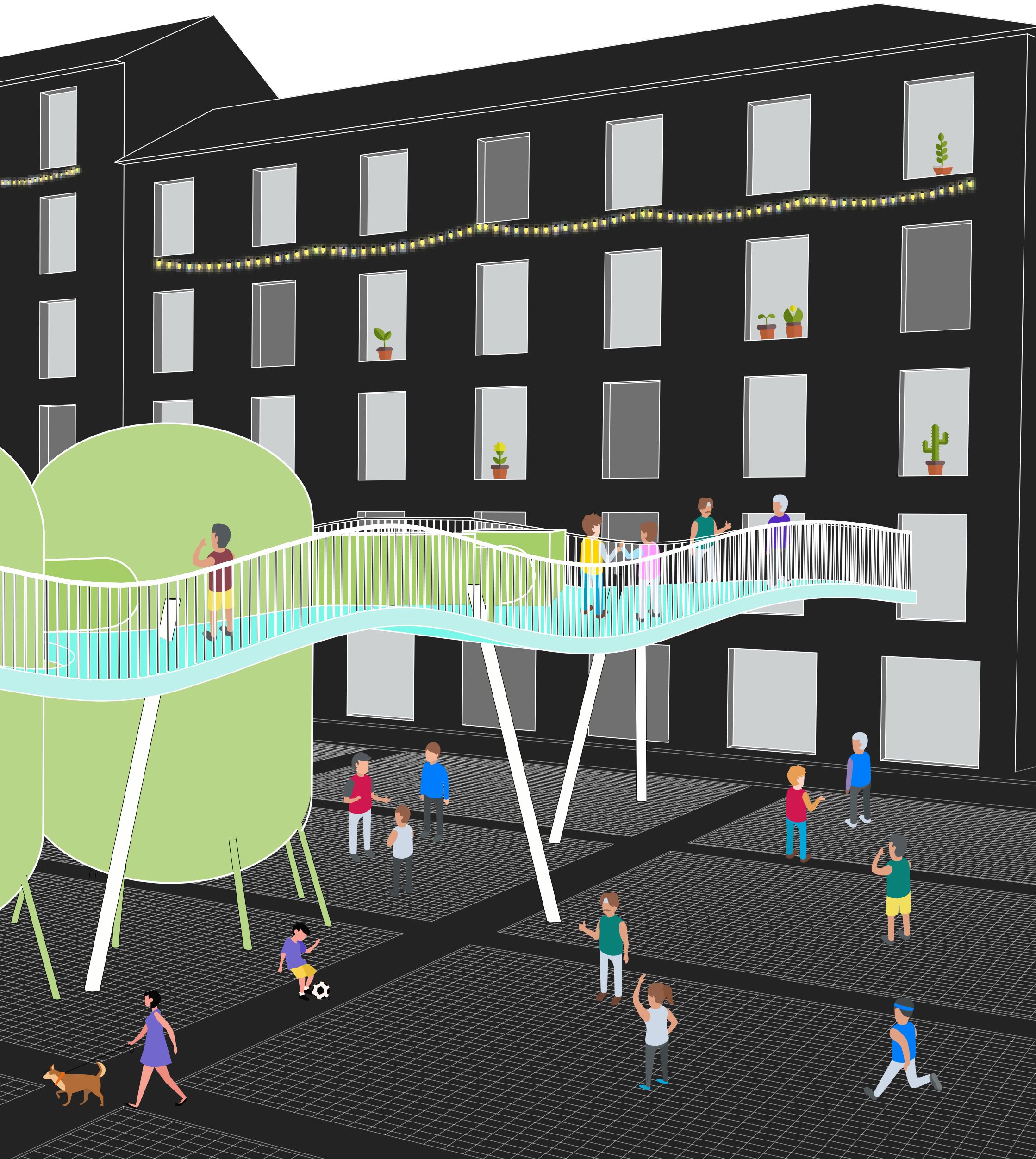
of Organic Waste = 401544€

E = Mass x Specific Heat x DT (T In - T Ext)
Mass = 55820 Kg
Specific Heat = 1 Kcal/Kg
DT = 38 - 15 = 23°C [17]

9% = 1492 KwH

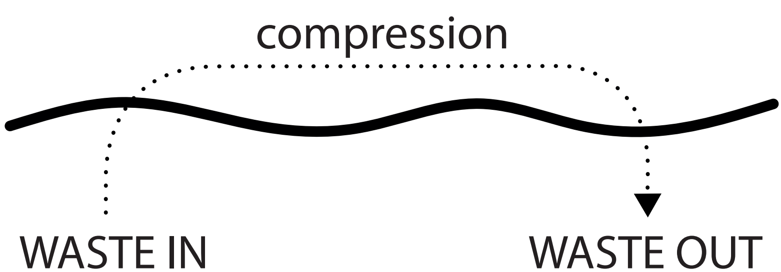
91% = 17626 Kwh



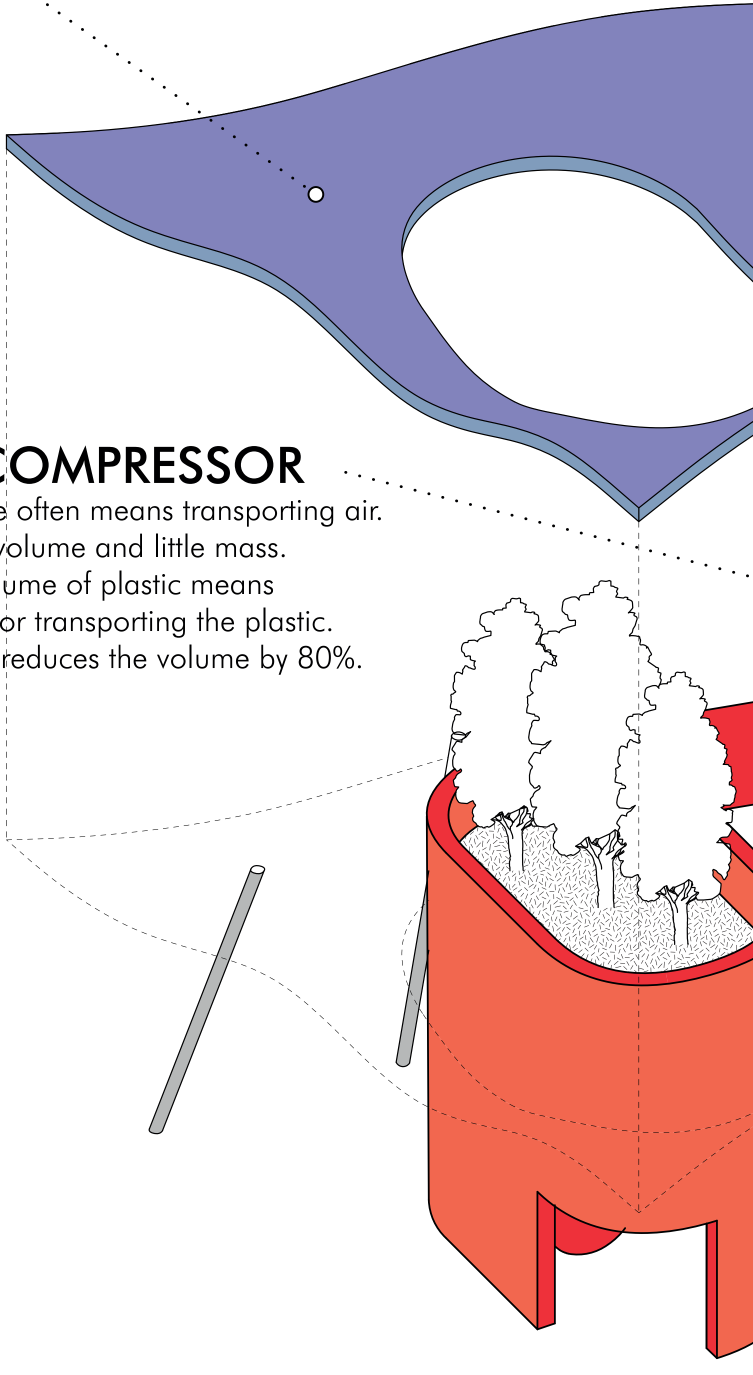


9.8 East Piazza Foroni: Urban Plastic Compressor

The intervention concerning the east area of piazza Foroni is the insertion of an element for the pre-treatment of plastic waste. As described above, it is complicated to completely treat a plastic waste within an urban context. The best solution is to compress the plastic materials, reduce them in volume and send them to the appropriate treatment centers. Nowadays the city of Turin has experimented the insertion of waste compactors, these have been positioned below the road level. This has proved difficult and expensive in economic terms due to the interference with existing infrastructures: by positioning these elements underground we have to deal with pipes and sewers. The idea proposed for tWhis square is to insert these compactors above ground, in a high floor. The intervention consists of a block for the drafting of plastic waste from the market, inside which there is a tube with a roller conveyor able to move the material upstairs, above the cover, where there is the compactor . Once inside the waste will be pressed and reduced by 80% of the volume. Positioning to a floor above ground facilitates the collection of waste: the roof is designed to have a height (4.30m) to make it possible to place a truck for waste collection. Then the plastic material, once compressed, will result as a single and compact block that will be lowered from the inside of the vehicle body to be transported in the appropriate center. The roof, as in the adjacent case, has a wavy profile and is inserted in the intersection of the opposite axes. In this case the area is limited and for the most part occupied by the compactor so it is not possible to step on it.

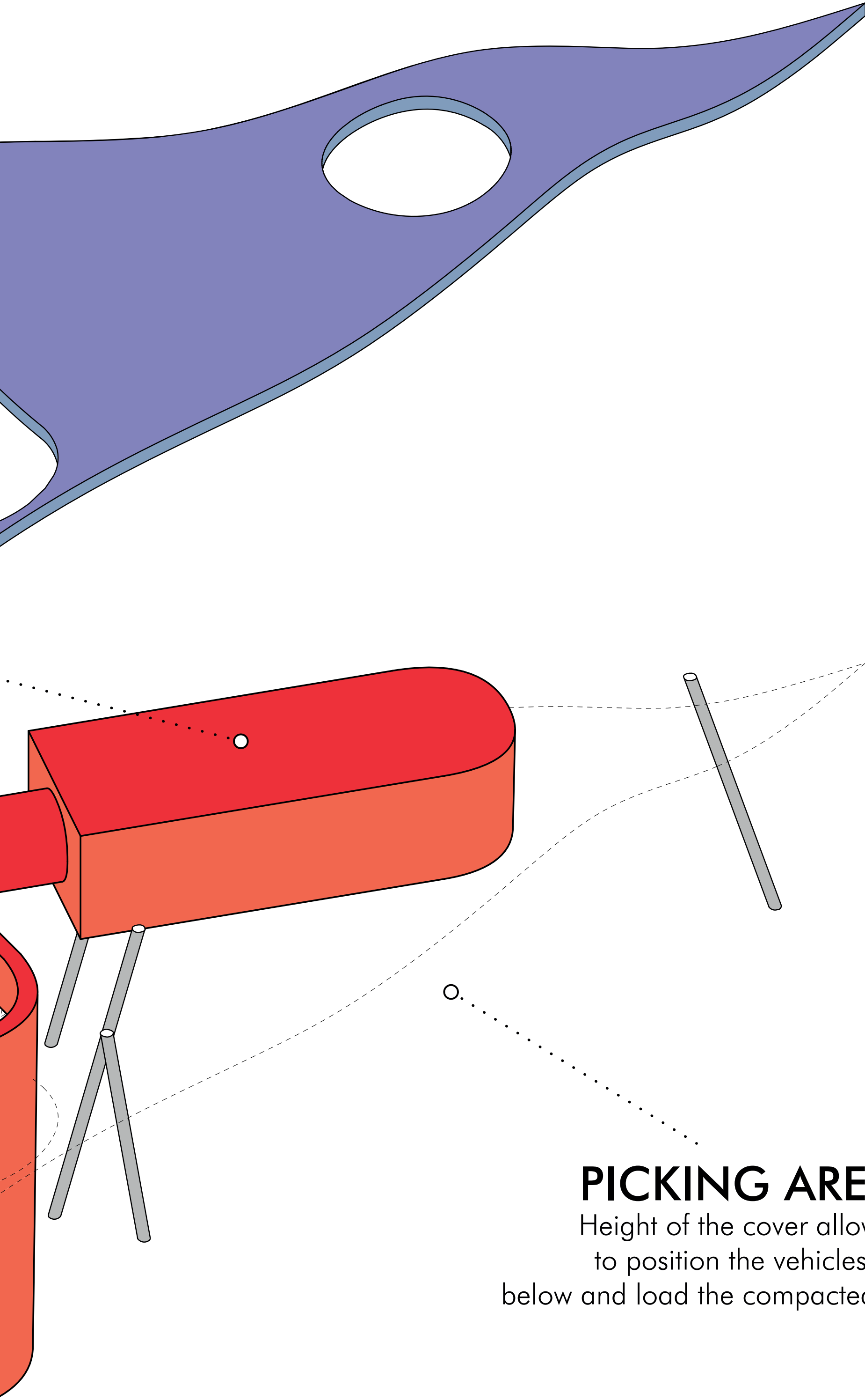


MARKET COVER ROOF



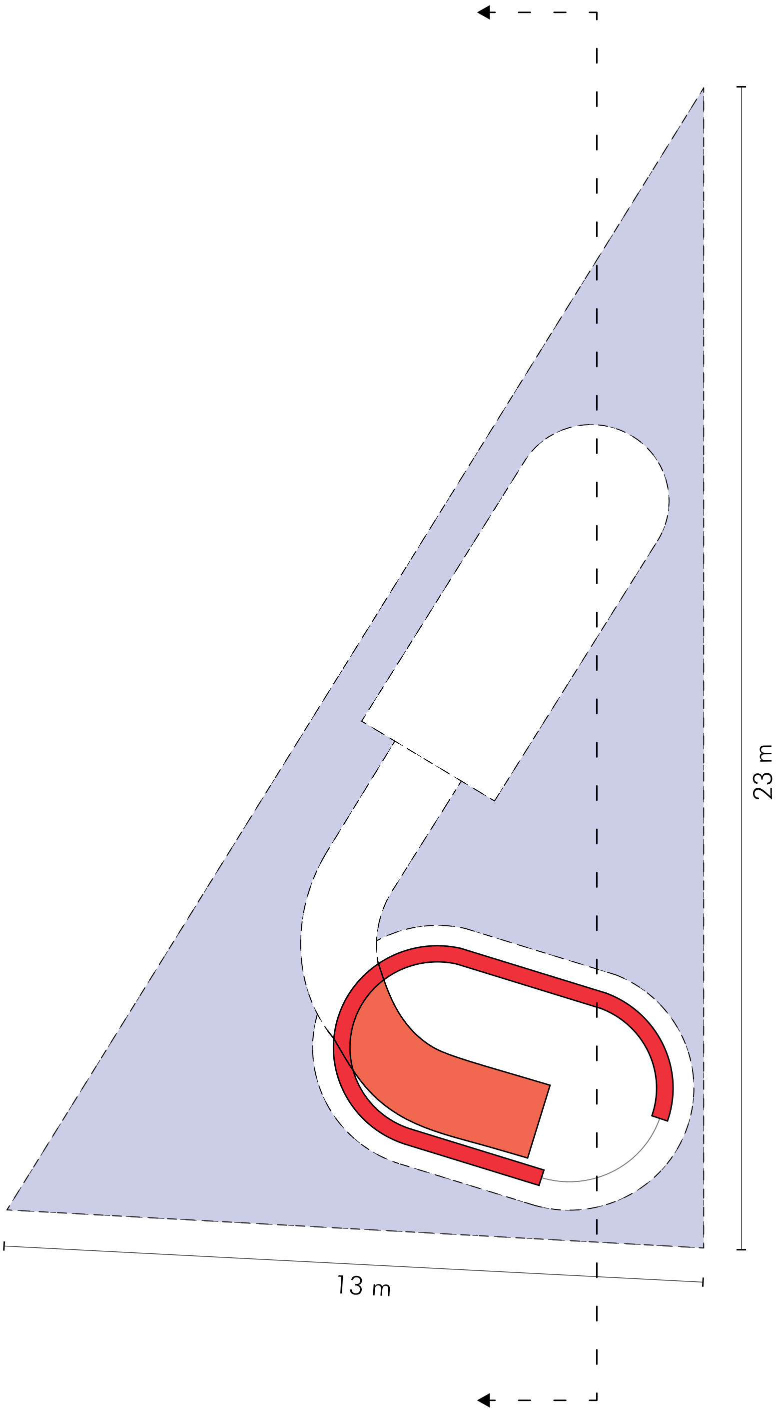
PLASTIC COMPRESSOR

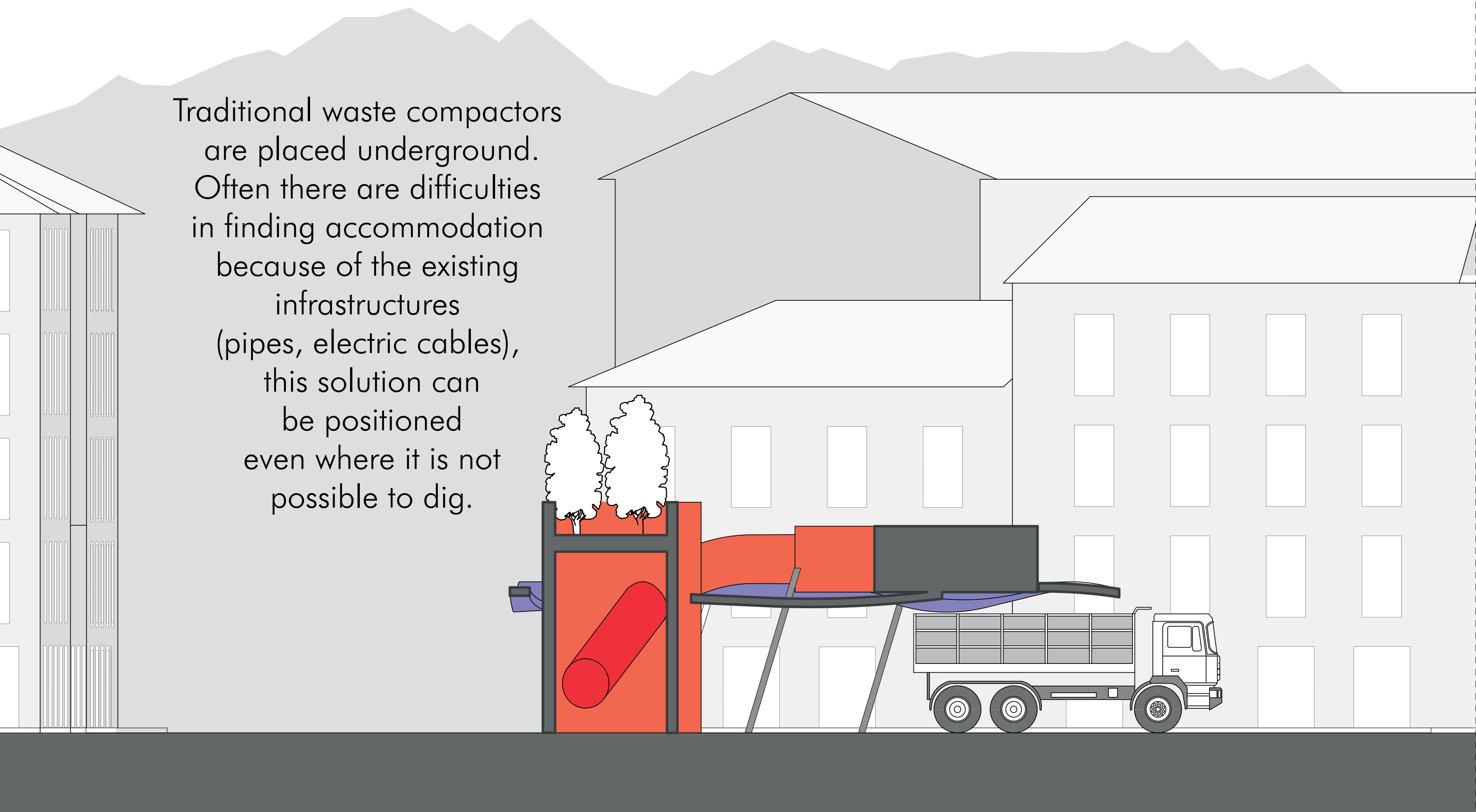
Transporting plastic waste often means transporting air.
Plastic is a lot of volume and little mass.
Reducing the volume of plastic means
optimizing the flows for transporting the plastic.
The plastic compactor reduces the volume by 80%.



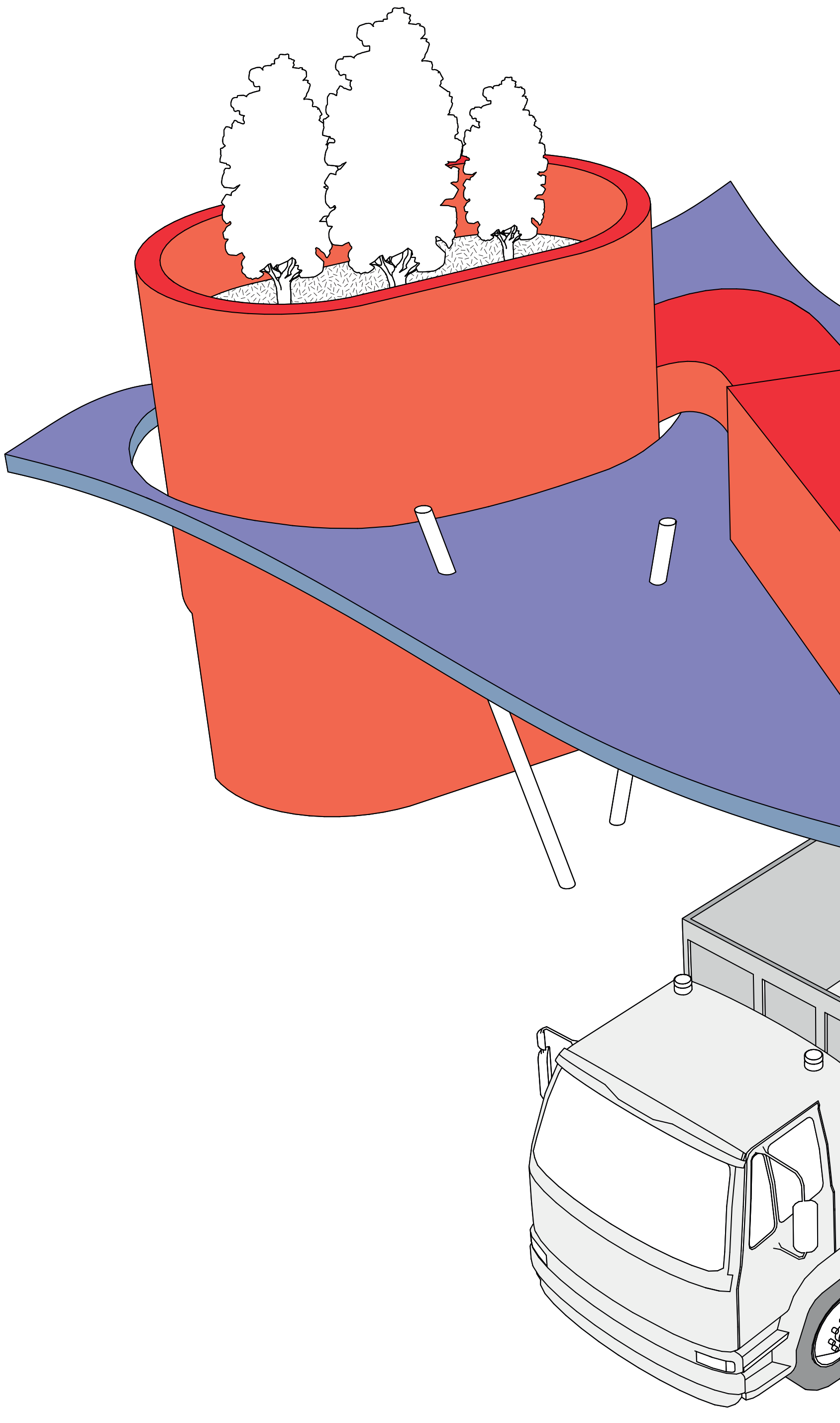
PICKING AREA

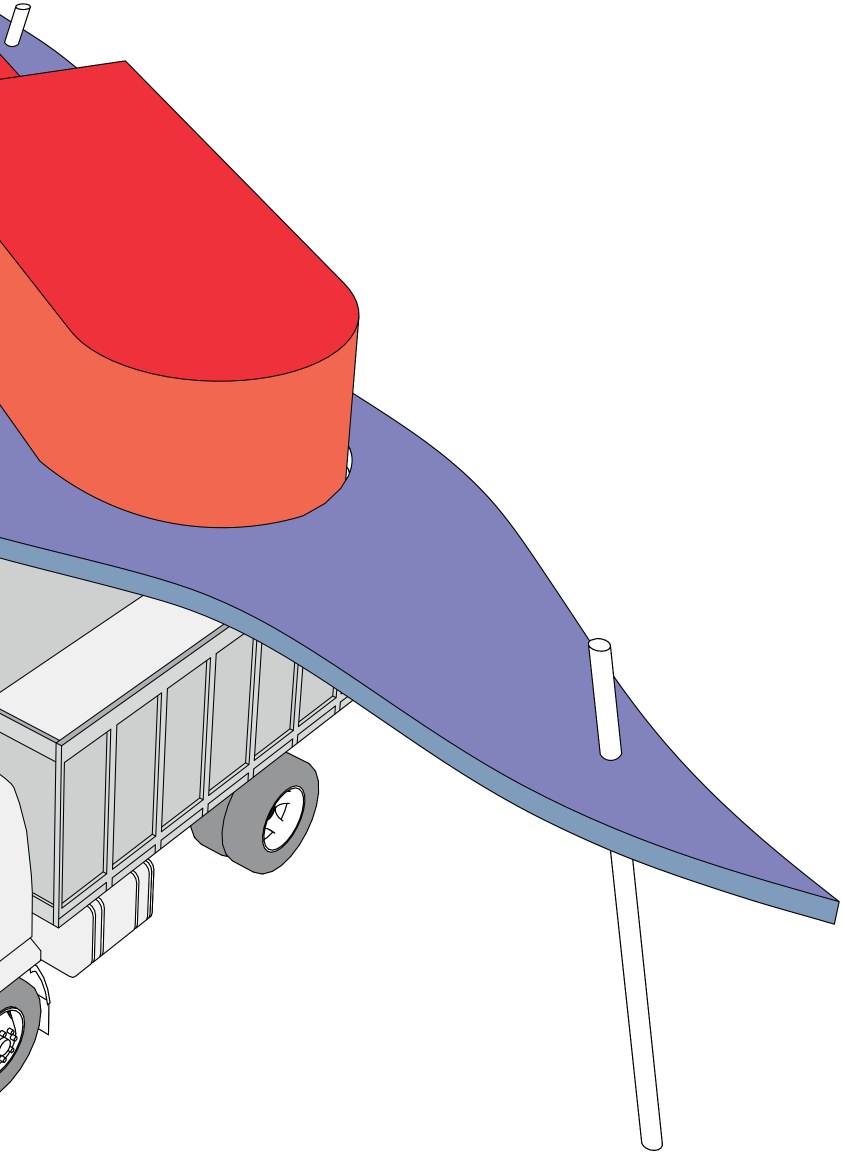
Height of the cover allows
to position the vehicles
below and load the compacted plastic.


23 m
13 m

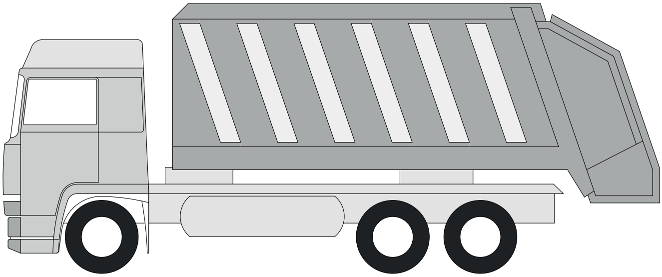


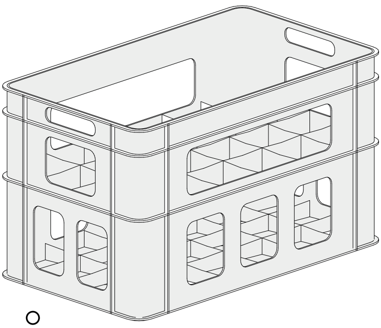
Traditional waste compactors
are placed underground.
Often there are difficulties
in finding accommodation
because of the existing
infrastructures
(pipes, electric cables),
this solution can
be positioned
even where it is not
possible to dig.





1520 Kg Plastic
Piazza Foroni





4 Km/liter averaged by trash truck

0,63 €/liter average price for Diesel 2018 (VAT excluded)

220000 - 80% = 44000 Km

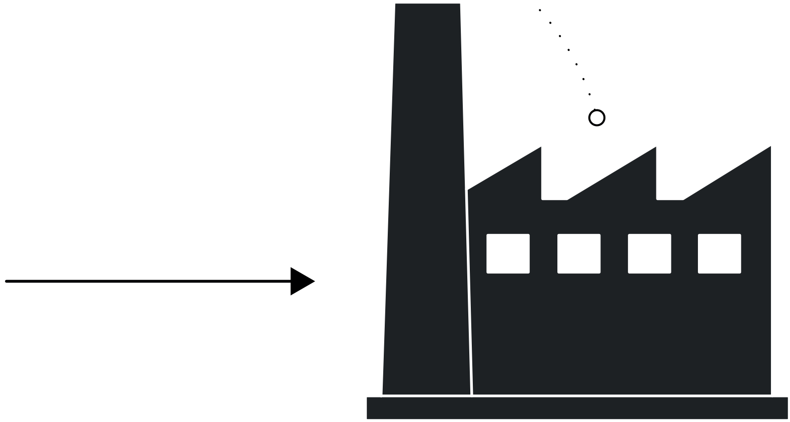
27720 €/year SAVINGS

168300 Kg Co2/year averaged by trash trucks

-80% = 33660 Kg Co2/year

134640 Kg Co2/year SAVINGS

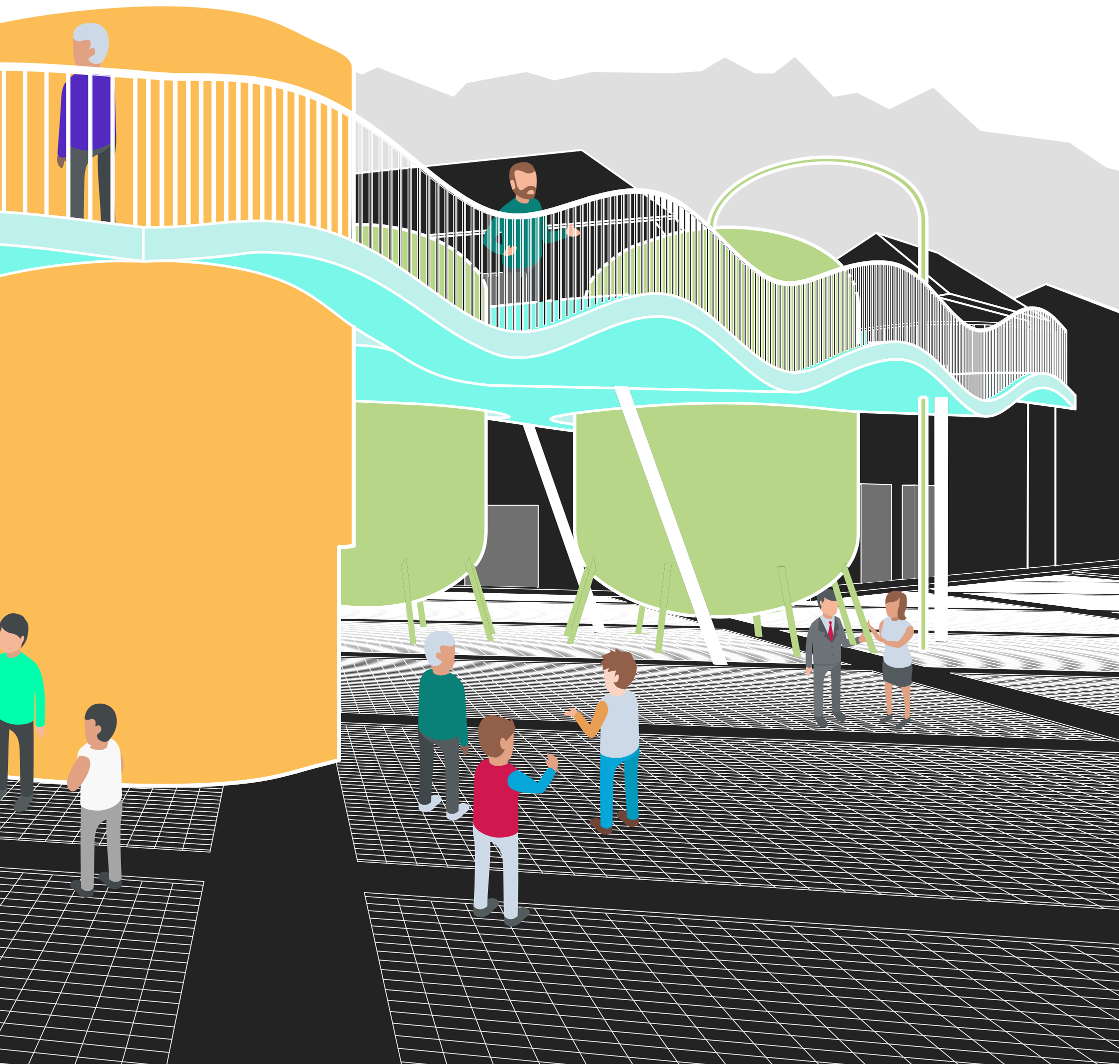
Waste x Week
Market (18)



220000 km/year averaged by trash trucks
765 g CO2/km averaged by trash trucks
(For the purposes of the estimation, the emission factor relating to the "highway" driving cycle for heavy vehicles was used range between 16 and 32 tons)
168300 Kg Co2/year averaged by trash trucks [18]

PLASTIC WASTE COMPRESSOR -80% VOLUME
=
-80% Km x year


MARKETPLACE
CIRCULAR
ECONOMY



CONSLUSIONS

Waste is a concrete problem.

The generations before mine have had the chance - and the unconsciousness - to pass on to their next many inconvenient tasks, among them the problem of waste disposal.
We are those “next” and the moment to act is now.

When my generation faces the interdisciplinary theme of protecting the planet, it must realize that in order not to worsen the already serious situation, we must compromise. It is necessary to realize that we are part of a very complex holistic system, it is concretely influenced by the actions that each of us performs on a daily basis. If this awareness were absorbed by the community, individualism would be eliminated. The citizen is not a secondary component of a society that moves independently of his choices, but is himself to move the society according to their decisions.

These awarenesses exist in the communities of the countries of northern Europe - I could see this in person by living in Rotterdam for about six months - where there is a strong sense of civic and meticulous attention to the repercussions that every citizen can have with their actions. This awareness is less in my country, Italy. Therefore, in order to develop this research, I have been inspired by North European models, trying to import some of their visions into my country in order to affirm that Italy too can keep up with the times by proving that it is not a provincial reality.

In northern Europe, there are already realities in which waste treatment takes place within the urban perimeter, while in Italy some regional regulations require that this happens outside of this perimeter for reasons of safety and hygiene. As demonstrated by the data shown in this research, bringing users closer to the waste cycle implements the quality of recycling, at the same time triggering a mechanism able to generate a strong sense of community and civic sense. One of the compromises, of which I spoke at the beginning of the chapter, to which my generation should accept could be this: limit the waste flows within the city perimeter, obviously respecting very strict safety and hygiene rules. We can no longer think of throwing a refusal without knowing where it will be treated and without worrying about what consequences this gesture may have.

The reference of Piazza Foroni, considered in this research for the analysis of urban regeneration, wants to show that even in a neighborhood like Barriera di Milano: multiethnic, contradictory and critical but at the same time strong in the spirit of rebirth it is possible to start a process participated in Circular Economy through waste disposal.

When addressing the issue of environmental protection and climate change, it must be realized that an inversion of course is mandatory. This inversion must be faced with positivity and courage.
And this is what I want to do, despite being aware of the current critical issues - today more than ever after having faced a research path that led me to the discovery of things shortly before unthinkable - tackle the inversion in a positive way, hoping to be able to resume in hand this thesis in about ten years and can say with a loud voice: all together we managed to change course.

SITOGRAPHY:

(1) Global Footprint Network. www.footprintnetwork.org/gfn_sub.php?content=global_footprint

(2) https://sustainabledevelopment.un.org/post2015/transformingourworld

(3) http://www.minambiente.it/pagina/lagenda-2030-lo-sviluppo-sostenibile

(4) https://www.un.org/sustainabledevelopment/sustainable-development-goals/

(5) http://www.ecoo.it/articolo/cos-e-la-green-economy-e-come-funziona/15279/

(6) http://montanari.racine.ra.it/iper_agenda21/rifiuto/storia_rifiuti.htm

(7) Online Etymology Dictionary. www.Etymonline.com

(8) https://www.nature.com/articles/s41598-018-22939-w

(9) https://www.theoceancleanup.com/

(10) https://preciousplastic.com/

(11) "Why can't I put my leftover gyproc/drywall in the garbage?". Recycling Council of British Columbia.
https://www.rcbc.ca/resources/faqs/hazard9

(12) http://www.gamberorosso.it/it/news/1023602-guerrilla-kitchen-dalla-spazzatura-alla-cucina-di-strada-ad-amsterdam-il-cibo-vive-due-volte?fb_comment_id=659789114124815_662965270473866#f2f3119b523531c

(13) VIDEO: "On the Road to Zero Waste", part 4. Paul Connett. 2004

(14) http://www.envac.it/envac/vacuum-system_history_1_1

(15) https://www.amando.it/societa/mondo/raccolta-rifiuti-sotterranea.html

(16)http://www.ecodallecitta.it/notizie/385094/tariffa-puntuale-rifiu-
ti-cose-come-funziona-intervista-ad-attilio-tornavacca-esper/

(17) http://www.israelalba.com/en/proyectos/estudio-ordena-
cion-de-usos-pt-valdemingomez/

(18)http://www.comune.torino.it/consiglio/documenti1/atti/allega-
ti/201601829_1.pdf

BIBLIOGRAPHY:

[1] E. Sutherland, G. Patterson, C. Dedicoat, S. Holliday, C. Tavares. Towards the circular economy: Economic and business rationale for an accelerated transition. Ellen MacArthur Foundation. 2013; Vol.1: 6-33

[2] Hawken, P. The Ecology of Commerce: A Declaration of Sustainability (Paperback - April 1995)

[3] Gianluca Cuozzo, A spasso tra i rifiuti. Tra ecosofia, realismo e utopia. 2014

[4] The Urban Bio-Loop: growing, making and regenerating, pag.7, ARUP, Milan 2017

[6] Circular Amsterdam, a vision and action agenda for the city and metropolitan area

[5] European Waste Catalogue and Hazardous Waste List.

[6] Dove vanno a finire i nostri Rifiuti? La scienza di riciclare, gestire, smaltire gli scarti. Mario Grosso, Maria Chiara Montani. Zanichelli 2015.

[7] Azzerare i Rifiuti. Vecchie e nuove soluzioni per una produzione e un consumo sostenibili. Guido Viale. Bollati Boringhieri. 2008.

[8] I prodotti per l'edilizia sostenibile. La compatibilità ambientale dei materiali nel processo edilizio. Roberto Giordano. 2010

[9] Standardization Administration of the People's Republic of China. Marking of plastics products. 2008.

[10] Andreas Künkel, Johannes Becker, Lars Börger, Jens Hamprecht, Sebastian Koltzenburg, Robert Loos, Michael Bernhard Schick, Katharina Schlegel, Carsten Sinkel, Gabriel Skupin and Motonori Yamamoto (2016). "Polymers, Biodegradable". Ullmann's Encyclopedia of Industrial Chemistry.

[11] Rapporto Riuti Urbani Italia, 2017. ISPRA.

[12] Stefano Montanari. Lo stivale di Barabba. L'Italia presa a calci dai rifiuti.

[13] Paul Connett. Zero Waste. 2012

[14] Canada Sucks: Montreal's vacuum system will making taking out the trash a breeze. Glave, James, Russell, Terrence (July 2010). Wired.

[15] The fairness of PAYT systems: Some guidelines for decision-makers. Batllevell, Marta and Kenneth Hanf. 2008.

[16] I RIFIUTI? NON ESISTONO! Due o tre cose da sapere sulla loro gestione. Marco Boschini e Ezio Orzes.

[17] Tiziana Tosco, Ph.D. - Associate Professor Polytechnic of Turin
Department of Environmental and Infrastructure Engineering.

Barbara Ruffino, Associate Professor Polytechnic of Turin Department of Environmental and Infrastructure Engineering.

[18] Il sole 24 Ore. "Trasporto su strada di rifiuti: quali sono i livelli di CO2?"

IMAGES:

1. Lasse Bak Mejlvang, Manila, 2013.

2. www.UN.org

3. Richard Allenby-Pratt, United Arab Emirates, 2013.

4. Sewage surfer - Justin Hofman, 2017.

5. Olaf Unverzart, Switzerland, 2004.

6. The Bioloop: Growing, Making and Regeneretin, Pag. 6, ARUP 2017.

7. The Bioloop: Growing, Making and Regeneretin, ARUP 2017.

8. The Bioloop: Growing, Making and Regeneretin, ARUP 2017.

9. Frank Day, Gulf of New Guinea, 2013.

10. Camille Michel, Greenland, 2014.

11. Mattia Ghigo, Bergamo, 2018.

12. Unknown Author.

13. Mario Cucinella Architects (Render), Scapigliato Fabbrica del Futuro.

14. Porta Palazzo, Turin, Unknown Author.

15. Pedro Armestre, Spain, 2009.

16. Israel Alba Estudio, Valdemingomez Forest Park, Madrid, 2016.

17. Schmidt Hammer Lassen (Render), Shenzhen East Waste-to-Energy Plant, China.

18. BIG (Render), Waste-to-Energy Plant, Copenhagen.

19. 20. 21. 22. 23. 24. 25. 26. 27. Circular Amsterdam Report, Pag. 18, City of Amsterdam, 2006.

28. Pétur Thomsen, Iceland, 2003.

29. Ecomuseo Urbano Circoscrizione 6

30. Variante 200, ToMake Masterplan, Turin, TRA Architetti, 2012.

31. Historic photo of Piazza Foroni, Unknown Author.

32. Unknown Author.

33. Unknown Author.