



Wèi Lái Ròu
a Hong Kong Meatfactory

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Hello, nice to meat you.

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Wèi Lái Ròu

a Hong Kong Meatfactory

Masterarbeit

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„Factories are truly radical structures, purely pragmatic boxes, spaces for machines that execute clearly defined production processes. When functionality means everything - and budget is limited - architecture finds itself taking on a fascinating role“¹

-Chris van Uffelen

INTRODUCTION

Global meat consumption and especially meat production are a delicate issue. This stems from the fact, that the production, which tries to keep up with the growing demand, poses an ecological threat. Not only does it produce vast amounts of CO2 eq. emissions, but it also occupies vast quantities of land and thus is responsible for deforestation and the death of biodiversity.

The novel technology of in-vitro-meat promises to mitigate most problems caused by conventional meat production. While certainly being a deviant form of production, its advantages are manifold.

My architectural intent is to speculate on a potential techno-biological paradigm shift and its cultural and spatial consequences, by designing an in-vitro-meat factory.

This thesis investigates the history of the factory typology and seeks to explore how this typology might transform in the future, while considering its new cultural significance.

The thesis is divided into 3 different chapters.

The first chapter discusses the subject of **MEAT**. It shows its impact on global economy, but also examines the importance of meat as a cultural object.

The second chapter covers the **FACTORY**. A brief history of the emergence of the modern factory and its genealogy over time, as well as contemporary trends are documented.

The last chapter is dedicated the **MEATFACTORY**. Combining the information from the previous chapters leads to the design of a new factory typology, located in Hong Kong. While the technology of in-vitro meat is proven to work at a smaller scale, at this point in time an industrial sized factory has yet to be built. Therefore some of the technological solutions might be applied incorrectly, considering, that the field of synthetic biology is a discipline, which involves various areas of expertise.

Whilst trying to provide appropriate technical solutions, the main focus lies on the question of how future factories could emerge and how the relationship with factories and production itself might change in the future.

Chapter 1
MEAT





Figure 1.0 | Meat processing plant in Oktyabrsky, Kursk(Russia)

THE ECOLOGICAL IMPACT OF MEAT PRODUCTION

As a reaction to the growing global demand for meat, which has doubled in the last 30 years, meat production entails many problems. In particular the growing demand in developing countries forces meat producers worldwide to optimize and expand their production.

The biggest issue is perhaps the direct and indirect occupation of arable land worldwide, often referred to as virtual land.

The expansion of virtual land for meat production leads to deforestation, especially in Southern America, and thus to the destruction of biodiversity.²

To breed as efficiently as possible, cattle is often bred in feedlots. The density and well managed spatial organization of these breeding farms greatly reduces direct land occupation and thus energy consumption and lastly costs. However, to maximize the yield, growth hormones and antibiotics are used in large quantities to decrease the time for each cattle to reach their maximum weight. This can even be seen from satellite images, as the feces, which are channeled into big lagoons, change their color.³

The next pages show said satellite images and their dimensions.

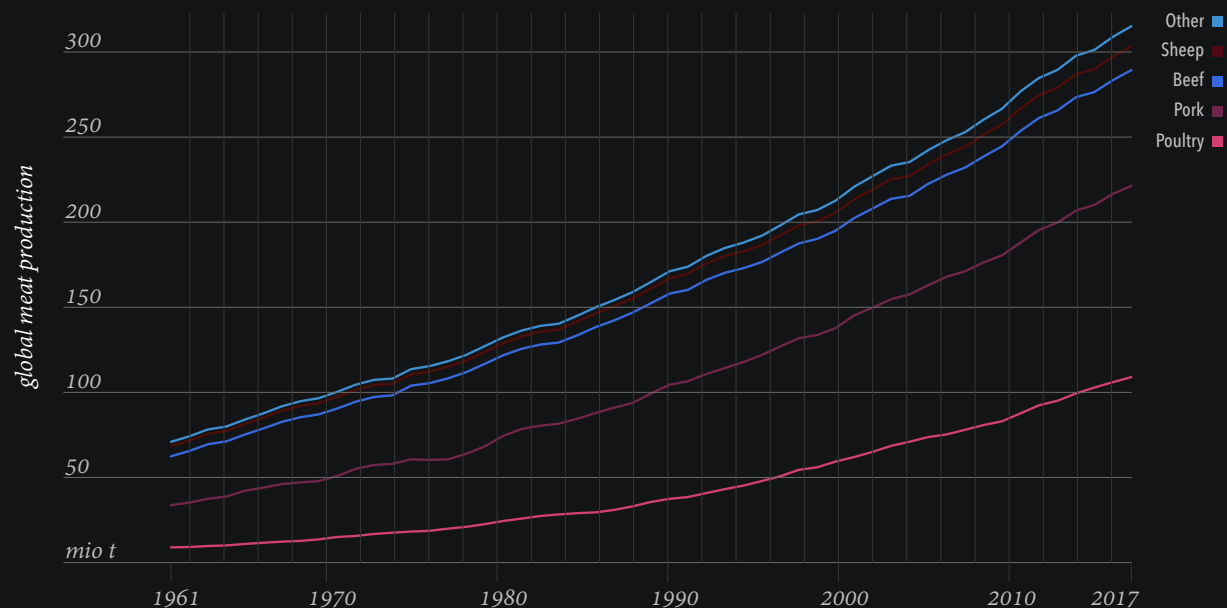


Figure 1.1 | Global meat consumption

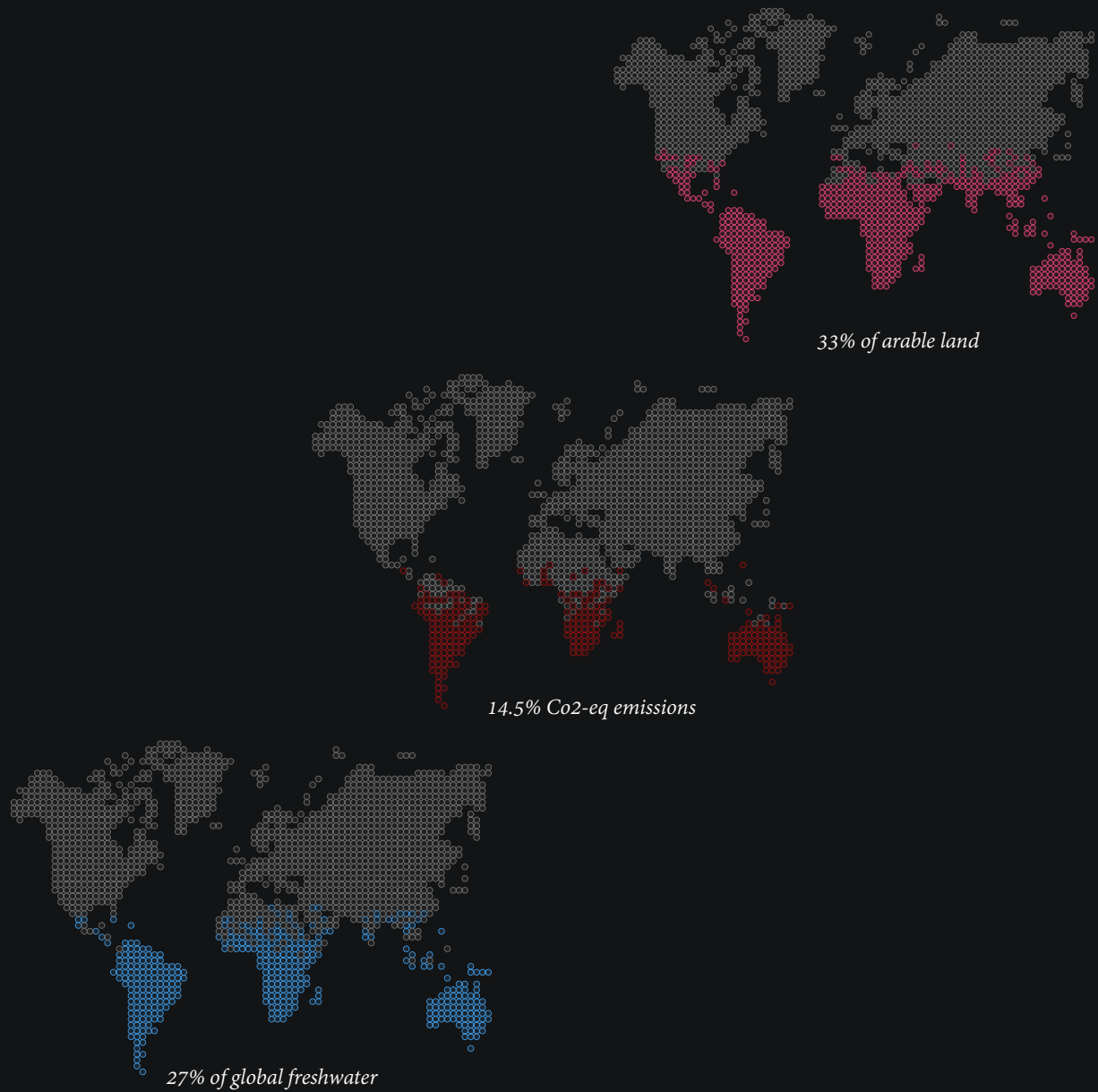


Figure 1.2 | Global impact of meat production



Figure 1.3 | Feedlot, Coronado Feeders, Dalhart Texas



Figure 1.4 | Feedlot, Tascosa Feedyard, Bushland Texas



Figure 1.5 | Feedlot, Coronado Feeders, Dalhart Texas



Figure 1.6 | Feedlot, Tascosa Feedyard, Bushland Texas

The conditions of livestock breeding does not only pose an ecological threat, but the unavoidable use of drugs in those breeding farms and other bad conditions are also suspected to pose health risks for humans, such as resistance to antibiotics or the transmission of diseases.

A big suspect of being a catalysator of disease transmission are wet markets and traditional food markets, where caged animals and open-air butchery can be found. Researchers estimate that up to 90% of meat in Asia is being slaughtered in wet markets.⁴ While the slaughter on site ensures freshness, often poor hygiene and immediate proximity to living animals and butchery itself gives reason to believe that these markets are likely the origin of zoonotic disease transmission.

“Beijing people talk about everything, Shanghai people buy everything and Guangdong people eat everything”⁵



Figure 1.7 | Deforestation of the amazon rainforest

China and Hong Kong especially appear to be the epicenters of several disease transmissions.

The avian influenza/A H5N1, or commonly referred to as bird flu for instance, originated in Hong Kong 1997. Another example is the SARS-CoV-1 outbreak in Foshan 2002, only five years later.

The most recent instance at this time being the outbreak of COVID-19 in Wuhan.⁶

All these instances are believed to have originated from wet markets.

Since it not possible to pinpoint the exact location of transmission, it cannot be stated with certainty that these instances really originated from wet markets.

Nonetheless, it is proven that unsanitary handling of meat poses a severe health risk.



Figure 1.8| Wet market in Taiwan



Figure 1.9 | Illustration of meat retail

THE CULTURE OF EATING MEAT

The consumption of meat is by far not only a means of nutrition, but also a symbol of status, wealth and even masculinity. This makes it an object of culture.

Before agriculture was even well established, the consumption of meat had social significance. The act of hunting and eating together established social bonding, while also being an act of determination of leadership skills.

When controlled fire was discovered 500,000 years ago, meat was suddenly easier to consume and easier to be preserved, through smoking. This ensured a long-term supply of food and thus enabled humans to go after larger preys. Settlement of human agricultural societies saw an increase of population, but decrease of meat accessibility, thus rendering meat a luxury item. For wealthier people, the accessibility of meat was equivalent to superiority. Meanwhile, ordinary people followed a mainly vegetarian diet and consumed only selected meat products on special occasions.⁷

These special occasions were most often tied to religious celebrations or ceremonies.

Some of these celebrations, which are associated with certain meat products, have lasted until today, even though the religious intent might not have survived. Some instances are turkey on Thanksgiving, the Christmas-Ham and the consumption of dog meat at the Lychee and Dog Meat Festival.



Figure 1.10 | Siberian Nenets eating raw meat

Since the invention of the modern slaughterhouse, the accessibility of meat, mostly in western countries, has grown continuously, to a point where meat has become an important element to most dishes. This continuing trend can only be maintained with the expansions of size and efficiency within the meat industry.

The increasing accessibility of meat products, however, has undesirable consequences. On one hand there are ecological consequences, as discussed in the first sub-chapter, and on the other hand, outsourcing of meat production, urban as well as global, has caused a dissociation between the consumer and the meat.

The involvement with meat production has disappeared almost completely since the emergence of the modern slaughterhouses. In the last few decades, it is sometimes not even possible to know where a meat product comes from and if it even is, what the package has described.

Nonetheless, meat still plays a major role in the culinary arts and is thus from preparation to presentation an object wrapped in aesthetics.



Figure 1.11 | Kuzu Pirzola made by Nusret Gökçe alias “Salt Bae”



Figure 1.12 | *The Slaughtered Ox* - Rembrandt van Rijn, 1655



Figure 1.13 | *Im Schlachthaus* - Lovis Corinth, 1893

THE CULTURE OF SLAUGHTER

About 10,000 years ago the domestication of animals, gradually replaced hunting with livestock breeding and slaughter. Already established hunting rituals were translated into slaughter rituals, turning meat into an artifact of religious ceremonies.

These orchestrated sacrifices were offerings to the gods in exchange for wealth, fertility and the sake of good will.

Ancient cultures, such as the Greeks only consumed ritually slaughtered animals.^{8,9}

Other religious groups integrated customs of slaughtering into religious laws. These religions still have strict laws regarding which type of meat can and cannot be eaten and which methods of killing domestic livestock must be followed.



Figure 1.14 | Jewish Shechita - depiction from the 15th century

The most renowned examples are the Jewish „Shechita“ and the Islamic „Dhabīhah“. They define which animals are „kosher“ or „halal“ and therefore allowed to be slaughtered. The rules of these religious methods of slaughter are very strict, they define which method of stunning is permitted, which cuts have to be used and in which order they must take place. Minor mistakes in doing so, such as misplacing the cut or pausing for too long can spiritually spoil the meat.¹⁰ Christianity offers an exception to these strict rules. While many Christians take the fasting season seriously, the new testament has in fact no explicitly defined rules concerning the slaughter of animals. This has led the western world to slowly adapt more practical, rather than religious methods.¹¹

This secularization of slaughter slowly transformed the spiritual duty of slaughter into a task of cruelty and thus stigmatized the ones performing it.

The emergence of the modern slaughterhouse and how it lead to the modern factory and hence modern architecture is discussed in the following chapter.



Figure 1.15 | Bleeding ritual - Kenya



Figure 1.16 | Sheep scalding - La Vilette, 1922

Chapter 2

FACTORIES





Figure 2.0 | Production line

FROM SHAMBLES TO SLAUGHTERHOUSES

In the late eighteenth-century, slaughtering took place in the centers of large European cities, such as London and Paris. Stockyards and wet markets, also known as „shambles“ were shattered all over the city, for instance in Châtelet, Paris. Louis-Sébastien Mercier, a French writer and resident of Paris called it “by far the worst-smelling place in the whole world.”¹²

During the industrial revolution, a series of issues, such as rapid urban expansion as well as social and health concerns led to a public disapproval of shambles. On top of that, Paris even suffered from an infrastructural overload. Around 1850 approximately a million animals traversed the city each year, causing street pollution and traffic congestions. The public yearned for a centralization and removal of slaughtering from the immediate vicinity.

Baron Georges-Eugène Haussmann, a prefect of Paris saw the opportunity and proposed the building of new slaughterhouses, connected to the railroads and thus in 1867 „Le Marché et Les Abattoirs de La Villette“, the first large and centralized abattoir opened in the district La Villette.



Figure 2.1 | Old Smithfield Market

While Paris reformed existing urban structures and thus decentralized meat production, Chicago was creating new urban structures. In order to connect markets, abattoirs were built centrally, directly connected to the railway system. Chicago's meat industry constantly invented and improved existing technologies, such as the invention of refrigerator rail cars, as well as the two-story disassembly line, invented 1845 in Cincinnati.

The Union Stock Yards, built in 1865, took advantage of these technologies, as well as its connection to the major cities of The United States and turned into Chicago's main meat production.

The astronomical growth of the Union Stock Yards turned the meat industry into Chicago's economical backbone and subsequently Chicago into America's biggest meat producer.

By the beginning of the twentieth century the number of annually slaughtered hogs had risen from 20,000 in 1850 to 13 million and Chicago had become the second largest city of the United States.¹³

Carl Sandburg, an American poet, called the city the „hog butcher to the world“¹⁴



Figure 2.2 | Les Abattoirs de la Villette

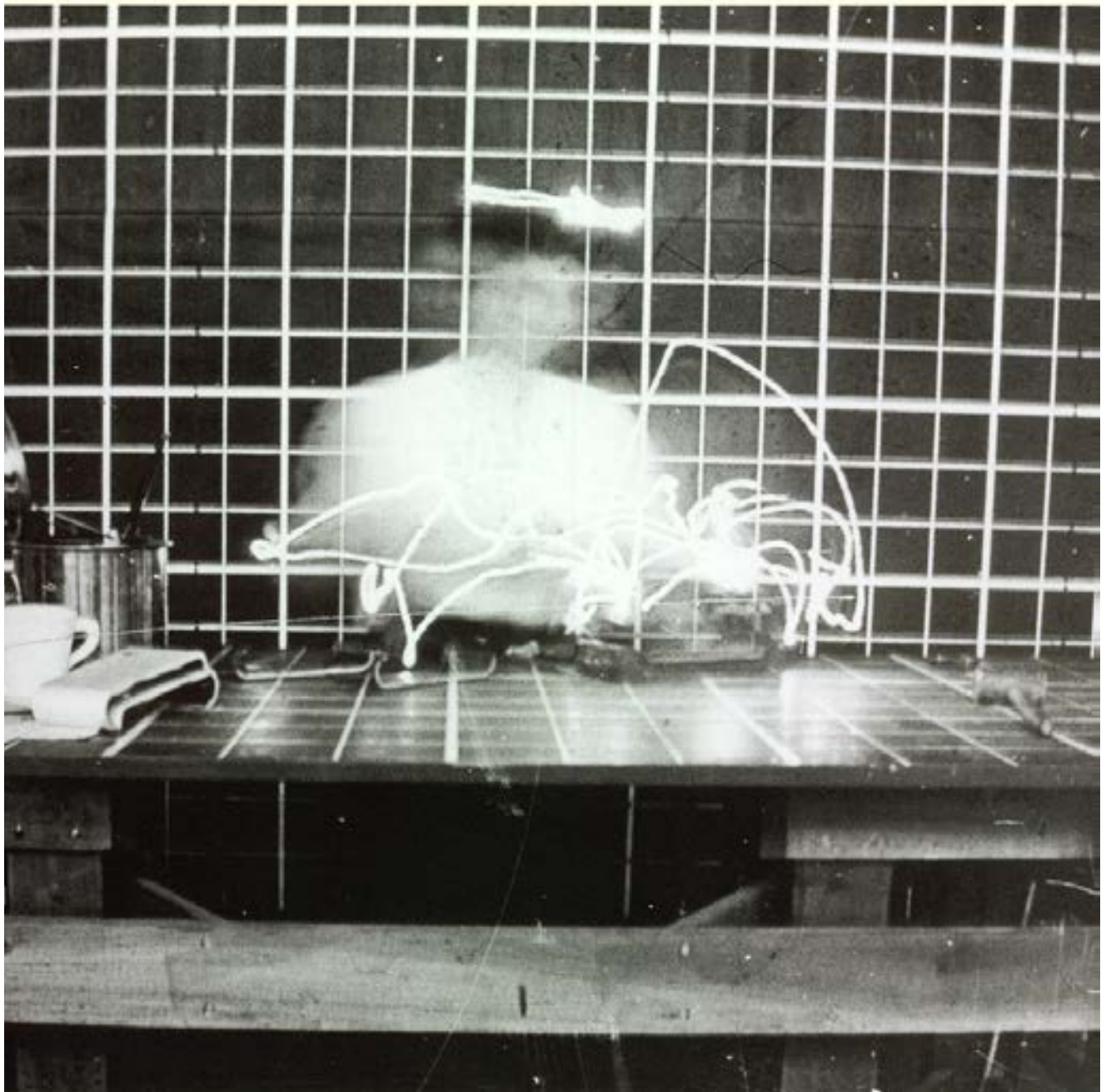


Figure 2.3 | Motion study by Frank Gilbreth, 1913

FROM DISASSEMBLY TO ASSEMBLY LINES

At the beginning of the 20th century, time management and motion efficiency was taken very seriously. Above all were Frederick W. Taylor and the married couple Lilian and Frank Gilbreth. Their endeavor was to maximize labor productivity by analyzing and managing the process and movement of production.

They made hundreds of photographic studies, attaching lights to workers and capturing their movement with long time exposures in order to track unnecessary motions and find the best way to perform a certain task.¹⁵

Paired with his own methods, Taylor developed the „Scientific Management“, a theory of analysis and improvement of work flows. Taylor applied his methods to dozens of factories before 1917. Soon after, his theory, which had become known as Taylorism gained massive popularity.

Combining methods of Taylor and Gilbreth, as well as various new technologies in 1913 Henry Ford created a revolutionary process to produce the Ford Model T at the Highland Park Ford Plant, one of his most important inspiration being the disassembly line, used in the Chicago meat industry. The successful development and integration of the assembly line drastically increased the production and ultimately marked a turning point in the history of manufacturing.¹⁶

In 1922 Ford said of the assembly line (through his ghostwriter Crowther):

„I believe that this was the first moving line ever installed. The idea came in a general way from the overhead trolley that the Chicago packers use in dressing beef“¹⁷

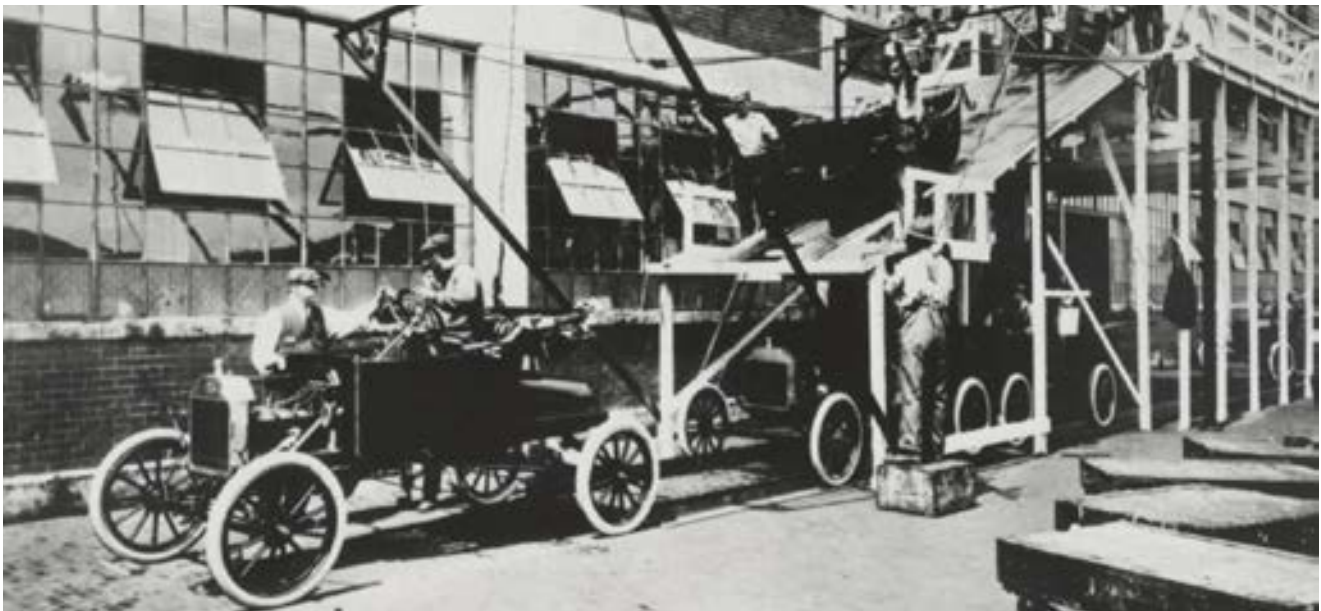


Figure 2.4 | Ford assembly line, 1913



Figure 2.5 | Meat packing in Cincinnati, 1873



Figure 2.6 | Ford assembly line, 1913

FROM MODERN FACTORY TO MODERN ARCHITECTURE

The spread of the modern factory was acknowledged worldwide. Fascinated by the functionalism and new aesthetics, Walter Gropius writes in an 1913 essay on industrial buildings the following:

„America, the Motherland of Industry, possesses some majestic original constructions which far outstrip anything of a similar kind achieved in Germany.“¹⁸

Captivated by Americanism, a movement which is associated with efficiency, rationalism and technological advance, European architects strived to build houses, hospitals and schools based on rationalism and functionalism, trying to imitate factories.

Most notably is the architectural office led by Peter Behrens, a German pioneer in industrial design. The building and ongoing involvement with the AEG turbine factory influenced his employees. Three of them, namely Walter Gropius, Ludwig Mies van der Rohe and Le Corbusier later became the forerunners of the modern architectural movement, arguably one of the biggest paradigm shift in architectural history.



Figure 2.7 | Fiat factory, Lingotto, 1926

While modernist architects translated the logic of engineer-designed structures onto other building typologies, the factory often remained the domain of engineers, rather than architects. Modern factories nonetheless created interesting buildings, that directly reacted to the manufacturing process.¹⁹

The fusion of new technologies, such as conveyors or spiral chutes had a direct influence on the buildings, creating previously unknown spatial concepts and industrial structures blatantly reduced to its functional requirements. In the 1930s Russian engineer Georgy Marsakov designed vertical fully-automated bread factories, 5 of them in Moscow and another 2 in St. Petersburg.²⁰



Figure 2.8 | Van Nelle factory



Figure 2.9 | Ford Plant, River Rouge - Charles Sheeler, 1927

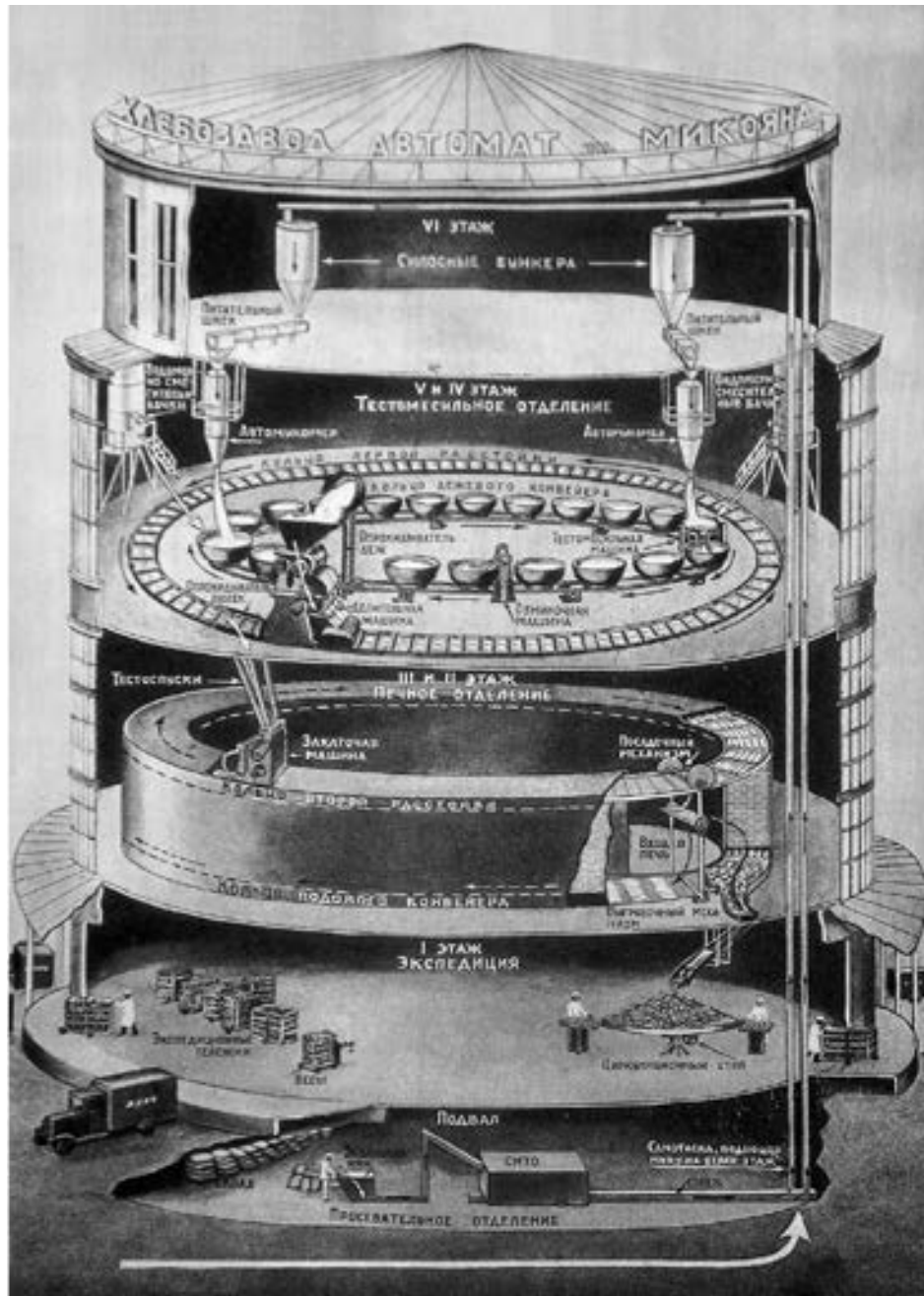


Figure 2.10 | Automatic Bakery - G.P. Marsakov, 1930s

THE POSTWAR FACTORY - BIRTH OF THE SHED

During and after the second world war, there was a strong urge for a new factory typology. While factories at the time were tailored to work as efficiently as possible, by spatially reacting to given processes, missing flexibility and high construction costs rendered them unfit to keep up with the bursting production demand.

Very short time frames, material scarcity and the lack of money led manufacturers towards prefabricated structures, resulting in single-floor open-plan spaces, rather than sophisticated arrangements of spaces.

Although the architecture was disconnected from the machinery, effectively transforming the building into a mere shed, many building technologies, such as air systems originate from the shed-factory. Even structural development benefited from the new factory, as architects and engineers continuously worked on better structural solutions, to create roofs that span longer distances.²¹



Figure 2.11 | Willow Run airplane plant

In contrast to the vertical growth of the modern factory, the shed grew horizontally and hence occupied vast areas of land.

This phenomenon and cheaper land costs of sub-urban sites led to the marginalization of factories.

The urban displacement of manufacturing and the indistinguishability of prefabricated facades resulted in the urban disappearance of factories.

The shed, with its immense occupation of land, is not an ecologically feasible solution. Nonetheless it is still the prevalent typology up until today.



Figure 2.12 | Willow Run airplane plant interior



Figure 2.13 | Chrysler Tank Arsenal, Michigan, 1941



Figure 2.14 | Willow Run factory, Ypsilanti, 1941

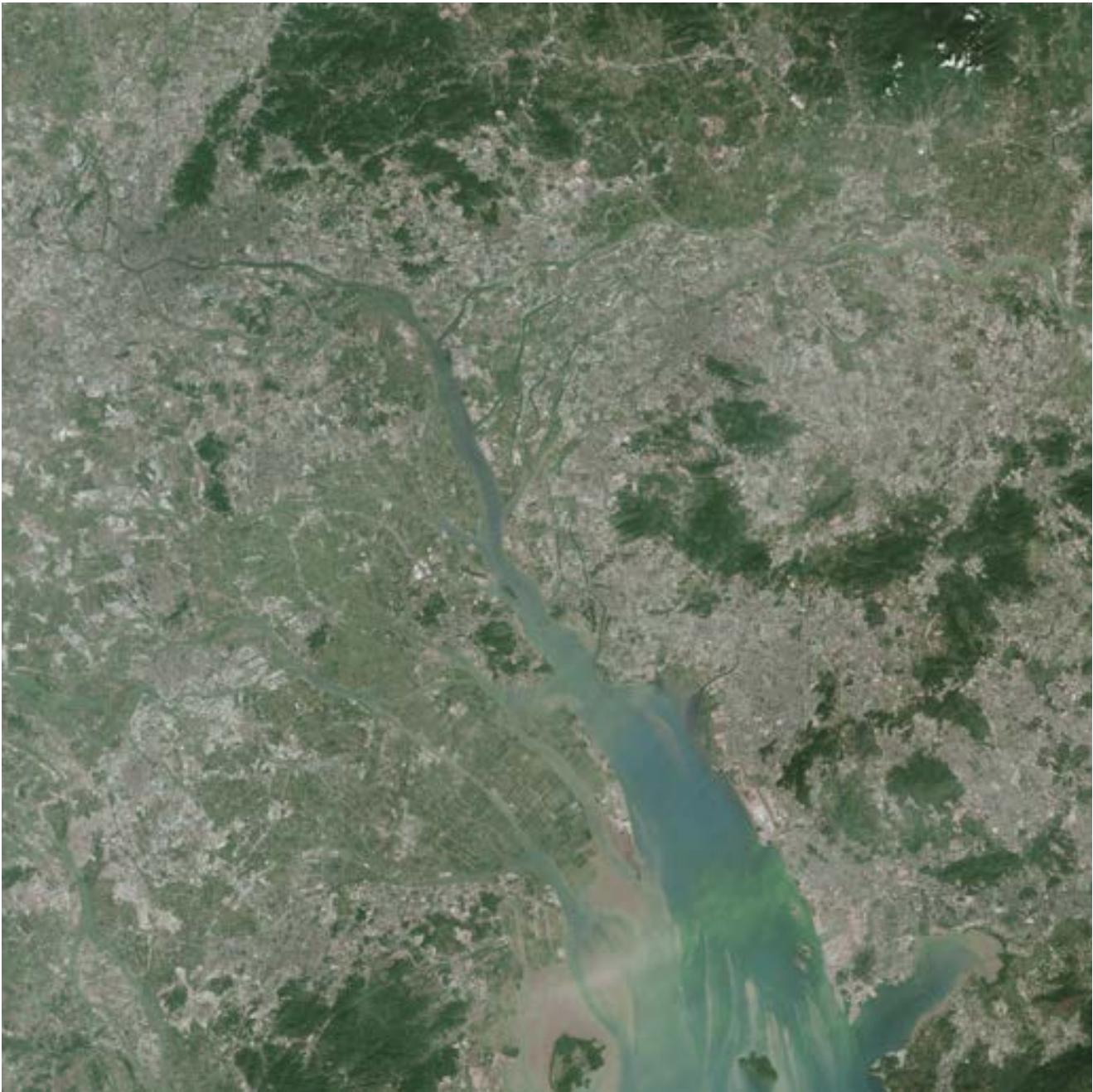


Figure 2.15 | Pearl River Delta, 2014

THE GLOBAL FACTORY

International trade agreements from the 1970s to the present has set the path for multilateral economic exchange. As a result, production of goods was often relocated to emerging countries with cheaper working conditions.

Noteworthy are trade agreements such as NAFTA (North American Free Trade Agreement)1994 or AFTA (ASEAN Free Trade Area)1992.

The latter established a free trade area between all ASEAN countries, namely: Malaysia, Singapore , Indonesia, Philippines, Thailand, Brunei, Burma, Cambodia, Laos ,Vietnam and China.²²

The creation of Special Economic Zones (SEZ) in China in 1979, among others multiple cities in the region of Guangdong contributed to the exponential growth of the region.

The upcoming explosive growth of the region transformed the Pearl River Delta, amongst other regions such as the Yangtze River Delta, into one of the most densely urbanized areas of the world.

At the end of the 20th century Hong Kong was the leading city of Guangdong. Its economic value was equal to one fourth of Chinas GDP.²³

Today however Hong Kong plays a minor role compared to the „Mega City Clusters“,which produce about 40 percent of the country's GDP.²⁴

These „super regions“ play such an important global role, that they are often referred to as the worlds factory.

This can be seen as the next big step of dissociation between the customer and production.

The following pages show the astronomic urban growth of the pearl river delta.

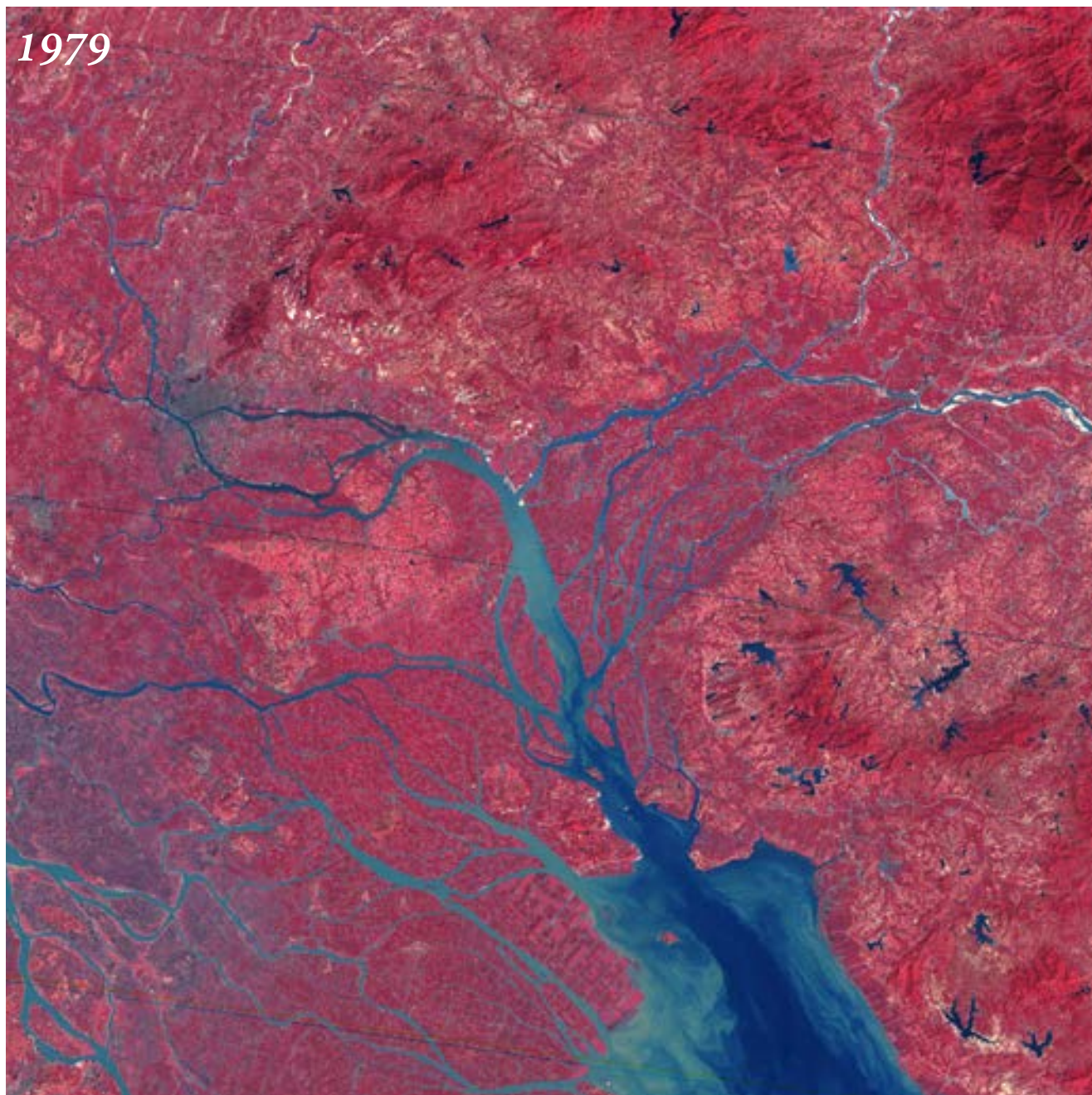


Figure 2.16 | Pearl River Delta, 1979

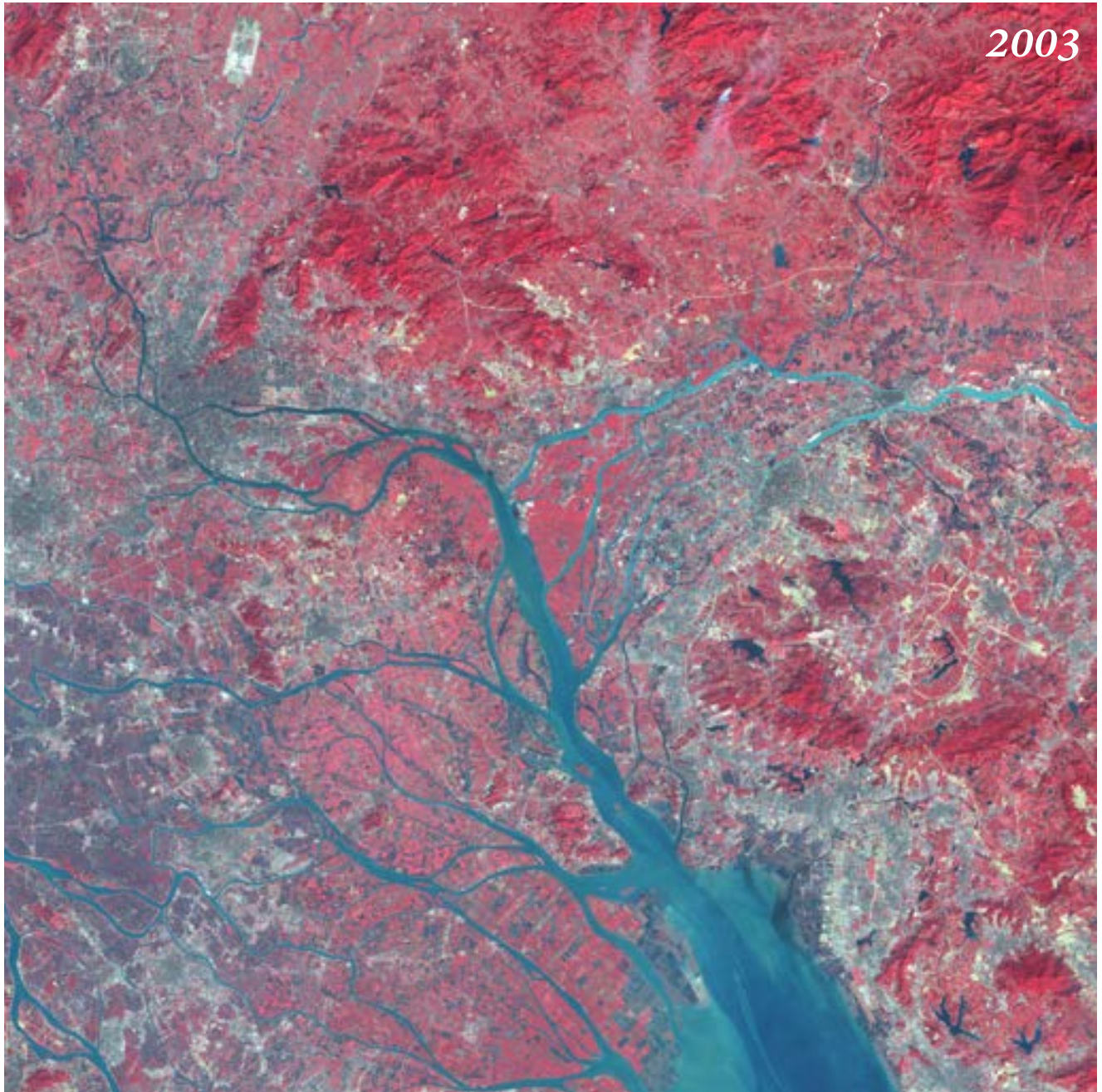


Figure 2.17 | Pearl River Delta, 2003

WORKING CONDITIONS

While automation already takes place in many industries, most notably the car and technology industry, today's manufacturing still heavily relies on manual labor. Manual labor has been a topic of social dispute since the first industrial revolution. While the conditions for blue-collar workers in western countries has improved significantly, the same cannot be said about low-skilled laborers in emerging countries.

Manufacturing takes place off-shore, where subcontracted facilities operate the manufacturing. The most famous subcontracting manufacturing is perhaps Hon Hai Precision Industry Co., Ltd., better known as Foxconn Technologies.



Figure 2.18 | Assembly bench in Foxconn's Longhua complex, Shenzhen

It is the world's largest manufacturer of electronics and produces electronic devices such as the Kindle, the Xbox One, iPhone 11 and many more. It operates dozens of facilities worldwide and produces about 40% of the world's consumer electronics.²⁵

It has been the center of various controversies, including a series of suicides, linked to low wages and bad working conditions.²⁶

To solve this issue today many factories have special nets installed to prevent suicides.



Figure 2.19 | Suicide prevention net

FACTORY OF THE SPECTACLE

As factories have almost completely disappeared from our immediate surroundings, branding has gotten more tangible and therefore has taken over the role of the face. With a multitude of nearly identical products, it has gotten obvious that branding today is often more important than the product itself.

Nonetheless there seems to be a new fascination with the mysteries of production and its mechanization. After all separation breeds desire.

Many consumers are not satisfied with the commodity itself, they want to take a look behind the scenes, by seeing the process of production and thus consuming the authenticity of a brand.

This phenomenon, which is known as factory tourism, offers a sneak peak behind the curtains. However, most times these factory tours distort the reality of production, loud and dirty production halls turn into quiet and clean showrooms, that often tell a selective narrative.²⁷



Figure 2.20 | VW Transparent Factory, Dresden

The transparent factory in Dresden took it one step further by making as many production spaces as possible transparent and hence turning the production hall into a stage, the product itself into a subject of spectacle.

When talking about the transparent factory, Gunter Henn, the architect of the factory, admitted the importance of the spectacle:

„The key link is the consumer; we had to respond to the consumer, not to the building client or the worker.”²⁸

However transparency is always bound to pollution and the general approval of certain procedures. The production of automobiles for instance, is most certainly acceptable whereas treatment of sewage or the act of slaughtering and post-processing meat is off-limits.

Contrary to today's meat industry, new technologies such as in-vitro meat get rid of any immediate brutality and thus could reintegrate meat affiliated factories into the city, creating typological hybrids, that possibly combine production with retail and consumption.

A hybrid factory using new technologies could react to today's longing for sustainability, not only environmentally, but also socially and urbanistically, creating a synergetic ecosystem, not only between the factory and the city, but also the production and people (workers, as well as customers).

The relocation to the city combined with vertically condensed production could help reduce delivery distances and save virtual agricultural land.



Figure 2.21 | Cloaca - Wim Delvoye

Chapter 3
MEATFACTORY





Figure 3.0 | Sham Shui Po, Hong Kong

PROJECT

The task of this project is to design a new type of meat factory, which tries to upscale the novel technology of in-vitro meat into a functioning factory.

As this new technology is drastically deviant from contemporary meat production, the whole process, including production, retail and consumption has to be questioned.

To house this new factory, careful attention has been paid to choosing a fitting context. Hong Kong has been chosen, as it is the nation with the highest meat consumption.

Furthermore it is an industry nation that is currently investing into new technologies in order to lower the emission of greenhouse gases and to reduce pollution. Lastly Hong Kong people seem to be willing to experiment on new meat products.

The design of the main production core is derived from a vertical process, which is based on gravity and is being held by a self bracing cylindrical shell structure. This hybrid resembles a cathedral containing fluid mechanisms.

The machinery on its own is an object placed within the city and yet disconnected from it. To properly implant it into the existing urban symbiotic system, the northern part of the building is formed into a vertical architectural promenade, a continuation of the city, a space for interaction. This vertical landscape serves as a open-space food hall, with various different restaurants. Furthermore it houses different interactive elements, in the form of columns. They show possible new ways of interaction with in-vitro meat, for instance automatic retail and machines, which 3d print and cook the meat.

The project aims to raise different questions, such as the tangibility and transparency of a factory, how novel technologies might alter existing production processes and how manufacturing can be merged seamlessly with the spectacle surrounding it.

Furthermore, it questions the use of synthetic biology and thus the design with (and of) life, posing philosophical questions.

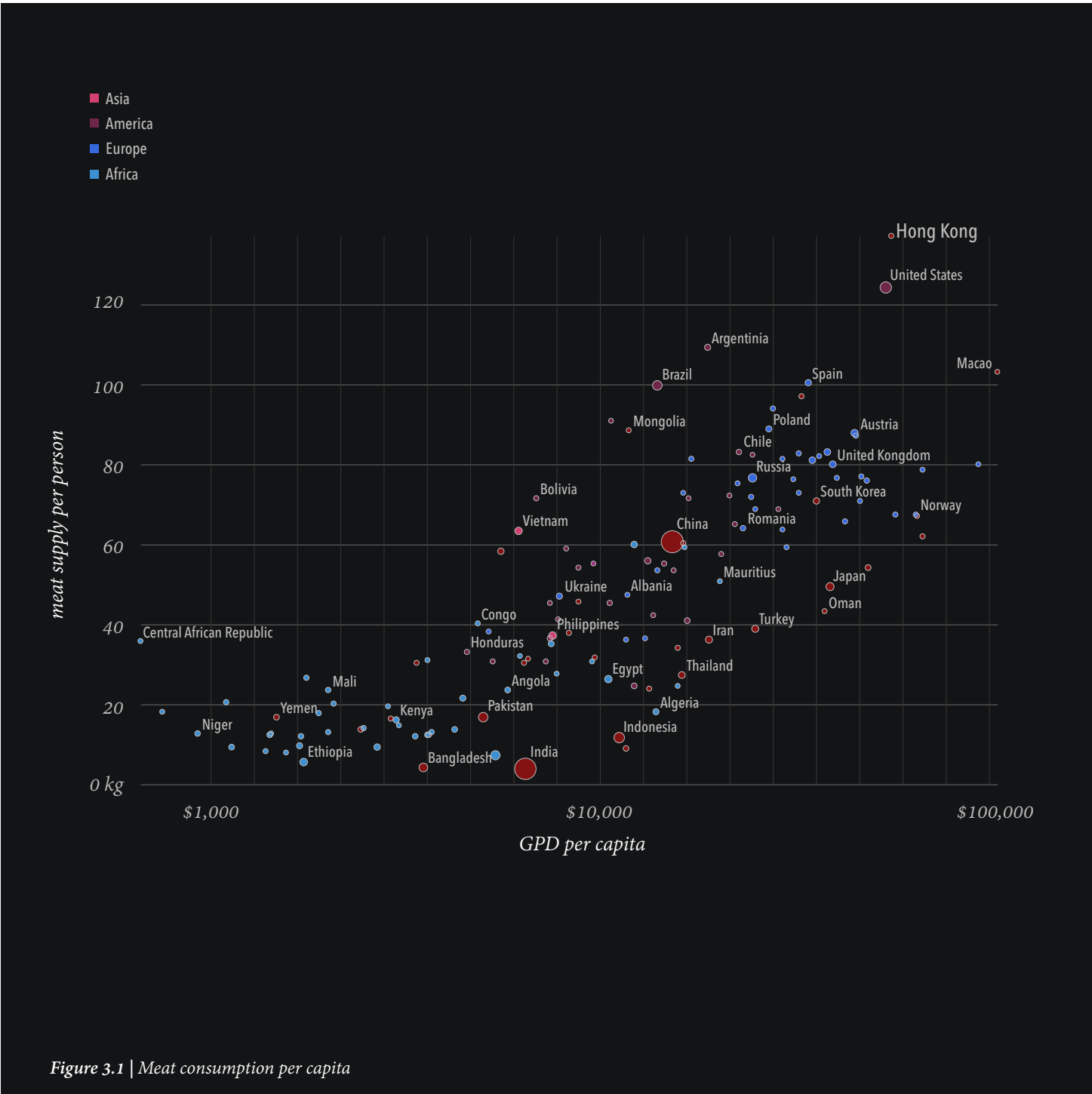


Figure 3.1 | Meat consumption per capita



Figure 3.2 | Guangdong Province Cities



average Hong Kong person eats
137.07kg meat/year

with a population of 7.451 million people

Hong Kong consumes
1,021,308t meat/year

to support its own meat consumption Hong Kong needed

76,802km²

which is roughly the area of 69x Hong Kong(1,106km²)

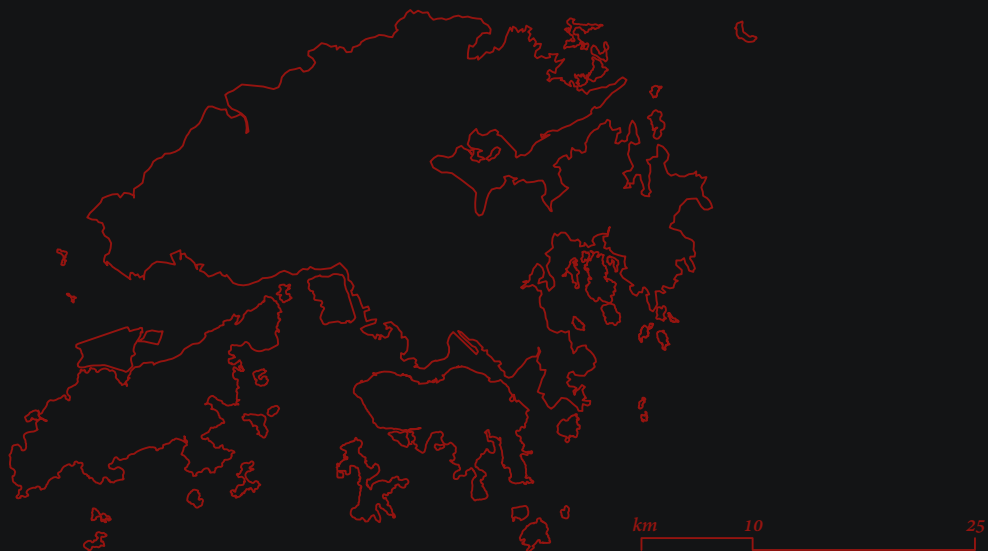




Figure 3.3 | Virtual land area for Hong Kong's meat consumption



Figure 3.4 | Location of Hong Kong Slaughterhouses

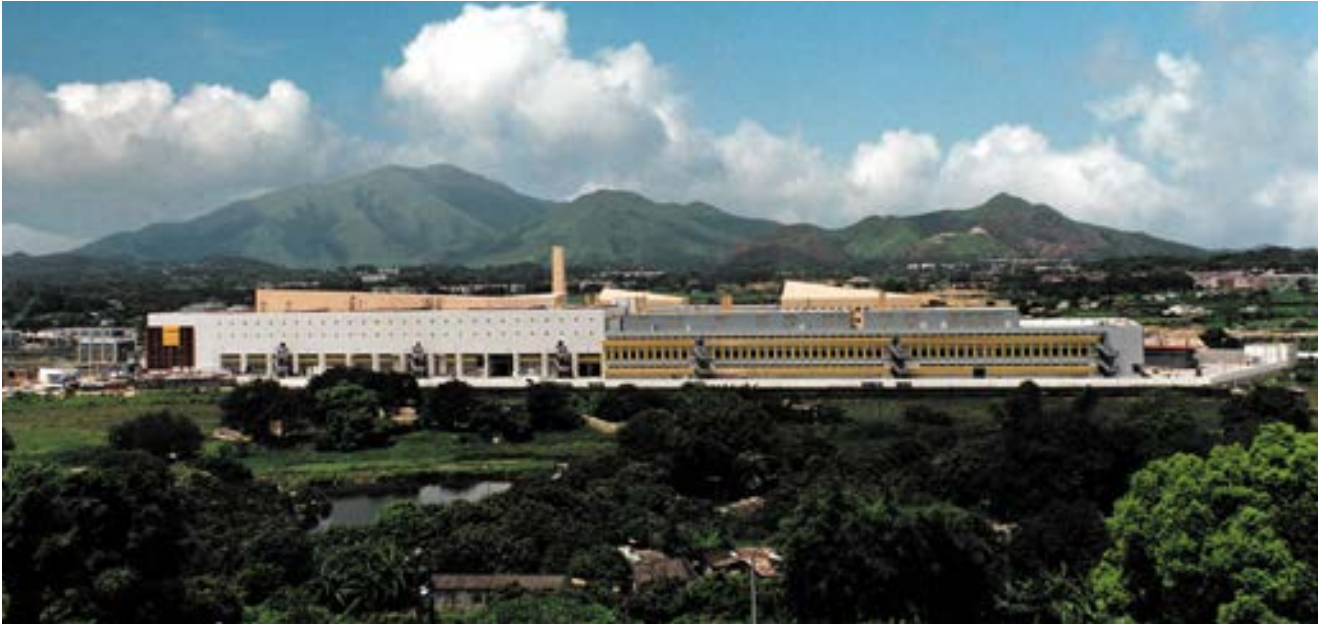


Figure 3.5 | Slaughterhouse Sheung Shui



Figure 3.6 | Slaughterhouse Cheung Sha Wan

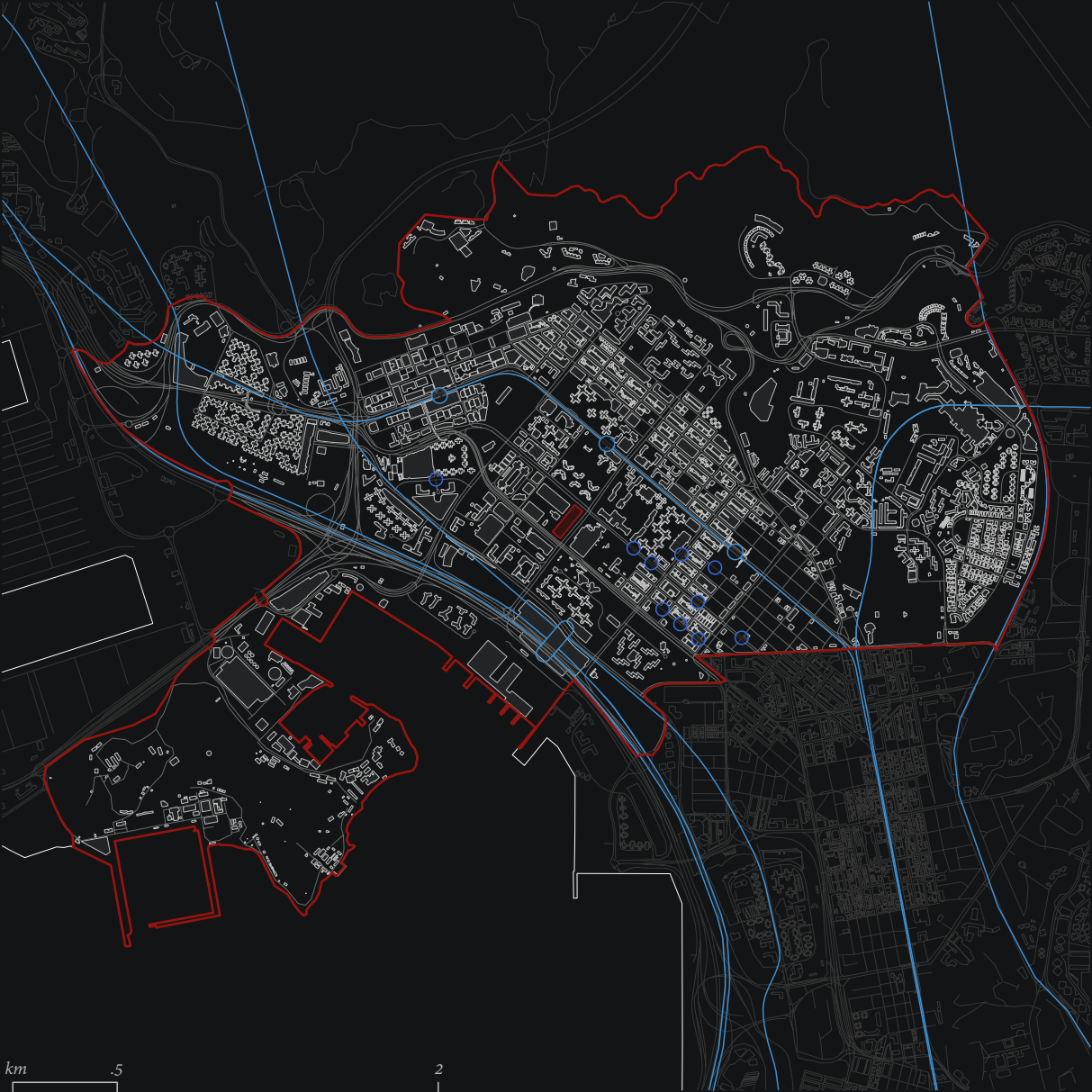


Figure 3.7 | Sham Shui Po District



Figure 3.8 | Sham Shui Po macro analysis

CHEUNG SHA WAN

Cheung Sha Wan is the central area of the Sham Shui Po District. After the second world war it was known as a manufacturing center, specialized in light industries, such as clothing and textiles.

During the open door policy of the People's Republic of China, however many manufacturers moved their factories to the mainland.

The abattoir of Cheung Sha Wan was one of Hong Kong's three main slaughterhouses, that operated from 1969 to 1999. All three slaughterhouses closed, when the government decided to build a single large meat producing facility, close to the chinese border, which opened in 2000.

The former building of the Cheung Sha Wan abattoir lies fallow ever since. In December 2019 the building has finally been demolished to make room for residential buildings. ²⁹

The site is surrounded by the West Kowloon Magistrate's Courts, the Sham Shui Po Park Swimming Pool, residential buildings and two operating vegetable markets.

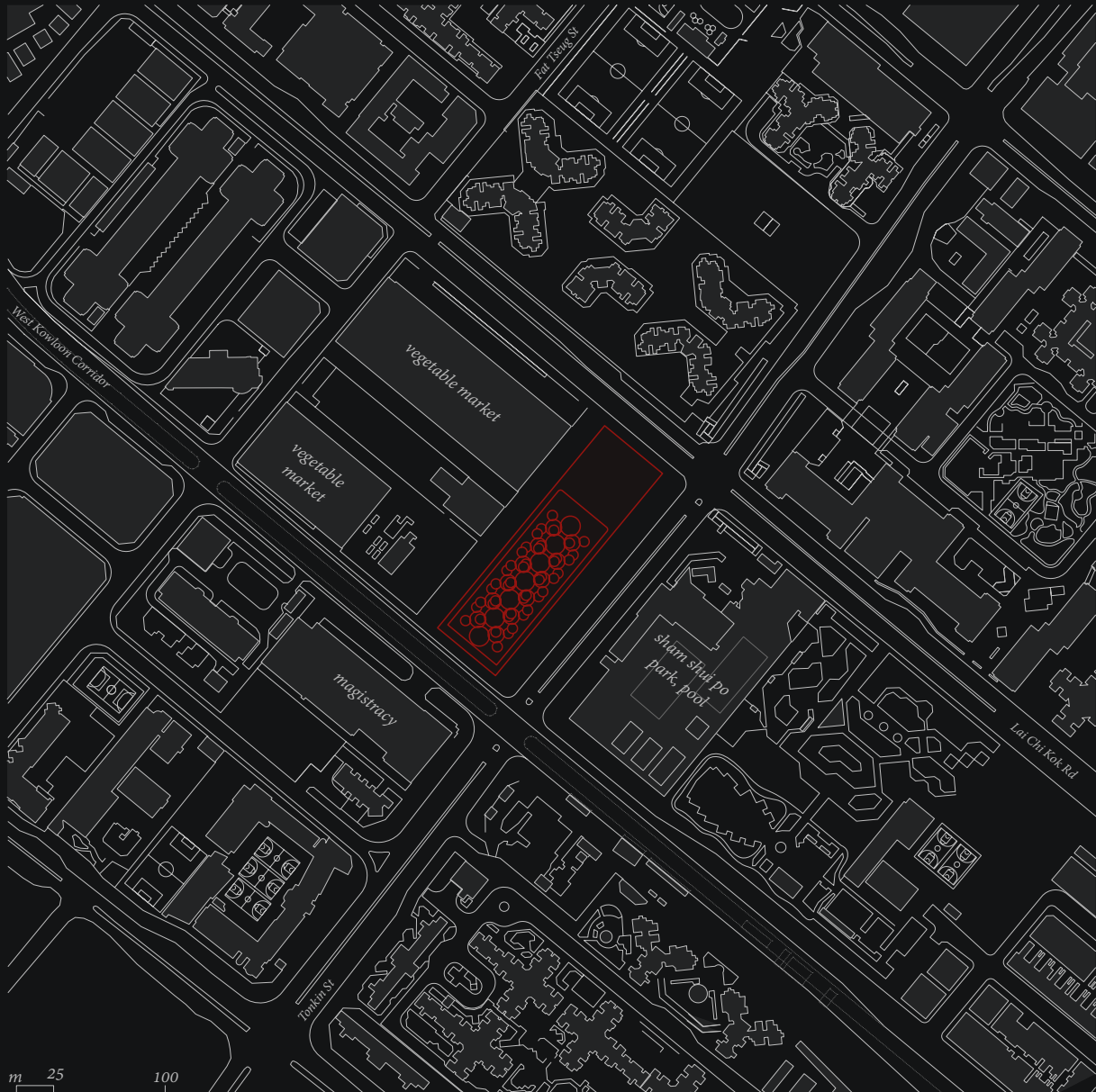


Figure 3.9 | Site Plan

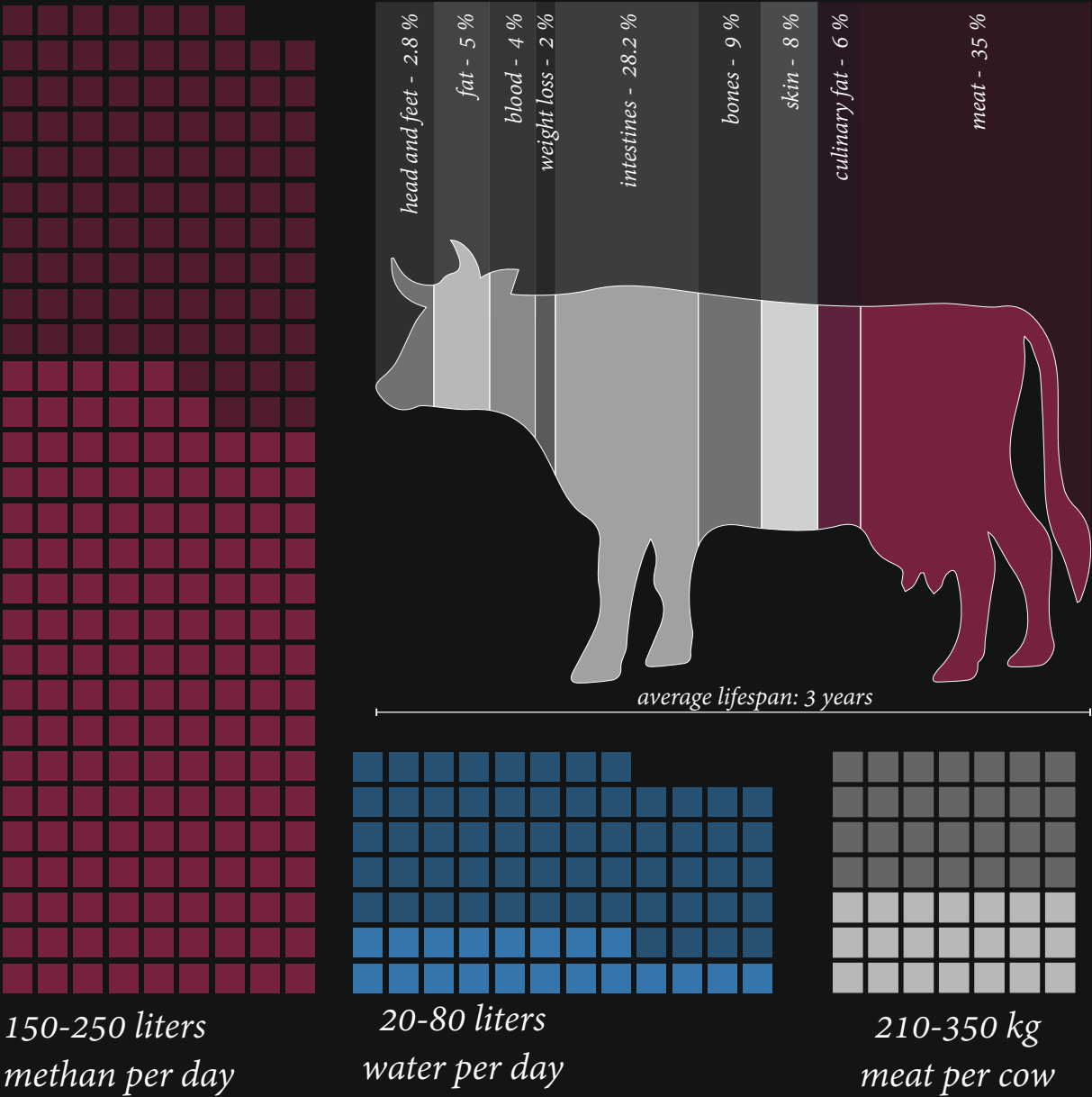


Figure 3.10 | Properties of a cow

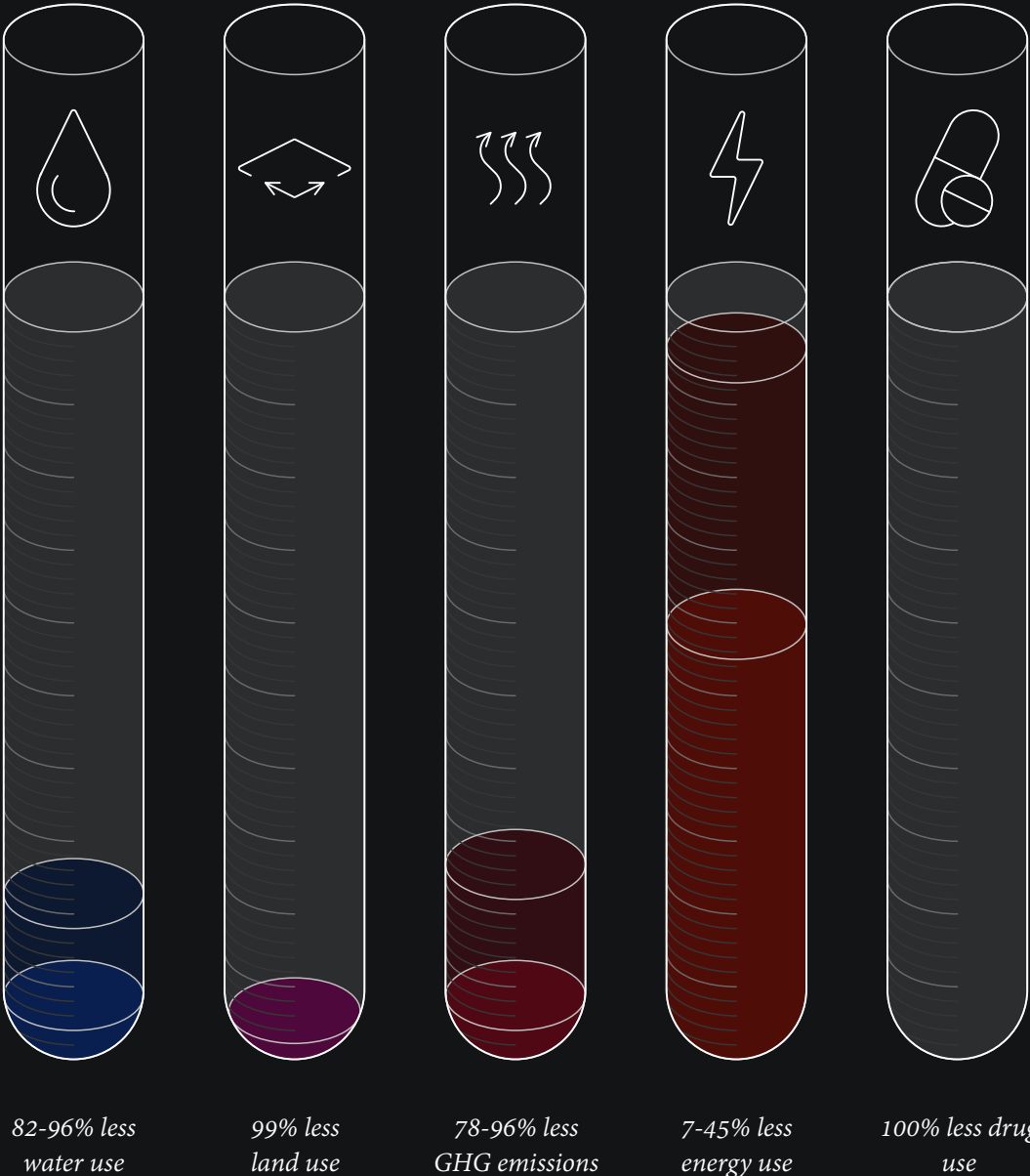
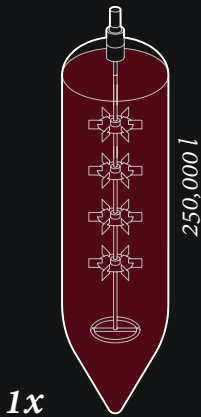
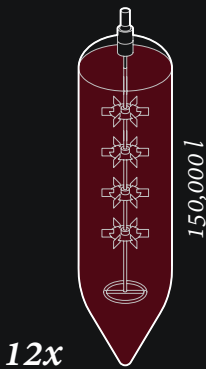
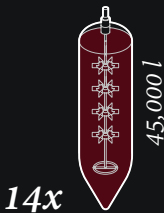


Figure 3.11 | Comparison between conventional and in-vitro meat production

未来肉

1m^3
bioreactor volume
 $\sim 1,000\text{kg}$
meat/year



2,680,000 liters/year
 $\sim 2,650$ tons/year

equals



19,333 HK people

200km^2



equivalent virtual area

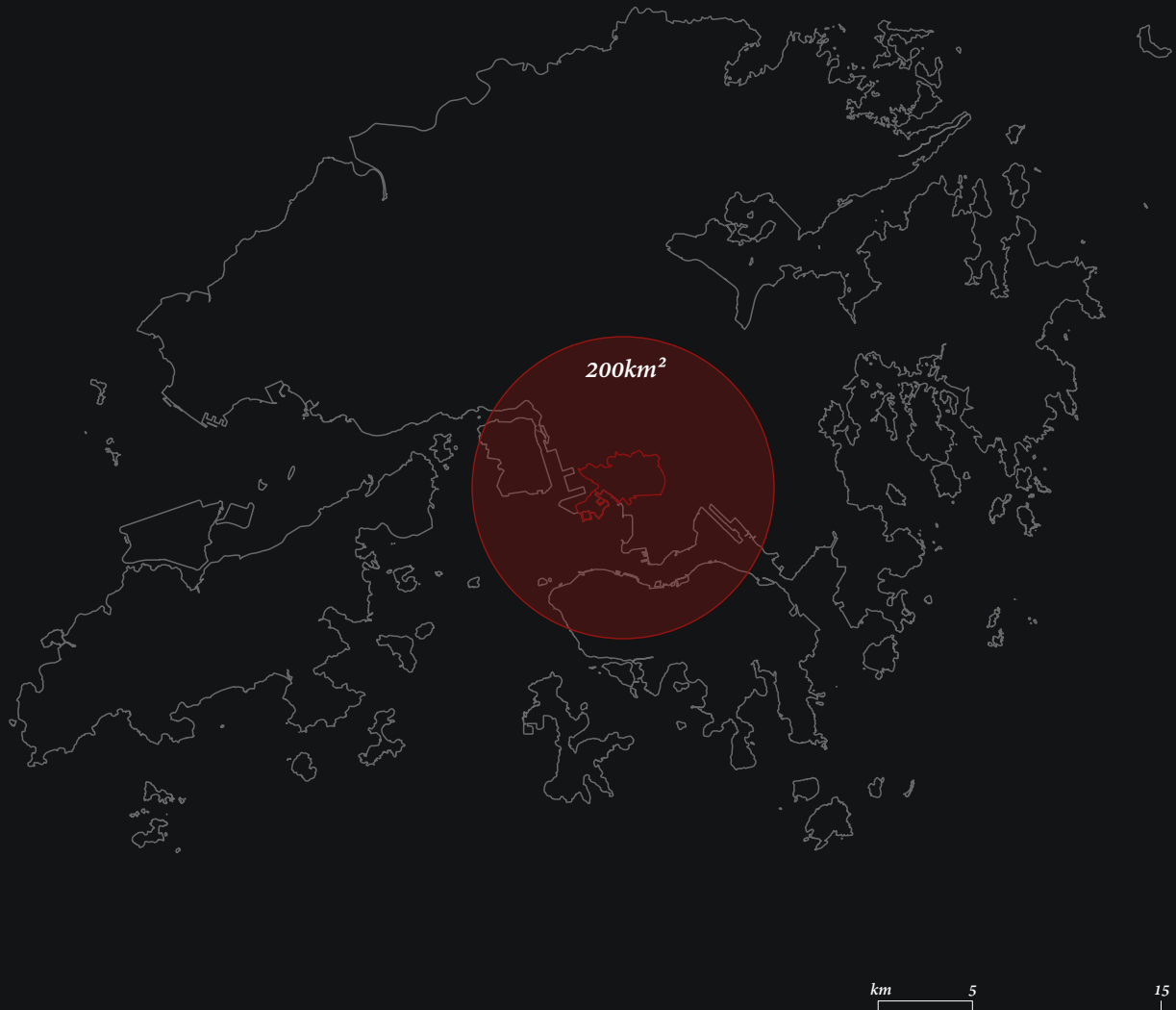


Figure 3.12 | Virtual land saved with one meatfactory

In-vitro meat production process

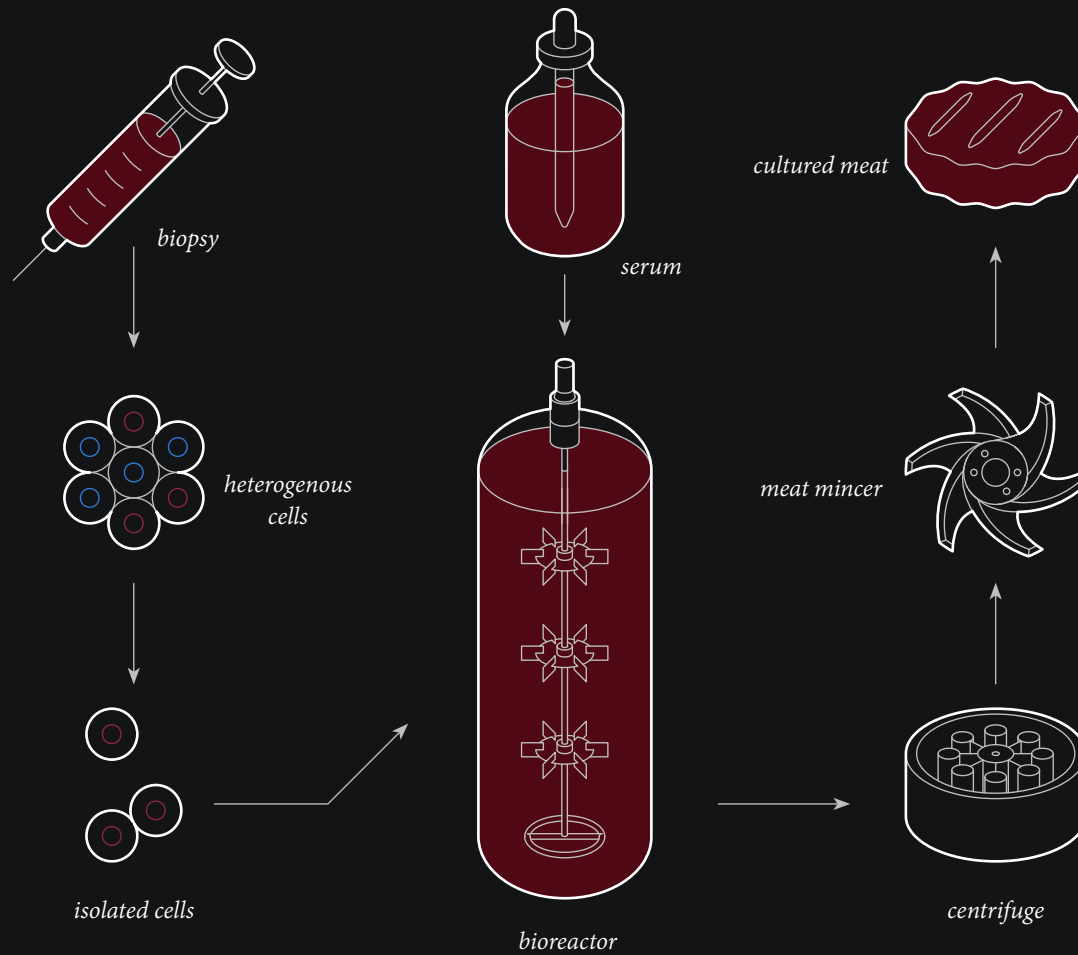
The production process of in-vitro meat is fundamentally different from conventional meat production, as it is a bottom-up process in which muscle and fat cells are cultured and processed, without the need to disassemble an animal.

Instead meat cells are being taken from living animals with a small biopsy. After the desired cell-types have been isolated, they are put in a bioreactor. The bioreactor is a sterile environment, which allows for a precise control over the cell proliferation and growth.

The cells need a nutritional medium in order to grow, this can be animal serum (fetal bovine serum) or a non-animal alternative, which is of great interest for tissue engineering researchers.

Other growth determining factors are proper ventilation, scaffolding and ph value regulation.

Once the meat cells have matured into myofibers, they are centrifuged and subsequently minced. During the mincing additives, such as vitamins or iron can be added.



myogenesis

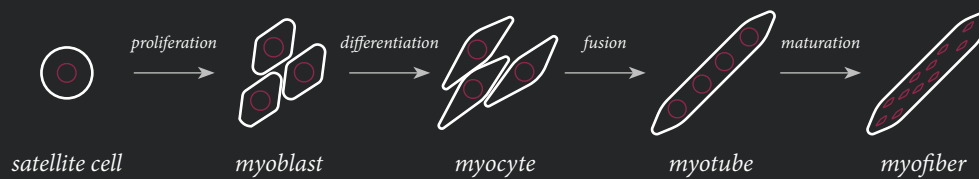


Figure 3.13 | In-vitro meat process

Production system for an automatic meat production

In order to fully automate the production process, multiple steps have to be taken. The first step is to physically connect all necessary elements. The silos, bioreactors, centrifuges and meat mincers are stacked vertically. This reduces the amount of electricity needed to pump the liquids from element to element. The principles of fluid mechanics have the effect, that fluid that leaves the silos towards the bioreactors, sucks the existing fluids from the bottom, with only a smaller pumping motor necessary to compensate for friction.

Once the meat has fully matured, the centrifuges separate the solids from the liquids. The solids are led to the meat mincers, meanwhile the residual liquids are led to a tank at the bottom of the system. From there it can be used as fertilizer for algae production and biogas production via anaerobic digestion.

In the meantime the minced meat is led to fillers, that are connected to a conveyor system, which automatically moves palettes with commercial containers to the fillers and from there to the freezing chamber.

Once a batch of meat is needed, the conveyors automatically move it towards the packing station.

The only junctions for human labour are at the dispatching area, where trucks are un- and reloaded.

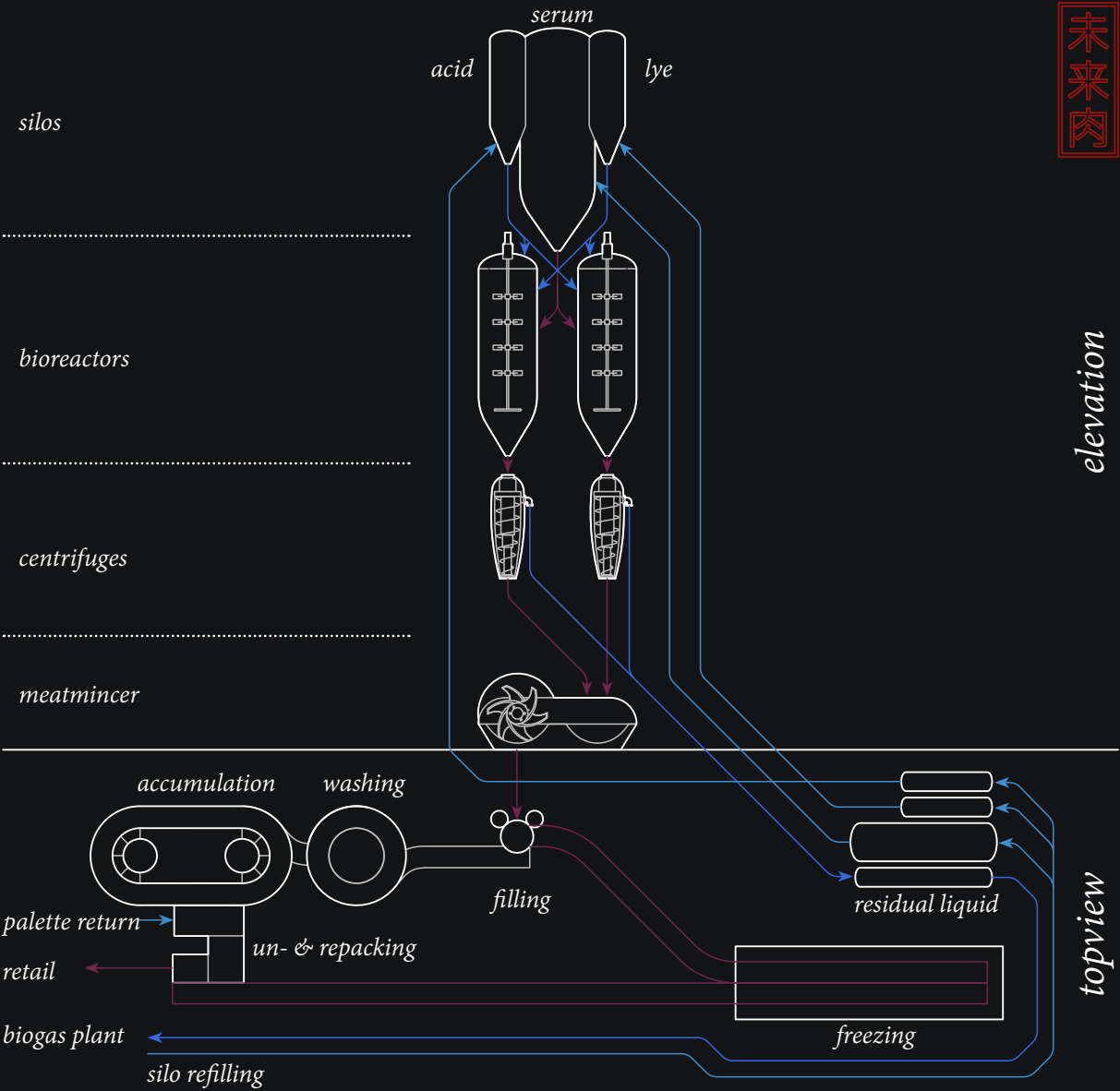
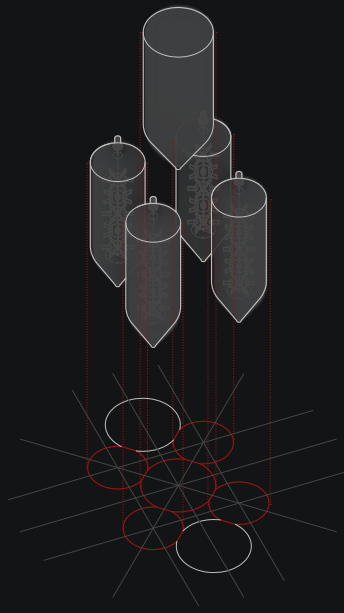


Figure 3.14 | Production system for automatic meat production

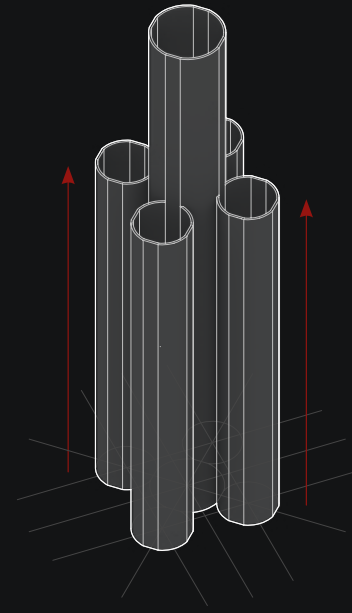
To create the inner shell, the main elements are arranged in a grid of slightly overlapping circles. The circles are extruded and given an appropriate material thickness to hold the elements. The extruded intersections pose as guidance to carve out arches.

In the next step similar elements are added to hold the outer bioreactors as well as the centrifuges.

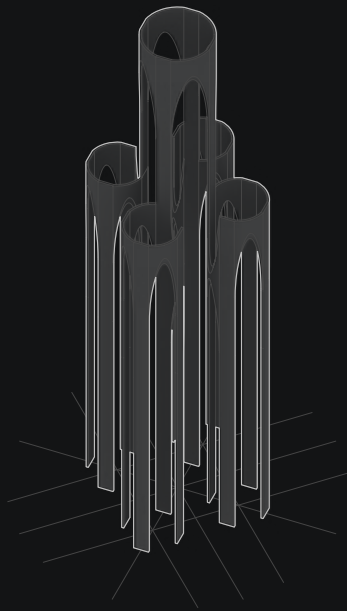
In the last step the geometry is iterated to create the entire structure.



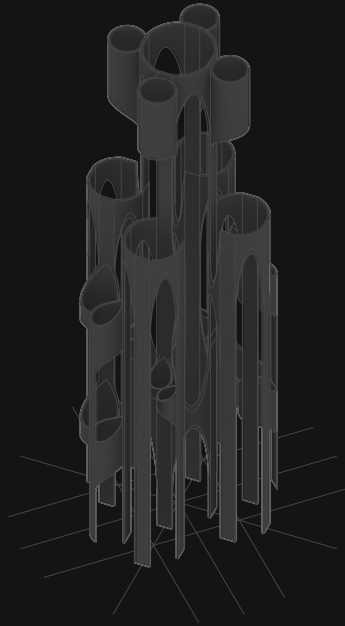
positioning



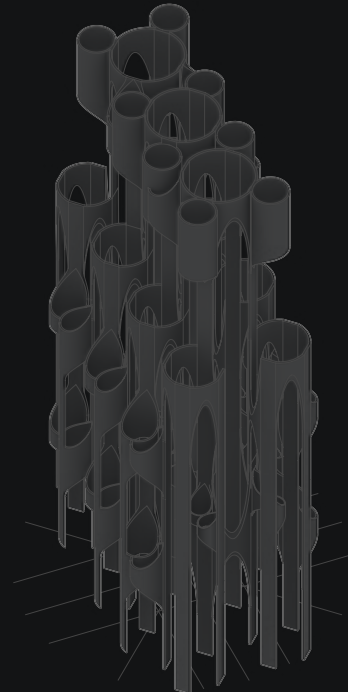
extrusion



cutting



addition



iteration

Figure 3.15 | Formal diagram



pumping

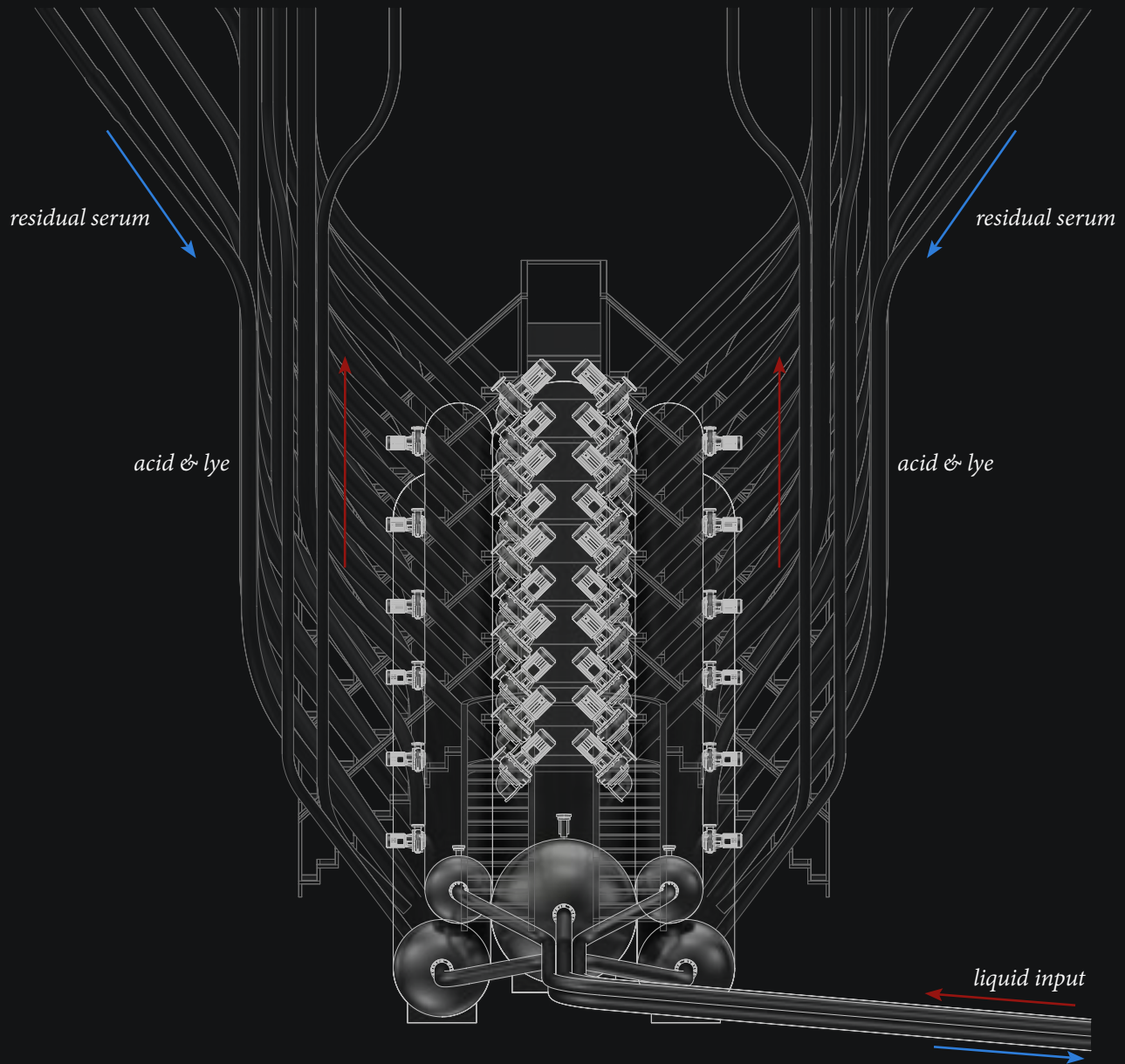
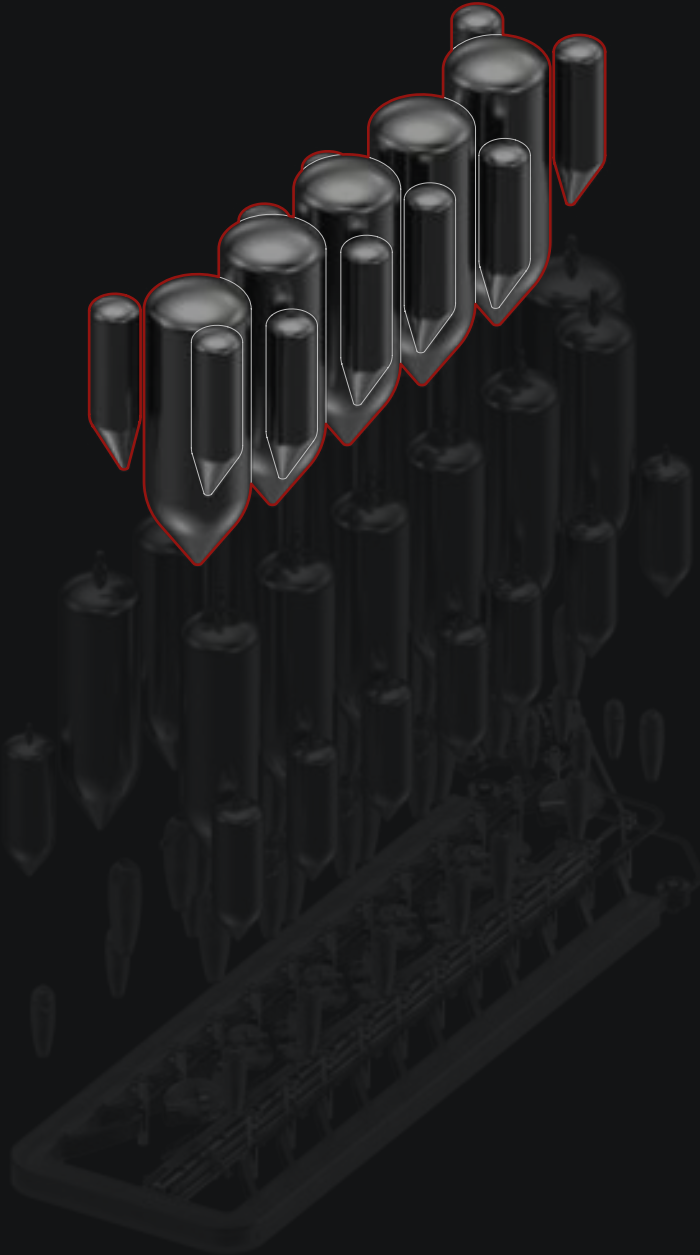


Figure 3.16 | Production elements - pumping



silos

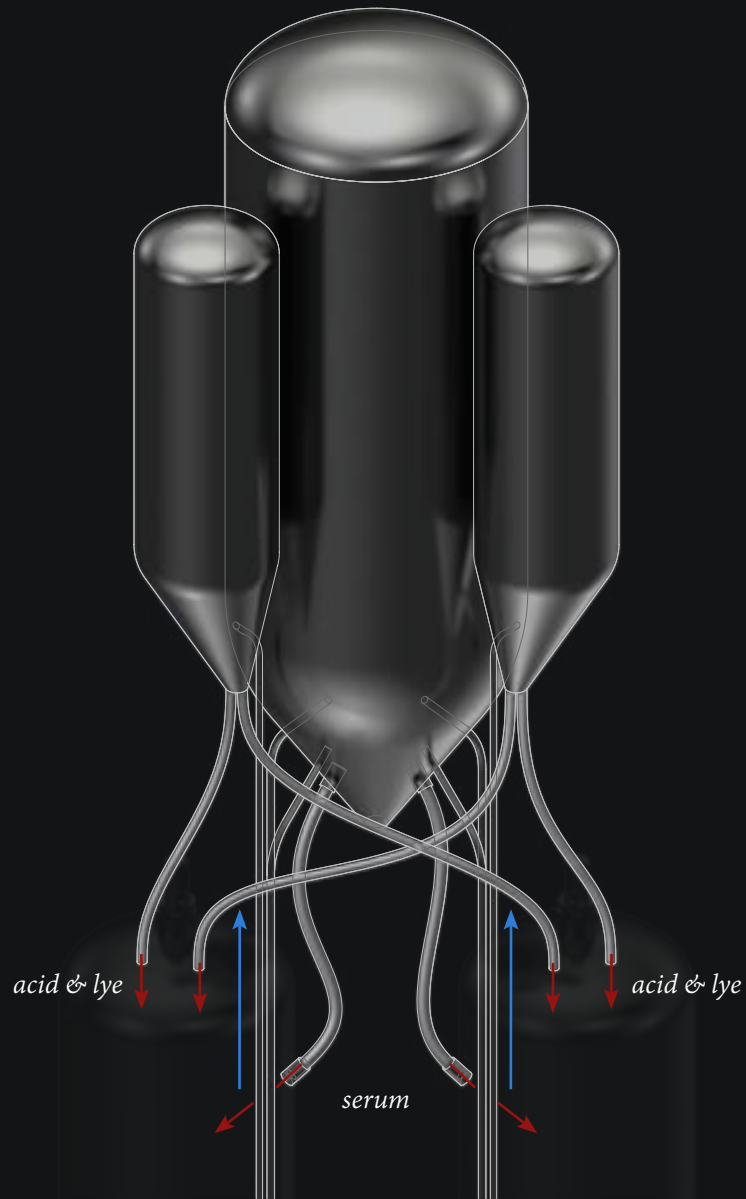
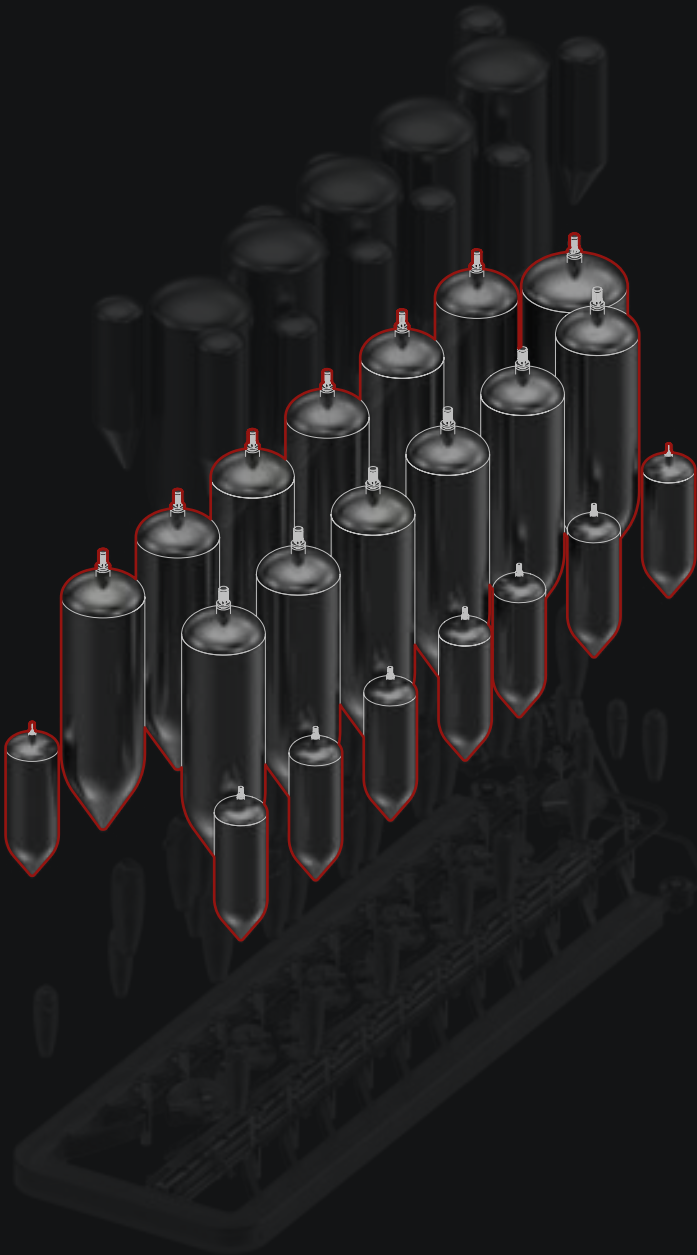


Figure 3.17 | Production elements - silos



bioreactors

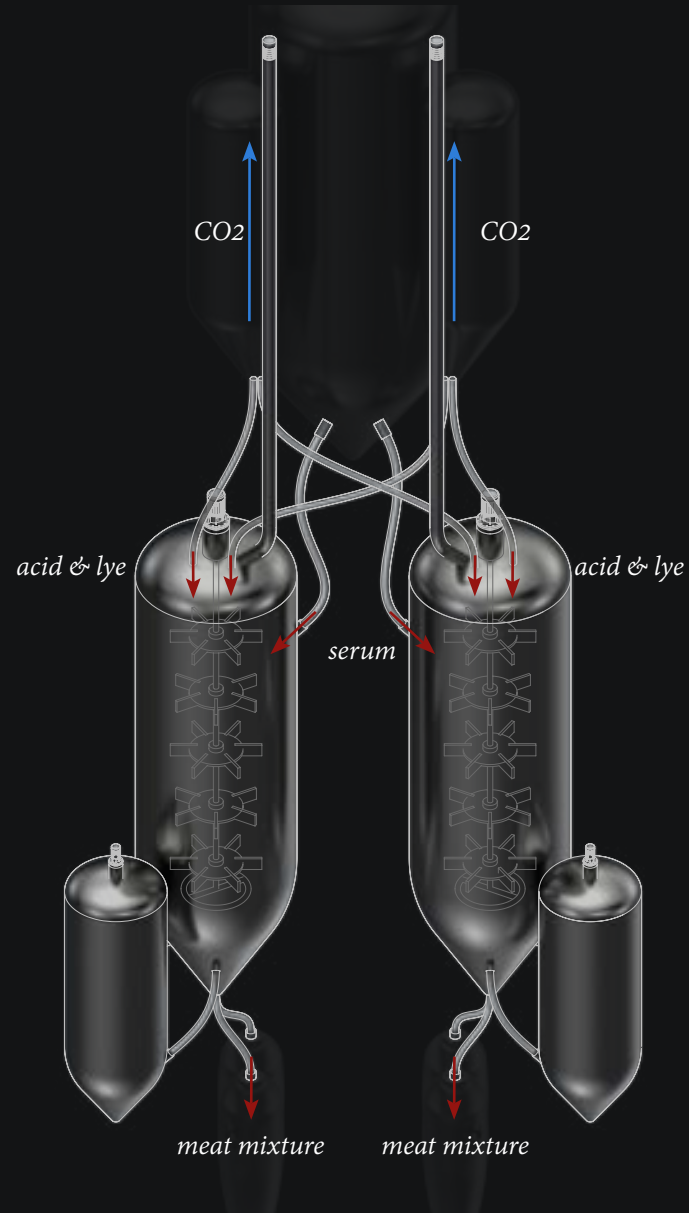
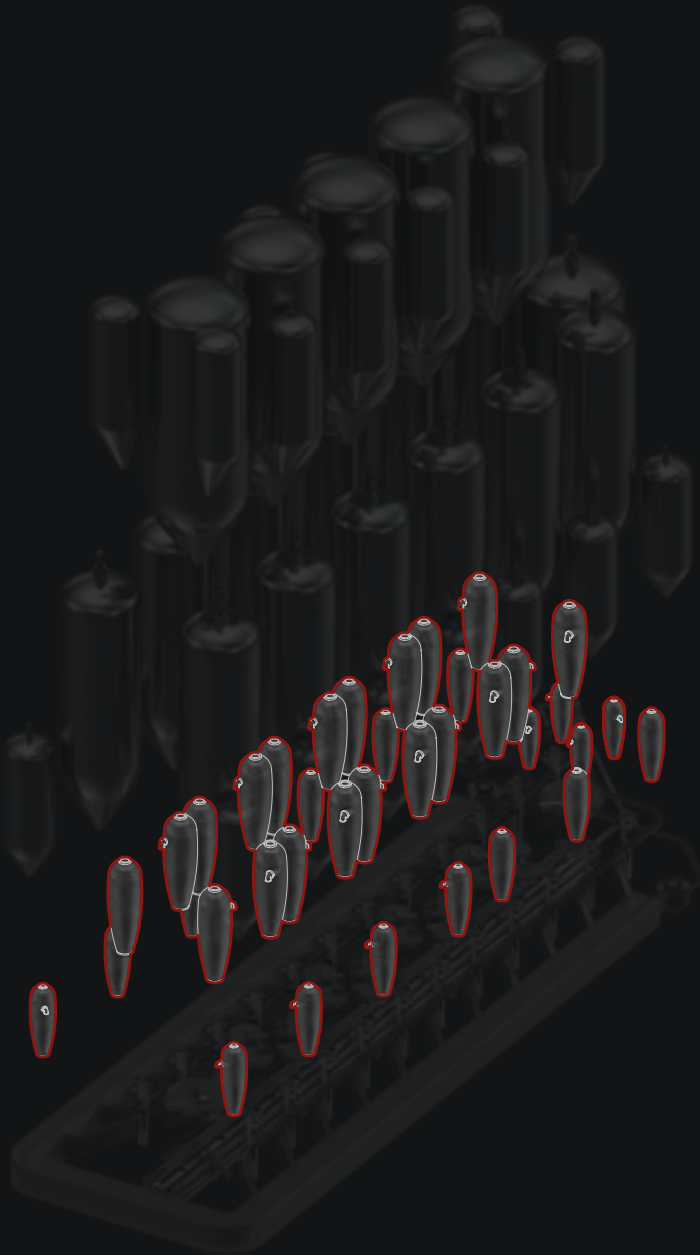


Figure 3.18 | Production elements - bioreactors



centrifuges

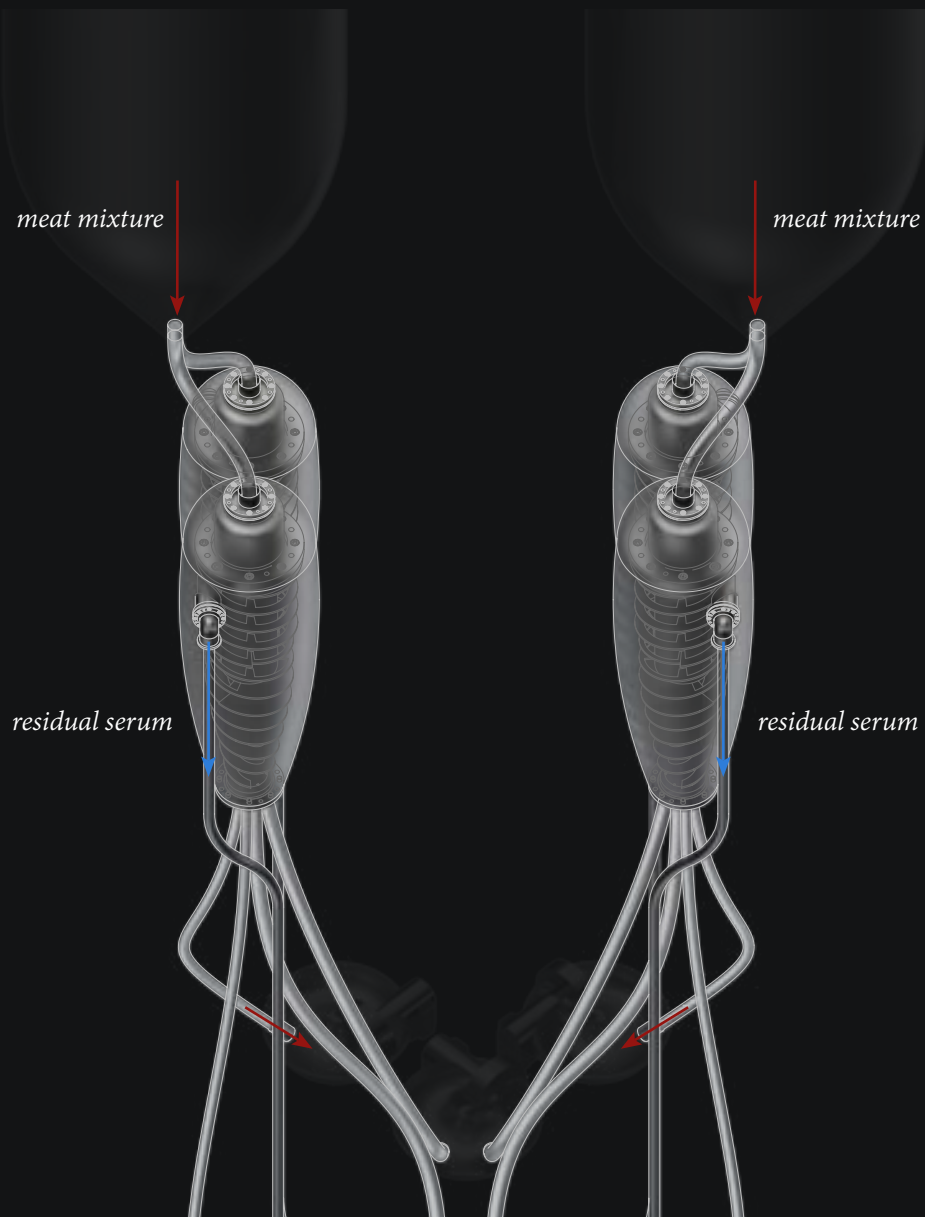


Figure 3.19 | Production elements - centrifuges



meat mincers

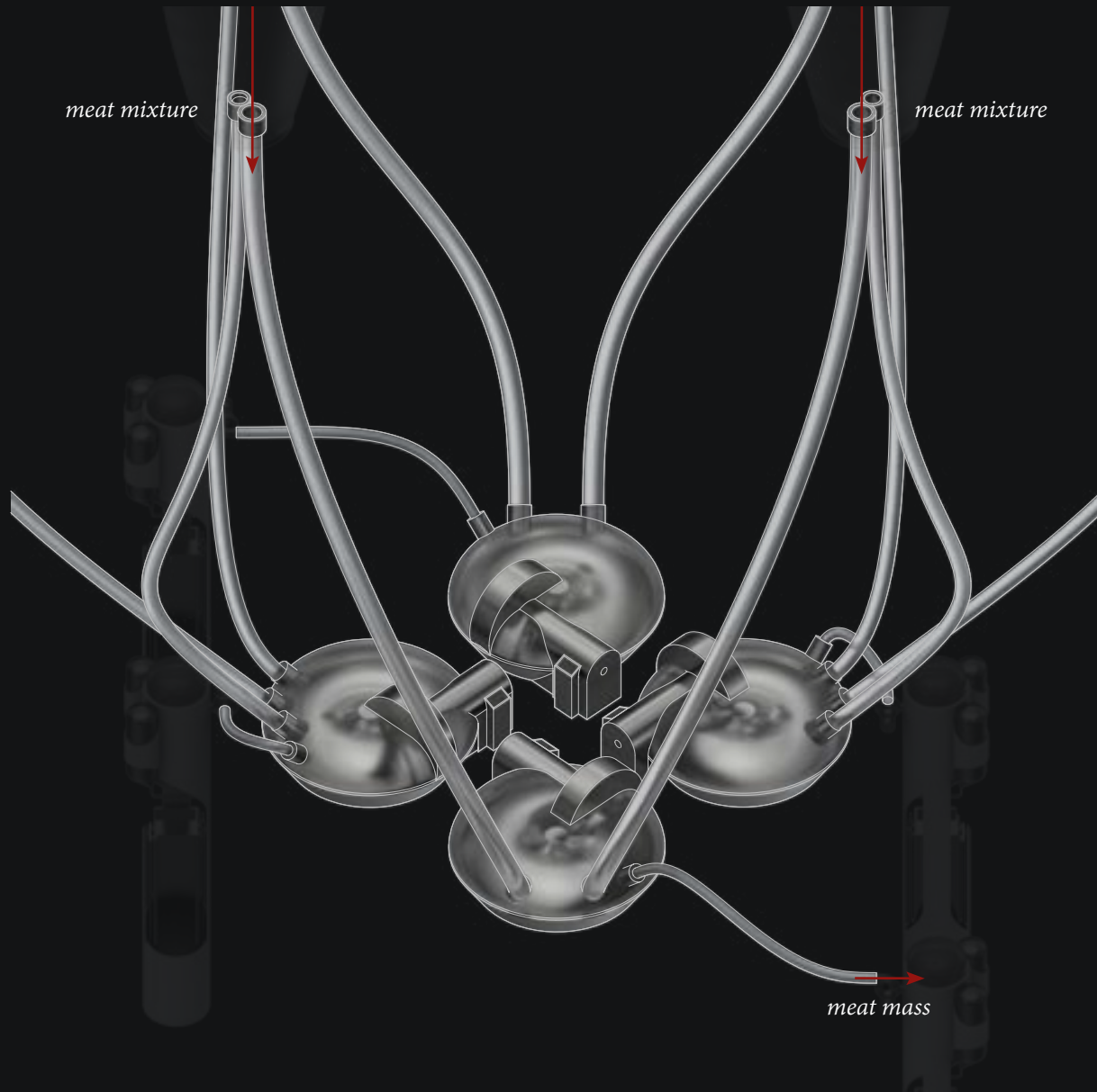


Figure 3.20 | Production elements - meat mincers



fillers

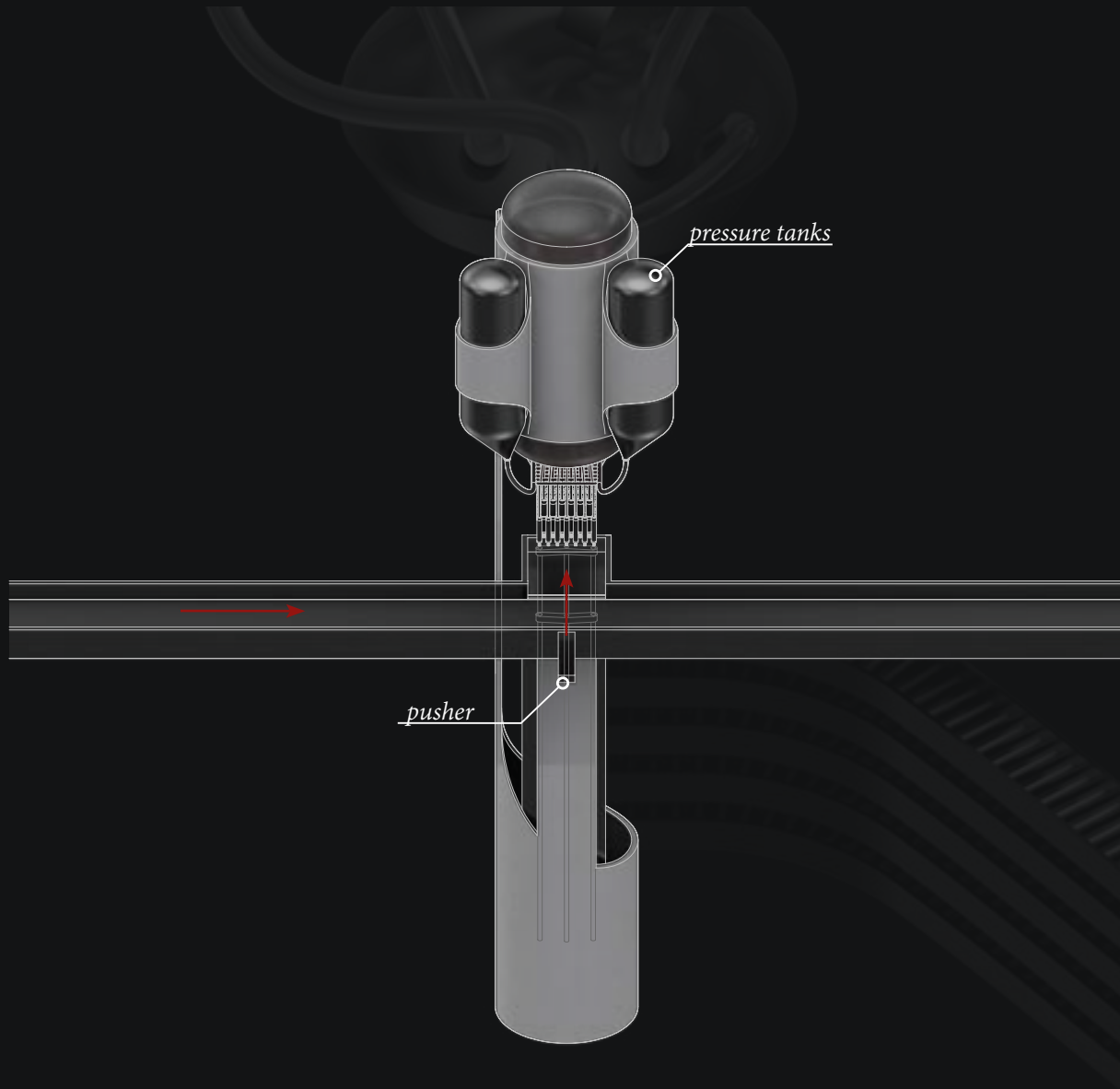
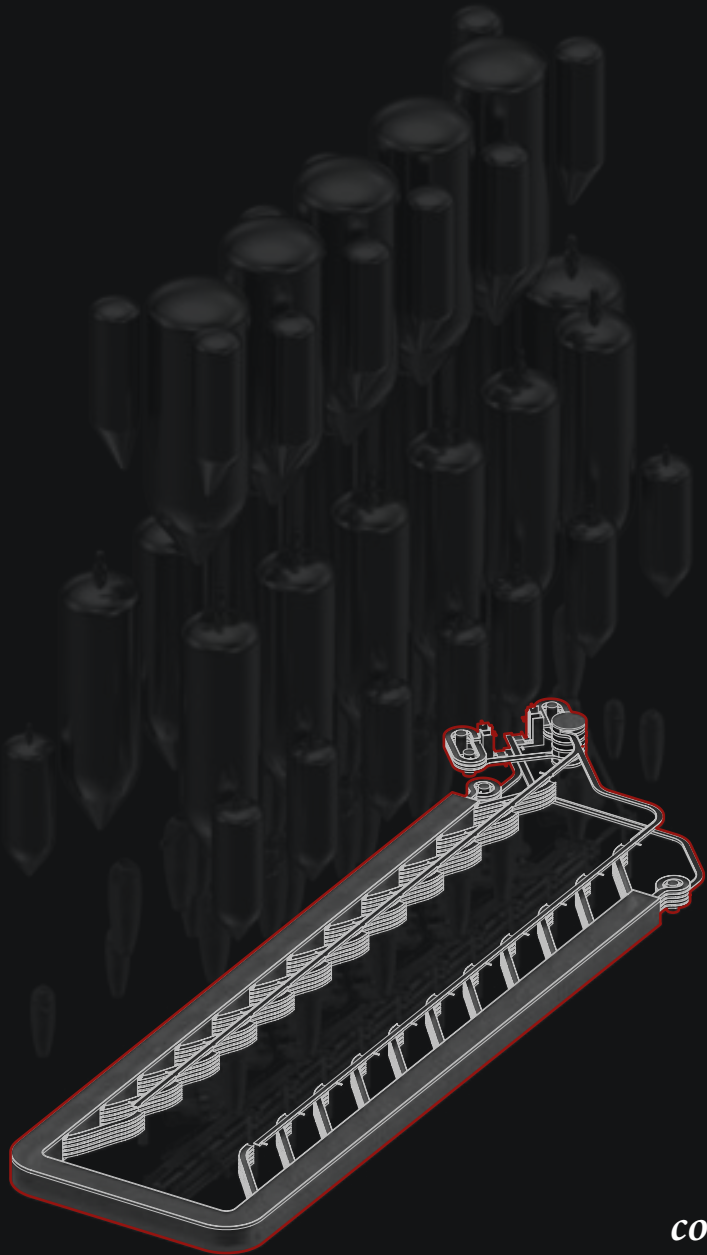


Figure 3.21 | Production elements - fillers



conveyor system

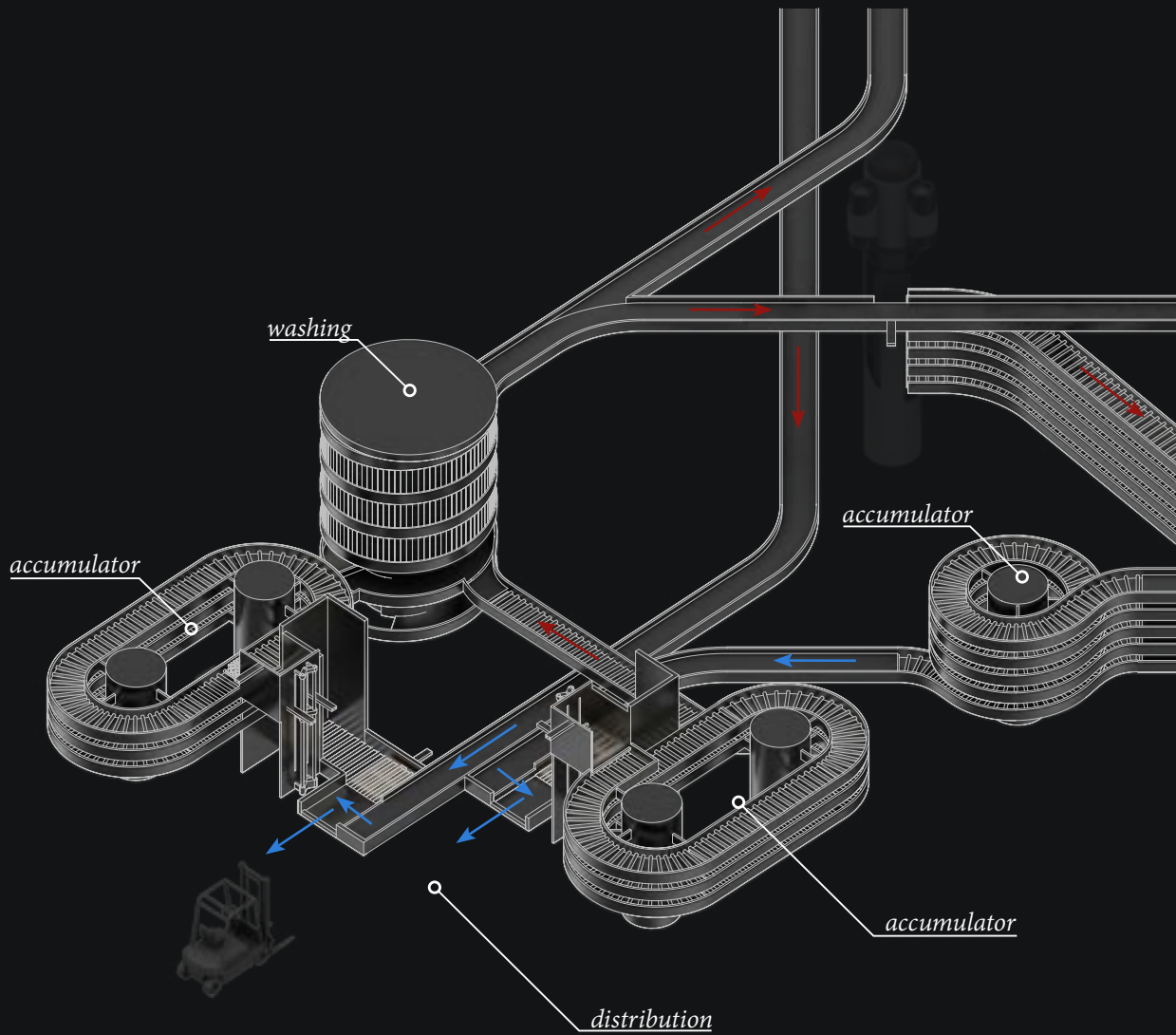


Figure 3.22 | Production elements - conveyor system

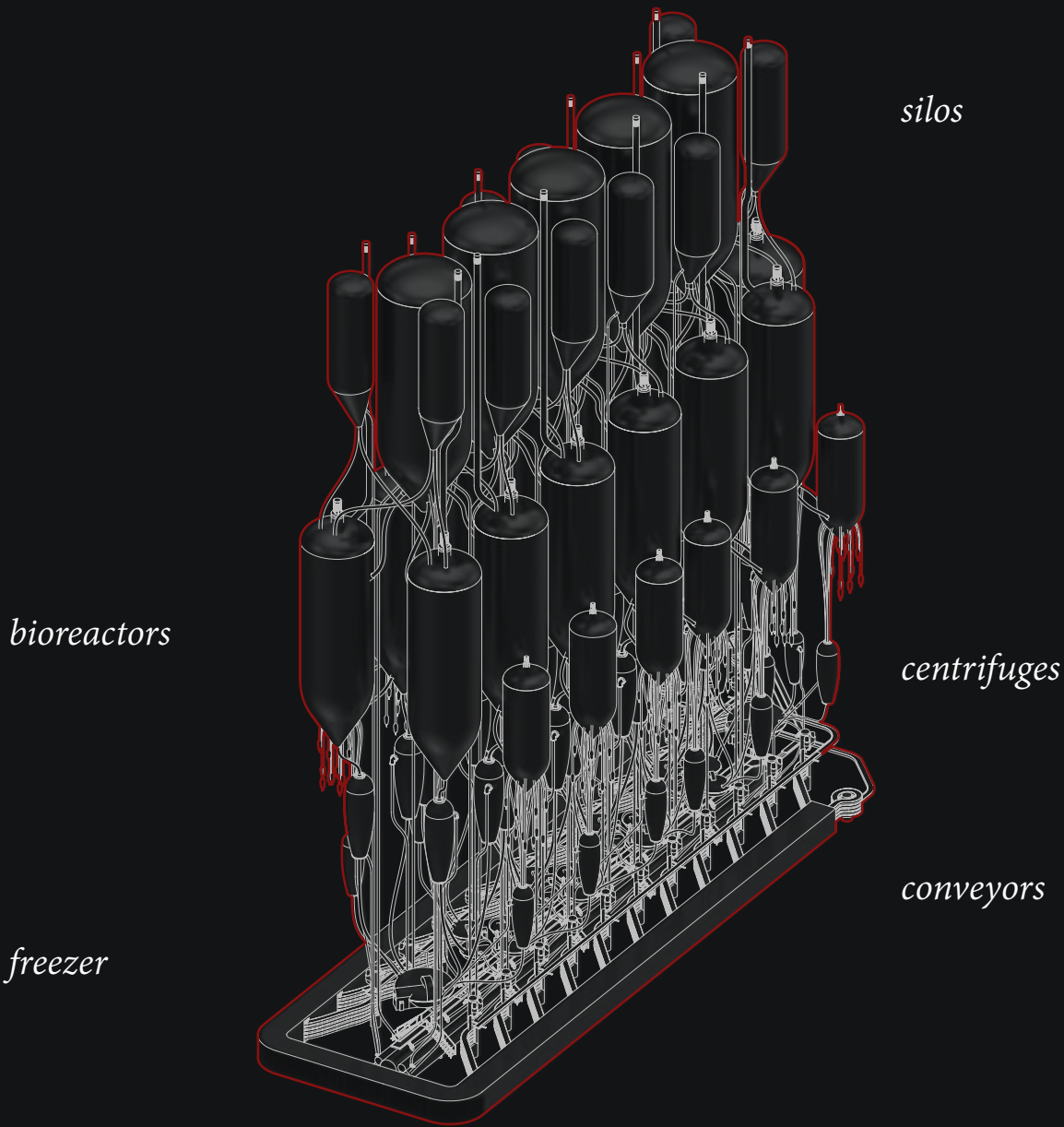


Figure 3.23 | Inner mechanism

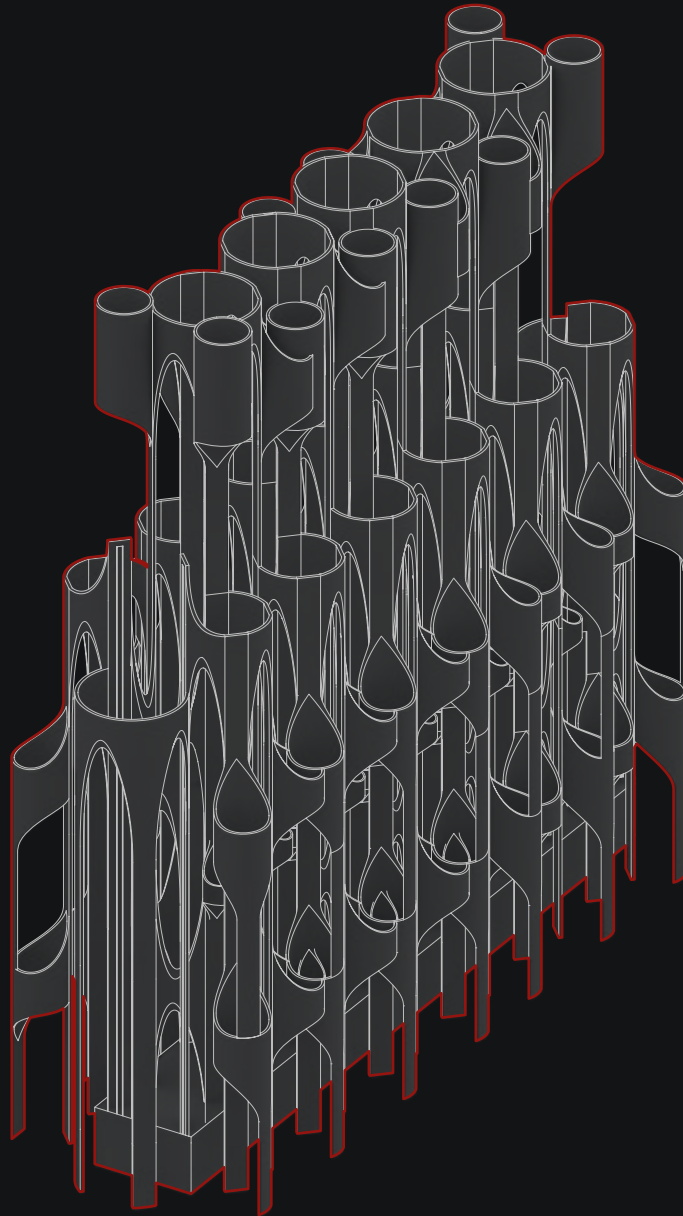


Figure 3.24 | Shell structure

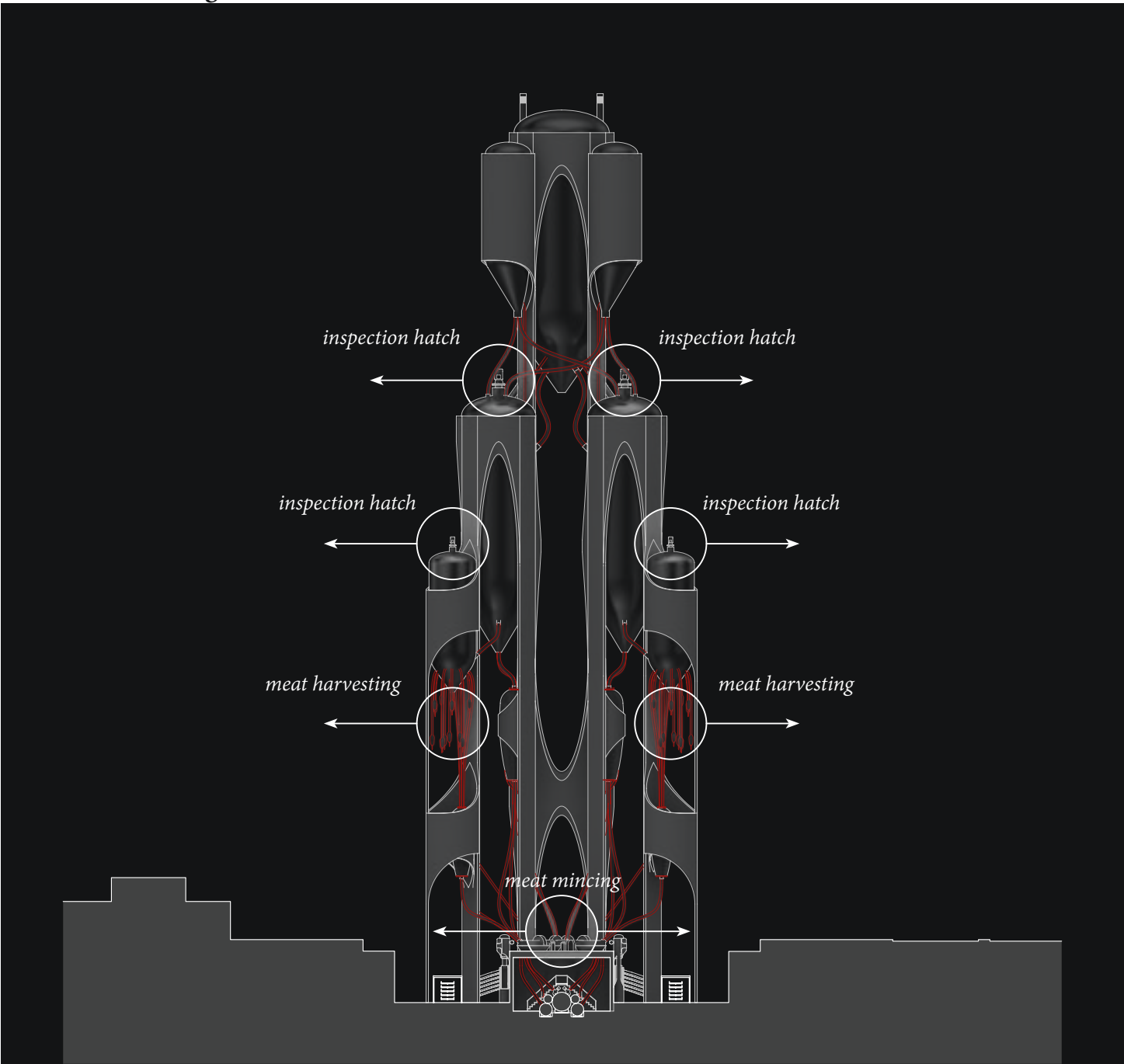


Figure 3.25 | Points of interaction

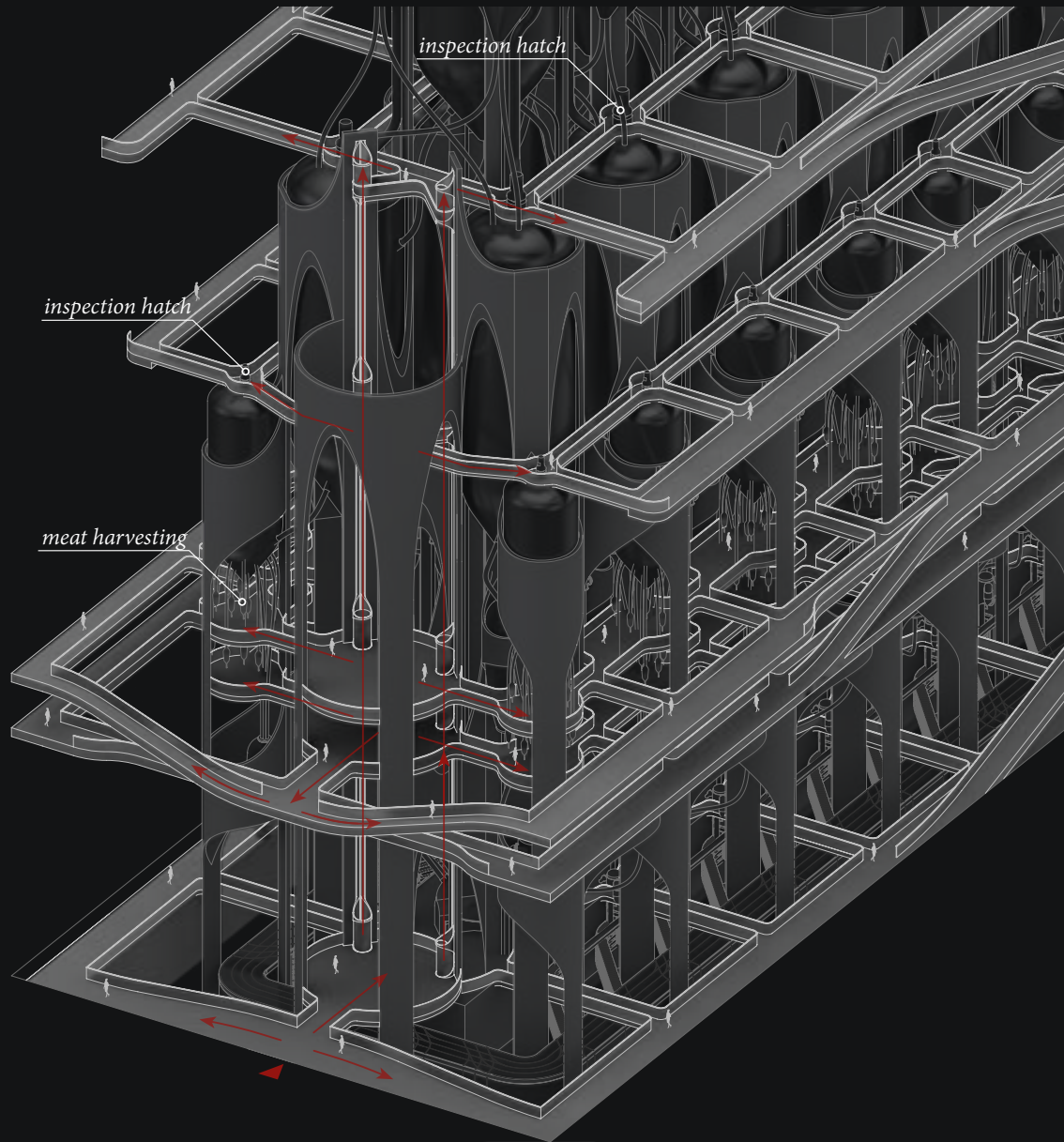


Figure 3.26 | Circulation, Bridges

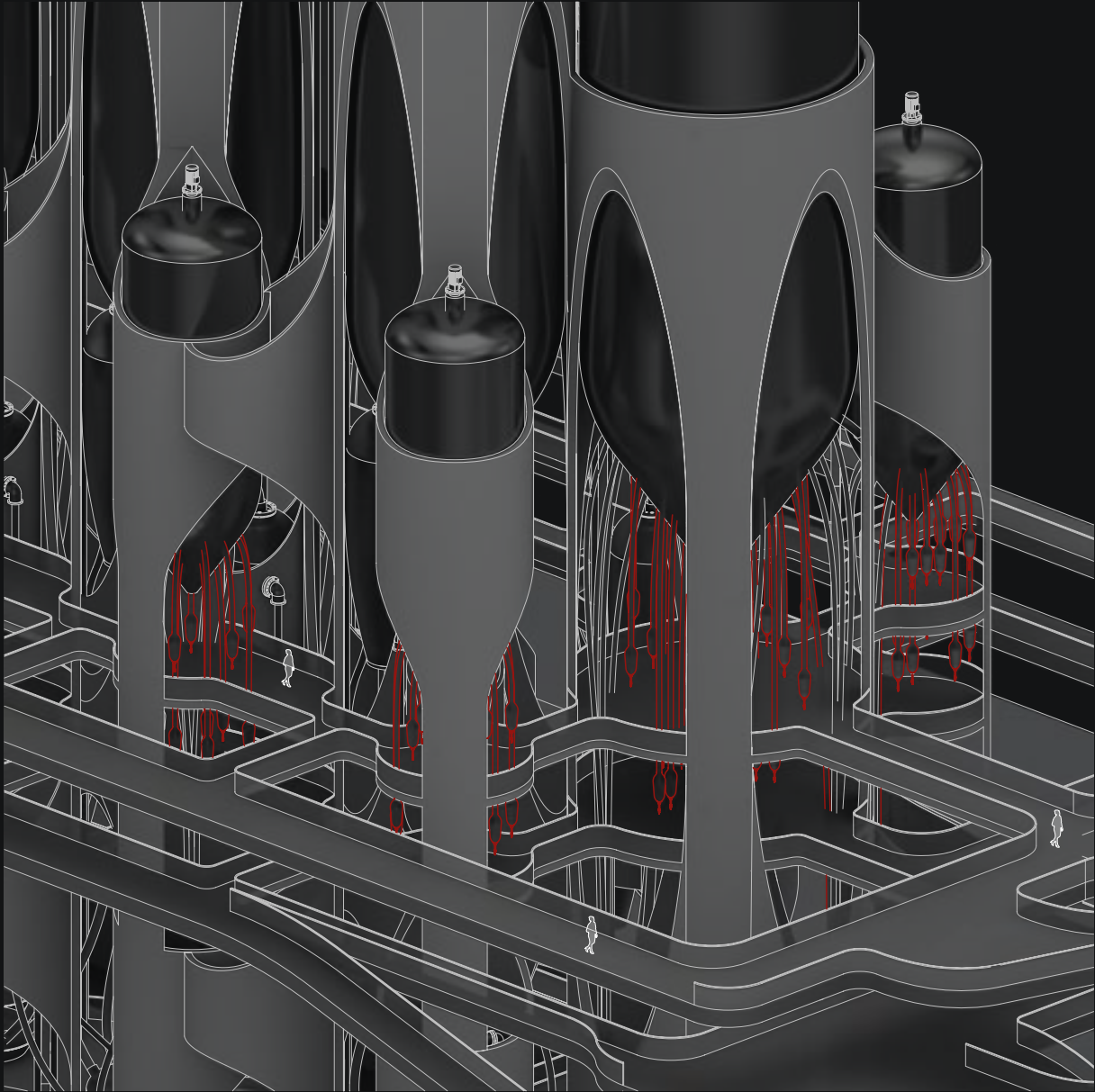


Figure 3.27 | Meat Harvesting

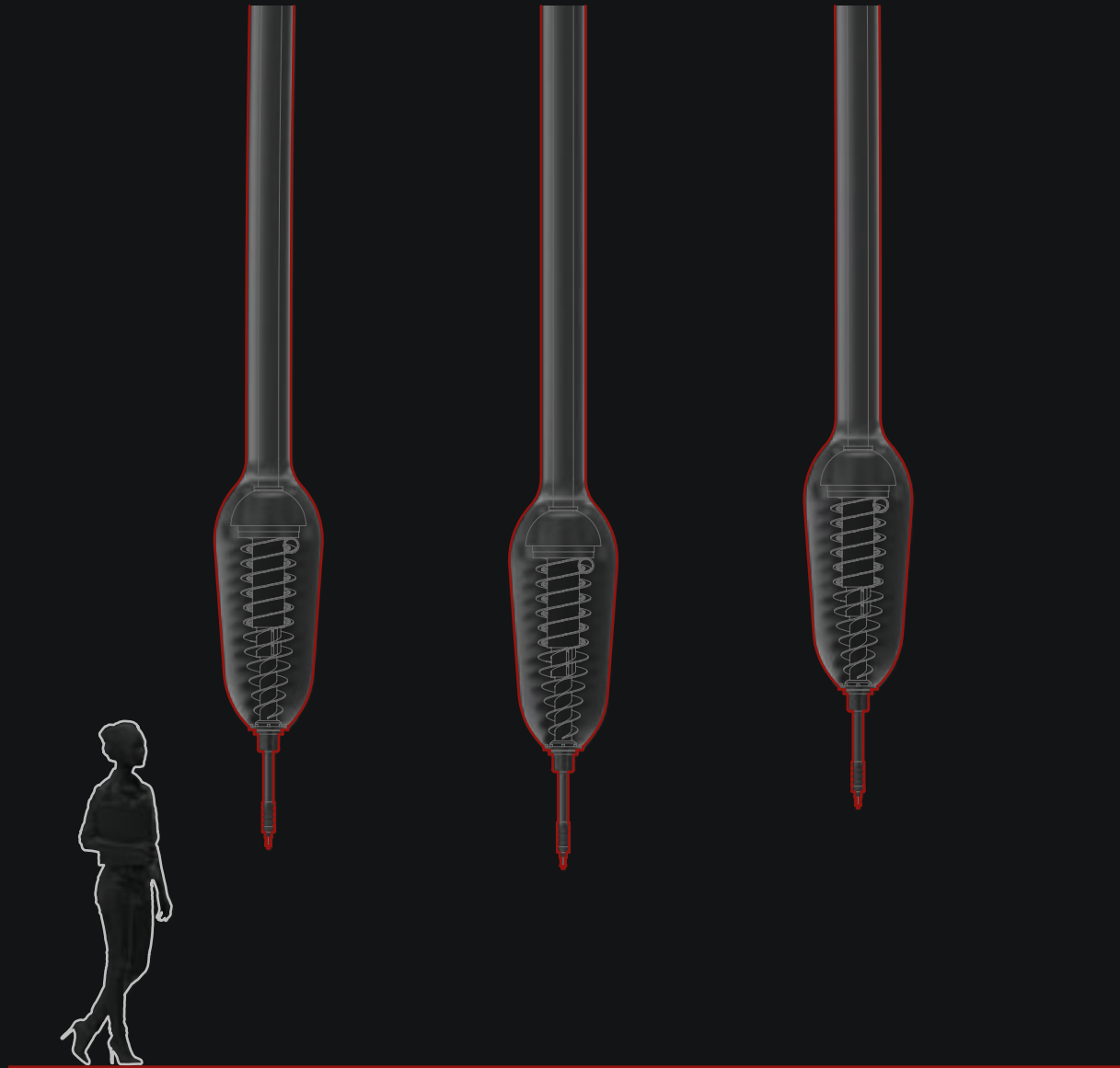


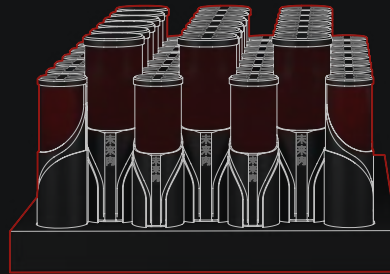
Figure 3.28 | Meat Harvesting Detail



Figure 3.29 | Meat Harvesting instruction



capsules
400g + 800g



quarter pallet
25.6kg



intermediate bulk container
60kg

Figure 3.30 | Commercial and Industrial Containers

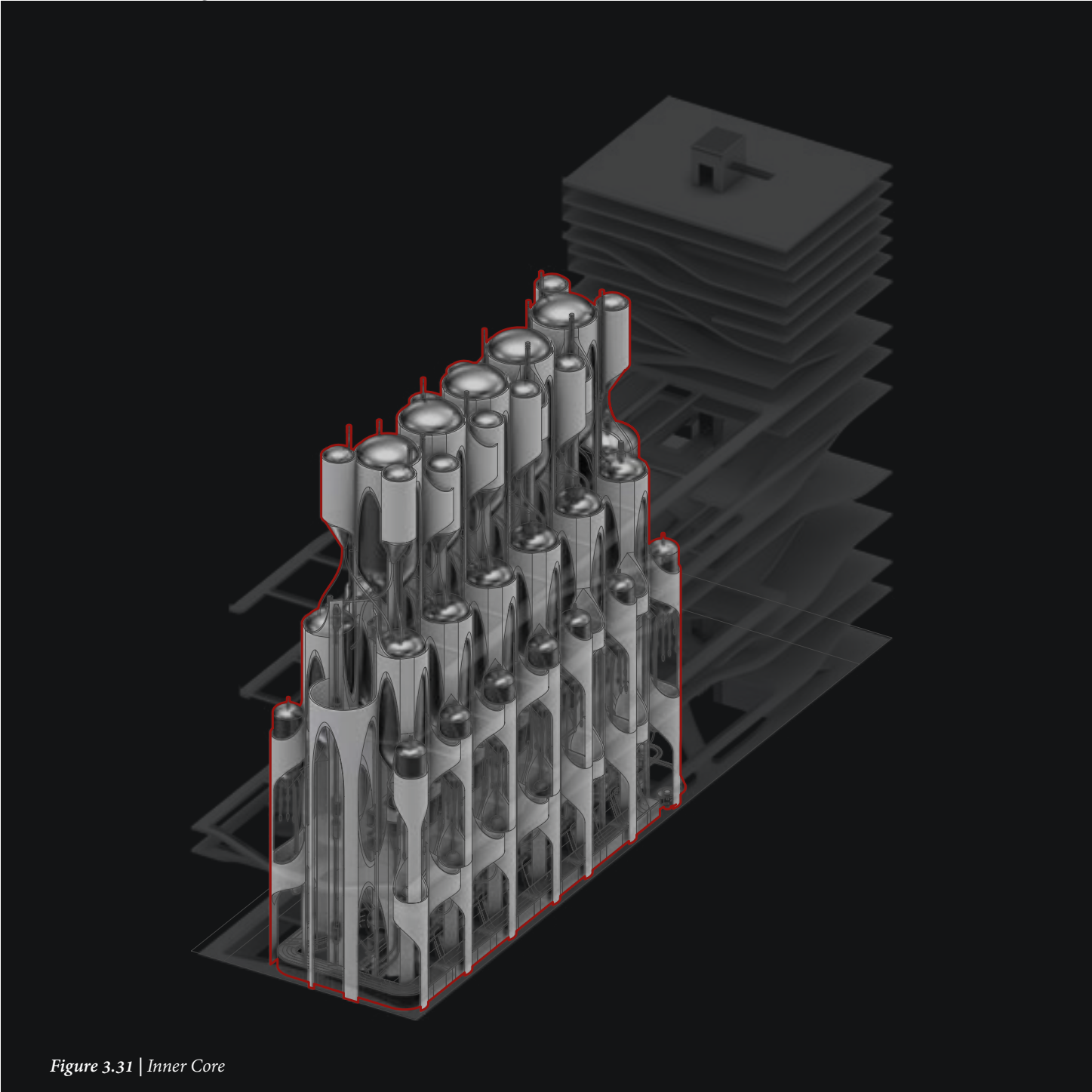


Figure 3.31 | Inner Core

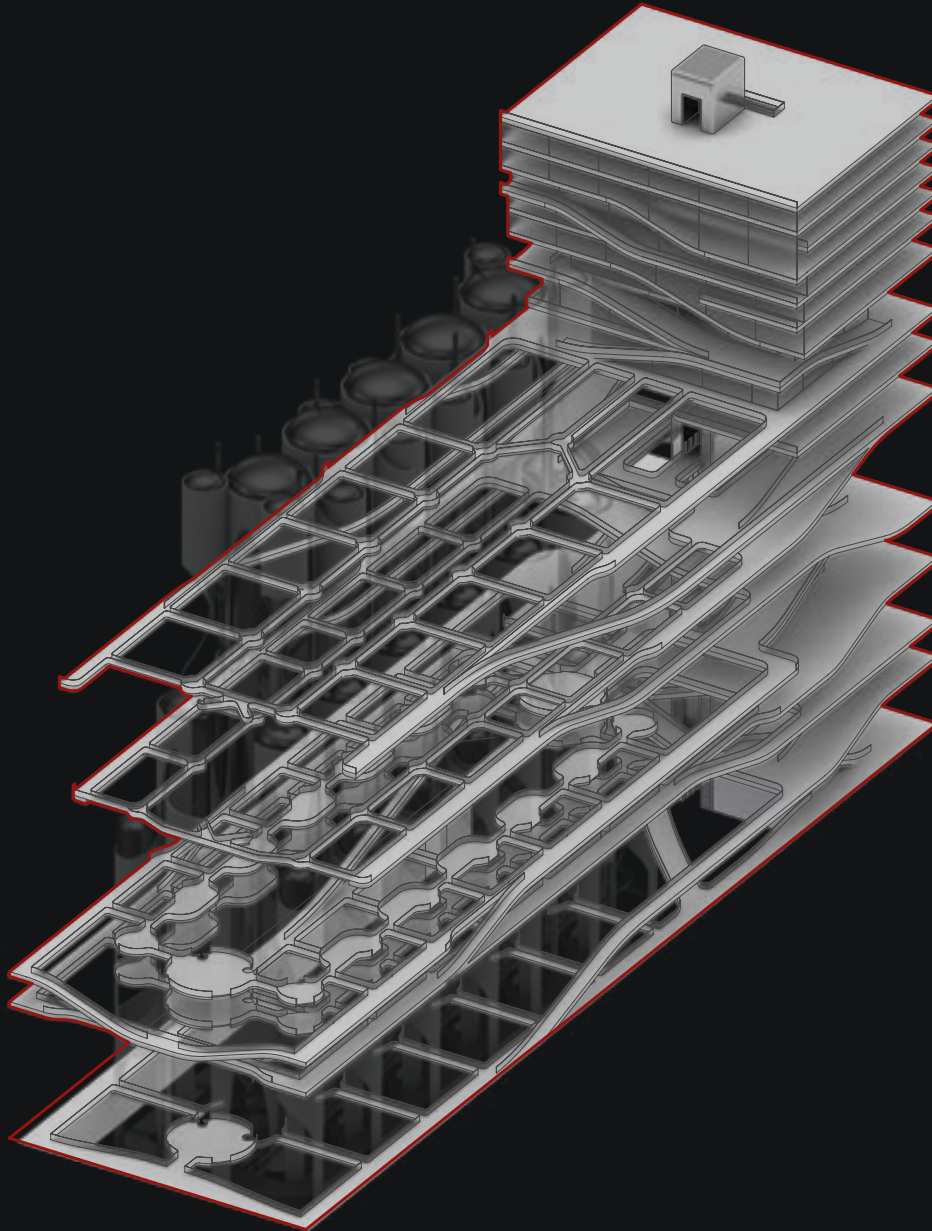


Figure 3.32 | Circulation Overview

Vertical culture-landscape

The system of platforms and ramps in the rear of the building acts as a negotiator between the city and the autonomous machinery. The vertical landscapes concept is based on a three-dimensional open floor plan, with generously sized ramps. It is a space of movement and instability and takes the idea of factory tourism one step further, turning it into an architectural promenade.

While there is a vertical division between public and private spaces, all areas of the public landscape are accessible on foot or by elevator. The vertically connected platforms and ramps act as a food hall, with multiple restaurants, food stalls and eating areas spread throughout. The eating places are meant to use the in-house produced meat, in order to show different uses and flavors of in-vitro meat. The implementation of popular food chains, as well as local restaurants is important in order to integrate the building culturally into the city. The slopes of the landscape provide an overview of the happenings and house functional columns, which offer an alternative interaction with the meat, such as automatic retail and machines 3d-printing and preparing the previous bought or harvested meat.

The private part of the buildings is reserved for research and educational purposes. As Hong Kong is currently investing heavily in new technologies, especially clean technologies and synthetic biology, the immediate proximity to the factory offers a great opportunity for research.

The upper floors are sealed off from the vivid and odour-intensive food landscape, but are still connected to the bridges leading to the main machinery.

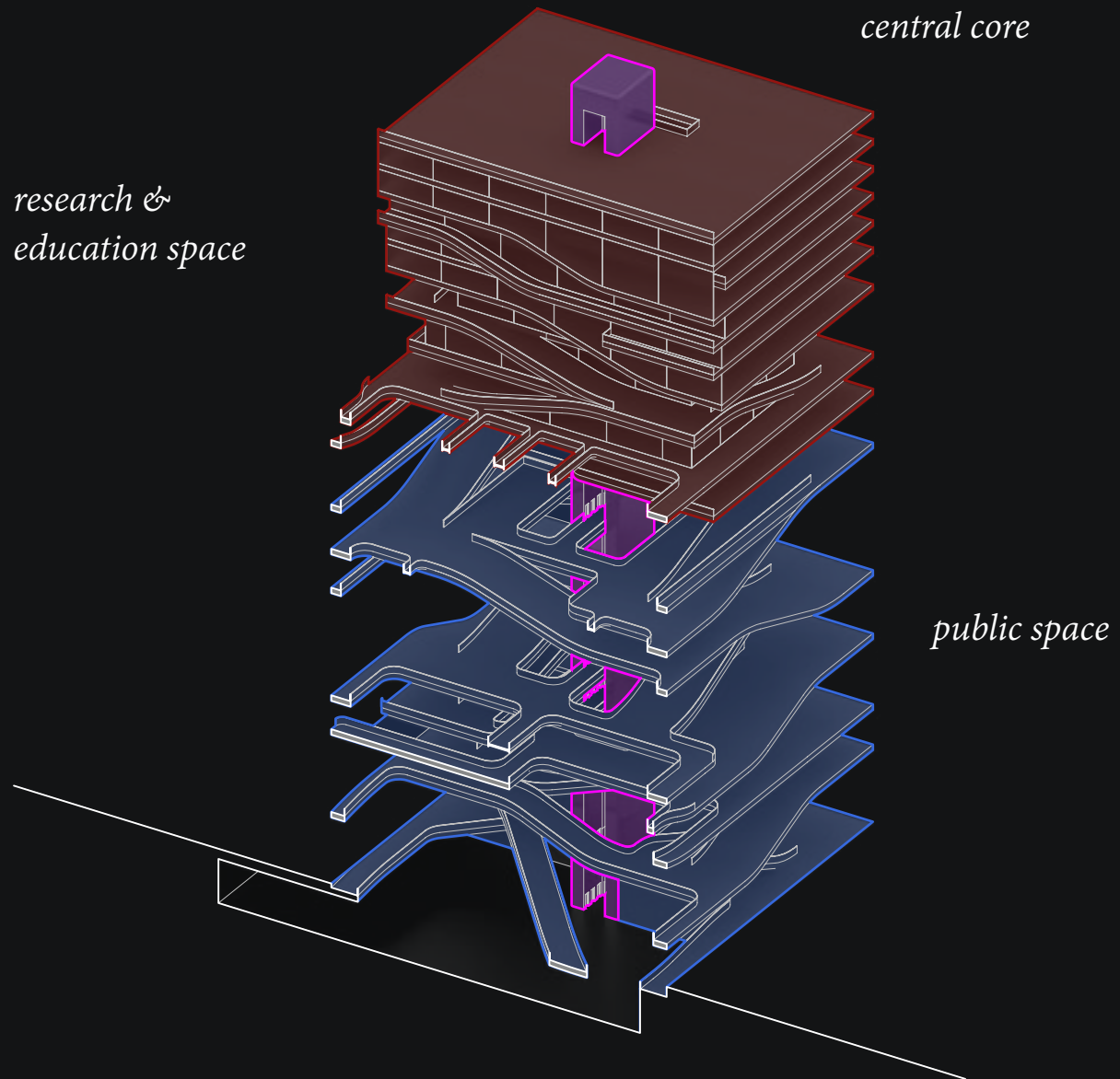


Figure 3.33 | Private and Public Spaces

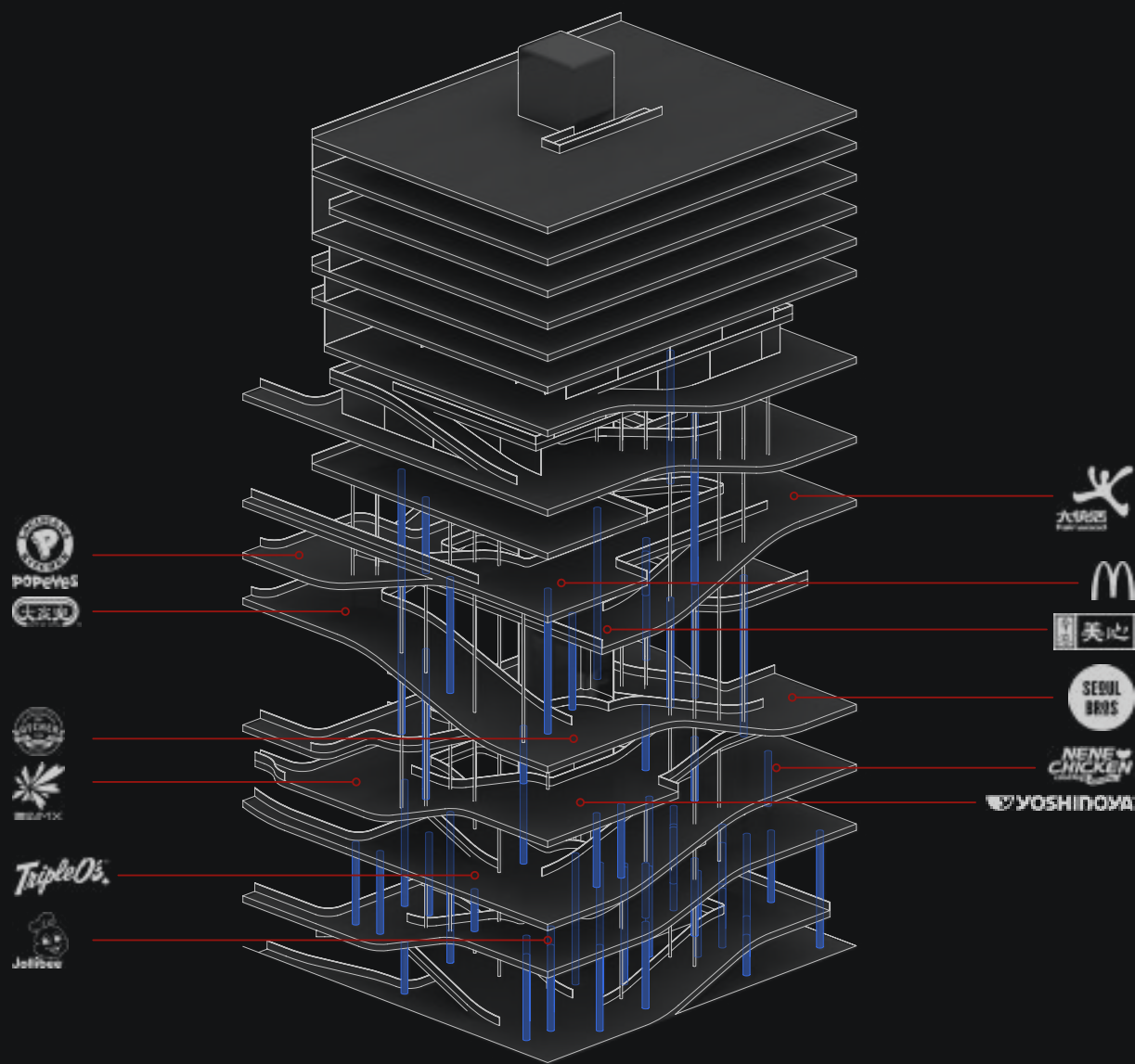


Figure 3.34 | Positioning of Food Stalls

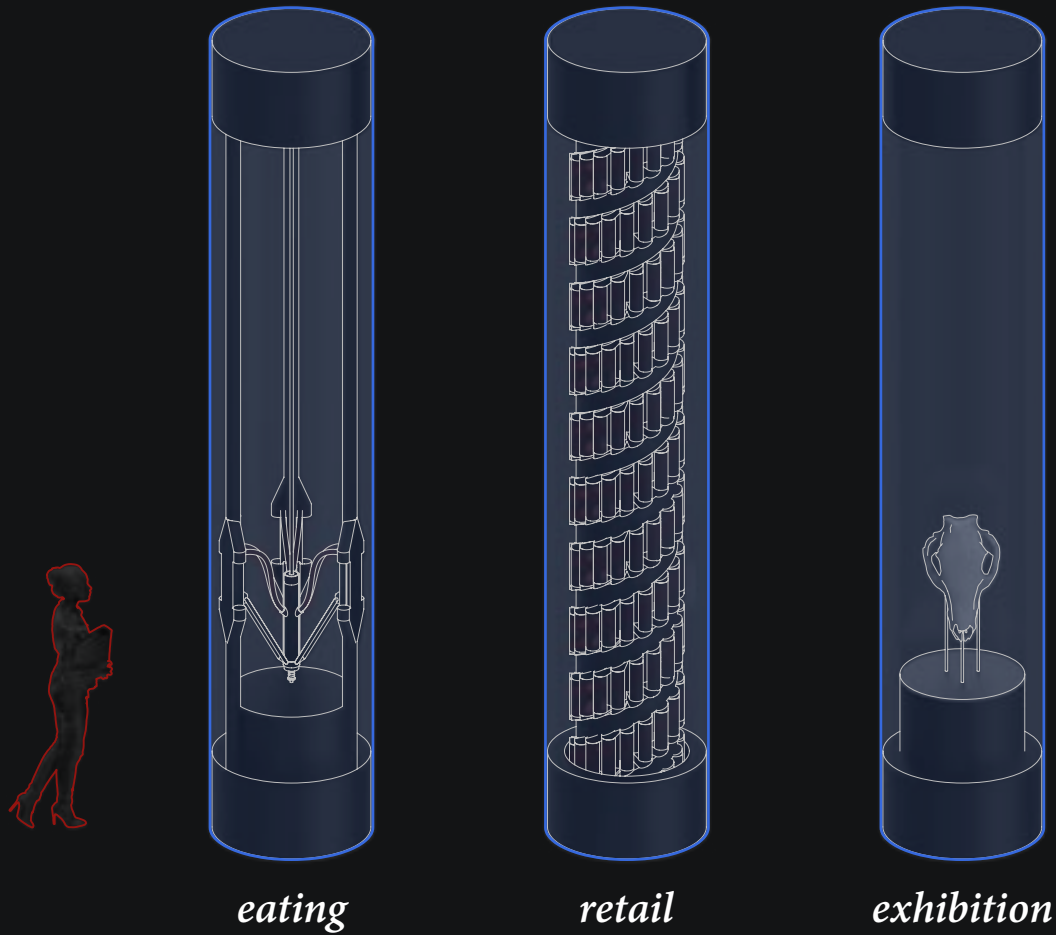


Figure 3.35 | Functional Columns

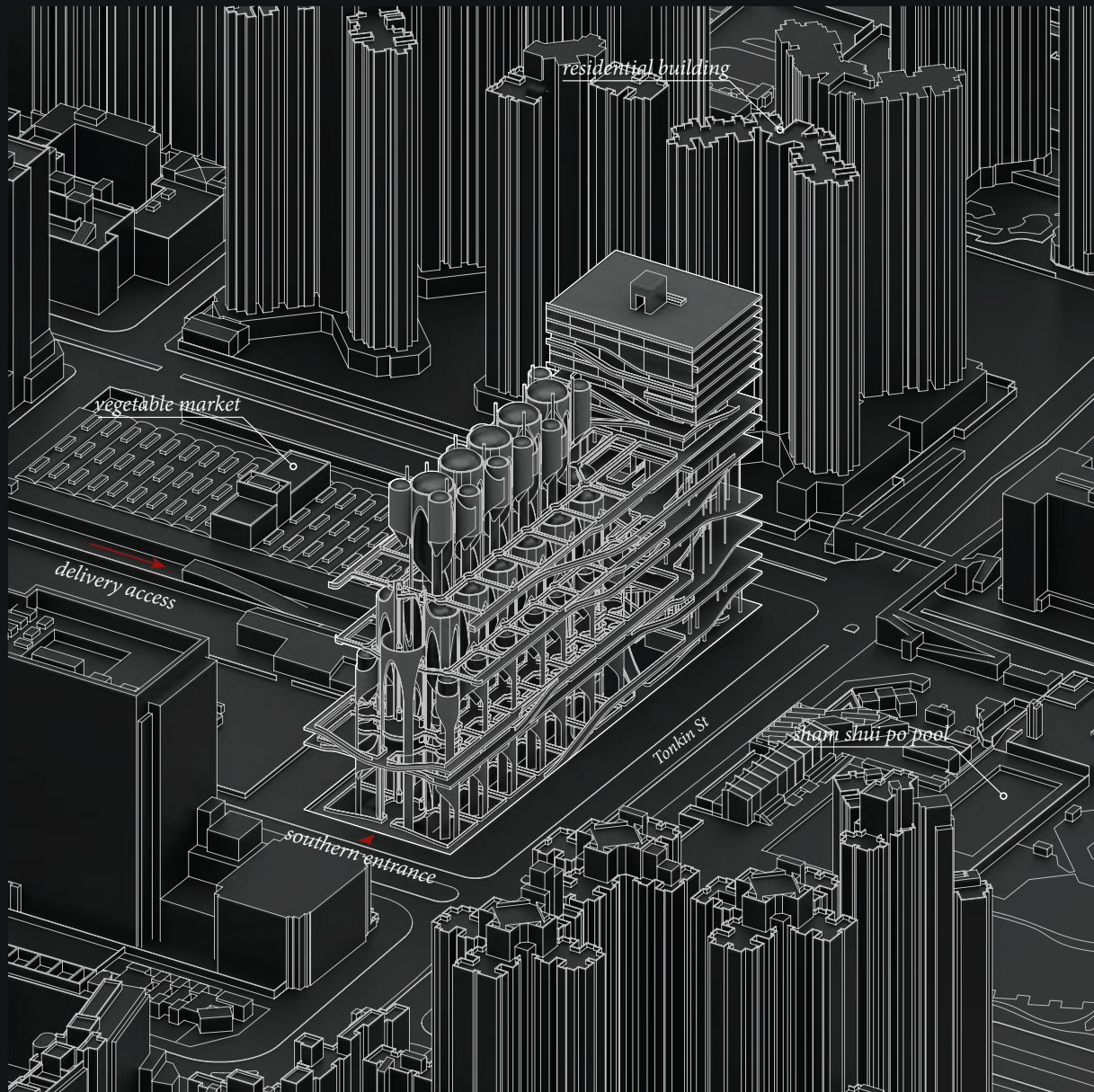


Figure 3.36 | Southern City Perspective

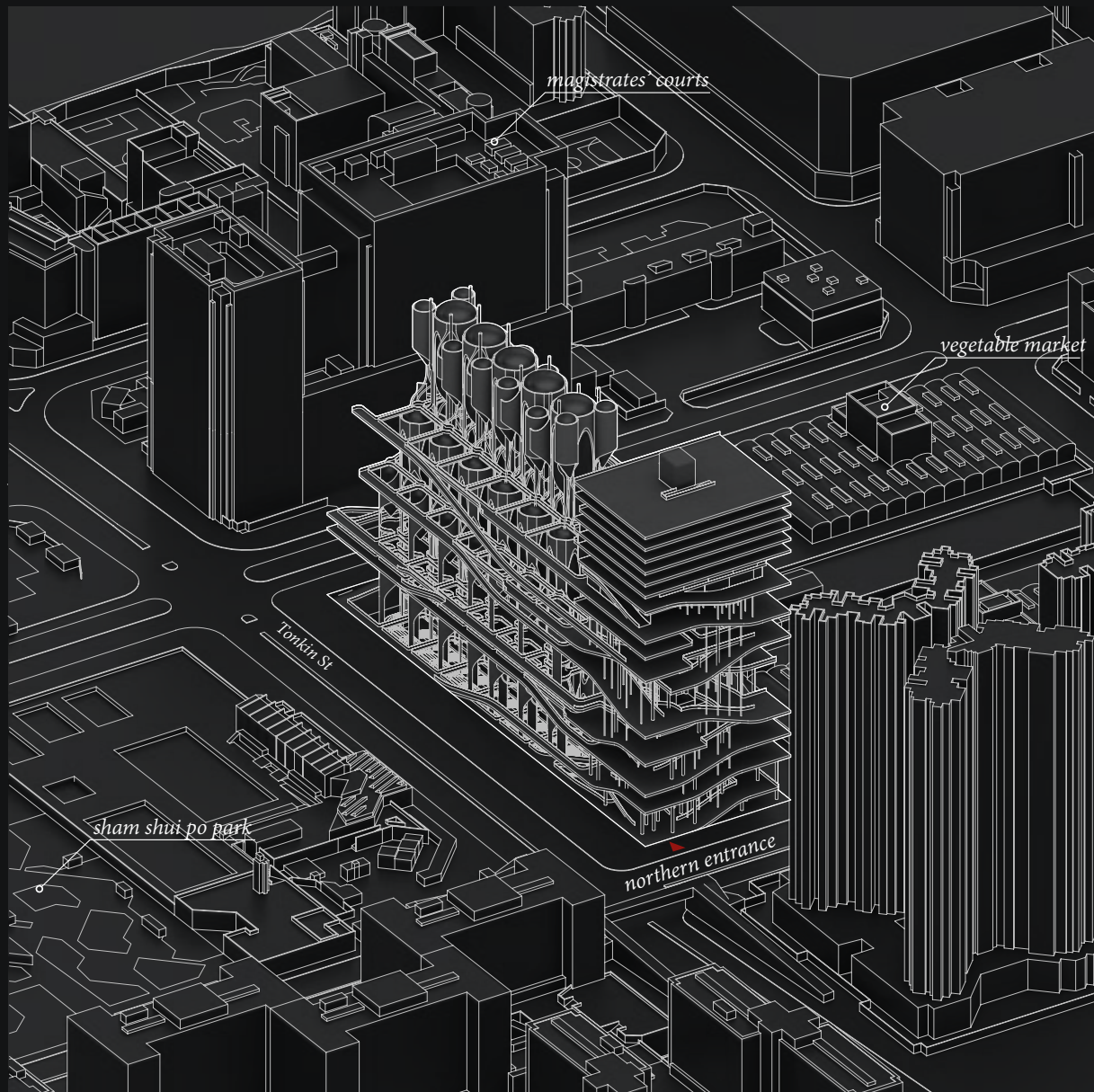


Figure 3.37 | Northern City Perspective

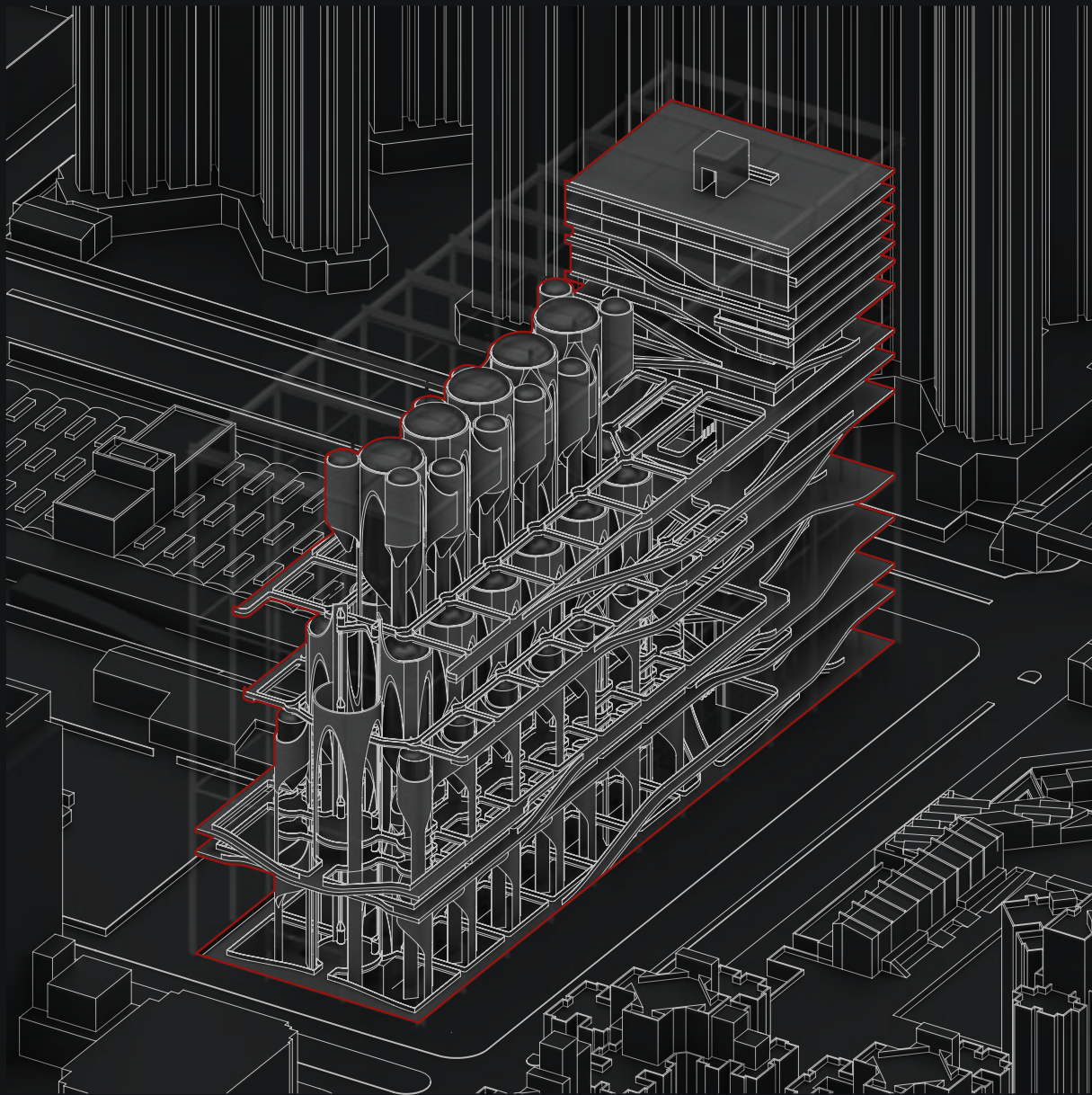


Figure 3.38 | Facade Overlay

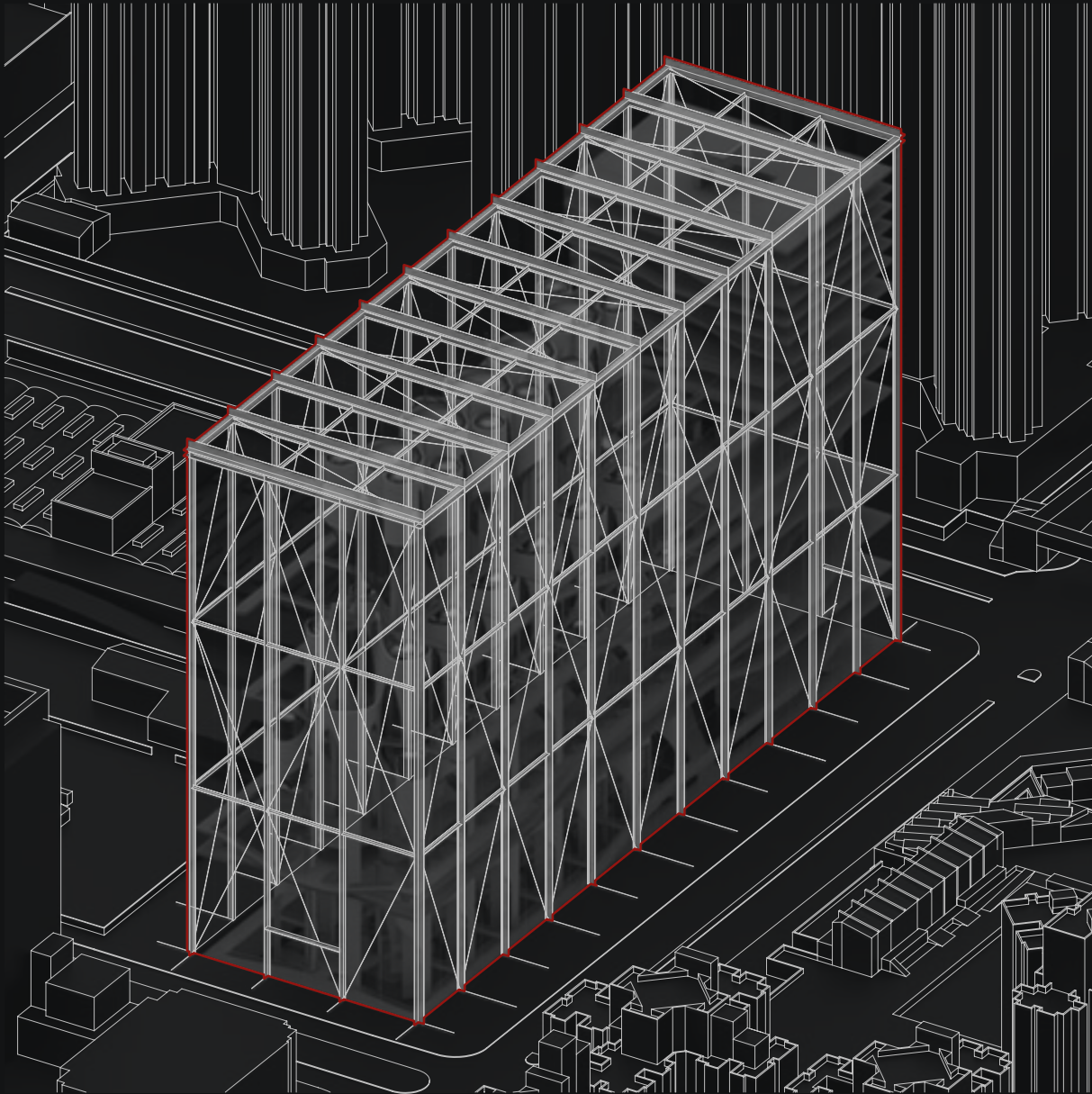


Figure 3.39 | Facade Structural Elements

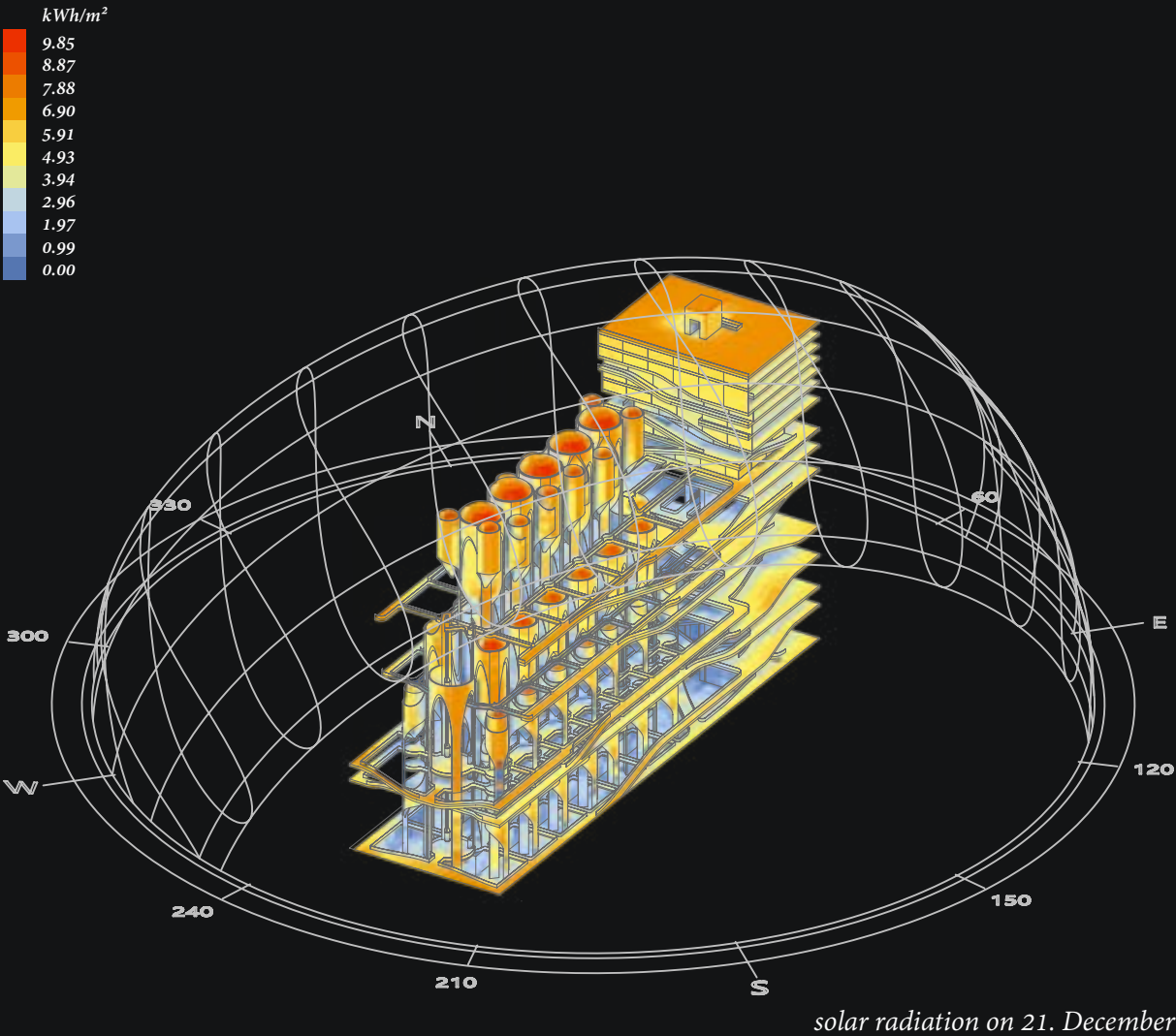


Figure 3.40 | Solar Analysis

optimal temperature

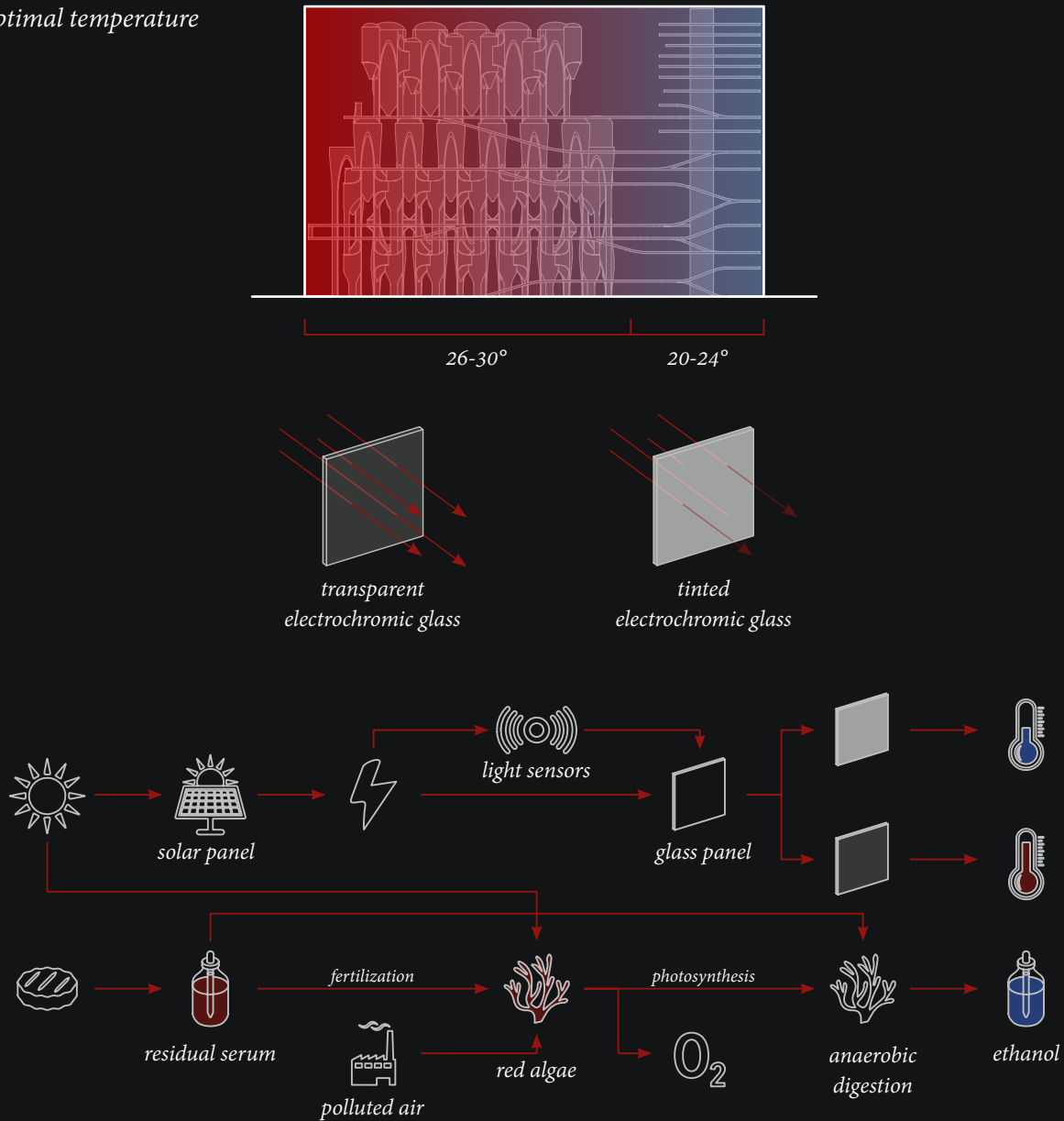


Figure 3.41 | Facade System

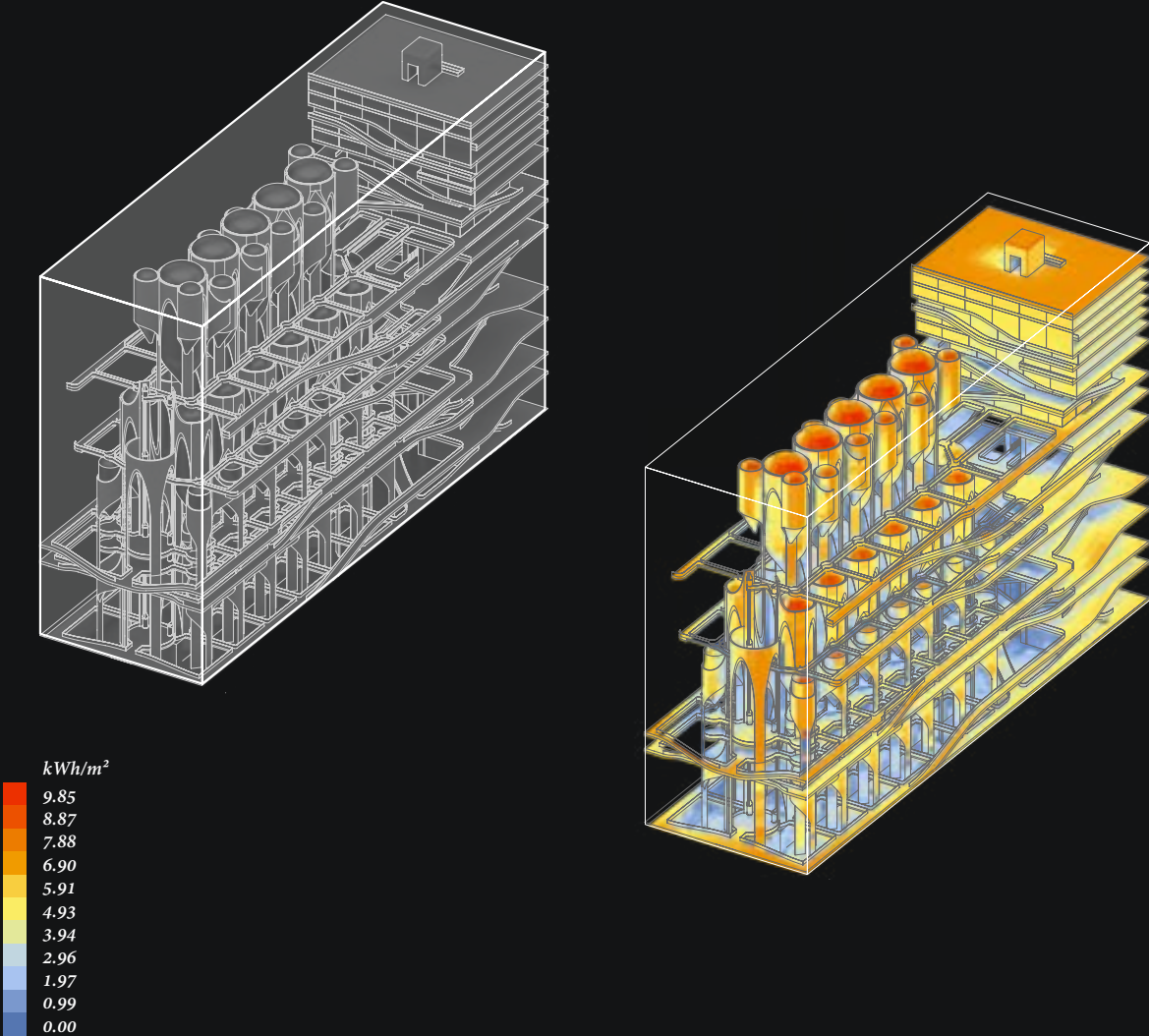


Figure 3.42 | Solar Analysis Transparent

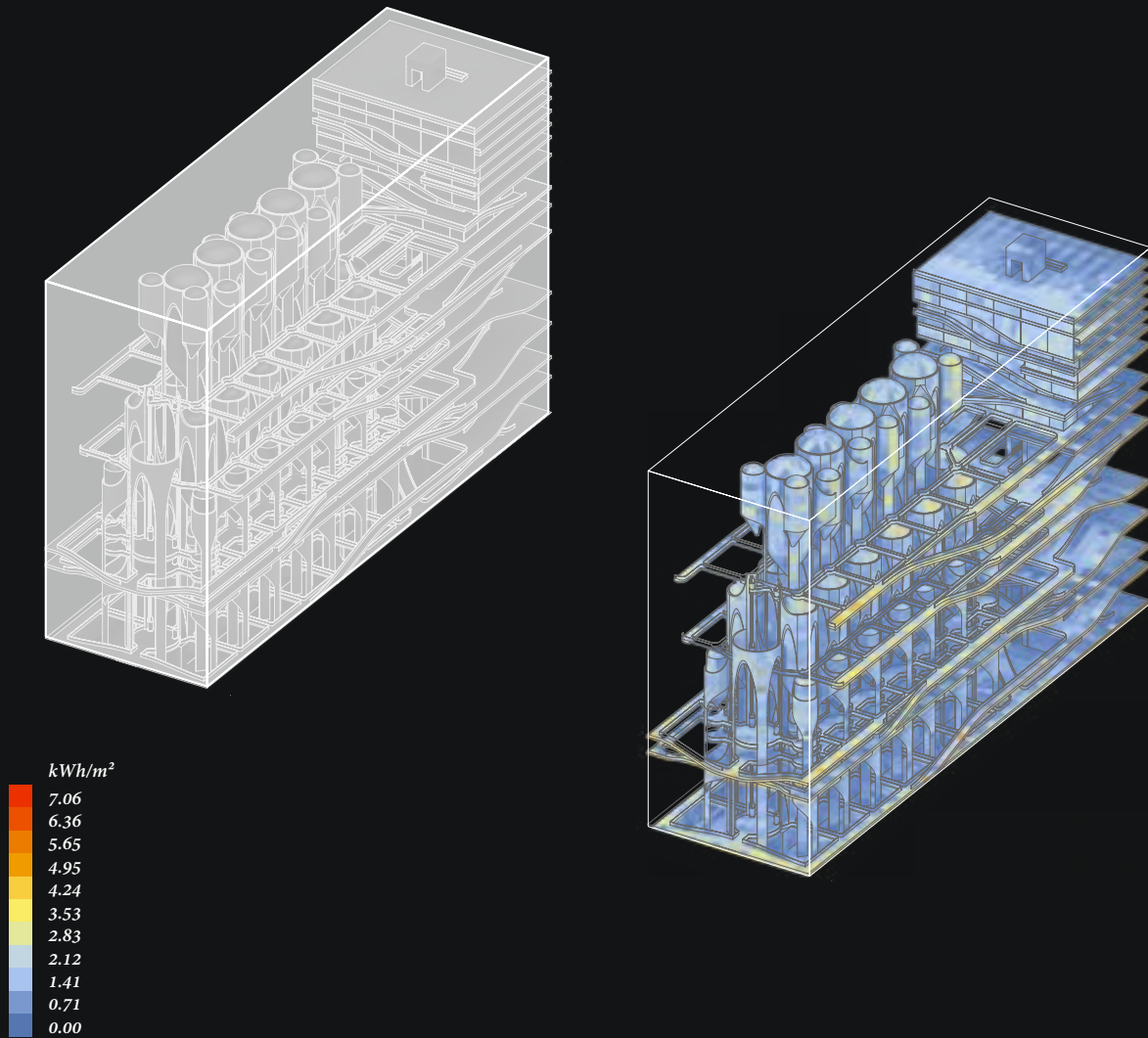


Figure 3.43 | Solar Analysis Opaque

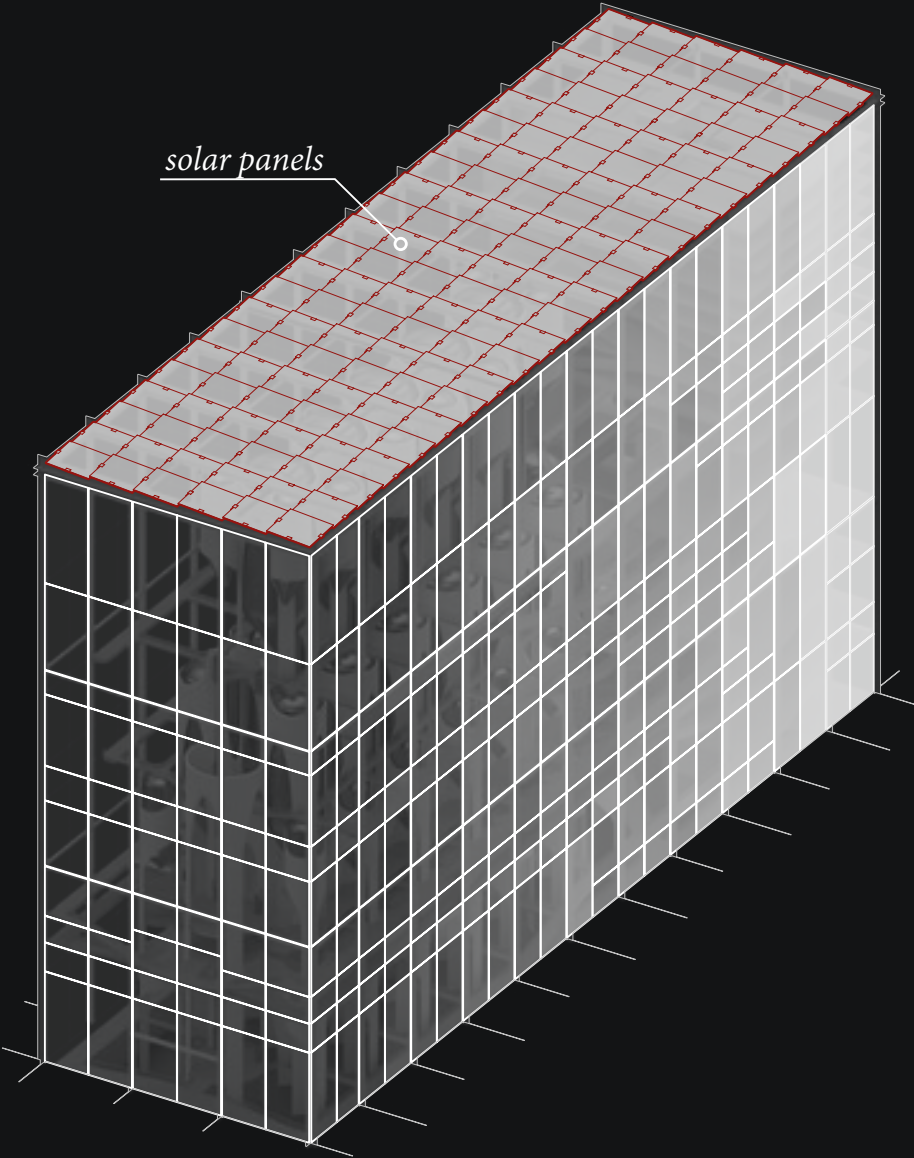


Figure 3.44 | Reactive Panel Pattern

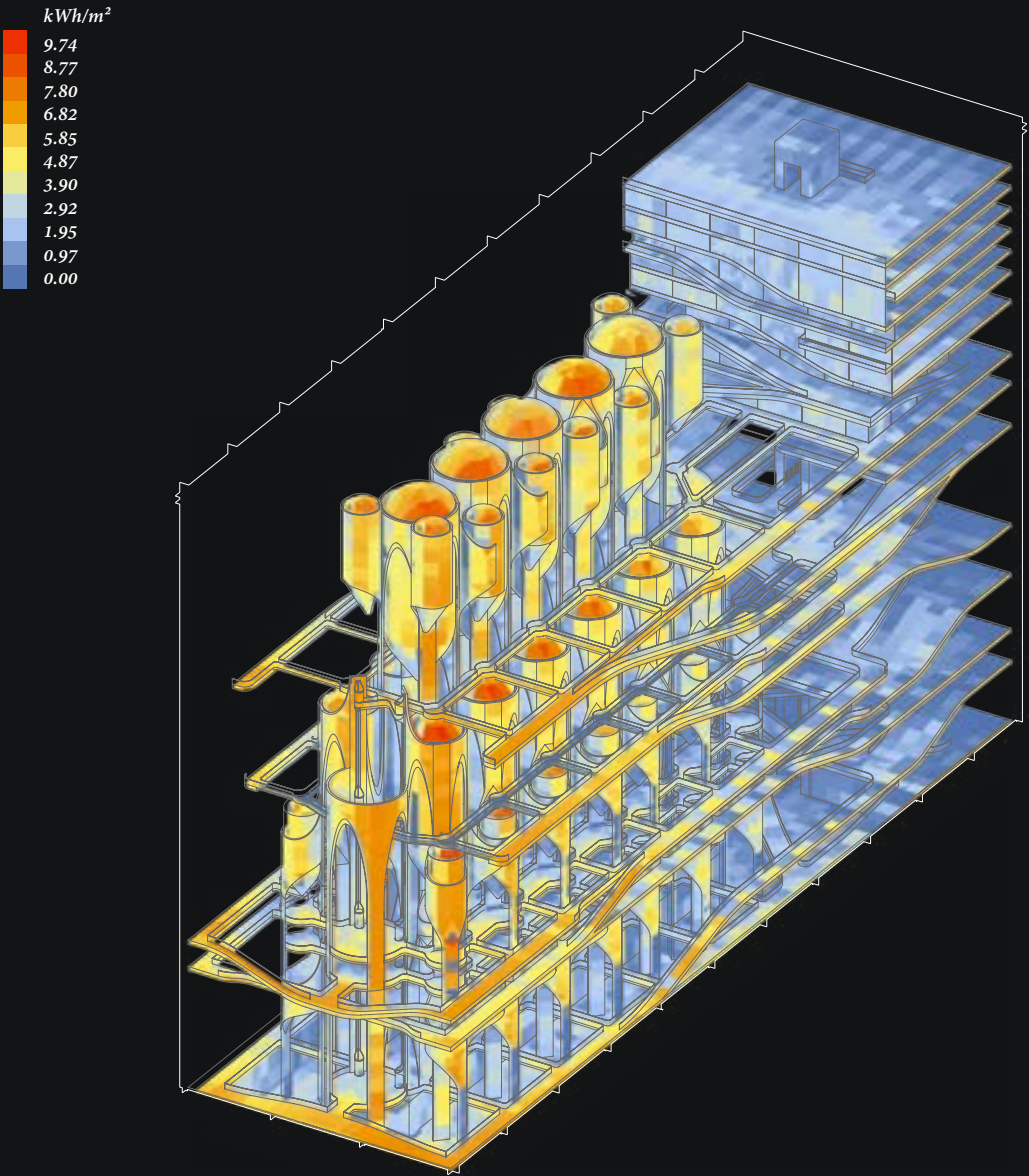


Figure 3.45 | Resulting Inner Radiation

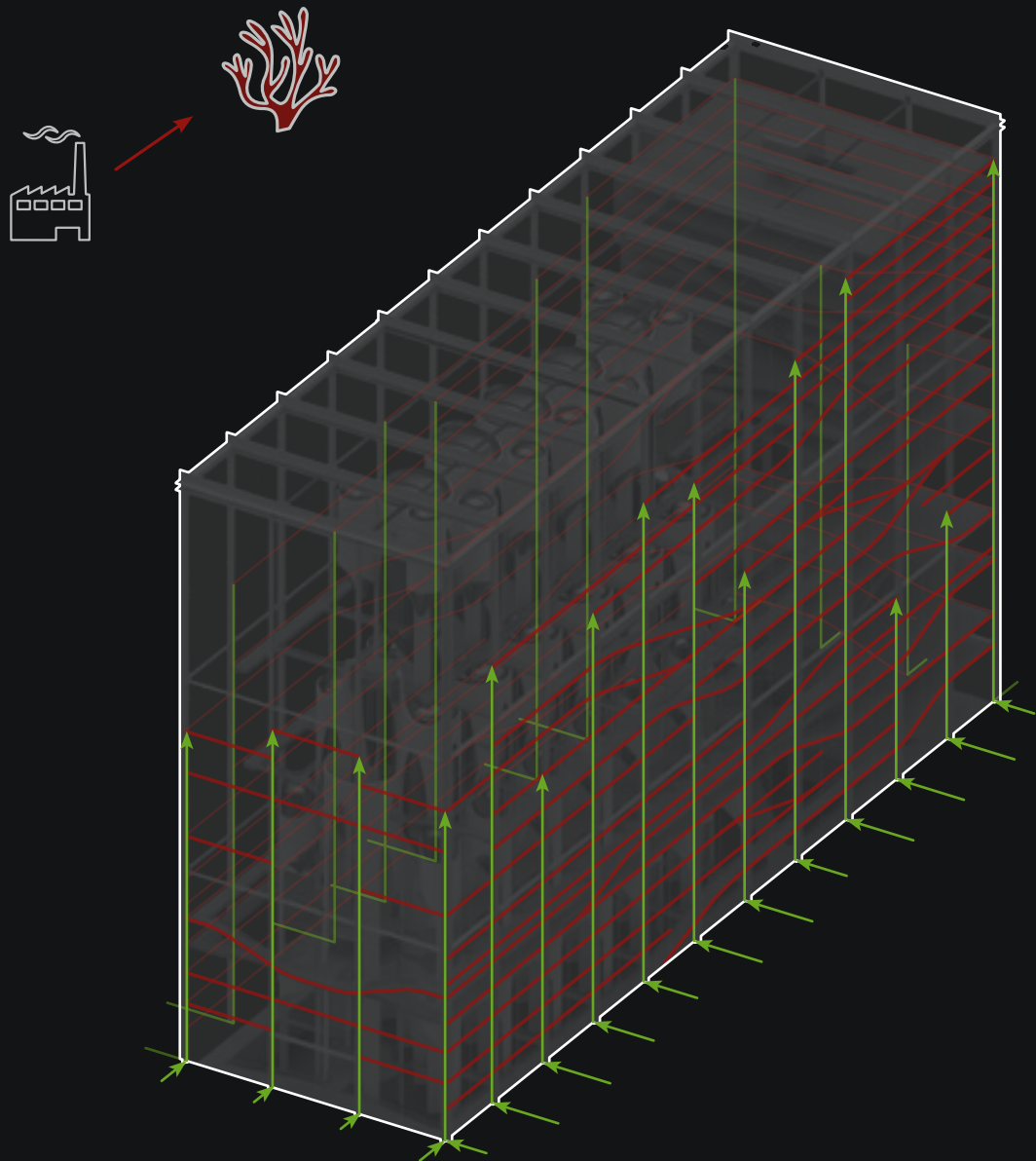


Figure 3.46 | CO2 Intake

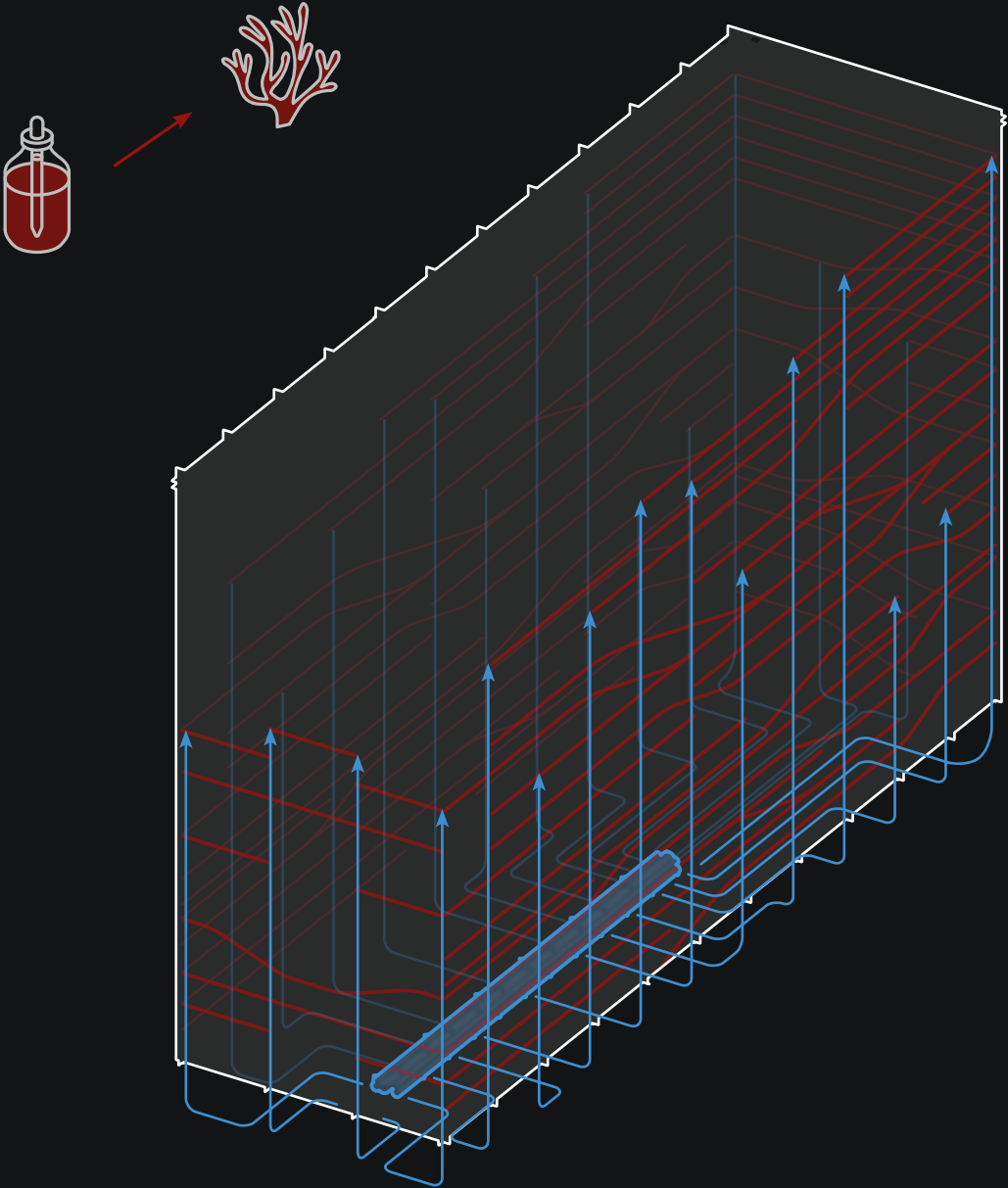


Figure 3.47 | Residual Serum Supply

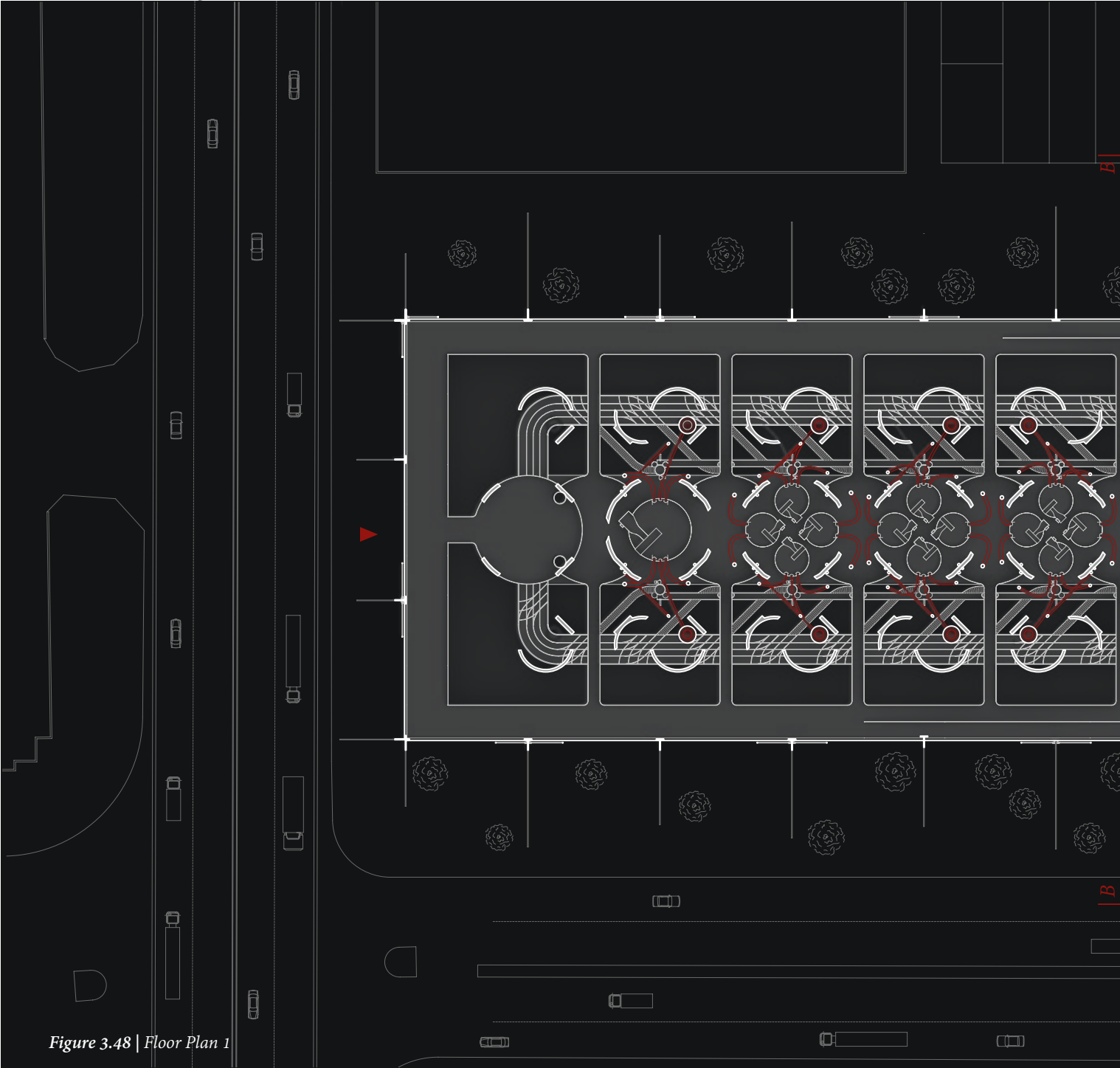
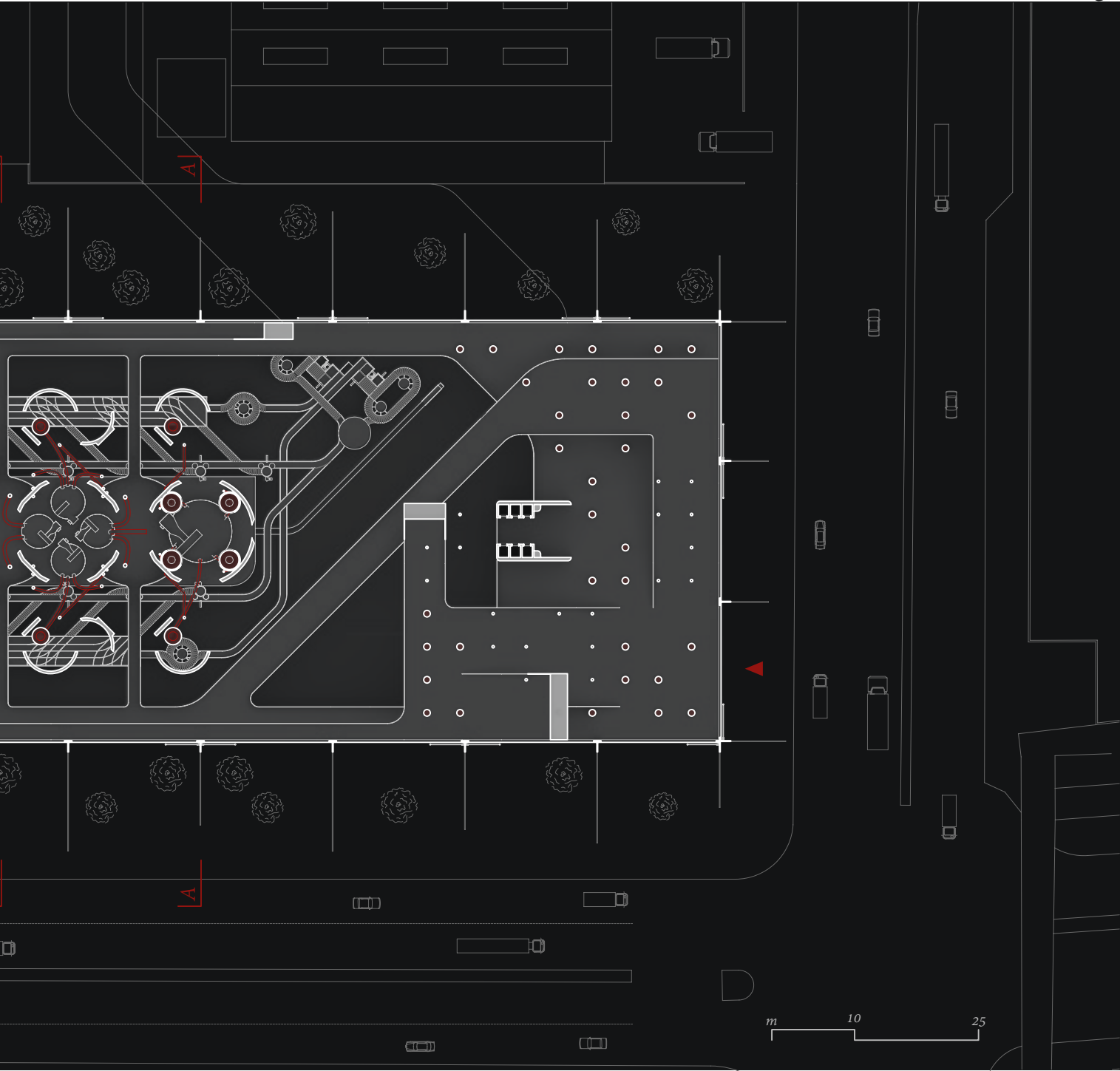


Figure 3.48 | Floor Plan 1



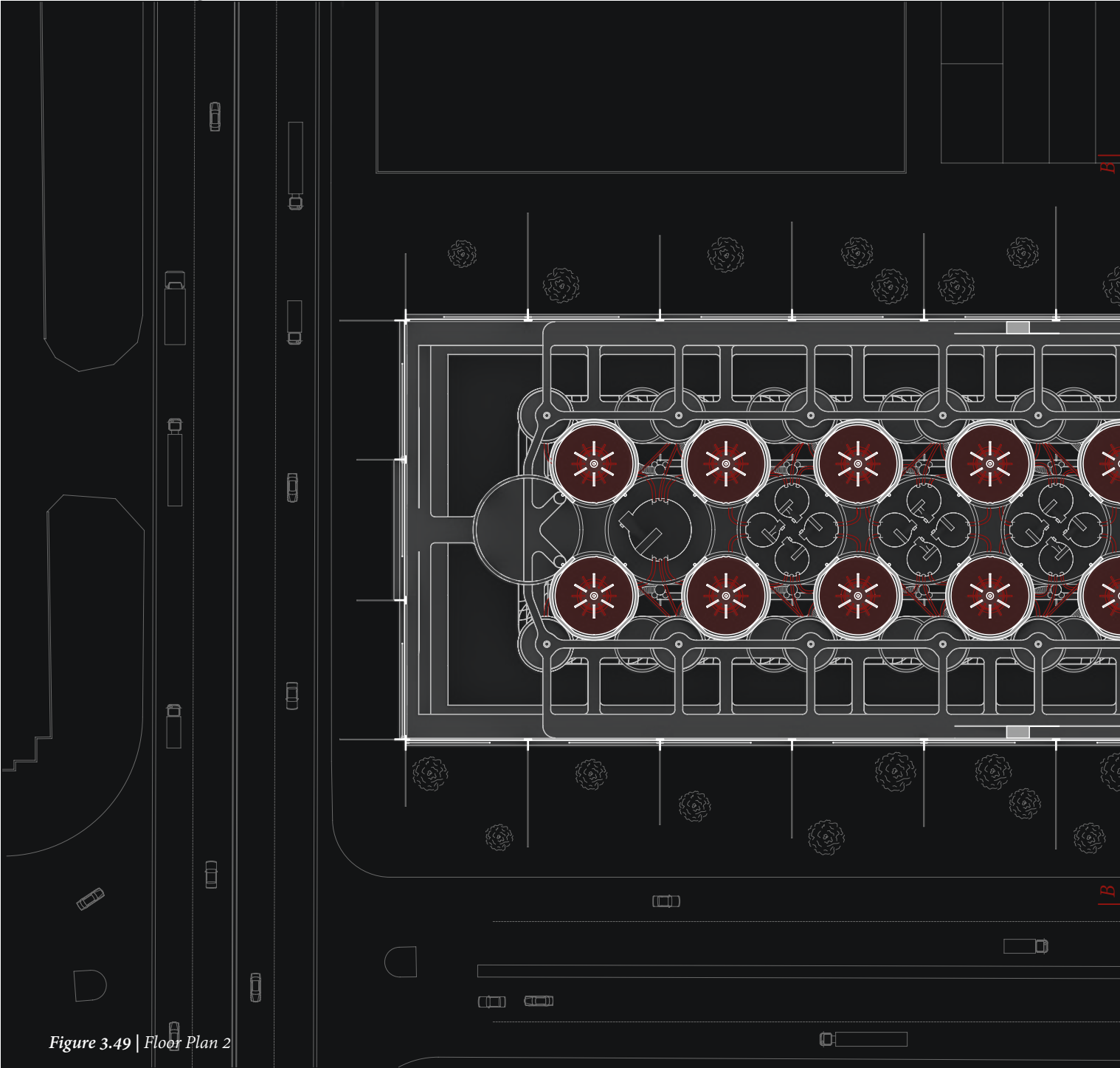
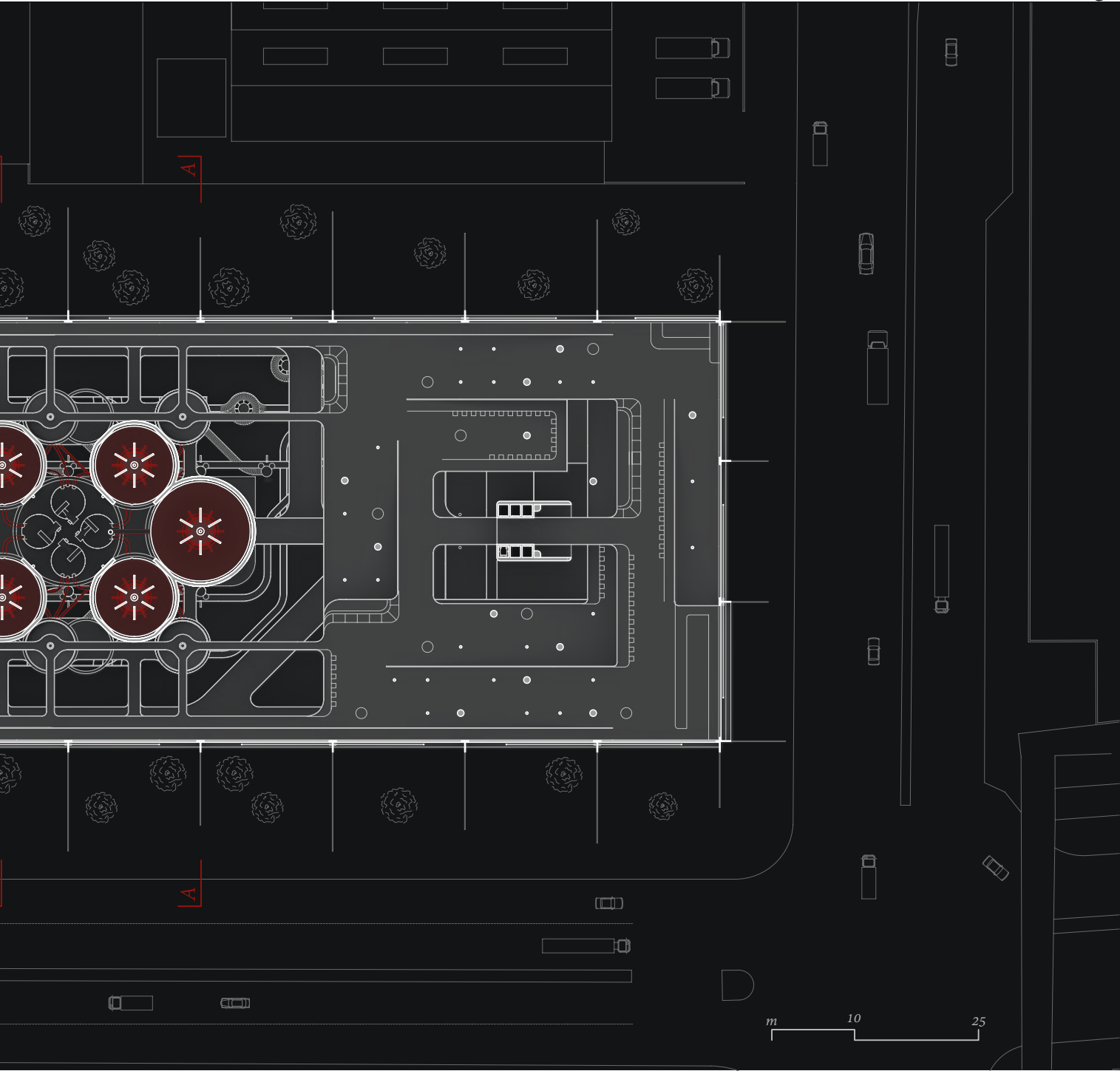


Figure 3.49 | Floor Plan 2



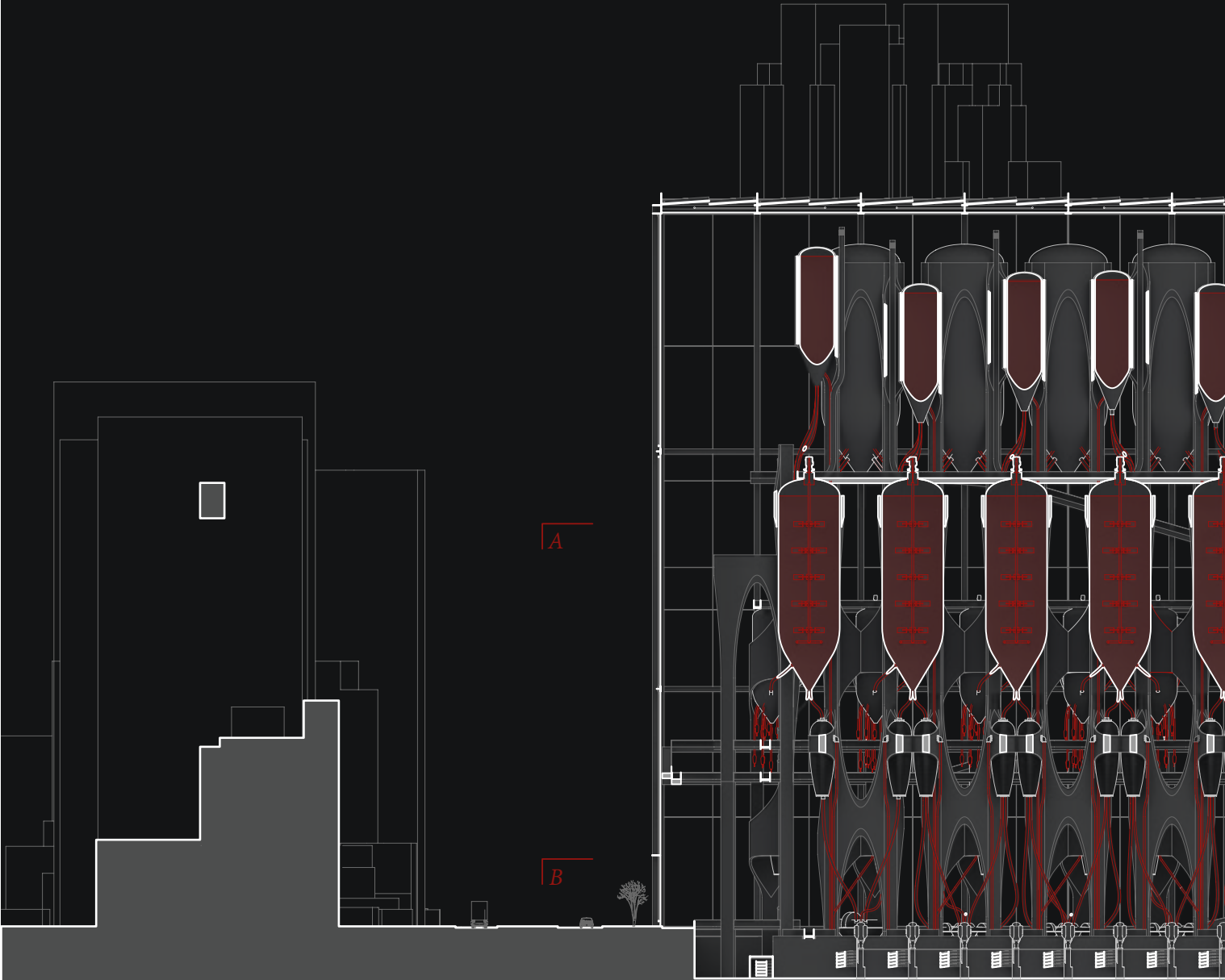
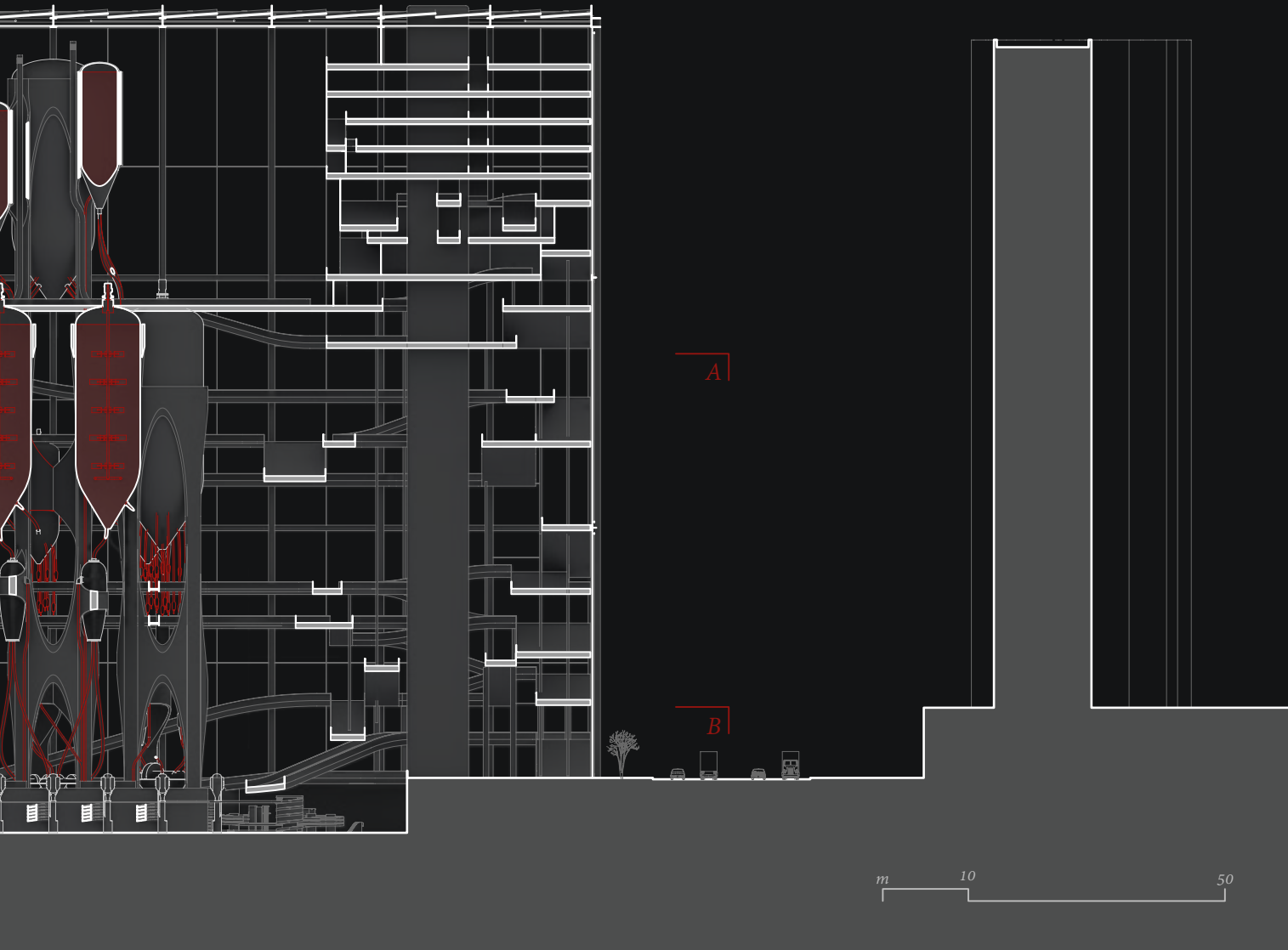


Figure 3.50 | Cross Section



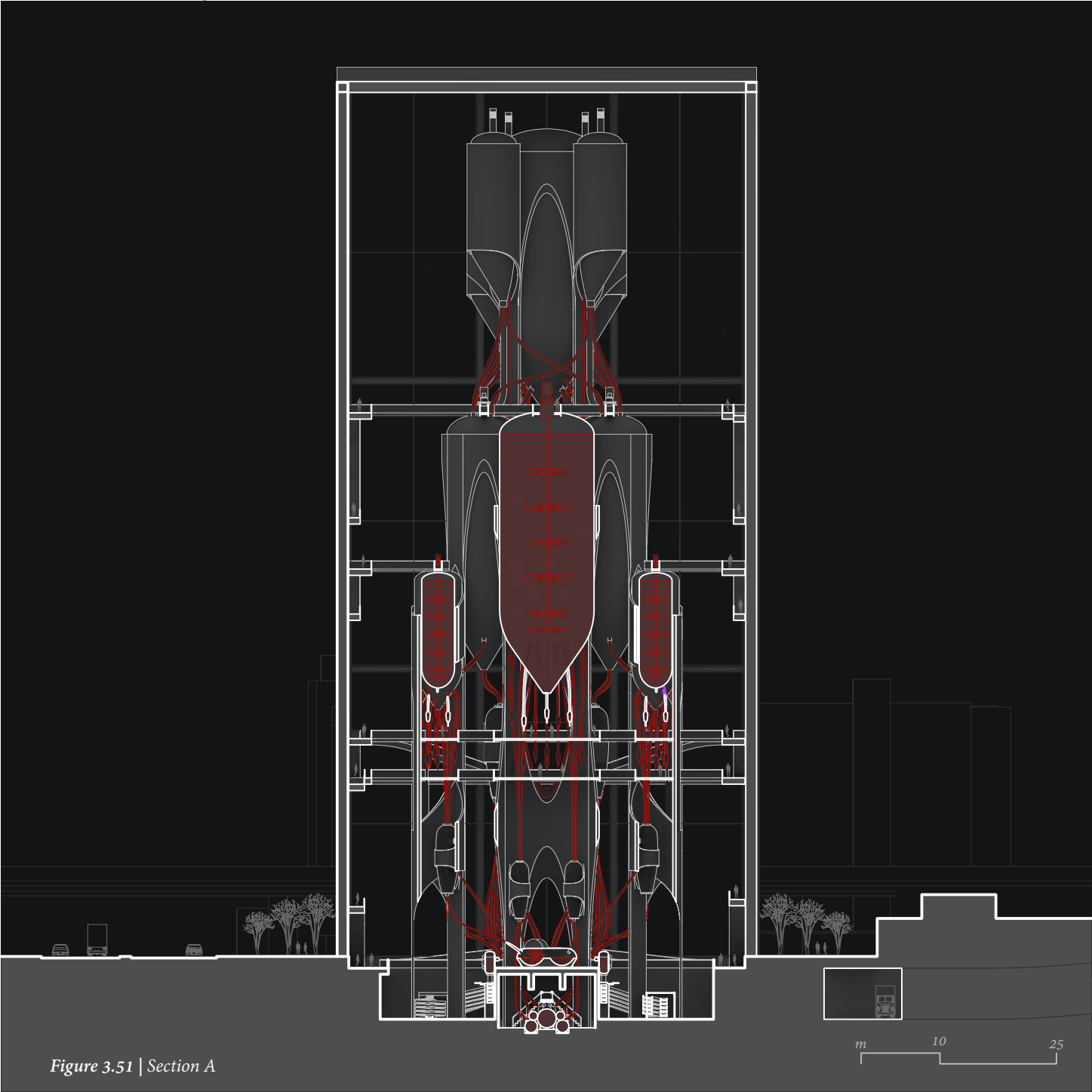


Figure 3.51 | Section A

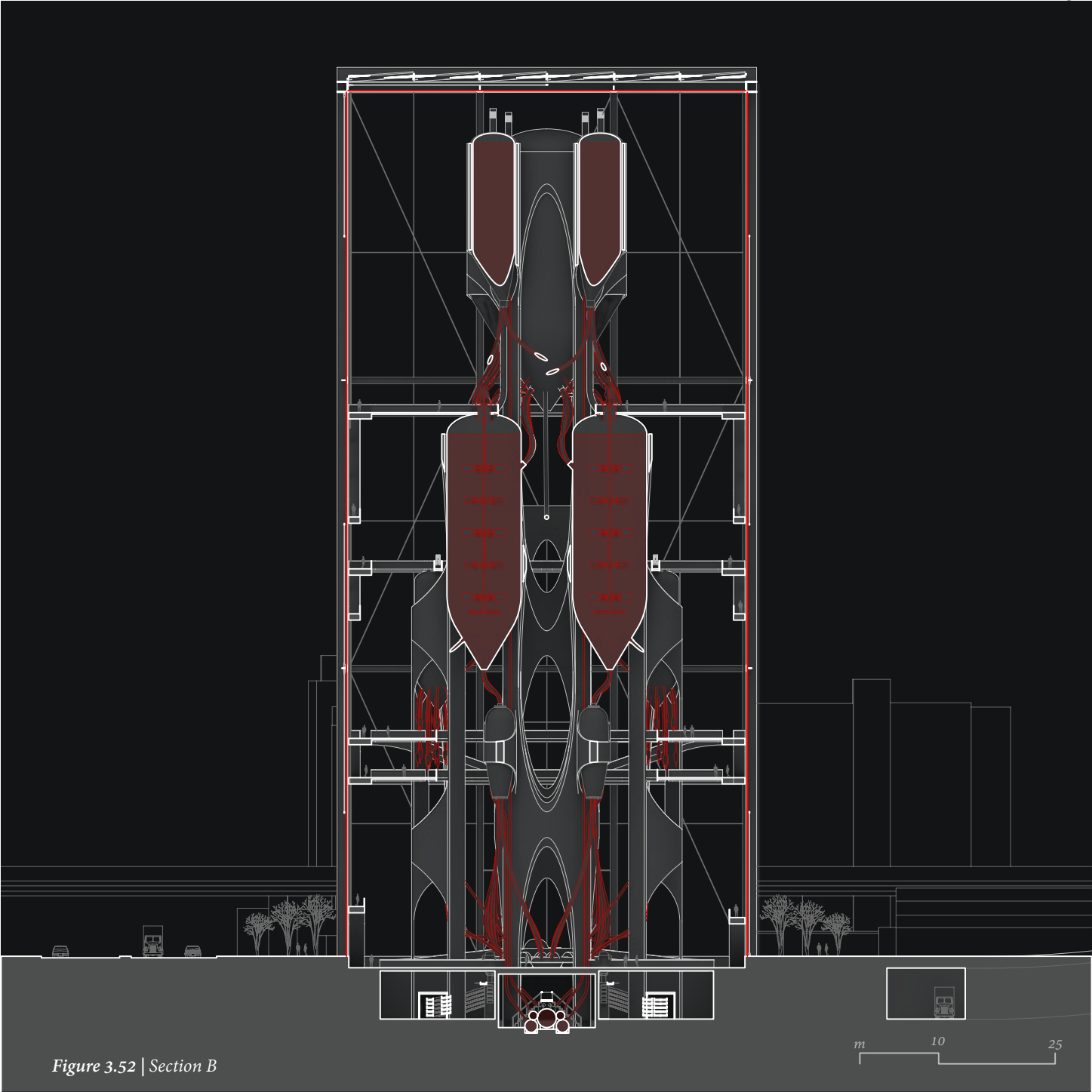




Figure 3.53 | Render 1

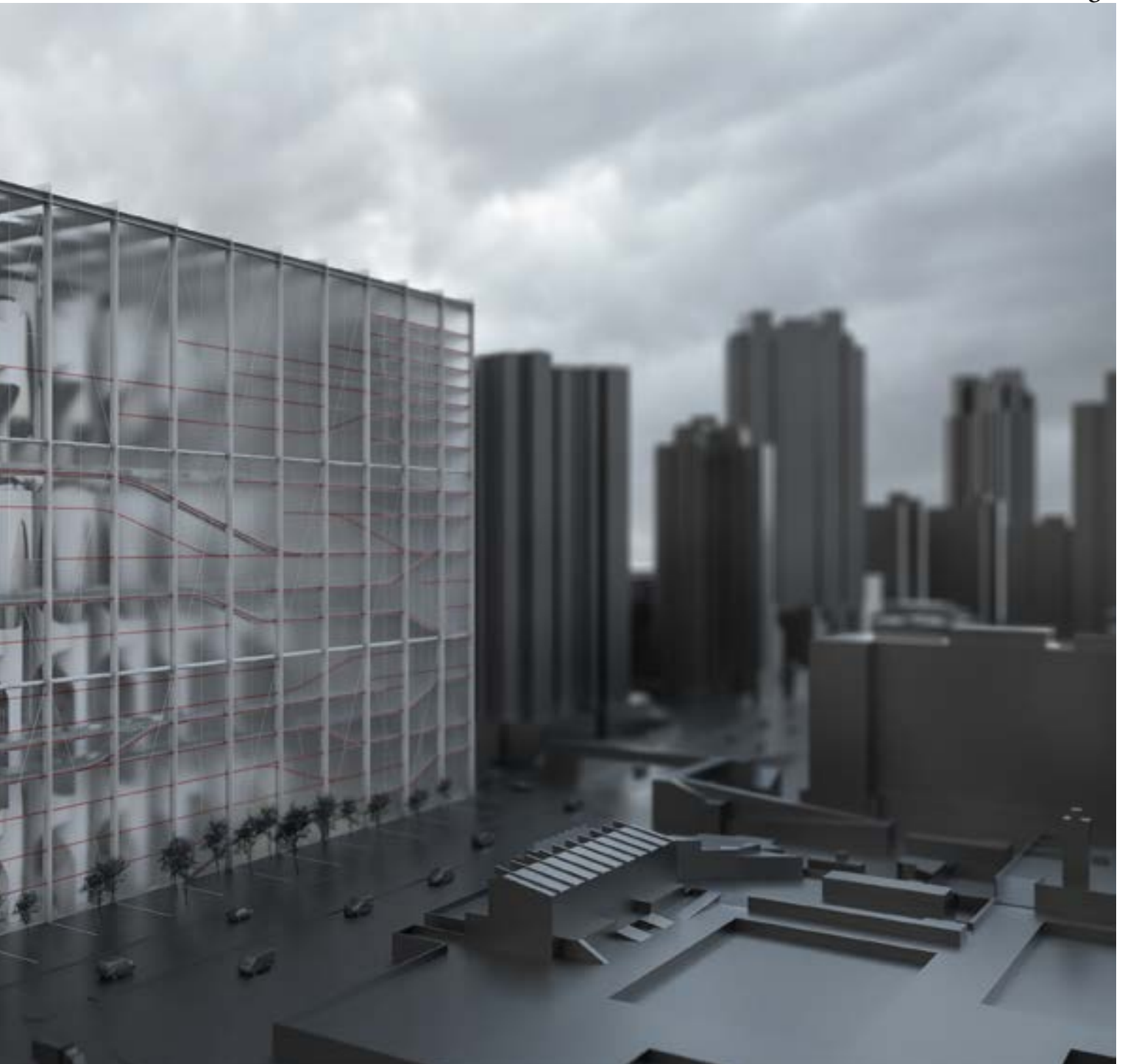




Figure 3.54 | Render 2



Figure 3.55 | Render 3



Figure 3.56 | Render 4





Figure 3.57 | Render 5



NOTES

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adapted from <https://bioinformant.com/wp-content/uploads/2017/03/skeletal-muscle-cells-AMSBIO.jpg> [date of retrieval: 06.10.2020]

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adapted from https://comradecowboys.files.wordpress.com/2016/01/img_5237.jpg [date of retrieval: 06.10.2020]

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adapted from <https://ourworldindata.org/grapher/per-capita-meat-consumption-by-type-kilograms-per-year> [date of retrieval: 06.10.2020]

Figure 1.2 | Global impact of meat production

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Scanes, Colin G., *Animals and Human Society*, 2018, Academic Press, pp. 427–449

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Figure 1.3 | Feedlot, Coronado Feeders, Dalhart Texas

<https://freight.cargo.site/t/original/i/578a505b5bb5aeae6909b273d44b4491bd0c4190fc851272e1547c7aeab83805/Coronado-Feeders--Dalhart--Texas.jpg> [date of retrieval: 06.10.2020]

Figure 1.4 | Feedlot, Tascosa Feedyard, Bushland Texas

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Figure 1.5 | Feedlot, Coronado Feeders, Dalhart Texas

<https://freight.cargo.site/t/original/i/003bec537615a995c2cc5e0006741c8b12c705849c00ece43717399759f80613/Coronado-Feeders--Dalhart--Texas--2012--Detail.jpg> [date of retrieval: 06.10.2020]

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<http://2.bp.blogspot.com/-FLnEyUhBo7g/T6F-rHkYpeI/AAAAAAAAADc/LHeFJyPi66Y/s1600/trois-images-prises-par-satellite-de-la-foret-amazonienne-acquises-respectivement-en-1986-1998-et-2005-la-serie-illustre-limportance-de-la-deforestation-c2a9-cnes-distribution-sp.jpg> [date of retrieval: 06.10.2020]

Figure 1.8 | Wet market in Taiwan

https://weanimalsmedia.org/wp-content/uploads/2020/03/WetMarket_Taiwan_JMcArthur_20190116-9605-2200px.jpg [date of retrieval: 06.10.2020]

Figure 1.9 | Illustration of meat retail

https://www.history.com/image/t_share/MTYzOTIyMzIxNzcyMzkwMTEz/meat-gettyimages-152404506.jpg [date of retrieval: 06.10.2020]

Figure 1.10 | Siberian Nenets eating raw meat

<https://i.pinimg.com/originals/be/51/77/be5177db7bea0db0d1115676c571c390.jpg> [date of retrieval: 06.10.2020]

Figure 1.11 | Kuzu Pirzola made by Nusret Gökçe alias “Salt Bae”

https://www.nusr-et.com.tr/nusret_files/201961016558963_Kuzu%20Pirzola.jpg [date of retrieval: 06.10.2020]

Figure 1.12 | The Slaughtered Ox - Rembrandt van Rijn, 1655

adapted from https://www.theeidencollection.com/wp-content/uploads/2018/03/Rembrandt_FlayedOx_MI169-300x408.jpg [date of retrieval: 06.10.2020]

Figure 1.13 | Im Schlachthaus - Lovis Corinth, 1893

<http://images.zeno.org/Kunstwerke/I/500-440/79k0007a.jpg> [date of retrieval: 06.10.2020]

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<https://en.wikipedia.org/wiki/Shechita#/media/File:Schect.jpg> [date of retrieval: 06.10.2020]

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Figure 2.0 | Production line

<https://www.economicshelp.org/wp-content/uploads/2017/03/assembly-line-factory-specialisation.jpg> [date of retrieval: 06.10.2020]

Figure 2.1 | Old Smithfield Market

<https://cdn.odysseytraveller.com/app/uploads/2019/11/Old-Smithfield-Market-1024x793.jpg> [date of retrieval: 06.10.2020]

Figure 2.2 | Les Abattoirs de la Villette

<http://ekladata.com/vkZ3DYEJgTFRwPJSqFW-XFYOL5o@800x533.jpg> [date of retrieval: 06.10.2020]

Figure 2.3 | Motion study by Frank Gilbreth, 1913

<https://planetneukoln.datacube.ro/wp-content/uploads/2015/02/frank-gilbreth-motion-study-1913.jpg>

[date of retrieval: 06.10.2020]

Figure 2.4 | Ford assembly line, 1913

<https://www.welt.de/img/kultur/history/mobile102012705/0561624077-ci23x11-w1280/bs-07-01-DW-Kultur-Detroit-jpg.jpg>

[date of retrieval: 06.10.2020]

Figure 2.5 | Meat packing in Cincinnati, 1873

https://de.wikipedia.org/wiki/Schlachthof#/media/Datei:Pork_packing_in_Cincinnati_1873.jpg [date of retrieval: 06.10.2020]

Figure 2.6 | Ford assembly line, 1913

<https://autonatives.de/wp-content/uploads/2014/01/1914-Ford-Highland-Park-Plant-assembly-line-760x543.jpg>

[date of retrieval: 06.10.2020]

Figure 2.7 | Fiat factory, Lingotto, 1926

<https://topolino.club/wp-content/uploads/2019/03/lingotto02.jpg> [date of retrieval: 06.10.2020]

Figure 2.8 | Van Nelle factory

https://en.wikiarquitectura.com/wp-content/uploads/2017/01/Van_nelle_21.jpg [date of retrieval: 19.08.2020]

Figure 2.9 | Ford Plant, River Rouge - Charles Sheeler, 1927

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Figure 2.10 | Automatic Bakery - G.P. Marsakov, 1930s

https://tatlin.ru/MyWeb-Image/table/files/field/file/content-field/content/equality-field/id/equality/2241/1/DSC00118__cr_cr.jpg

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Figure 2.11 | Willow Run airplane plant

<https://static.thisdayinaviation.com/wp-content/uploads/tdia/2016/06/Screen-Shot-2016-06-27-at-07.54.05.png>

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Figure 2.13 | Chrysler Tank Arsenal, Michigan, 1941

https://cdn.ca.emap.com/wp-content/uploads/sites/12/2011/05/1_Arsenal_de_chars_de_Chrysler_Albert_Kahn-1024x819.jpg

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Figure 2.14 | Willow Run factory, Ypsilanti, 1941

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Figure 2.15 | Pearl River Delta, 2014

https://upload.wikimedia.org/wikipedia/commons/3/32/2014_NASA_Earth_Observatory_image_of_Pearl_River_Delta.jpg
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adapted from <https://ourworldindata.org/grapher/meat-consumption-vs-gdp-per-capita> [date of retrieval: 06.10.2020]

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adapted from Google Earth, earth.google.com/web/ [date of retrieval: 06.10.2020]

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Figure 3.5 | Slaughterhouse Sheung Shui

<https://www.wongouyang.com/storage/Slaughter-Hse-01-View-fr-South.jpg> [date of retrieval: 06.10.2020]

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https://upload.wikimedia.org/wikipedia/commons/0/00/Cheung_Sha_Wan_Abattoir.jpg [date of retrieval: 06.10.2020]

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Figure 3.10 | Properties of a cow

adapted from Proviande, “Schweizer Fleisch”, *Die Schlachtausbeute als Spiegelbild von Lifestyle und globalisiertem Markt*, Fleisch Information, 2-2009, p. 2, <http://www.haltbar.info/wp-content/uploads/2014/02/Die-Schlachtausbeute-als-Spiegelbild.pdf> [date of retrieval: 06.10.2020]

Figure 3.11 | Comparison between conventional and in-vitro meat production

adapted from Tuomisto, Hanna L./Teixeira de Mattos, M. Joost, *Environmental Impacts of Cultured Meat Production*, *Environmental Science & Technology*, 2011, 45, 14, pp. 6117–6123, <https://pubs.acs.org/doi/10.1021/es200130u> [date of retrieval: 06.10.2020]

Figure 3.12 | Virtual land saved with one meatfactory

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Figure 3.13 | In-vitro meat process

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Figure 3.14 - 3.40

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Figure 3.41 | Facade System

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